Feasibility Assessment of a Water Transactions Program in the Walker River Basin, California

Prepared for

Resource Conservation District of Mono County
Post Office Box 327
Coleville, CA 96107

Prepared by

Shannon Peterson Ciotti
11210 Camjen Lane
Auburn, CA 95603
541-973-5608
shannontpeterson@gmail.com

And Partners

Bruce Aylward: Ecosystem Economics
Amy Merrill: Stillwater Sciences
Debbie Leonard: McDonald, Carano Wilson
Greg Young: Tully & Young Comprehensive Water Planning

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ECOSYSTEM ECONOMICS Stillwater Sciences McDONALD·CARANO·WILSON Tully & Young Comprehensive Water Planning

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FEASIBILITY ASSESSMENT OF A WATER TRANSACTION PROGRAM IN THE WALKER RIVER BASIN, MONO COUNTY, CALIFORNIA

EXECUTIVE SUMMARY

This report was prepared for the Resource Conservation District (RCD) of Mono County. The RCD is spearheading an effort to conduct an analysis of the potential impacts of water transactions in the California portion of the Walker Basin. The primary goal was to provide the RCD with objective information to assist in the County's discussion surrounding potential participation in the water transactions component of the Walker Basin Restoration Program. The analysis of outcomes is driven by a set of three potential objectives for water transactions in Mono County:

Objective 1: Provide water to the state line for delivery to Walker Lake, with the understanding that the water is then intended for delivery to Walker Lake.

Objective 2: Improve productivity for fish and wildlife in area waterways.

Objective 3: Improve or minimize impacts on pasture and crop productivity.

The team approached the analysis through a series of interrelated tasks.

Task 1. Determine and map current water use throughout the Walker Basin within Mono County.

Task 2. Water Flow and consumptive use analysis.

Task 3. Determine potential impacts on agricultural productivity and habitat conditions.

Task 4. Determine potential economic impacts to both individual landowners and the community.

Task 5. Identify options to minimize and mitigate for impacts of concern.

Task 6. Complete an alternatives analysis to determine the most viable options for water transactions.

Task 7. Determine the legal and procedural approaches related to implementation of a water transactions program

As described in Sections 2 and 3, the geographic scope of this study covers all irrigated ground in the Mono County portion of the Walker Basin, as well as waterways that may be affected by transactions. For purposes of the quantitative models used, the scope was limited to the Antelope and Bridgeport Valley floors. Antelope Valley was divided into "Hydrologic Response Units" based on what ground receives irrigation from which diversion point. Bridgeport was treated as a single valley unit. The Team selected five water transaction scenarios on which to focus further study. The scenarios were selected based on potential for quantifiable water savings and expressed irrigator interests. The selected transaction scenarios are not the only ones that might apply to the Mono County portion of the Walker Basin, but were modeled by the Team to quantify water savings, agricultural productivity changes, habitat impacts, economic considerations, and legal and procedural pathways.

The water transaction scenarios chosen were:

1. Full season dryland.
   No irrigation on specific acreage for the entire season.

2. Partial year – Early season fallowing.
   No irrigation before June 1. Ground receives normal irrigation after June 1.

3. Partial year – Late season fallowing.
   Ground receives normal irrigation until July 1. No irrigation after July 1.

4. Reduced irrigation throughout the season.
   The intent behind this transaction approach is to approximate deficit irrigation … where only the minimum water needed is applied. As this is very site-specific management, it was difficult to model for water savings and production impacts with the given information. Instead, the team looked at irrigating during a normal or wet year, but using only as much water as was normally available in a dry year.

5. Release of storage water for instream flows.
   Storage water is released but remains instream. While there is potential for storage releases at any time needed, the Team considered the most straightforward approach; releasing water just after the end of the irrigation season.

For each transaction scenarios the Team considered:

- Geographic location within Bridgeport Valley or Antelope Valley Hydrologic Response Unit.

- Type of land use, including pasture, alfalfa, crop or non-agricultural.

- Spatial extent of the transaction, including 100%, 50%, or 20% of ground within the model.

- Time frame of the transaction, including 1 year, 5 year, or permanent agreements.

- Water year type, identified as dry, normal, or wet. For modeling purposes 2002 is used as the sample dry year, 2010 as the sample normal year, and 2005 as the sample wet year. This selection was made because of overall availability of evapotranspiration, flow, and diversion data was best for these recent years.

Not all of these situations were explicitly modeled for every Task, as they were dependent on information available. However, all situations were considered in the overall analysis. Finding of note are outlined below.

WATER AVAILABILITY FROM CONSUMPTIVE USE SAVINGS

Ecosystem Economics, working closely with the Desert Research Institute and local water users, compiled all water right information, estimated diversion amounts, delineated Hydrologic Response Units (HRU) based on what areas were irrigated from which diversions, and used METRIC derived evapotranspiration maps to calculated potential consumptive use savings from water transactions.

Consumptive use savings were calculated with two different approaches. The first is the standard accepted method of Net Irrigation Water Requirement (NIWR), which, in simple terms, is determined by evapotranspiration minus precipitation. This is the typically accepted approach, and is used in Nevada to determine water saved through water transactions. Due to concerns about subirrigation from shallow groundwater, Ecosystem Economics developed an Irrigation Water Budget Model to account for shallow groundwater contribution to evapotranspiration.

Summary of water savings based on METRIC NIWR Results and Irrigation Water Budget Results for Irrigation and Decree Sources for Decree Rights

(all figures in ft of ET)	DRI - METRIC Analysis				Irrigation Water Budget Model							
	Net Irrigation Water Requirement				Antelope Valley				Bridgeport Valley			
	Antelope Valley		Bridgeport Valley		All Sources*		Decree Only		All Sources*		Decree Only	
Transaction Type	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Full Year - Temporary	3.1	3.5	3	3.3	2.1	3.2	1.7	3	1.5	1.9	1.3	1.7
Full Year - Permanent					3.2	3.7	2.8	3.5	3.3	3.7	3.2	3.6
Partial Year - Late Season	1.6	2	1.4	1.5			0.3	1.4			0.4	0.7
Partial Year - Early Season	0.8	0.9	1.0	1.1			0.9	1.1			0.6	0.7
Temporary Full Year Reduction	0.4		0.3		1.1		1.3		0.4		0.4	

Notes: *All sources do not include water table / groundwater for temporary transactions but do include this for permanent transactions

VEGETATION RESPONSE TO WATER TRANSACTIONS

Potential environmental impacts of a water transaction program in Antelope and Bridgeport Valleys are described in this report. A conceptual model that articulates linkages among surface water, groundwater, crop production, natural vegetation, fisheries, and wildlife was used to direct this assessment (Figure 3-1). For either all or part of Antelope Valley and for all of Bridgeport Valley, potential impacts associated with five water transaction scenarios are considered: (1) no irrigation for full season; (2) late season fallowing – no irrigation after July 1; (3) early season fallowing - no irrigation until June 1; (4) reduced irrigation throughout the irrigation season; and (5) end of season storage water release. Overall, a scarcity of quantitative information limited the degree to which conclusions could be made. However, we outline basic comparisons among water transaction scenarios and their associated potential impacts.

In order to assess likely impacts of a water transactions program on the agricultural, upland, and riparian vegetation, and related sensitive animal and plant species, the following vegetation-related information was needed for the areas in Antelope and Bridgeport Valleys (under five percent slope):

- Key species composition for dominant vegetation types in, including riparian corridor, rangelands, other natural lands, and managed crop lands;
- A map of the location and approximate extent of each major vegetation type; and
- Potential vegetation type-specific responses to variations in water availability expected to occur with changes in irrigation.

Using existing information, field surveys, 2012 NAIP imagery, and canonical correlation analysis, Stillwater Sciences developed map of local vegetation types in Antelope and Bridgeport Valleys. This included identification of special-status plant species whose geographic distributions overlap with the study area, but actual presence of these species was not determined (Table 3-5). Based on spatial identifications of vegetation, soils, slope, and groundwater, an overall sensitivity ranking of expected effects of water stress on vegetation was created, summarized by HRU in Antelope Valley and across Bridgeport Valley as a whole. This analysis was used to determine potential impacts of changes in water availability to crop, forage, and natural vegetation, with the intent to tie these changes into economic impacts to producers and changes to wildlife habitat.

Alfalfa is grown in roughly one-fifth of the irrigated area in Antelope Valley and therefore is an important agricultural crop in this area. Garlic is also grown on a small portion of Antelope Valley. Water transaction scenarios that suspend irrigation of existing alfalfa stands in Antelope Valley would have significant impacts to overall production rates, cutting production yields to less than two tons/ac per season. Conversion to alfalfa cultivars specific to dryland cultivation would be recommended for alfalfa production under this scenario. Of the twelve areas within Antelope Valley that share an irrigation ditch, those dependent upon Big Slough for irrigation include the greatest amount of land supporting alfalfa production and therefore implementing this transaction scenario to this part of Antelope Valley would result in the greatest negative impact to alfalfa production. Delaying irrigation until after June 1 would have a similarly large effect on alfalfa production since this would sharply impact the first and usually largest cut of the season. Although halting irrigation following July 1 could also reduce alfalfa production, production under this scenario could still be roughly 80% of current levels. This is the recommended approach for alfalfa and is already applied in other regions. Scenario 4 (reduced irrigation throughout season) would have impacts similar to halting irrigation as of July 1, and end of season water releases would be expected to have no impact on alfalfa production.

Both Antelope and Bridgeport Valleys include rangelands, which cover over 80% of Bridgeport Valley and approximately 60% of Antelope Valley. Under Scenario 1 (no irrigation), forage production is expected to decrease substantially in both valleys. While impacts to forage production in Bridgeport Valley could be important, large uncertainties regarding near-surface groundwater levels and the degree of natural sub-irrigation without diversions make it difficult to determine if there would be significant impacts to rangeland production in this valley. Within Antelope Valley, rangelands irrigated by Big Slough, Swauger, and Rickey and Private would experience the impact on rangeland production. Proportionally, areas irrigated by West Goodenough & Harney, Swauger, Powell, and Alkali would be most impacted. Shutting off irrigation on July 1 (Scenario 2) could reduce forage production for the first one to two years, but given appropriate weed and grazing management, as plants adapt and compositions shifts, production could return close to existing levels within several years of ongoing management. Delaying irrigation until June 1 could have a small impact on forage production in Antelope Valley, but these effects could vary depending upon fall precipitation and temperature. Forage production is not expected to be impacted in Bridgeport Valley if irrigation is delayed until June 1. As with alfalfa, Scenario 4 (reduced irrigation throughout season) impacts would be similar to those described for Scenario 2, and water releases after the growing season (Scenario 4) would have no impact on forage production.

Potential impacts of the water transaction scenarios to existing natural vegetation overlap with the rangelands assessment because many of these areas are the same. Thus, the density, above ground production, and native forb diversity could be impacted in moist grasslands found in both Antelope and Bridgeport Valleys. Smaller impacts to dry grass vegetation found within and separate from areas supporting sagebrush are expected to occur for irrigated areas or areas adjacent to irrigated lands. Several sensitive forb, grass, and moonwort plant species that could occur in the Study Area and that are associated with moist grass or sedge areas could be affected; however surveys have not been performed for these species so their actual occurrence in the Study Area is unknown. Coyote willow and Woods' rose also occurs along many irrigation canals, and in low, wet spots in both valleys. Reduced all-season and early-season irrigation could impact these shrub thickets. Native riparian vegetation along the West Walker River in Antelope Valley includes Fremont cottonwood and several different native willow tree and shrub species. Water transaction scenarios that increase channel flows in a way that is similar to the natural hydrograph could increase recruitment and survival of native cottonwood and willow trees along the riparian corridor. This could increase the density and species richness of the river area, and diversify the age structure of the riparian forests, which are currently skewed towards mature and senescent age classes of cottonwood and red willow.

HABITAT IMPACTS FROM WATER TRANSACTIONS

The wildlife impact assessment is closely tied to our understanding of potential impacts to vegetation as wildlife habitat. There are various common and special-status wildlife species that occur or could occur in the California portion of the Walker River Basin. Select species were included in this document because of their special-status designation and/or high public interest value, as well as their potential to be affected by water diversions. Antelope and Bridgeport Valleys could provide important habitat for many wildlife species, including the greater sage-grouse, yellow warbler, mule deer, pygmy rabbit, western white-tailed rabbit, and the American badger. Because the pygmy rabbit, western white-tailed rabbit, and American badger are all well adapted to dryland habitats, none of the water transaction scenarios are expected to negatively impact these species. Greater sage-grouse thrives in areas with a mixture of sagebrush, dry grass, and moist grass vegetation. It is hypothesized that an increase in the amount of interface between these vegetation types could positively affect greater sage-grouse, but the importance of this is unknown, as is the extent and distribution of any greater sage-grouse populations in the Study Area. Any assessment of potential effects on greater sage-grouse associated with changed vegetation in the valley bottoms would need to be centered upon the current distribution of greater sage-grouse in the valley(s). Only Scenario 1, implemented for multiple years, is expected to have a significant effect on the amount of interface between sagebrush and moist meadow vegetation. Other scenarios are expected to have negligible-to-minor effects on the greater sage-grouse that might occupy one or both valleys.

The yellow warbler also occurs in the Study Area and prefers open canopy or deciduous riparian forest and shrubs. Therefore, increases in willow and riparian forest cover that could occur with Scenario 1 and 3 (increased stream flows all or in the early part of the season) could positively affect yellow warbler. On the other hand, decreased extent of coyote willow in other parts of Bridgeport and Antelope Valleys with reduced early season irrigation could negatively affect yellow warbler habitat. Thus, the impacts could be mixed for this species. Mule deer, which have a varied diet that spans the vegetation types in both valleys, are not likely to be affected either way by any of the water transaction scenarios. Yosemite toad, Mt. Lyell salamander and Sierra Nevada yellow-legged frog were also considered in this assessment but determined not to have potential habitat within the Study Area.

Instream effects on native and non-native fish species were assessed, again with limited quantitative information, particularly in Bridgeport Valley. To assess the potential effects of different water transaction scenarios on fish resources in the Walker River Basin, we consider flow magnitude and timing in relation to the life history timing of fish expected to be present within affected reaches. The general approach is to evaluate changes between current flow conditions and potential future conditions expected under an alternative flow/diversion scenario as they relate to the fish species of interest, during times when habitat conditions are potentially limiting. Stream reaches likely to show substantial changes in aquatic habitat conditions as a result of water transactions are the focus of the assessment. Note that available data to support the assessment of the potential effects of water transactions on fish resources in the Walker River basin are sparse. The approach described above, and assessment presented below, is based primarily on (rough) flow estimates, general regional climactic conditions, general life history and habitat requirements of focal fish species from studies mostly done elsewhere, and professional judgment. The information that would be required to make strong informed conclusions about water transactions on fish populations would include: fish sampling (species abundance, size, and age distribution), flow management (diversion timing and volume), streamflow (in-channel and accretion flow), aquatic habitat conditions (habitat frequency, cover, and complexity), flow-habitat relationships for focal fish species and life stages, entrainment (season and flow), and water quality (temperature and nutrients). This data would form the basis of a more comprehensive assessment of the factors controlling fish populations, and could lead to additional information needs such as food availability and bioenergetics modeling to understand key linkages between fish habitat and population abundance.

The Walker River Basin in California currently supports both native and non-native fish species. Native fish species include Lahontan cutthroat trout and whitefish, as well as sucker, minnows and sculpin. Introduced fish species include brook, brown, and rainbow trout that have been planted in various lakes, reservoirs, and stream reaches for improved recreational fishing opportunities. Lahontan cutthroat trout occupy less than three percent of their historic range, which formerly included all or most of the Walker River Basin, and are listed as threatened under the Endangered Species Act. Current populations in California are isolated in small headwater streams and do not overlap with the irrigated lower valleys. Thus, the water transaction scenarios are not expected to affect these existing populations of Lahontan cutthroat trout. However, non-native brown and rainbow trout do exist in the river reaches that flow through Antelope and Bridgeport Valleys and could benefit from increased early and late season flows that could occur under Scenario 1, and to a lesser degree, under Scenarios 2 and 3. These benefits to non-native trout are primarily associated with creating cooler stream temperatures due to increased instream flows during critical times of year. Most of the native fish in Antelope and Bridgeport Valleys are less sensitive to stream temperatures but could experience minor benefits from the water transactions due to reduced entrainment in diversions.

Twin Lakes provide upper watershed storage for the Bridgeport Valley, and it is possible that water storage here, and other upstream storage reservoirs, could be managed differently if sale incentives for stored water were to change. Based on available information, upper and lower Twin Lakes would likely maintain mean and maximum depths sufficient to provide suitable water temperatures during the irrigation season for resident trout survival, during years when maximum drawdown is reached (**Error! Reference source not found.**). The long-term effect of annual maximum drawdown on existing fish populations in Twin Lakes and Robinson Creek are uncertain. Historic information indicates that flows in Robinson Creek downstream of Twin Lakes may reach zero in dry years, however, flow greater than zero is generally maintained to support the recreational fishery and associated businesses (Case Study Report #48, no date). The extent to which stored water sale incentives would change management of flow into Robinson Creek is uncertain; however, it appears that flow could reach zero, which could result in impacts to fish populations in Robinson Creek downstream of Twin Lakes.

FINANCIAL NET BENEFITS FROM WATER TRANSACTIONS

Payment for an acre foot of water was based on NFWF's 2014 Program Appraisal Report. Permanent purchase of diversion rights were set at $1,800 /AF, and storage rights at $1,500/AF. Lease rates for diversion rights were set at $108/AF/year, and storage rights at $90/AF/year.

Financial Benefits from Water Sales and Leases, Using METRIC NIWR

		Water Not Consumed - NIWR in AF Available to Sell or Lease		**Payments ($/Acre)**	
Transaction	**Price ($/AF)**	**Antelope Valley**	**Bridgeport**	**Antelope Valley**	**Bridgeport**
Permanent Transaction ($/AF)					
Full Season Purchase - Decree	$1,800	3.34	3.16	$6,012	$5,688
Purchase - Storage Water	$1,500				
Single Year Transaction ($/AF/yr)					
Full Season Lease	$108	3.34	3.16	$361	$341
Partial Year Lease - Late Season	$108	1.84	1.45	$199	$157
Partial Year Lease - Early Season	$108	0.91	1.02	$98	$110
Temporary Full Year Reduction	$108	0.39	0.24	$86	$32
Storage	$90				

Ecosystem Economics estimated the net income for landowners participating in water transactions, using both NIWR and Irrigation Water Budget Model estimates of water savings. Both approaches result in favorable benefits for all land uses, except alfalfa growers in Antelope.

Net Financial Benefits to Water Right Holders from Water Transactions; METRIC NIWR

	Payments ($/acre)		**Opportunity Costs ($/acre)**			**Net Benefits ($/acre)**		
	Antelope	Bridge-port	Antelope		Bridge-port	Antelope		Bridge-port
Transaction			Alfalfa	Pasture	Pasture	Alfalfa	Pasture	Pasture
Permanent Transaction ($/acre)								
Full Season Purchase - Decree	$6,012	$5,688	-$9,499	-$819	-$863	-$3,487	$5,193	$4,825
Purchase - Storage Water	$1,500/AF							
Single Year Transaction ($/acre/yr)								
Full Season Lease	$361	$341	-$844	-$40	-$41	-$483	$321	$300
Late Season Lease	$199	$157	-$244	-$2	$0	-$45	$197	$157
Early Season Lease	$98	$110						
Full Season Reduction	$86	$32						
Storage	$90/AF							

With respect to potential fiscal impacts, the three primary ways water transactions have the potential to affect the local economy are through changes in a) local spending by landowners; and b) property development/taxes; and c) recreation/tourism associated with water-related amenities (e.g., Twin Lakes) and the region more generally.

In general, there are two types of local spending by landowners that have the potential to be affected – expenditures to support agriculture production (e.g., fuel, machinery, labor) and expenditures resulting from agricultural revenues accrued by landowners (e.g., restaurants, groceries). With the exception of the general store in Bridgeport, personal communication and anecdotal evidence suggests that the majority of agriculture related purchases are made outside the County, often in Nevada, and that diesel is typically trucked up from Sacramento in order to comply with California standards. engaging in a water transaction is unlikely to affect overall post-production expenditures, as, at least in theory, a landowner would not engage in a water transaction unless he/she received at least as much revenue from the transaction as he/she would from full water production. While not analyzed in this study as it would greatly depend on the location and specifics of each water transaction, one additional expenditure by landowners engaging in permanent (and potentially full-season) water transactions relates to shared maintenance for the irrigation ditch systems in both valleys. It could be possible that if a sufficient number of users chose to participate in water transactions, the remaining users might not be able to afford the costs of maintaining the system. Such an analysis may be useful related to individual transactions. Thus, water transaction impacts on local spending is expected to be negligible.

While changes to property taxes would vary depending on the specific of each situation, this analysis suggests that a significant drop in tax income is not likely. Full- or partial-season leases are unlikely to result in changes to property zoning or assessed property values, although there may be that potential with permanent purchases. However, there are numerous considerations that have the potential to affect that result. Whether this would result in higher or lower taxes would depend on whether the property lost its agricultural deferral and the basis and rate for the tax calculations. Furthermore, while it might be expected that less value being generated might reduce taxes, experience in other jurisdictions suggests that tax policies are often designed to subsidize agricultural properties and therefore there is typically no decline in tax paid, and the tax paid potentially could even rise. Irrigated agricultural land is generally zoned agriculture and the maximum density requirements vary depending on the location of the property. With respect to permanent water transactions, if agricultural land, particularly land in pasture, were to no longer be irrigated, the land would likely revert back to high desert sage and scrub brush. It appears that such land would unlikely be rezoned anything other than agriculture without a request by the owner. While analyzed here, an additional impact on property values (and thus associated taxes) is related to the general aesthetics of the regions. Transition from irrigated pasture to high desert sage and scrub brush landscape might impact neighboring property values.

It is generally believed that the majority of local water-related activities (e.g., fishing, boating, camping/hiking) could benefit indirectly as a result of increased instream flow associated with water transactions. However, the degree to which such indirect benefits may result in changes to recreational use patterns and/or associated local spending was outside the scope of this analysis. One caveat to the assumption that the direction of impacts would generally be positive relates to recreational activities occurring on small reservoirs (e.g., Twin Lakes). There is concern that water transactions could result in decreased water levels in these reservoirs during the recreation season because of releases for the benefit of Walker Lake. Leasing of storage water could be structured as releases at the end of the irrigation and recreation season to avoid this impact.

The basic analysis of the County-level economic impacts from a water transaction program, including the multiplier effect, concluded that given the a) “leaky” nature of county-level economics in general; b) evidence that many agricultural purchases and subsequent income expenditures by ranchers/farmers are done outside the County; and c) the assumption that farmers/ranchers would still be compensated if participating in a water transaction, it suggests that changes to the County-level economy are unlikely to be substantial.

ADDITIONAL SUPPORT FOR LANDOWNERS INVOLVED IN WATER TRANSACTIONS

Most water transactions will result in decreased irrigation to specific acres, which will reduce productivity. However, there may be other complementary changes in land, livestock, or crop management which could maintain productivity at higher levels than expected. The goal for any landowner participating in a water transaction program should be to reach maximum productivity with minimum water use. Some options include:

- Rotational grazing
- Transition from cow/calf pairs to lightweight yearlings
- Grass banking
- Dryland seeding
- Change in alfalfa cultivar
- Irrigation efficiency methods

There are a myriad of avenues for landowners to receive technical and financial support related to conservation-based management changes on their property. These programs, in addition to water transaction agreements, may help to offset costs related to productivity and management changes under reduced irrigation. Multiple programs or approaches can be bundled together to enable landowners to make changes they would like to see on their property and offset some of the costs of those changes. These include a host of different programs under the Agricultural Act of 2014 (Farm Bill), conservation easements, and restoration grants.

While this analysis chose to focus on the five transaction scenarios described for modeling purposes, there are a host of other transaction options that may be beneficial in the area of interest. These options would likely be of interest to the Walker Basin Restoration Program if they resulted in protecting additional water instream. Even if they do not all fit the goals of the Walker Basin Restoration Program, there are opportunities to find funding from other sources to complete transactions.

1. Change in point of diversion in order to decrease delivery losses, or increase stream flow in a critical stream reach.
2. Improve efficiency at the diversion point, in conveyance to the irrigation location, or on-field.
3. Minimum flow agreements, where irrigators agree to not divert after streamflow reaches a specified low flow level.
4. Rotational sharing, where multiple water users on the same system could coordinate their irrigation practices in a way that would either use less water, or divert less water at any one time.
5. A change in crop type between pasture / alfalfa / hay / or other crops.
6. Instream flow water right donations. While still in the early stages, there is increasing interest in tax deductions given for water right donations. In some cases the IRS has allowed the value of such donations to be deducted for tax purposes.
7. Water trading or water banking.

LEGAL FRAMEWORK FOR TRANSFER OF CALIFORNIA WALKER RIVER WATER RIGHTS

The greatest legal obstacles that the proposed water transfers program may confront can be narrowed to essentially three related issues: time for regulatory and court approvals, transaction costs to secure those approvals and the no-injury rule. Additionally, the interstate nature of the proposed transfers adds an additional layer of legal complexity. Transactions will need to assure that there is no injury to other users, primarily that the amount of water protected instream is the real consumptive use savings. The Decree Court has jurisdiction over changes to decree water rights, and is likely to request recommendations from both the California State Water Resources Control Board and the Nevada State Engineer. As such, if the Decree Court's approval is required, there may be an extended time period before the transaction is finalized.

Before any transaction can move forward in the California portion of the Basin, two other activities need to be complete:

1. Under the Mono County / NFWF Memorandum of Understanding, funding for California transactions in the Walker Basin is predicated on Mono County's compliance with its obligations under CEQA. Mono County will need to complete a CEQA analysis before approval of overall program participation. One-year transfers and forbearance agreements may be exempt from CEQA under California law, in which case NFWF and Mono County may agree to move forward with select transactions concurrent with (and perhaps to inform) CEQA.

2. A Section 7 ESA Consultation on the effects to listed or candidate species and their habitat must occur. Bureau of Reclamation would be the lead agent on the Consultation.

The chart below can be used to help identify the appropriate legal mechanism to use under various transaction conditions.

Legal mechanisms applicable to water transactions in the Mono County portion of the Walker Basin

Legal Mechanism	Initial Step	Benefit and Burden	Time
Decree	Petition Decree Court directly under its "exclusive jurisdiction" over interstate transfers to dedicate water for instream beneficial uses under the identified adjudicated water right	Decree Court sanction of dedication. Significant procedural action to modify decree.	9 months to 1.5 year to complete
Forbearance	Engage water user and downstream users to forbear from using water.	Must engage a large number of potential diverters in order to secure water for desired objectives	3 months to 3 years to complete (if there are protracted negotiations with multiple landowners)
Water Code §1707	File petition with SWRCB in order to dedicate a water right to instream purposes	Decree Court would still need to modify the decree in order for 1707 right to be protected.	2 to 5 years to complete
Water Code §1435	File petition with SWRCB for a temporary urgency change.	Under Decree Court Rules and Regs, temporary change must be ratified by the Decree Court.	Up to 6 months based on state requirements; then dependent on Decree Court
Water Code §1725	File petition with the SWRCB to dedicate water for instream purposes	Temporary change must be ratified by the decree court	6 months based on state requirements; then dependent on Decree Court
Water Code §1736	File petition with the SWRCB to dedicate existing water right for instream purposes	Permanent change must be ratified by the decree court	2 to 5 years

POTENTIAL IMPACTS OF CONCERN TO MONO COUNTY

Based on the analysis and interviews completed as part of this study, we have identified potential impacts which may be in conflict with policies and goals identified in the Mono County General Plan, and considerations to mitigate for or minimize the negative effects. Please note that this discussion covers all potential impacts of concern as identified by this Assessment. This includes concerns raised by residents and County officials, even if the Assessment did not explicitly study them. At the request of RCD the Team is providing insight into all concerns raised, even if there is not data specific to those impacts. Some of these potential impacts may not come to fruition, or the County may determine that they are not points of concern. It is important to note that for many of these concerns there are regulations in place that would already provide protection, including under California water law, the Walker River Decree, and existing County policies. The County may or may not decide if it is in their interest to add an extra layer of protection by including certain limits or regulations as part of their discretionary approval of water transactions. This discussion presents ideas for the County to consider based on information gathered, but by no means intends to convey that these are all certain impacts, or that all or any of the mitigation or minimization steps are necessary for a functional program.

Potential Impacts of Concern	Recommendations to Minimize or Mitigate for Impacts
Maintain agricultural land use for economic base, open space, and rural character of the region.	Mono County has guidelines in place limiting parcel sizes and requiring extensive processes to allow for additional development or conversion from agricultural zoning to other zoning. These guidelines can help to maintain the open space and rural character of the region as they are intended to do with or without a water transactions program. However, it may benefit the County to implement additional safeguards targeted specifically at acreage under water transaction agreements. The County may state clearly as part of the agreement to participate in the water transactions program that the program should not undermine the agricultural economy, advance development, or contribute to the loss of open space. Limits may be placed on the ability of landowners to subdivide their properties through county zoning or planning regulations, transfer of development credits, or conservation easements.
Maintain scenic qualities and aesthetic character of the region	To reduce the impact of irrigation cessation on the scenic vista and visual character of the area, the extent of high-risk acres entered into transactions for permanent cessation of irrigation may be limited. There is an expressed concern that the County should place limitations on the Program before agreeing to participate, as once that agreement has been made it might be more difficult to protect local interests. These limitations may be set through overall County policy or could be considered as thresholds set on the extent of the program as a condition of the County's participation. The County will have to explore the legal ramifications of limiting the number of acres allowed to participate in specific transactions, and the approach used. This Assessment did not consider legal standing of landowners who might then be excluded due to those limitations. This Assessment is not able to make recommendations for what specific acreage limitations should be. Specific thresholds may be identified as part of an in-depth CEQA analysis, however even with extensive background data it may be difficult to determine appropriate controls. Vegetation transitions can take years to occur and are dependent on numerous factors. As such, the County may explore options to

	assure the ability to exercise adaptive management, enacting or changing any limitations as necessary as program participation progresses. Water Transactions that have been carried out under the program thus far include vegetation management plans.
Protect habitat values and species of concern	VEGETATION This Assessment identified 11 plant species under the California Rare Plant Ranks that might be present in the project area, and thus may potentially be impacted by irrigation cessation. These are not plants listed as rare or threatened under the Federal or State Endangered Species Acts, but their status on the CRPR list means that they must be considered under CEQA. The County can mandate that if there are suspected special status plants present on specific ground involved in a full dryland (complete irrigation cessation) water transaction, then surveys should be conducted before the transaction is in place
	WILDLIFE This Assessment highlighted ten species because of their special-status designation and/or high public interest value, as well as their potential to be affected by water diversions. Of these species, the yellow warbler and the greater sage-grouse were determined to have the potential of being affected by a change in irrigation regime. Yellow warbler might be benefited by an improvement in riparian vegetation, but could lose some habitat if willow decreases along ditches within the fields. Sage grouse could be negatively impacted if there is a loss in moist grass vegetation, although they use a mix of sagebrush, dry grass, and moist grass habitats. Detailed information about grouse population extent and habitat use in the area is not known. If the bistate population of greater sage grouse is officially listed with the proposed critical habitat, then federal law would require an ESA Section 7 Consultation under USFWS. Before any transactions are carried out, Reclamation will consult with the U.S. Fish and Wildlife Service on potential effects to endangered or threatened species and their critical habitat. Ideally, a programmatic-level ESA (section 7) consultation would be completed to cover the entire Program and all necessary listed species/critical habitat. Any water transactions would be subject to limitations imposed by the Consultation. Landowners working cooperatively (such as within the AVMWC) or as part of a County-led effort may develop a Habitat Conservation Plan (HCP), Safe Harbor Agreement (SHA), or Natural Community Conservation Plan (NCCP) for the greater sage grouse which would protect the bird while potentially providing more flexibility in land and water management. Water transactions would be subject to the requirements of the Plan.
	FISHERIES A timed release in storage water may lower water levels in small reservoirs or their outflows to the point that it would have a detrimental impact on the fisheries in the reservoirs. While normal irrigation may lower water levels to the same extent, there is the potential that it would happen more often as part of a water lease. There may be added incentive to do a complete fill and drawdown for multiple years or to abbreviate the release timeline. Limits may be placed on the timing of the storage releases, and/or the extent of drawdown in reservoirs, and/or minimum flows in outflow creeks. The maximum drawdown in Twin Lakes appears to maintain sufficient habitat for resident fish. However, the impact of multiple years of maximum drawdown is unknown. The County

	might want to suggest that under a water transaction agreement full drawdown cannot occur in consecutive dry years, and in every other consecutive dry year a certain amount of the storage water right needs to remain in reservoir. Timing of the drawdown for instream purposes could be limited to outside of the recreation season and critical time periods for fish of concern. Such a storage water transaction could also be coupled with a minimum flow agreement for the outflow stream. Since these limitations on the amount and timing of water released are beyond limitations set by the Decree rights and water law, they would need to be incorporated into the agreement in which Mono County agrees to participation in the Water Transaction Program, or in agreement between the water purchaser and seller.
Protect Wetland Values	Antelope and Bridgeport Valleys, as well as the Swauger Creek region, have extensive areas identified as wetlands. Some are naturally occurring wetlands, while others are irrigation-induced. Multiple layers of protection for wetlands currently exist at the federal, state, and county levels. Additional information could be collected to provide a better understanding of the extent of the impact of reduced irrigation on wetland conditions. Currently, only portions of Bridgeport have a wetland delineation complete. A more complete delineation should include 1) determination between irrigation-induced and natural wetlands, 2) if the natural wetlands are dependent on irrigation, and 3) identification of areas that may be significantly important to wildlife. As this exercise would be quite burdensome to complete across all irrigated ground, it may be more practical to require a site-specific wetland delineation only for properties considering irrigation cessation for longer than three years. It is important to note that irrigation cannot be required to maintain non-natural wetlands created by irrigation.
Protect Groundwater Resources	There are three potential concerns related to groundwater resources and a water transactions program: 1) The leasing or selling of groundwater, 2) Exploitation of groundwater as a substitute for surface water irrigation when water users enter into water leases or sales, and 3) Reduced irrigation would decrease water recharge into the deep aquifer. It is not recommended to include groundwater in a water transactions program at this time. This is due to limited and new regulation on California groundwater extraction, the absence of groundwater in the Walker River Decree, and general concerns about the transfer and depletion of groundwater resources. Mono County and the Program can specifically state that groundwater is not eligible for transactions at this time, and explicitly disallow the substitution of groundwater (or storage water) for direct diversion surface water. This prohibition can be included in the County's overall agreement to participate in the program, as well as a non-rewatering clause in every lease or sale agreement. Where necessary, participants can be required to provide records of past groundwater use (pumping, diesel, or other records) and agree to monitoring of field conditions, diversions, and pumping activity during the lease. There is currently very limited information on aquifer interactions with irrigation water and shallow groundwater. This Assessment does not have the information to comment on any potential impacts on groundwater recharge.
Maintain economic stability for both individuals	PROPERTY TAX CHANGES While changes to property taxes would vary depending on the specific of each situation, this analysis suggests that a significant drop in tax income is not likely. There are already specific policies in place to address zoning changes, requiring thorough review and approval from the County. These policies should assure that changes in

and communities	land use, and thus related tax income, are within County guidelines with or without a water transactions program. The County may wish to consider how to directly or indirectly affect the pace and extent of permanent transactions to sell water rights through agreement with NFWF or by altering county policies governing land and water use. Through agreement with the Program the County could reserve their future right to consider the amount of acreage permitted to permanently cease irrigation if it appears to be having a detrimental impact on tax income. The scope of the CEQA analysis can be set to cover the permanent sale of water rights only on a limited total acreage, or up to a certain amount of lost tax income from properties involved in water sales.
	RECREATIONAL ECONOMIC BENEFITS It is generally believed that the majority of local water-related activities (e.g., fishing, boating, camping/hiking) could benefit indirectly as a result of increased instream flow associated with water transactions. One possible exception to the assumption that the direction of impacts would generally be positive is related to recreational activities occurring on small reservoirs. There is concern that water transactions could result in decreased water levels in these reservoirs during the recreation season because of releases for the benefit of Walker Lake. Limits may be placed on the timing of the storage releases, and/or the extent of drawdown in reservoirs as part of a water transaction. These limits could be arranged either through the initial agreement between the County and the Program, and/or per agreement between the water purchaser and irrigator. The easiest approach to assure that the reservoir recreation facilities are not impacted by a water lease or sale is to only allow the drawdown after the height of the recreation season.
Protect Cultural Resources	This Assessment did not include identification of cultural resources. No significant impacts would be expected as the program would simply keep water instream, but this Assessment did not explicitly consider these impacts. Mono County has policies in place to identify and protect cultural resources.
Protect other water users from injury	California water law and the Walker River Decree both provide protection to other water users from injury caused by other's water transactions. There are four aspects to changes in irrigation that often cause concern to neighbors that may not be considered legal injury. These are 1) delivery of other's irrigation water on a shared ditch, 2) maintenance costs on a shared ditch system, 3) noxious weed control, and 4) dust management and air quality. The County can include in the agreement to participate that carry water is a point of concern and needs to be considered when structuring transactions. There are various ways transactions can be structured to protect other users on a shared ditch system, depending on the individual transactions. Lease agreements could include requirements that all normal shared costs would continue to be paid. For this to be successful, payment rates for the leases would have to be sufficient to cover these costs without resulting in a monetary loss for the lessor. Mono County could include such a requirement in the overall agreement to participate in the Program. The County may mandate that water transaction agreements include a requirement that landowners maintain weed control within a set distance from neighboring properties and develop a plan for dust management. The County may wish to establish a weed control program with the Program under a joint MOU, to avoid any adverse impacts from cessation of irrigation. The County could also enact land use regulations

	specifically surrounding properties engaged in water leasing or sales. There are existing programs to help with weed and dust management, and current water transactions under the Program include a vegetation management component.
Transferring water across state lines.	Transferring water out of basin or across state lines is a controversial practice. While leaving natural flow instream is not the typical "water exportation" project, similar concerns surround the instream transfers because water that was previously permitted for irrigation in Mono County would now be permanently dedicated for instream use in Nevada and would no longer be available for any out-of-stream use in Mono County. Out-of-basin extractive transfers currently require permits from the Mono County Planning Commission. The County could consider permanent transfers under the Walker Basin program under the same rules and requirements. Another option is to set a limit for the amount of water that could be permanently dedicated to instream uses in Nevada. This limit could be set under a few different approaches: 1) Beneficial instream flow targets for the East and West Walker systems, as determined by further analysis of instream habitat conditions; or 2) A percentage of the amount of water targeted for increased flow into Walker Lake, currently under development by NFWF. This percentage could be based on California's percentage of irrigated acreage within the Basin, or California's percentage of consumptive use of water within the Basin.
Conflict with existing conservation plans	There is no expected conflict with any existing conservation plans. All such plans take precedence over a water transaction, and land on which such irrigation changes are not compatible with existing plans would not be eligible for the program. All applicants should be made aware of this limitation early in the process.

It is equally important to highlight that many of Mono County's objectives could be positively addressed through participation in the program. There are aspects of the program that could deliver clear benefits to the County. Outdoor recreation and the fisheries found in the East and West Walker systems are a critical part of the identity and economy of the region. Mono County policies recognize the value of these resources, and specifically support efforts to regulate instream flows, support riverine and riparian habitats, and increase wild trout populations. Although a complete stream habitat assessment was not within the scope of this effort, it is evident that habitat is limited by low flows in many stream reaches. Leaving irrigation water instream, especially throughout the season or in late season, would clearly improve habitat conditions and connectivity. Anecdotal evidence suggests that Slinkard, Mill, Swauger, ByDay, Summers, Robinson, and Buckeye Creeks all run critically low in many years. While the water transaction scenarios are not expected to affect these existing populations of Lahontan cutthroat trout in the near term; however, restoring flow and connectivity is the first step towards expanding the population in the future. Additionally, non-native brown and rainbow trout do exist in the river reaches that flow through Antelope and Bridgeport Valleys and would benefit from increased early and late season flows.

Outstanding points related to the overall feasibility of a water transactions program in the Mono County portion of the Walker Basin

1. Settling on a reasonable estimate of water savings in different locations for individual transactions. The accepted methodology in Nevada and elsewhere is to use the Net Irrigation Water Requirement, essentially evapotranspiration minus precipitation. Ecosystem Economics developed a model to account for shallow groundwater contribution to consumptive use. It is important to stress that the model results in estimates based on

incomplete information. Without a detailed picture of flow regimes and groundwater dynamics many assumptions were made. Throughout the process the most conservative assumptions were used. The true consumptive use savings are likely somewhere between NIWR and the model results, depending on location and time of season. Refer to Table 19, Section 3.7

2. The time, effort, and expense required to move a water right change through the Decree Court. The Decree Court has jurisdiction over all water right changes, and will likely involve the California Water Board and the Nevada State Engineer. As such, the recommendation is that water leasing and sales are done on a larger scale cooperative or programmatic manner. In addition, the regulatory requirements related to CEQA and the ESA should be met in a programmatic fashion, approving the transaction program in California as a whole instead of by individual lease or sale.

3. Addressing concerns about reduced irrigation on greater sage-grouse habitat. The entire area of interest for this study is proposed critical habitat for the greater sage-grouse. Sage-grouse require a mosaic of habitat, including large expanses of sage brush and wet meadows. They are known to use irrigated areas adjacent to sagebrush habitats. Thus, a water transaction scenario that suspends all water delivery to irrigated areas or wet meadows may reduce the availability and/or quality of nesting, brood-rearing, and summer foraging habitats. However, since sagebrush habitat is currently mapped on less than 20% of the land in both Bridgeport and Antelope Valleys, and the meadow vegetation types take up most of the remaining area, an increase in sagebrush habitat would likely increase the amount of area where a combination of both habitat types are available, potentially benefiting the greater sage-grouse. Additionally, maintaining instream flows is intended to benefit another listed species, the Lahontan cutthroat trout. It is unclear how USFWS might balance the needs in an ESA consultation for the Water Transactions Program. Certain irrigation changes can certainly be made in most locations without detriment to the sage-grouse. It is recommended that a more detailed assessment of sage-grouse distribution and habitat use throughout the area of interest take place as a precursor to water transactions.

NEXT STEPS

The intent of this Assessment is to provide Mono County RCD with objective information to assist in the County's decision regarding participation in the water transactions component of the Walker Basin Restoration Program. This Assessment is only one contribution to the County's decision making process. At this point Mono County may

- conduct further research to fill the "information gaps" identified in this Assessment, and/or
- move forward with one year trial transactions to gain a better understanding of the process and potential impacts, to help inform CEQA, and/or
- move forward with a CEQA analysis, or
- end or pause consideration of participation in the Walker Basin Water Transactions Program

Summarized below are information gaps identified though this analysis. It is not suggested that all or any of this additional information is needed to move forward with a Water Transactions Program.

- Complete water budgets based on real flow measurements for both Bridgeport and Antelope Valleys, including diversion and return flow timing, location, and volume.
- Shallow groundwater elevations, movement, and interactions in both Bridgeport and Antelope Valleys.
- Irrigation effects on deep groundwater recharge.
- Detailed accounting of East Walker River flow and tributaries on the Bridgeport Valley floor, including diversions and the acreage they serve.
- Diversion regulation data from the Federal Water Master for both Valleys.
- Site-specific rare and endangered plant surveys.
- Sage grouse population, presence, and seasonal habitat usage.
- Seasonal fish presence and habitat surveys, including flow-habitat relationships.
- Water quality conditions.
- Decree Court / State Water Board determinations related to transactions, including storage refill, injury, and consumptive use water savings.
- Methods for protecting instream flows into Nevada and through to Walker Lake.

In addition to scientific data, unknowns remain about the actual transaction process. As is often the case in legal questions, the outcome is unsure until tested and considered by the legal or regulatory agencies. Outstanding topics include:

- Undetermined ESA restrictions
- Ability to exercise storage refill rights after release of storage water for beneficial instream use.
- Instream protection of leased water into Nevada under both simple forbearance agreements and legal instream dedications.
- The timeline and process that the Federal Decree Court will require for legal instream dedications.
- Federal Decree Court involvement in forbearance agreements without a California legal instream dedication.
- Legal and physical restraints related to passing leased water through Bridgeport Reservoir and the main stem West Walker River past the Topaz Reservoir diversion.

The best way to understand the process and impacts of transactions is to actually carry them out on the ground. Trial Transactions in the project area would serve to inform the process, provide monitoring sites, and be an overall test to gauge how realistic different transactions might be. One year Trial Transactions might be exempt from CEQA with approval from the California Water Resources Control Board, and could occur parallel with a CEQA analysis to continue consideration of potential program participation. The ability to carry out trial transactions would primarily be driven by private landowner interest. It would be ideal to implement both a storage right lease and direct surface diversion Decree right lease on each of the East and West Walker systems. However, either transaction type in either location, or only one trial transaction, would be an invaluable process.

Water transactions under the Walker Basin Restoration Program (Program) are federally funded and, therefore, must comply with the ESA. The Bureau of Reclamation (Reclamation) administers the funds that would be expended on California's Walker Basin water transactions. Before any such transactions are carried out, Reclamation will consult with the U.S. Fish and Wildlife Service on potential effects to endangered or threatened species and their critical habitat. Ideally, a programmatic-level ESA (section 7) consultation would be completed to cover the entire Program and all necessary listed species/critical habitat. However, there is value in differentiating between temporary leasing and permanent acquisition of water rights, as potential impacts on listed species and critical habitat may vary greatly depending on time frame. As information gaps related to critical habitat remain, it may be best to complete an initial ESA consultation on the first few leases – such as Trial Transactions - individually. At the point trial transactions would occur the County would not yet have determined if there was interest in full program participation or what the structure and limitations to that program might be. A program-wide consultation would not be reasonable at that stage. Experience and information learned from the initial transactions may help inform the program-wide consultation if and when the County moves forward.

A CEQA impacts analysis must be carried out by Mono County before water transactions, beyond pilot projects, can commence in California. While there is significant information available towards an environmental impacts analysis, depending on the scope of the overall program there may be interest in further research to fill the information gaps described earlier. However, the County could select to move forward with CEQA, adjusting the project scope so the analysis will fall within the bounds of existing information. As noted throughout this Assessment, impacts from permanent water transfers and irrigation management changes may be magnitudes greater than from temporary transfers. Most if not all impacts from temporary leases could likely be reversed by a return to full irrigation. Mono County might consider scaling the initial program to include only temporary water leasing and conduct a CEQA analysis based upon that limited scope. Permanent water right acquisitions could be omitted from the program and CEQA analysis at this point. Alternately, a tiered CEQA approach could include permanent acquisitions, with the analysis identifying information gaps, if any, that would need to be addressed. If gaps for permanent acquisitions are identified the complete analysis of permanent acquisition could be completed at a later date tiering of the initial CEQA document. Temporary water transfers (such as a trial transaction) are expected to be exempt from the CEQA process, provided the Water Resources Control Board is notified. Therefore trial transactions can move forward before or in conjunction with a CEQA analysis on the overall Program if the appropriate parties agree.

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1 INTRODUCTION

1.1 Purpose

This report was prepared for the Resource Conservation District (RCD) of Mono County. The RCD is spearheading an effort to conduct an analysis of the feasibility of water transactions in the California portion of the Walker Basin. The primary goal was to provide the RCD with objective information to assist in the County's discussion surrounding potential participation in the water transactions component of the Walker Basin Restoration Program. The intent is that a water transactions program within the California portion of the Walker River Basin would complement the ongoing water leasing and sales efforts in Nevada currently led by the National Fish and Wildlife Foundation (NFWF). Legislation that created the Walker Lake restoration program specifically restricted program funds from being used to lease water appurtenant to land in the California portions of the Walker Basin without Mono County's consent. In 2012 NFWF and Mono County signed a Memorandum of Understanding to move forward with exploration of expanding the water transaction program into California. This report is a result of the RCD effort to collect information to inform the County as they consider steps towards implementation of a transaction program.

The analysis of impacts is driven by a set of three theoretical objectives for water transactions in Mono County:

Objective 1: *Provide water to the state line, with the understanding that the water is then intended for delivery to Walker Lake.*

The driving force behind the analysis of the impacts of water transactions is the Walker Basin Restoration Program, which is working to improve flows to Walker Lake and promote sustainable land and water management in the Walker Basin. While it is understood that the Program would lease or purchase water for delivery to Walker Lake, the scope of this assessment is limited to within the California portion of the Walker Basin, and only considers delivery of any leased or sold water to the California border. In the case of Bridgeport and Antelope Valley, it is likely that in order to qualify for water leasing or sale landowners would need to offer water that would otherwise have been consumed in the Valleys. Analysis of the impacts of potential water transactions will therefore generally rely on analysis of how changes in the timing and amount of water diverted to and used on irrigated fields affect the evapotranspiration of water from these fields.

Objective 2: *Improve productivity for fish and wildlife in area waterways.*

At present, the storage and release of reservoir water and the diversion and return of stream flow for irrigation water are actions that subtract water from area creeks and streams (at diversions) and adds water to area creeks and streams (at points of return flow). Reduced flows in streams may be a limiting factor for the survival, health, and productivity of fish and wildlife. To the extent that water transactions move water through these valleys in the form of additional stream flow at times when low flows are a limiting factor, then water transactions would improve instream hydrological conditions with resulting improvements in passage, connectivity and habitat for aquatic species, particularly fish.

Objective 3: *Improve, or minimize impacts on, pasture and crop productivity.*

Providing water for Objectives 1 and 2 will mean changes to on-site water use and management. Ideally, the changes in water use and/or water management would be consistent with increasing productivity. If not, then any decrease in productivity and reduction in financial returns to livestock and cropping would need to be more than compensated for by payments received by producers for entering into water transactions.

1.2 Approach

The team approached the analysis through a series of interrelated tasks.

Task 1. Determine and map current water use throughout the Walker Basin within Mono County. Develop a map of land use, irrigated fields, diversion points, delivery, and drainage ditches. Identify Hydrologic Response Units related to primary diversions to use in the development of Water Balance Models for each Valley.

Task 2. Water Flow and consumptive use analysis. Develop a model of historic flows and diversions to estimate instream flows under different irrigation scenarios. Collaborate with the Desert Research Institute to determine evapotranspiration patterns in select wet, dry, and normal years across the area of interest, as well as develop a basic picture of groundwater patterns across the area of interest. Determine Net Irrigation Water Requirements. Develop basic water balance models to parse out the contribution of shallow groundwater to evapotranspiration. Estimate potential water savings under different water transaction scenarios.

Task 3. Determine potential impacts on agricultural productivity and habitat conditions. Estimate the changes in pasture and alfalfa production across the area of interest under different water transaction scenarios. Identify species of interest within the project area and consider the impact of different water transaction scenarios on key habitats.

Task 4. Determine potential economic impacts to both individual landowners and the community. Consider changes in agricultural productivity, agricultural operational costs, and land values. Consider larger scale impacts to the local agricultural community, as well as recreation and tourism industries.

Task 5. Identify options to minimize and mitigate for impacts of concern. This includes creative approaches to water transactions; other adaptations to land; livestock and crop management; and identification of applicable sources of technical and financial support

Task 6. Complete an alternatives analysis to determine the most viable options for water transactions. Identify thresholds of spatial extent, timeframes, and geographic locations to limit negative impacts of the program on community or habitat interests.

Task 7. Determine the legal and procedural approaches related to implementation of a water transactions program. Consider California water law, Nevada water law, and the Walker River Decree to identify various pathways to complete different transaction types. Identify potential obstructions to water transactions, and opportunities to overcome those obstructions. Identify other state or federal regulatory requirements that may apply.

1.3 Water Transaction Options and Irrigation Scenarios

As described in Sections 2 and 3, the geographic scope of this study covers all irrigated ground in the Mono County portion of the Walker Basin, as well as waterways that may be affected by transactions. For purposes of the quantitative models used, the scope was limited to the Antelope and Bridgeport Valley floors. Antelope Valley was divided into “Hydrologic Response Units” based on what ground receives irrigation from which diversion point (See Figure 2-7). Hydrologic Response Units is an approach commonly used by the Desert Research Institute to define study areas based on irrigation delivery. Ecosystem Economics, the Desert Research Institute, and local water users together determined the boundaries of the Hydrologic Response Units.

After hydrologic analysis and conversation with community members, the Team selected five water transaction scenarios on which to focus further study. The scenarios were selected based on potential for quantifiable water savings and expressed irrigator interests. The selected transaction scenarios are not the only ones that might apply to the Mono County portion of the Walker Basin, but were modeled by the Team to quantify water savings, agricultural productivity changes, habitat impacts, economic considerations and legal and procedural pathways.

The water transaction scenarios chosen were:

1. Full season dryland.
   No irrigation on specific acreage for the entire season.

2. Partial year – Early season fallowing.
   No irrigation before June 1. Ground receives normal irrigation after June 1.

3. Partial year – Late season fallowing.
   Ground receives normal irrigation until July 1. No irrigation after July 1.

4. Reduced irrigation throughout the season.
   The intent behind this transaction approach is to approximate deficit irrigation—where only the minimum water needed is applied. As this is very site-specific management, it was difficult to model for water savings and production impacts with the given information. Instead, the team looked at irrigating during a normal or wet year, but using only as much water as was normally available in a dry year.

5. Release of storage water for instream flows.
   Release storage water for instream flows. While there is potential for storage releases at any time needed, the Team considered the most straightforward approach—releasing water just after the end of the irrigation season.

For each of transaction scenarios the Team considered:

- Geographic location - Bridgeport Valley or Antelope Valley Hydrologic Response Unit (HRU).
- Type of land use - including pasture, alfalfa, crop, or non-agricultural.
- Spatial extent of the transaction - including 100%, 50%, or 20% of ground within the model.
- Time frame of the transaction - including 1 year, 5 year, or permanent agreements.
- Water year type - identified as dry, normal, or wet. For modeling purposes 2002 is used as the sample dry year; 2010 as the sample normal year; and 2005 as the sample wet year. This selection was made because of overall availability of evapotranspiration, flow, and diversion data was best for these recent years.

Not all of these situations were explicitly modeled for every Task, as they were dependent on information available; however, all situations were considered in the overall analysis.

1.4 Overview of Geographic Area

The Walker River Basin drains from the Sierra Nevada range in California south of Lake Tahoe to the terminal Walker Lake in the Great Basin area of Nevada. The East and West Walker Rivers and their tributaries are the headwaters of the basin in northern Mono County, California (Figure 1-1). The West Walker River flows northeast from the Sierras through the Antelope Valley and past the Topaz Lake reservoir, and into Nevada. The East Walker River flows from its headwaters northeast through Bridgeport Valley and into Bridgeport Reservoir. The outflow from Bridgeport Reservoir passes through a small canyon and into Nevada. The two forks join to form the Walker River just before the town of Yerington, in Lyon County, Nevada.

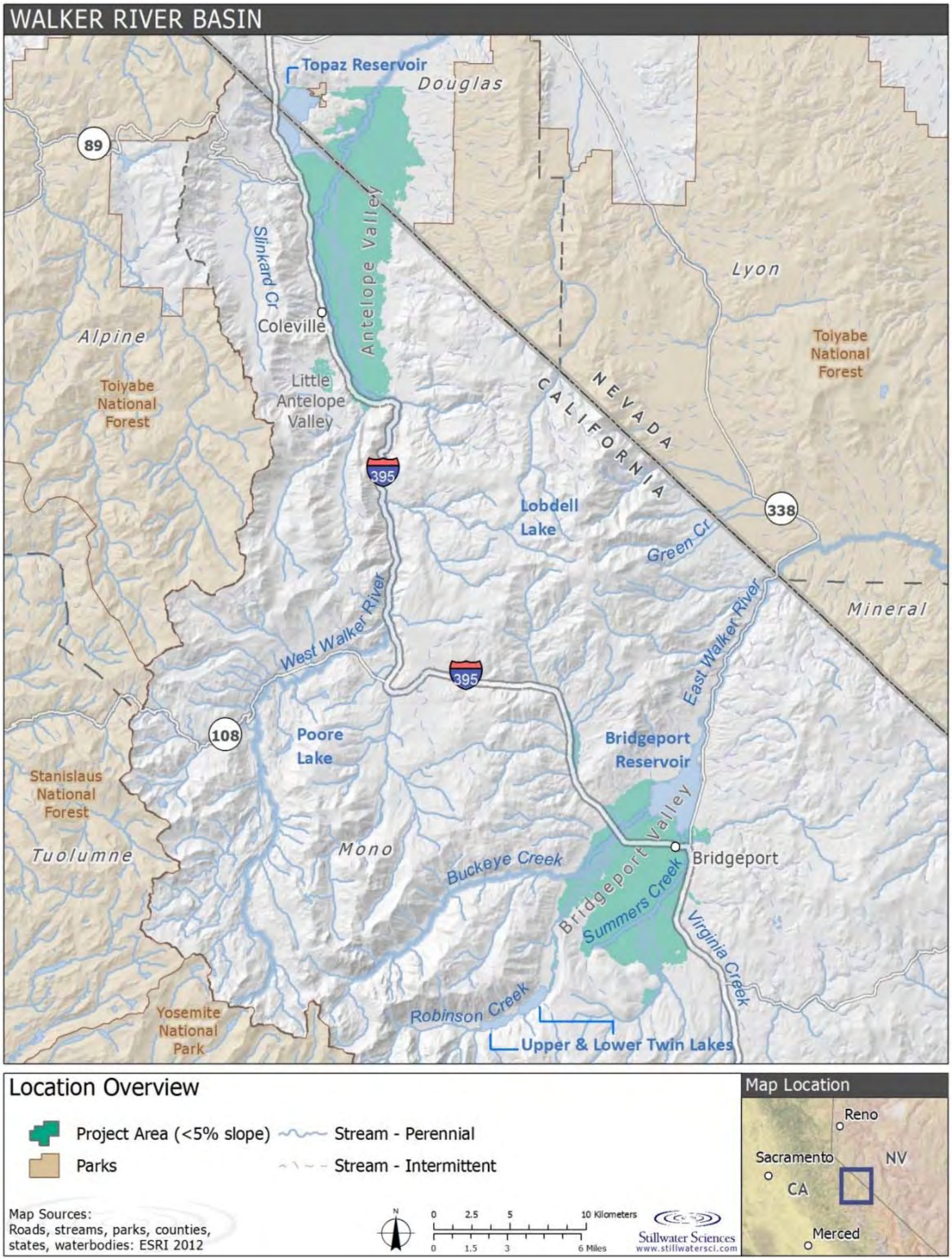
The area of interest for this project includes all irrigated areas within the California portion of the Walker Lake Basin. This is not only the Bridgeport and Antelope Valley floors, but also surrounding meadows such as Little Antelope Valley, Huntoon Valley, Sinnamon Meadows, and Upper and Lower Summers Meadows. However, the spatial extent and variation of agricultural ground made it difficult to apply quantitative models to all areas. Therefore, the spatial scope of the models included only Antelope and Bridgeport Valley floors. This does not in any way signify that the other surrounding meadows are more or less suitable for water transactions to occur.

Antelope and Bridgeport Valleys are two meadow valleys that occur in California along the western and eastern forks of the Walker River. In these areas, as well as smaller surrounding meadows, rich soils and ample water provided from the high mountains to the east have supported agricultural production for over 150 years. The climate in Antelope and Bridgeport Valleys is humid continental, in that most of the precipitation occurs during long cold winters. Temperatures are moderate—commonly 60-70^{o}F in the summer, and 20-30^{o}F in the winter. Located in the rain shadow of the Sierra Nevada crest, both Antelope and Bridgeport Valleys receive the overwhelming majority of their water as runoff that descends from the adjacent mountains. Annual precipitation within the valleys averages 8–12 inches, while precipitation in the headwater reaches of range from 35–40 inches. Brief summer monsoon rainstorms can occur, but the majority (roughly 75%) of precipitation falls from October through April. Snowmelt in the upper watershed and associated run off remain high from May through July, depending on the water-year. Because both valleys are in the rain shadow of the Sierra Nevada, direct precipitation is a far less critical hydrologic input than surface flows from upstream and subsurface groundwater inputs. The bottoms of both valleys can be considered impermeable (Carroll and Pohl 2013) so that subsurface recharge comes from the valley sides, and primarily from the western slopes. Elevations of the contributing areas range from 10,007 feet for Antelope Valley; elevations for the valley itself range from 5,000–5,800 feet. Bridgeport Valley is a little higher, at 6,450–6,750 feet, and with a contributing area that reaches 12,303 feet along the Sierra Crest.

Private land in the area of interest is almost exclusively used for agriculture, most of it irrigated. In Antelope Valley, the majority of the ground is cattle pasture, with alfalfa as the second most common land use. There are also hay and row crops. Little Antelope Valley is currently grazing pasture. Bridgeport Valley and surrounding meadows are exclusively used as pasture.

In addition to agriculture, recreational tourism is of great importance to the area. Tourists visiting sites in the Sierra Nevada, as well as areas of historical interest, often stay in the area. Both the East Walker and West Walker rivers are considered world-class trout streams, with miles of the West Walker designated as a Wild and Scenic River.

Figure 1-1. East and West Walker Rivers Drain Bridgeport and Walker Valleys, Located on the Eastern Side of the Sierra Nevada



Map Sources:
Roads, streams, parks, counties, states, waterbodies: ESRI 2012

2 WATER USE

Please see Appendix A for a detailed discussion of the approach, data, and analysis used.

2.1 Background, Overview and Rationale

As outlined in the Introduction, there are three cascading objectives that could result from water transactions in Bridgeport and Antelope Valleys. Each of these outcomes results from the changes to water use and/or water management that are incentivized by particular types of water transactions. A change in water use and/or water management likely will change the hydrology of the fields and streams, which in turn would affect both stream and field ecology and species. Subsequently, these changes may have financial, social, and/or economic impacts on residents, producers, and tourists in the Valleys. The analysis of outcomes is driven by a set of three potential objectives for water transactions in Mono County:

Objective 1: *Provide water to the state line for delivery to Walker Lake.*

Objective 2: *Improve productivity for fish and wildlife in area waterways.*

Objective 3: *Improve, or minimize, impacts on pasture and crop productivity.*

In order to assess the impacts of water transactions in terms of these three objectives, a series of hydrologic, ecologic and economic questions need to be analyzed. The primary goal of this Section is simply to understand how potential water transactions that meet Objective 1 would alter the pattern of water use and management in the two valleys.

Generally speaking, water transactions may change:

1. The amount of storage water assigned for diversion and use in irrigation;
2. The point at which water is diverted from the stream to the field;
3. The source that is used (i.e., switching from surface water to groundwater);
4. The efficiency with which water is diverted and conveyed to the field;
5. The efficiency with which water is used on the field;
6. The amount of ground that is irrigated; and/or
7. The proportion of the season that fields are irrigated.

Any of these approaches has the potential to improve instream conditions in the two valleys and fulfill Objective 2. Without being conclusive at this stage, it would be reasonable to hypothesize that only Approaches 1, 6 and 7 would qualify as means to reduce consumptive use in irrigation, thereby providing savings that could potentially be carried through to Walker Lake, and fulfilling Objective 1.

Changes to the timing and location of storage releases and diversions are likely to pass water by diversions and on downstream, resulting in raised stream flow in downstream reaches. Reducing diversions and the use of irrigation water may then impact crop evapotranspiration as well as the infiltration of excess water into the water table. Changes to infiltration will affect groundwater levels, which in turn may also affect the ability of plants to access the water table for the purposes of transpiration and growth. Changes to groundwater levels and the extent to which plants draw from groundwater for transpiration will then affect the rate and amount of water that moves through the subsurface geology of the valleys and back to the streams. So, changes in water use and/or water management likely will also affect stream flow below diversions where the water would have returned to the streams, but for the water transaction.

The relationship between surface water, plants, and the groundwater system are complex. Typically, they can be addressed conceptually, and numerically. For example, for the Walker River below Topaz and Bridgeport and down to the US Geological Survey (USGS) gage at Wabuska, scientists at the University of Nevada Reno and the Desert Research Institute have developed combined surface water distribution and groundwater models that provide numerical analysis of potential water transactions (Boyle *et al*. 2009, 2013; Minor *et al*. 2009). In the Lower Walker River below the Wabuska gage, the USGS has prepared a groundwater model (since surface water distribution is straightforward) to simulate stream flow through to Walker Lake (Allander *et al*. Forthcoming).

These modeling efforts have taken years and millions of dollars; however, these studies and models have involved only minimal efforts to characterize and describe the headwater valleys in California. In this study, therefore, such precision cannot realistically be attained. Rather, this Task represents an initial attempt to gather relevant information and examine how it can be deployed to create a simple water balance model that will describe how water moves through the system and how water transactions may alter the status quo.

In this effort Ecosystem Economics was fortunate enough to benefit from parallel efforts at data collection and analysis made by researchers from the Desert Research Institute. In particular, the Team relied considerably on the following work:

- Tim Minor worked with the RCD members and Ecosystem Economics to digitize relevant features from Bridgeport and Antelope Valley, including but not limited to points of diversion and irrigated fields, grouped into "hydrologic response units";
- Tim Minor and Justin Huntington developed and processed information on meteorological conditions and Landsat images to provide spatial information on evapotranspiration; and
- Greg Pohll and Rosemary Carroll carried out a preliminary assessment of recharge in the two valleys (Carroll and Pohll 2013).

While much of their information is integrated into this report, all errors and omissions in the report below remain the property of the report authors.

2.2 Water Rights

Water use in the Walker Basin comes from both surface water and groundwater. Surface water rights comprise the majority of water rights in Antelope and Bridgeport Valleys and are primarily made of up appropriative rights adjudicated by a federal court decree. There is also groundwater use in Antelope Valley, largely used to supplement decreed surface water rights.

2.2.1 Decree Rights

The oldest water rights in the Walker River system are for the direct diversion of the natural flows (including return flows) of the Walker River and its tributaries as set forth in Decree C-125, the federal Walker River Decree. Issued initially in 1919 as Decree 731, and then re-adjudicated by the federal District Court in 1936, Decree C-125 was issued in final amended form in 1940. See Figure 2-3 for an accumulation summary of priority dates.

Under the decree, Antelope Valley rights were generally granted 0.016 cubic feet per second (cfs) per acre and an irrigation season of 245 day (March 1 to October 31). Bridgeport Valley rights were also generally granted 0.016 cfs per acre; however, the irrigation season is only 199 days (March 1 to September 15). Total decreed irrigation water rights in California under the C-125 decree are 41,811 acres, of which 23,669 acres on the East Walker drainage and 18,142 on the West Walker drainage. A portion of these rights is found outside Antelope and Bridgeport Valleys proper, but the vast majority is in these valleys (see Figure 2-1and Figure 2-2). The Tables that follow provide current information as provided by Historical Mapping Service and DRI on the quantities of water rights within and outside the valleys.

Table 2-1. C-125 Decree Water Rights in Antelope Valley

Ditch	Acres	Diversion Rate (cfs)	Maximum Annual Diversion (AF)
Alkali	428	6.72	3,266
Big Slough	9,928	154.80	75,225
Carney	1,112	17.41	8,461
Hardy	210	3.36	1,633
Harney	426	6.64	3,227
Little Antelope	456	7.19	3,496
Main	360	5.61	2,727
Powell	159	2.54	1,234
Ricky	463	7.30	3,547
Swauger	2,183	34.03	16,537
West Goodnough	343	5.47	2,656
Totals	16,067	251.07	122,009

Notes: The maximum diversion based on diversion for all 245 days of the irrigation season

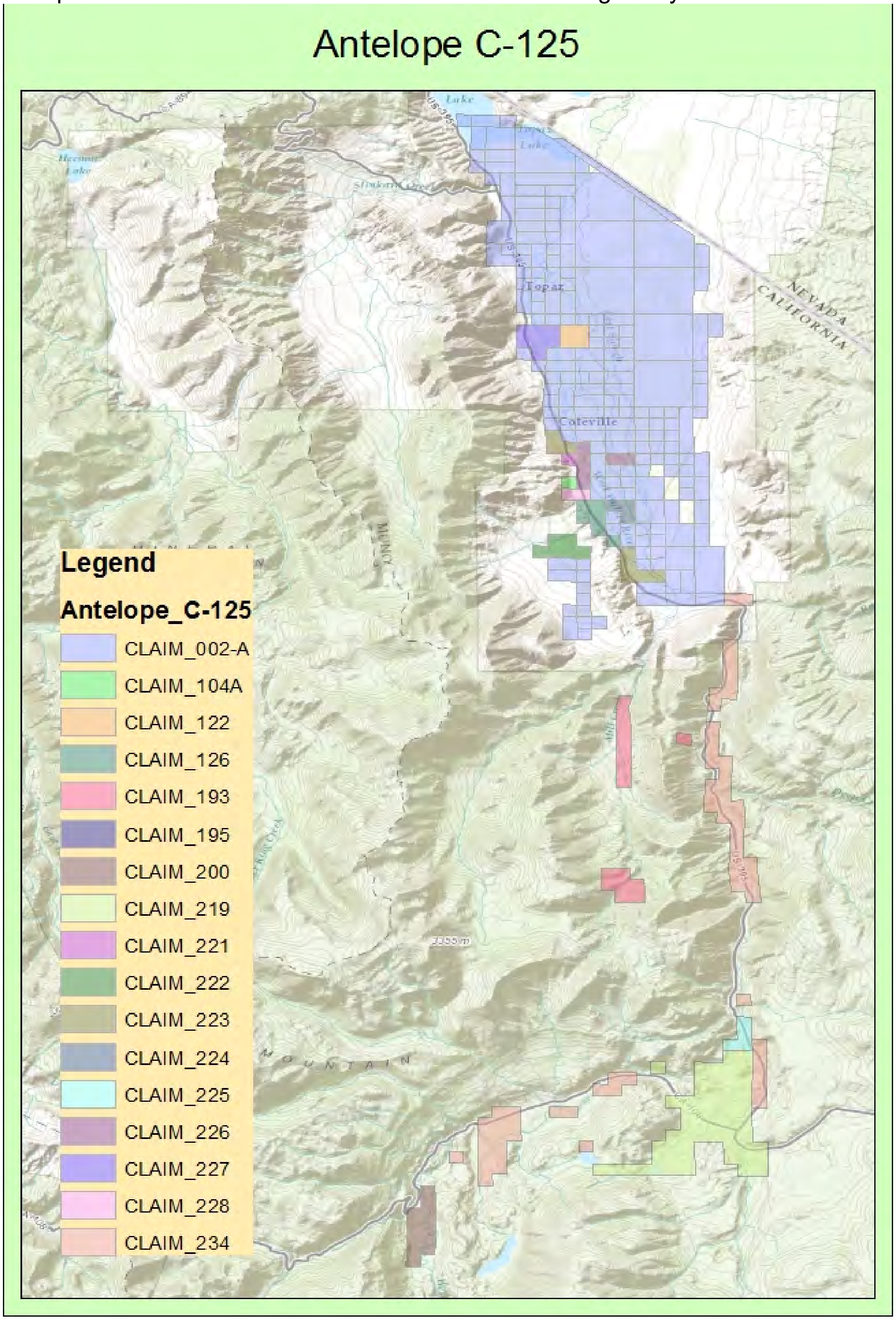
Table 2-2. C-125 Decree Water Rights from West Walker Upstream from Antelope Valley

Claim	Name	Acres	Diversion Rate (cfs)	Notes
219	Junction Range	1,150	18.40	between Junction Creek and Little Walker River; 12 miles above Antelope Valley
225	Adams, R & V	40	0.64	near confluence of Little Walker and West Walker; 11 miles above Antelope Valley
200	USFS/Tholke, R	485	7.76	off Wolf Creek (14 miles above Antelope Valley) and west Walker in vicinity of Poore Lake
195	Dressler, M	80	1.28	from Hot Creek, trib to the Little Walker; 14 miles above Antelope valley
193	Cal F&G	320	5.12	up Mill Creek; likely forfeited/abandoned due to non-use
Totals		2,075	33.20	

Table 2-3. C-125 Decree Rights in the East Walker Drainage

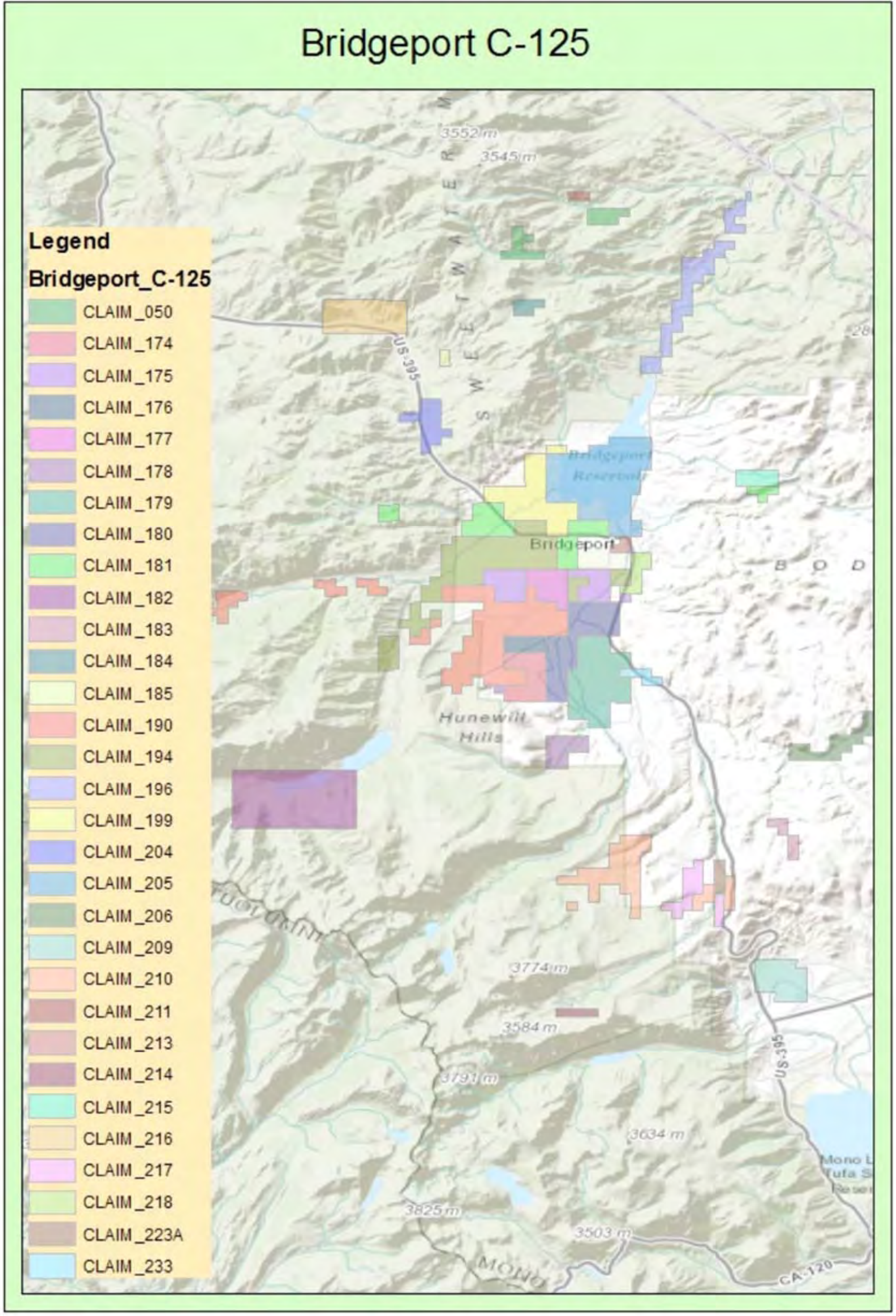
Claim No.	Acres	Diversion Rate (cfs)	Maximum Annual Diversion (AF)
174	971.0	15.53	6,130
175	1,855.5	29.76	11,747
176	468.0	7.49	2,956
177	280.0	4.48	1,768
178	540.0	8.64	3,410
179	1,875.0	30	11,841
180	1,544.0	24.71	9,753
181	1,540.0	24.64	9,726
182	290.0	4.64	1,831
183	240.0	3.84	1,516
185	80.0	1.28	505
190	3,660.0	58.56	23,115
194	3,530.0	56.48	22,294
199	1,870.0	26.72	10,547
204	800.0	12.8	5,052
206	640.0	10.24	4,042
207	160.0	2.56	1,010
208	480.0	7.68	3,031
209	375.0	6	2,368
210	1,680.0	27.08	10,689
213	100.0	1.6	632
214	40.0	0.64	253
216	100.0	1.6	632
217	100.0	1.6	632
218	130.0	2.08	821
223B	160.0	2.56	1,010
233	160.0	2.56	1,010
Total	23,668.5	375.77	148,323

Figure 2-1. Map of West Walker River C-125 Decree Water Rights by Claim



Source: Desert Research Institute

Figure 2-2. Map of East Walker River C-125 Decree Water Rights by Claim



Source: Desert Research Institute

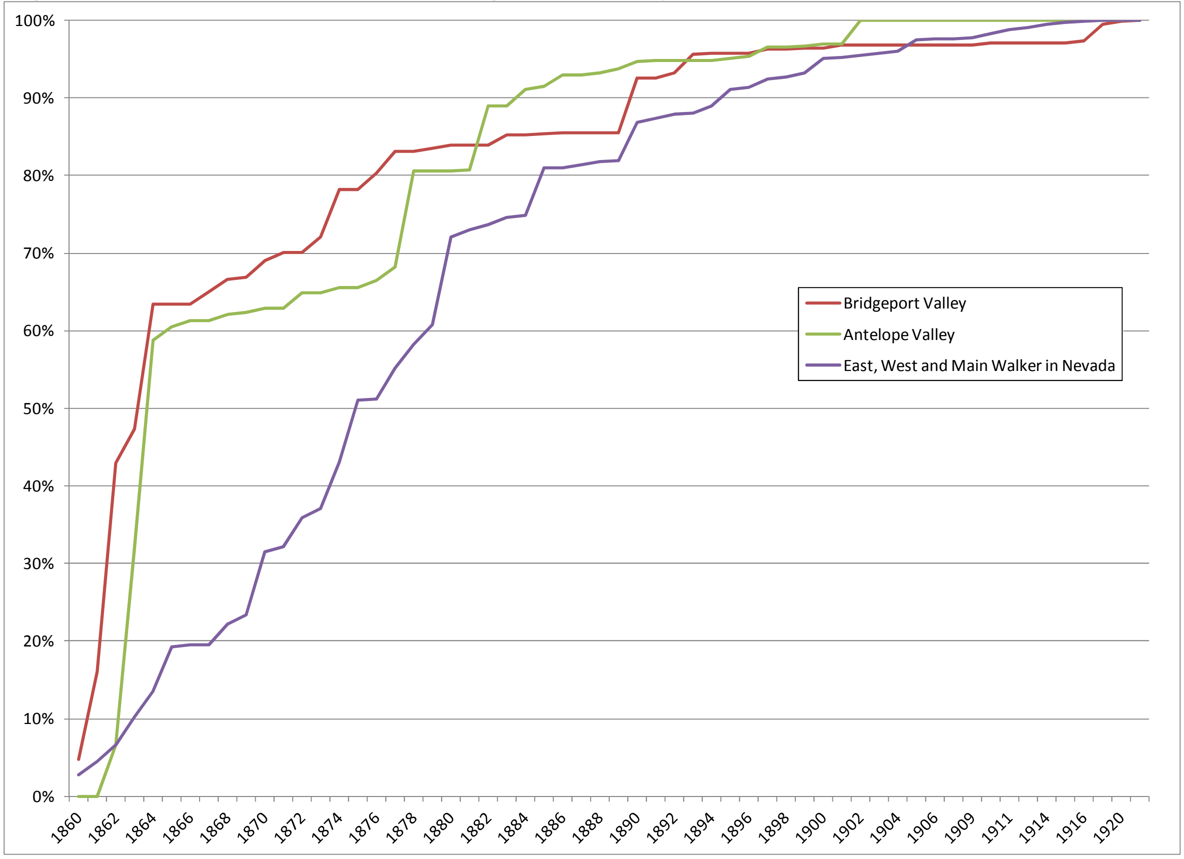
Since Walker Basin water rights are governed by the doctrine of prior appropriation, the priority date of a water right (typically the date first put to beneficial use) is very important. The older the water right, the more senior that right is. In the event the river does not yield enough water to satisfy the demand of all water rights (nearly every year in the Walker Basin, to some extent), the most junior water right is cut off first, then the next most junior, and so on until there is no shortage.

Between Antelope and Bridgeport Valleys, there are 45 different priority dates ranging from 1860 to 1925. The priority dates in each valley, along with their corresponding acreage, diversion rate and maximum annual diversion are presented in Appendix A.

To visualize the relative priority of water rights in different valleys or reaches, it is helpful to plot "accumulation" curves. With the priority date on the x-axis and the most senior date nearest the origin, the cumulative percentage (the percent of the total volume of rights for that priority date and more senior dates) is plotted for each priority date. The curve increases on the y-axis until it reaches 100%.

Figure 2-3 below shows these accumulation curves for Bridgeport Valley, Antelope Valley, and the remaining downstream decree rights in Nevada. This figure shows that the California decree rights are substantially more senior than the Nevada decree rights. The accumulation curve for both valleys increases rapidly. Over 60% of the California decree rights have an 1864 or more senior priority date whereas the corresponding figure for Nevada rights is just 12%. The implication of this finding is that the California rights are far more reliable on average (as explored further below) and therefore might be considered higher value, all other things equal.

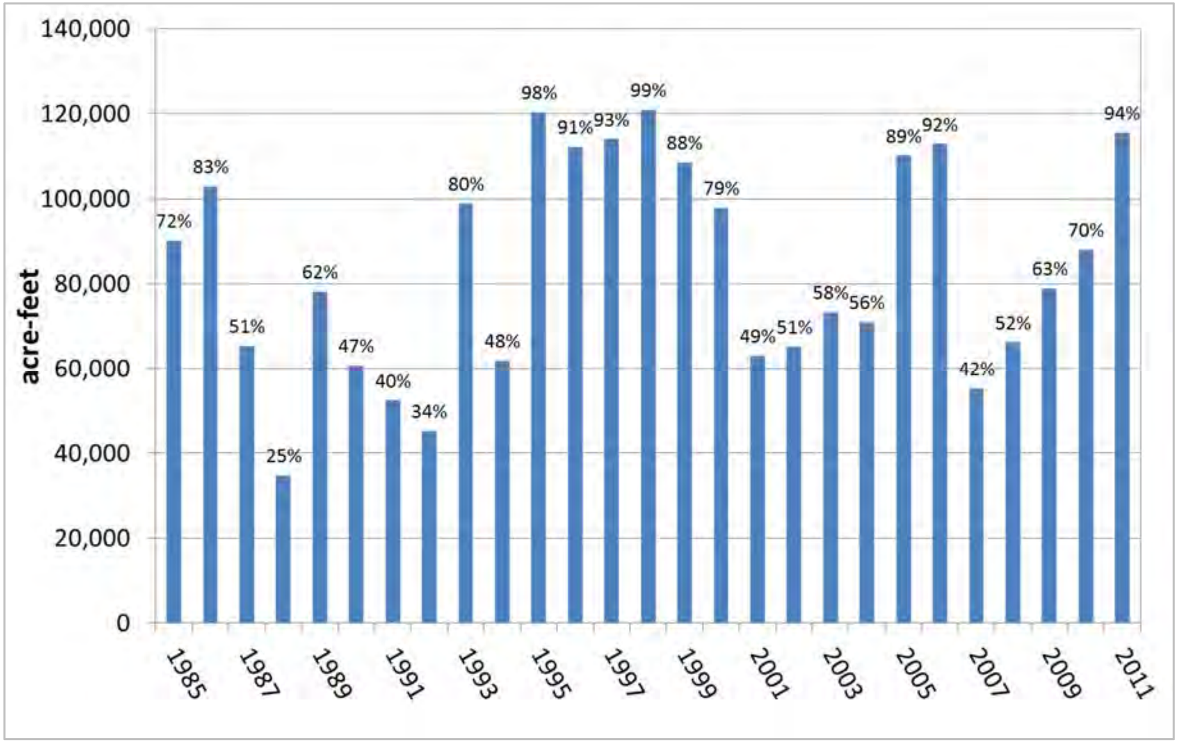
Figure 2-3. Walker River Decree Rights Seniority Accumulation Chart



The Federal Water Master (FWM), also known as the Chief Deputy Water Commissioner of the U.S. Board of Water Commissioners, is appointed by the federal decree court and administers the delivery of water to authorized points of diversion on the Walker River. In Antelope, Smith and Mason Valleys, the FWM office receives orders for water, and determines the priority dates which can be served by the water available. If, for example, the priority date being served in Antelope Valley is 1864, then that means only decree rights with an 1864 priority date and earlier (more senior) can divert water, and any right with an 1865 priority date or later (more junior) may not divert. There are no provisions under the current FWM to allow partial diversion for the most immediate junior right (1865 in the example above). The FWM does not have gages in Bridgeport Valley and generally relies on the cattle operators in the valley to work among themselves in times of water shortage.

FWM regulation data for Antelope Valley (1985-2011) are publicly available as evidentiary materials on the first Nevada transfer of water rights by NFWF in front of the Nevada State Engineer under Application No. 80700. These data were compiled and applied to the C-125 water rights information for Antelope Valley, presented above. The volume of water in priority each year as well as its percentage of the maximum face value is presented in **Figure 2-4**. The FWM does not provide regulation data for Bridgeport Valley, although the East Walker regulation data would likely be a good indicator of reliability. The Antelope Valley figure; however, provides a sufficient indication of the annual variation in reliability of the California water rights. The principal message is that even senior decree rights are subject to considerable variability in their water supply, even if on average they receive more water than junior rights. In this regard it is worth mentioning that the junior Nevada rights (1874 priority date and junior) have access to supplemental storage water from Bridgeport Reservoir and Topaz Lake. This supplemental supply tends to even out somewhat the variability in supply and the apparent mismatch in seniority between Nevada and California rights. Nevertheless, as storage rights are separable from decree rights for the purposes of water transactions it remains the case that the California decree rights will have a competitive advantage purely in terms of reliability.

Figure 2-4. Antelope Valley Water Reliability by Year in Volume and Percentage of Face Value



In Antelope Valley, a vast majority (over 90%) of the surface water rights are held in the name of the Antelope Valley Mutual Water Company (AVMWC) and a minority are privately held. Many, if not all of the owners of privately held rights also have shares in the Antelope Valley Mutual Water Company. Six of the twelve ditches (including the largest, Big Slough) serve both private and AVMWC patrons. Antelope Valley Mutual Water Company patrons own shares that entitle them to a fraction of a cfs per share on any given day of the irrigation season, based on the priority date being served (as set by the FWM). The fractions of cfs per share are listed in the AVMWC "share sheet." Private rights, however, are only served based on the specific priority dates and cfs for their decree rights – for each priority date they are being served or they are not, there is no fractional arrangement.

In Bridgeport Valley, all the surface water rights are private and there is nothing similar to the AVMWC. Based on interviews, it was determined that the Bridgeport irrigators tend to rotate their use, with more days on for the more senior users and fewer days on for the more junior users. The FWM sets the priority dates being served for downstream users in Nevada based on what is flowing out of Bridgeport Valley, and based on interviews appears to not need to actively enforce the decree in Bridgeport Valley. The FWM historically set the priorities served in Bridgeport Valley and measured deliveries, but measurement devices were removed sometime in the 1960s-70s.

2.2.2 Storage Rights

Many agricultural communities in the American West have stored irrigation water available so as not to rely solely on the availability of natural surface flow during the irrigation season. In contrast to Mason and Smith Valley, located downstream from Mono County in the Walker Basin, Antelope and Bridgeport Valleys have, in comparison, very little storage water. The volumes, locations, and priority dates for these limited storage resources are presented in Table 2-4 and Table 2-5. In the case of Lobdell Lake, the storage right is specified as a diversion rate with no reported storage capacity. Actual capacity is reported as 640 acre-feet (AF).

Table 2-4. Antelope Valley Storage Rights

Reservoir Name	Water Source	Decreed Right	Priority	Place of Use	Claim No.
Lobdell Lake	Deep Creek	6 cfs	1864	S. Smith Valley	172
Black Reservoir	Black Creek	350 AF	1907	Sonora Junction	220
Poore Lake	Poore Creek	1200 AF	1901	Antelope Valley	201-203

Table 2-5. Bridgeport Valley Storage Rights

Reservoir Name	Water Source	Priority Date	Decreed Storage Right (AF)	Refill Right (AF)	Refill Priority Date
Green Lakes	Green Creek	1895	400		
Lower Twin Lake	Robinson Creek	1888	4,050	4,050	1905
Upper Twin Lake	Robinson Creek	1905	2,050	2,050	1906

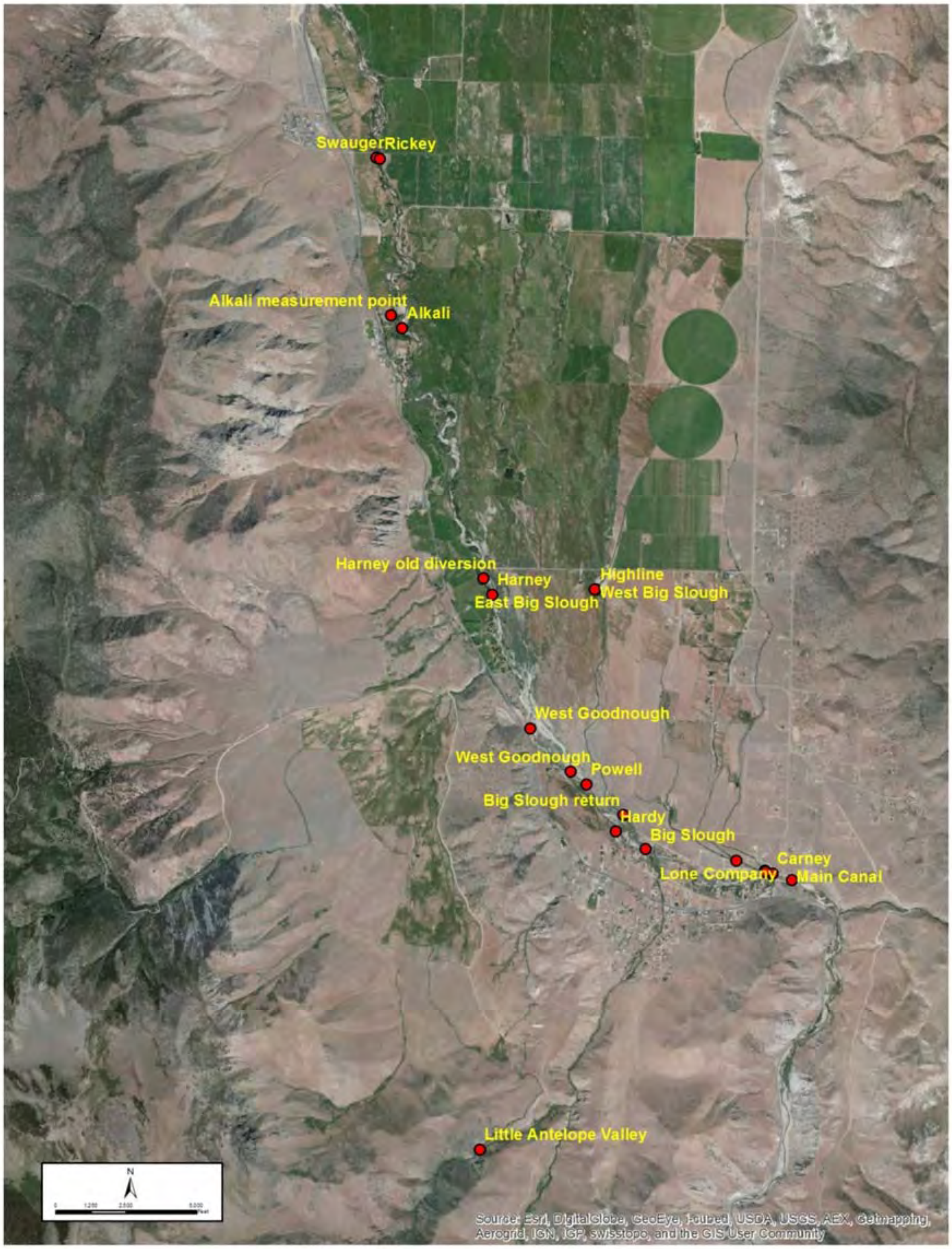
2.2.3 Groundwater

No groundwater permits or certificates were located, due to how the State of California deals with groundwater. Based on interviews with Antelope Valley irrigators, there are some irrigators who use groundwater to supplement their decree rights. Details and estimates from the interviews are presented in the next Section under water use.

2.3 Irrigated Lands and Hydrologic Response Units (HRU's)

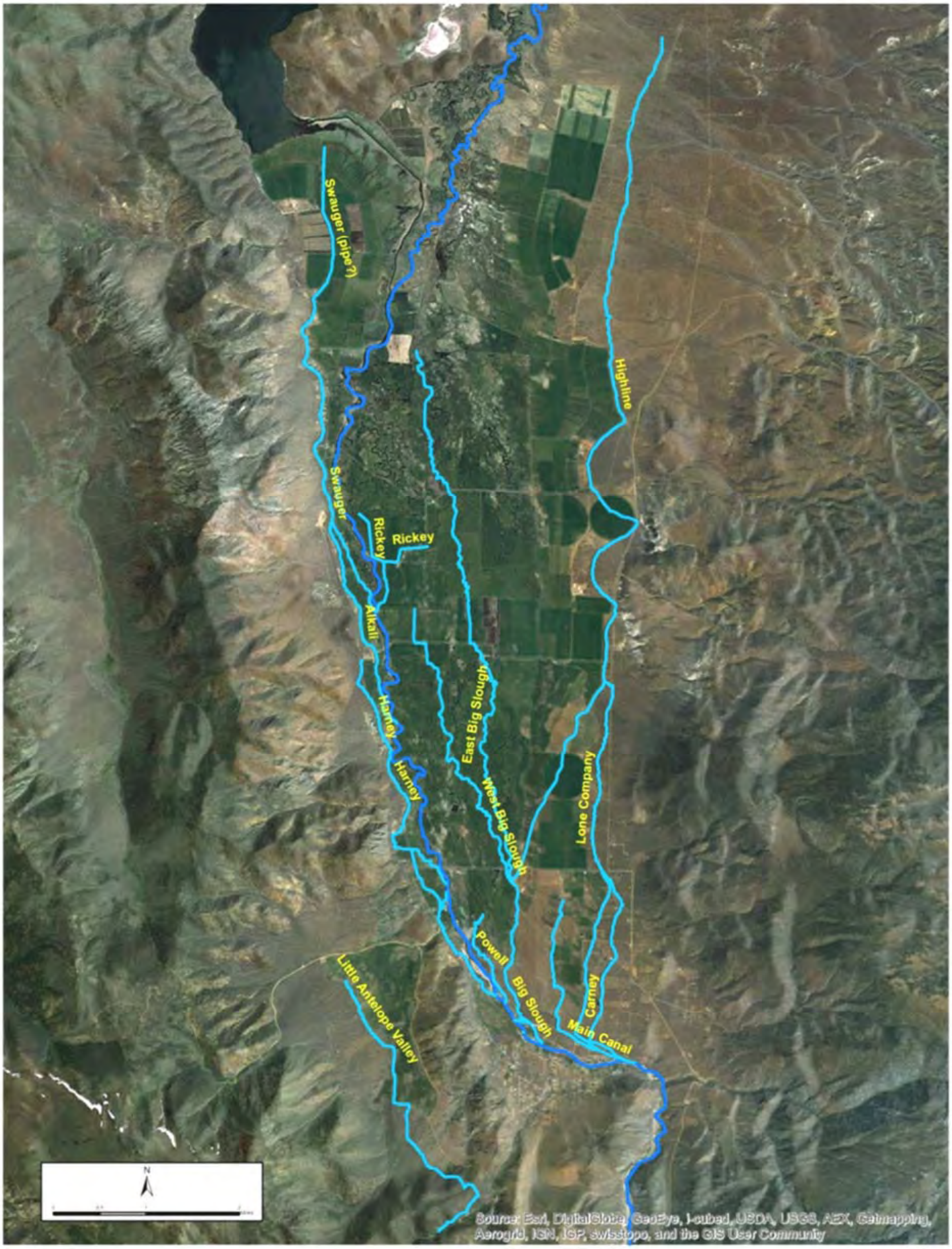
To assess spatial variability of water use, agricultural practices and specifically evapotranspiration (ET) within Antelope Valley, Hydrologic Response Units were defined based on the fields served with surface water via the major points of diversions and ditches. Tim Minor at DRI delineated irrigated fields through interpretation of aerial photos and interviews with Antelope Valley irrigators. The HRU boundaries were also determined based on interviews with Antelope Valley irrigators and personnel of Antelope Valley Mutual Water Company, which serves most of the irrigators in Antelope Valley. The points of diversion are displayed in Figure 2-5; delivery ditches in Figure 2-6; and resulting HRU boundaries in Figure 2-7. Minor then calculated the corresponding acreage of each field using GIS and summed these by HRU (Table 2-6). Over 65% of the irrigated acreage in Antelope Valley is associated with a single HRU, the Big Slough. According to information gathered from landowners somewhat less than one-third of the acreage uses groundwater to supplement surface water. The irrigated acreage derived from the field mapping is very close to the acres derived from the Antelope Valley Mutual Water Company's "share sheet" (Table 2-7) and the acres derived from the C-125 decree (Table 2.8). As the crop type for each field was also assigned in the GIS**,** Table 2.8 provides the totals for each crop by HRU.

Figure 2-5. Map of Antelope Valley Surface Water Points of Diversion



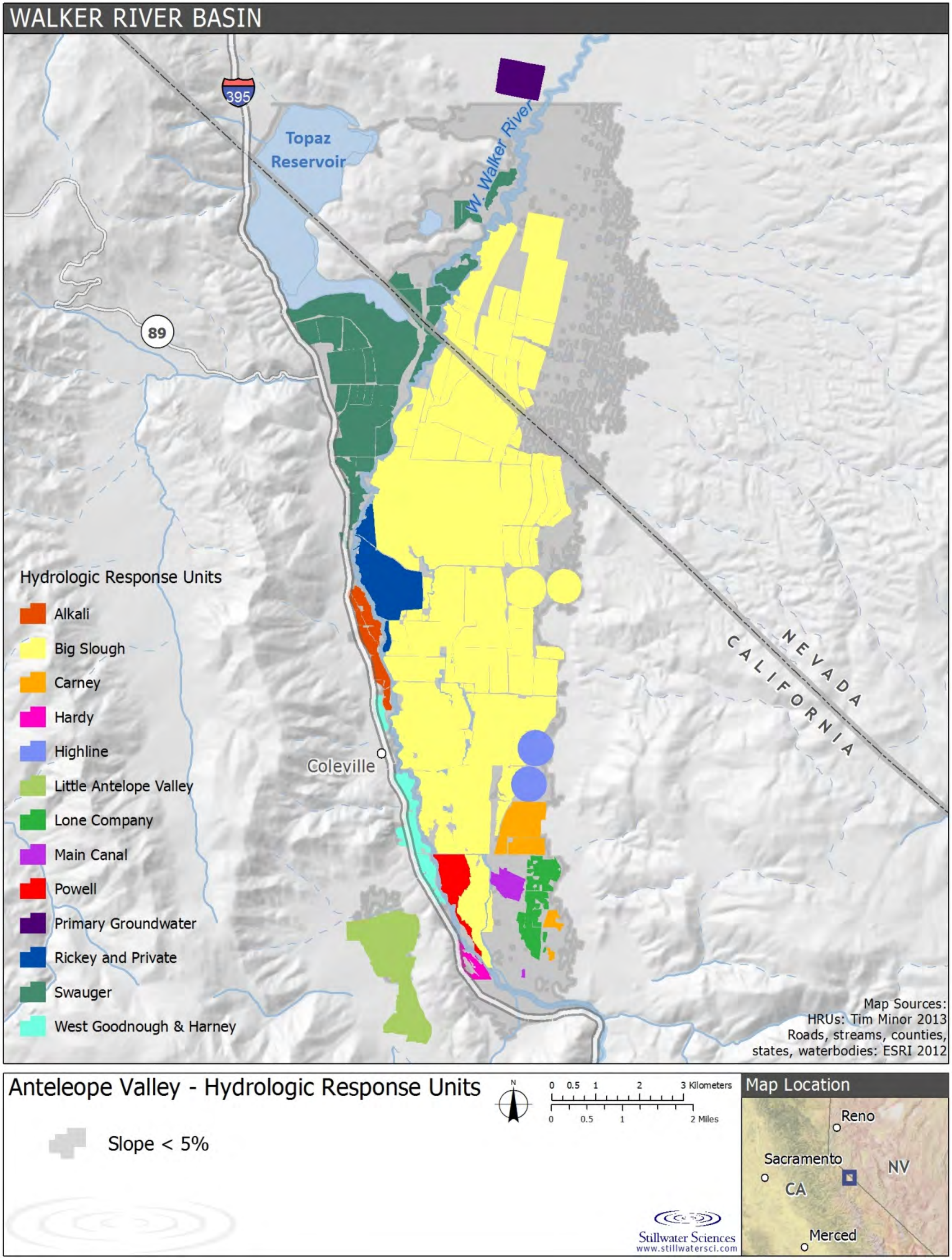
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 2-6. Map of Antelope Valley Ditches



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 2-7. Map of Antelope Valley Hydrologic Response Units



Map Sources:
HRUs: Tim Minor 2013
Roads, streams, counties, states, waterbodies: ESRI 2012

Table 2-6. Antelope Valley Irrigated Acreage by Ditch and Type

HRU	Acres	Diversion Rate (cfs)	Maximum Annual Diversion (AF)	Acres with Supplemental Groundwater
Alkali	206	3.30	1,605	0
Big Slough	9,839	157.43	76,503	2,641
Carney	316	5.06	2,459	0
Hardy	57	0.91	443	0
Highline	259	4.14	2,012	259
Little Antelope Valley	663	10.61	5,158	0
Lone Company	272	4.36	2,119	0
Main Canal	98	1.56	760	0
Powell	181	2.90	1,408	0
Rickey and Private	493	7.89	3,833	214
Swauger	2,271	36.34	17,659	781
West Goodnough & Harney	266	4.26	2,072	0
Totals	14,923	238.77	116,031	3,895

Notes: *cfs derived from acres multiplied by 0.016 cfs/acre

Table 2-7. Antelope Valley Water Rights from AVMWC "Share Sheet"

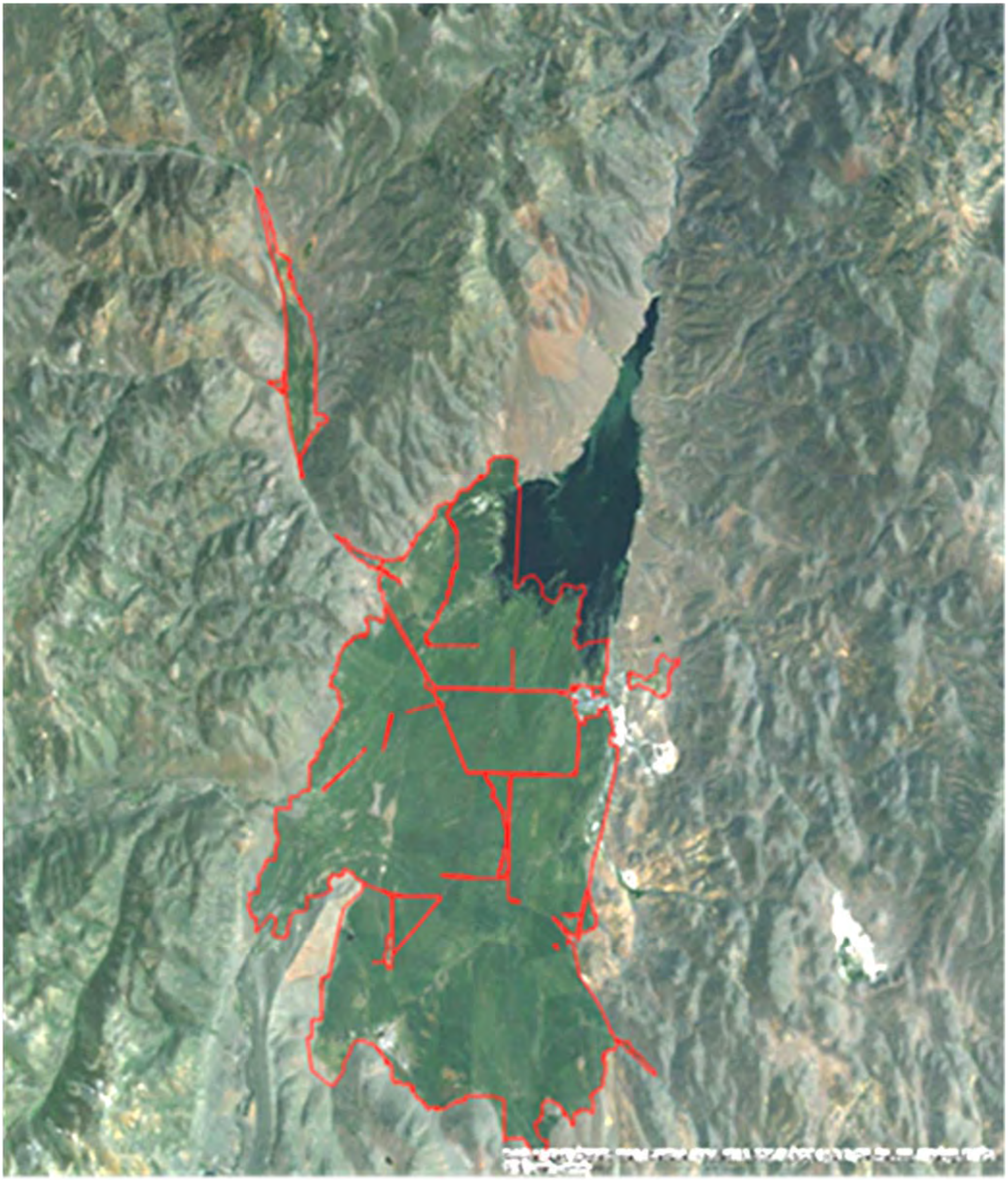
Ditch	Acres	Diversion Rate (cfs)	Maximum Annual Diversion (AF)
Alkali	363	5.80	2,819
Big Slough	9,942	159.07	77,300
Carney	987	15.79	7,673
Hardy	210	3.36	1,633
Little Antelope	450	7.19	3,496
Lone Company	415	6.64	3,227
Main	351	5.61	2,727
Powell	159	2.54	1,234
Ricky	485	7.77	3,774
Swauger	2,029	32.47	15,780
West Goodnough	342	5.47	2,656
Totals	15,732	251.71	122,320

Table 2-8. Antelope Valley Irrigated Acreage by Ditch and Crop

HRU	Alfalfa	Grains	Hay	Pasture	Totals
Alkali			100	106	206
Big Slough	1,982	55	1,862	5,940	9,839
Carney	277			40	316
Hardy				57	57
Highline	259				259
Little Antelope Valley				663	663
Lone Company			76	197	272
Main Canal				98	98
Powell				181	181
Rickey and Private			214	279	493
Swauger	572		44	1,656	2,271
West Goodnough & Harney	25		82	159	266
Totals	3,115	55	2,377	9,376	14,923

HRUs were not developed for Bridgeport Valley because specific information regarding which ditches serve which fields could not be obtained and because water rights by ditch could not be verified. However, based on field delineation of Bridgeport Valley by Minor (**Error! Reference source not found.**), an irrigated area of 17,926.8 acres was calculated. The calculated area actually irrigated is far less than the total decree acres of 23,669. This difference likely is due to the C-125 decree including acreage outside Bridgeport Valley proper (such as Upper Summers, Lower Summers, and Sinnamon meadows), and likely some area no longer irrigated. The face value of the water rights associated with the calculated acreage equals 286.83 cfs and a maximum annual diversion of 113,216 AF.

Figure 2-8. Map of Bridgeport Irrigated Area

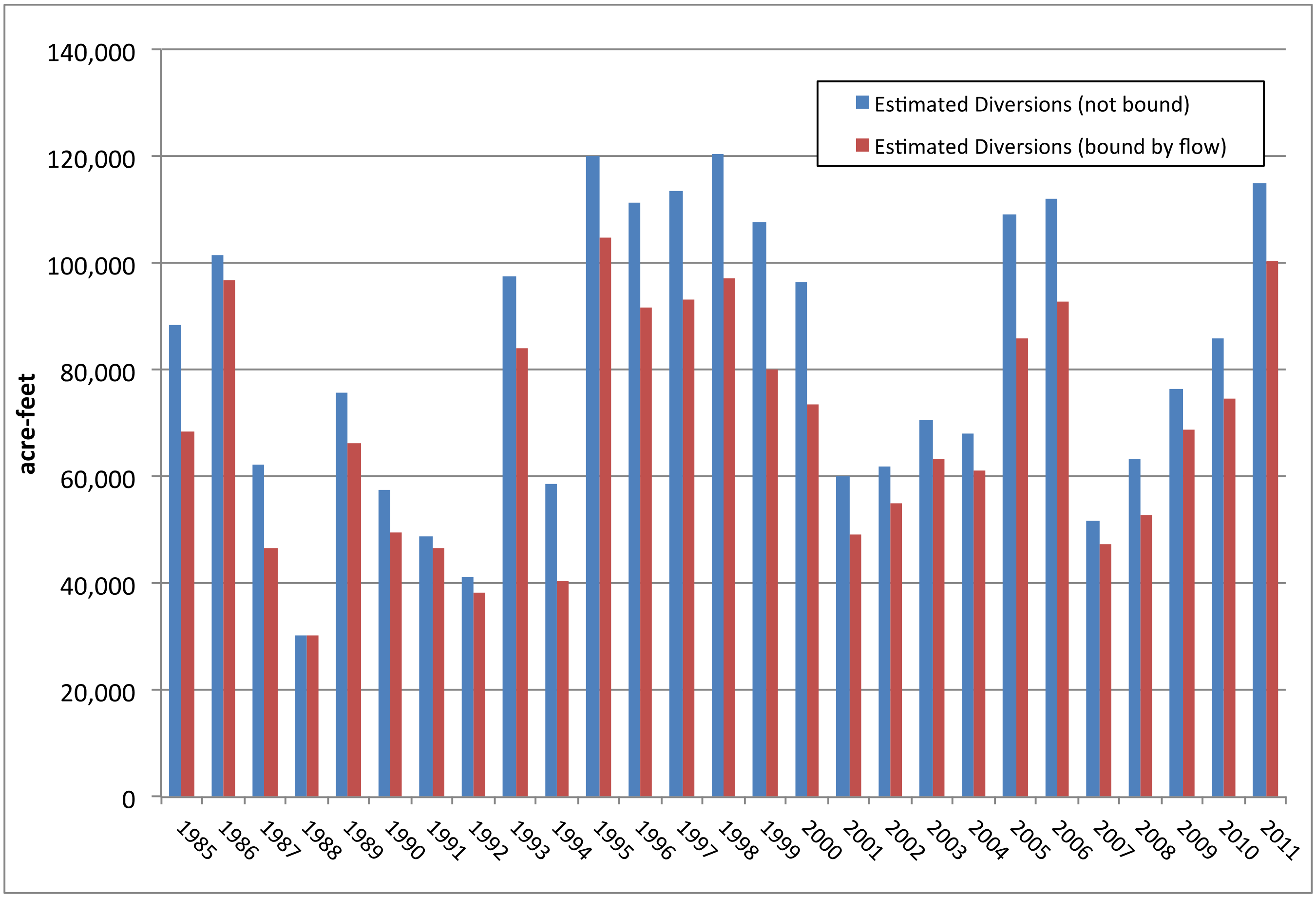


2.3.1 Diversion Estimates

The AVMC share sheet outlined in Table 2-7 breaks down the diversion rights by ditch and by priority date. This information was used, along with the daily regulation data from the FWM (1985-2011), to estimate daily diversions based on what irrigators could have diverted (Figure 2-9, Estimated Diversions (not bound)). At total of almost 82,000 AF is the average figure for potential diversions during this time period.

Based on feedback obtained at a meeting of the AVMWC, diversion estimates were also calculated to account for times when the face value of rights in priority exceeded the flow available. In doing so, the face value of rights in priority was compared to the flow available at the Coleville gage and the lesser of the two values was tabulated, on a daily basis. Figure 2-10 provides the results of the original estimates, not bound by flow (in blue) and the new estimates (bound by flow), limited by West Walker River flow coming into the Antelope Valley. The bound by flow approach yields an average of 69,000 for the period which is on average 15% lower than the unbound value. Differences between the two methods appear to be larger in wetter years. The difficulty with the bound by flow approach is that it ignores the return flows that accrue back from irrigated lands downstream from Coleville. In practice the FWM's regulation of the river would accommodate these return flows, effectively allowing for water to be diverted more than once as it passes through the valley.

Figure 2-9. Antelope Valley Diversion Estimates



2.4 Evapotranspiration Calculated by METRIC

Mapping Evapotranspiration at high Resolution using Internalized Calibration (METRIC) is a state-of-the-art and widely accepted method of using remote sensing and model to estimate evapotranspiration (ET) from vegetation. DRI carried out a METRIC study of Antelope and Bridgeport Valleys as an input to the RCD study and the results are presented below.

Due to the complexity and time involved in calculating METRIC results for any given year, the DRI team selected just three years for analysis in cooperation with the RCD study team. The three years were chosen based on aerial photograph and meteorological data availability as well as the extent of flow conditions (dry, normal/mid or wet): 2002 (dry), 2005 (wet), and 2010 (median or “mid”) (see Appendix A for year classifications and percentiles).

Results of the Antelope Valley METRIC analysis are presented in Table 2-9. Actual ET results are provided for each HRU, as defined earlier. The reference ET for the valley is provided at the bottom of the first Table. Both calendar year and March to October totals are provided. The March to October ET figures are the actual measured ET that are related to irrigation water use for each of the three years. The dry year ET for the irrigation season (3.28 ft) is less than that for the wet year (3.72 ft), as the reference ETs are similar it is not surprising that there is a higher ET in the wet year when more irrigation water is available. In the median year the reference ET is less than either dry or wet year, but the actual ET is almost the same as in the dry year. This suggests that the median years ET might have been higher, and more similar to the wet year, had the weather conditions that drive ET not been so dissimilar from the other two years (i.e., temperature and wind). So it does appear that on the dry to wet year continuum that ET is higher under wetter conditions, although there appears to be more of a difference between the dry and median years than between the median and wet years. Another way to understand this is shown in the last row in Table 2-9, which subtracts the ET from the reference ET. This shows that the gap between reference ET and actual ET declines in a fairly continuous fashion as years moved from dry to median to wet.

Table 2-10Table 2-10 uses the ET rates and the acreages to derive total ET for the Antelope Valley HRUs. The corresponding figures for ET rates and total ET for Bridgeport Valley are shown in Table 2-11. As described earlier, HRUs were not established for Bridgeport so the totals are for the entire Bridgeport Valley. In the case of Bridgeport irrigation ET increases as the years change from dry (3.18 ft), to median (3.38 ft), to wet (3.59 ft). Note that the sequence for reference ET is the reverse, suggesting more evapotranspirative demand in the dry as opposed to the wet year.

Comparing results for the two valleys in Table 2-9 and Table 2-11 suggests slightly higher calendar year ET in Bridgeport than Antelope Valley (by around 0.4 ft on average); however, for the irrigation season the ET figures in Antelope Valley are approximately the same, most likely due to the longer irrigation season in Antelope Valley.

Table 2-9. Antelope Valley METRIC Results

(all figures in feet)	Calendar Year			March-October		
HRU	Dry (2002)	Mid (2010)	Wet (2005)	Dry (2002)	Mid (2010)	Wet (2005)
Alkali	3.22	3.30	4.10	3.02	3.11	3.88
Big Slough	3.51	3.55	4.10	3.36	3.34	3.95
Carney	3.25	3.53	3.92	2.98	3.29	3.70
Hardy	1.38	2.57	2.84	1.16	2.37	2.65
Little Antelope Valley	2.63	2.96	3.32	2.33	2.76	3.09
Lone Company	2.15	2.63	2.58	1.93	2.44	2.43
Main Canal	1.56	1.82	2.01	1.35	1.66	1.89
Powell	3.45	3.17	3.98	3.12	2.97	3.74
Rickey and Private	3.75	3.76	4.37	3.69	3.71	4.23
Swauger	3.63	3.69	4.13	3.46	2.62	2.94
West Goodnough & Harney	3.73	3.69	4.24	3.48	3.53	4.13
Total Actual ET	3.48	3.51	4.02	3.28	3.18	3.72
ETr	5.67	5.18	5.49	4.91	4.63	4.94
ETr less Actual ET	2.19	1.67	1.47	1.63	1.45	1.23

Table 2-10. Antelope Valley METRIC Total ET

		March-October ET (AF)		
HRU	Acres	Dry (2002)	Mid (2010)	Wet (2005)
Alkali	206	623	643	801
Big Slough	10,097	33,924	33,755	39,930
Carney	316	944	1,040	1,169
Hardy	57	66	135	151
Little Antelope Valley	663	1,546	1,828	2,049
Lone Company	272	526	666	661
Main Canal	98	132	162	184
Powell	181	564	538	678
Rickey and Private	493	1,818	1,827	2,083
Swauger	2,271	7,857	5,945	6,666
West Goodnough & Harney	266	927	942	1,099
Total Actual ET	14,922	48,926	47,481	55,473
w/out L Antelope Valley	14,259	47,381	45,653	53,424

Table 2-11. Bridgeport Valley METRIC Results

(figures in feet unless noted)	Acres	Calendar Year Total			Mar-September 15 Total		
		Dry (2002)	Mid (2010)	Wet (2005)	Dry (2002)	Mid (2010)	Wet (2005)
Total Actual ET		3.82	4.05	4.44	3.18	3.38	3.59
Total Actual ET (AF)	17,927	68,523	72,603	79,644	57,096	60,512	64,364
ETr		5.25	5.02	4.86	3.99	3.87	3.62
ETr less Actual ET		1.43	0.97	0.42	0.81	0.50	0.03

2.5 Precipitation and Net Irrigation Water Requirement

Precipitation data from each valley was prepared by DRI from the PRISM Climate Group's 800m dataset, employing a centroid place in the center of each valley. Results were multiplied by the acres in each HRU for Antelope Valley and by the delineated irrigated acreage in Bridgeport Valley. The monthly totals for the three years used in the METRIC analysis are presented in the Tables below.

Actual ET less precipitation for a given period is generally accepted as a measure of the water that is evapotranspired due to the application of irrigation water. In the DRI work this is referred to as the net irrigation water requirement (NIWR). NIWR is an accepted approach for determining the consumptive use of irrigation water. NIWR is also generally used as a measure of the water that can be leased or transferred to points downstream without causing conflict or injury with other water users. NIWR can be estimated directly if actual ET and precipitation data are available. Otherwise, ET can be estimated for particular crops by developing the reference ET, then adjusting this general ET to crop-specific ET estimates according to coefficients developed for each crop, and then subtracting out precipitation. In Nevada, the Department of Water Resources has developed such NIWR figures for every basin in the state.

The month-by-month calculations for the two valleys for ET, precipitation, and NIWR by year are provided below in Table 2-13 and Table 2-14. Totals are provided for the calendar year, for the full irrigation season and for two periods of interest for the study: March through May and July through the end of the irrigation season. A summary of the findings of these Tables is presented in Table 2-12. The results suggest comparable NIWR levels in the two valleys. The annualized total volume difference in NIWR between wet and dry years for the irrigation seasons are in the 4,000 to 6,000 AF range with Bridgeport Valley seeing the lowest variation.

In the case of Bridgeport Valley the wet to mid to dry years show small decreases in NIWR as might be expected due to lower availability of water supply. In Antelope Valley the mid-year is an outlier as NIWR is lower than for the dry year. An important contributor to this result is a large batch of precipitation in October of 2010. Whether or not all of this precipitation contributed to crop ET is unknown, but its contribution is expected to be minimal, as much vegetation has already shutdown in October due to colder temperatures. Where large rainfall events occur they may not all go to crop ET. This suggests the difficulty with calculating NIWR simply as if it is ET net of precipitation. For example in the winter months negative NIWR numbers result from this procedure (as seen in the Tables below). These numbers are of no value for the current purpose, of course, as these months are outside the irrigation season. The issue of the potential sources of ET is pursued further in the modeling effort in the next Section.

Table 2-12. Summary of NIWR for Antelope and Bridgeport Valleys

Valley and Year	NIWR (feet)	NIWR (AF)	ETr (feet)
Antelope Valley (Mar-Oct)			
Wet (2005)	3.53	52,676	4.94
Mid (2010)	2.93	43,723	4.63
Dry (2002)	3.14	46,856	4.91
Wet/Dry Difference	0.39	5,820	0.03
Bridgeport Valley (Mar-Sep 15)			
Wet (2005)	3.28	58,752	3.62
Mid (2010)	3.17	56,867	3.87
Dry (2002)	3.04	54,430	3.99
Wet/Dry Difference	0.24	4,321	(0.37)

Table 2-13. Antelope Valley Net Irrigation Water Requirement

(feet)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals	Irrigation Subtotals		
														Season	Mar-May	Jul-Oct
Dry (2002)																
ET	0.05	0.10	0.20	0.31	0.45	0.60	0.65	0.54	0.34	0.17	0.07	0.05	3.55	3.28	0.97	1.71
Precip	0.02	0.01	0.06	0.03	0.00	0.00	0.01	0.02	0.01	0.01	0.22	0.18	0.57	0.14	0.09	0.04
NIWR	0.03	0.09	0.14	0.28	0.45	0.60	0.64	0.53	0.34	0.16	(0.16)	(0.12)	2.98	3.14	0.87	1.67
Mid (2010)																
ET	0.04	0.08	0.21	0.32	0.39	0.57	0.72	0.60	0.33	0.17	0.08	0.04	3.54	3.32	0.92	1.83
Precip	0.19	0.16	0.05	0.07	0.02	0.00	0.04	0.00	0.00	0.19	0.10	0.37	1.21	0.39	0.15	0.24
NIWR	(0.16)	(0.09)	0.16	0.25	0.36	0.57	0.68	0.59	0.33	(0.02)	(0.02)	(0.34)	2.33	2.93	0.77	1.59
Wet (2005)																
ET	0.02	0.07	0.27	0.38	0.50	0.60	0.74	0.66	0.43	0.27	0.11	0.04	4.10	3.86	1.16	2.10
Precip	0.31	0.10	0.08	0.05	0.08	0.01	0.02	0.02	0.02	0.03	0.03	0.40	1.16	0.32	0.22	0.09
NIWR	(0.29)	(0.03)	0.19	0.33	0.42	0.59	0.72	0.63	0.41	0.23	0.09	(0.35)	2.95	3.53	0.94	2.00

Note: This includes the 14,922 acres of HRUs using surface water in Antelope Valley

Table 2-14. Bridgeport Valley Net Irrigation Water Requirement

(feet)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals	Irrigation Subtotals		
														All	Mar-May	Jul-Sep 15
Dry (2002)																
ET	0.07	0.15	0.26	0.35	0.49	0.65	0.72	0.57	0.31	0.14	0.08	0.04	3.82	3.18	1.09	1.44
Precip	0.04	0.03	0.06	0.04	0.00	0.01	0.02	0.01	-	0.01	0.13	0.14	0.50	0.15	0.11	0.03
NIWR	0.03	0.12	0.19	0.30	0.49	0.64	0.70	0.56	0.31	0.13	(0.06)	(0.10)	3.32	3.04	0.98	1.41
Mid (2010)																
ET	0.05	0.10	0.24	0.34	0.55	0.68	0.71	0.67	0.38	0.17	0.11	0.05	4.05	3.38	1.14	1.56
Precip	0.15	0.14	0.03	0.08	0.03	0.03	0.01	0.01	0.04	0.21	0.05	0.23	1.01	0.20	0.14	0.04
NIWR	(0.09)	(0.05)	0.21	0.26	0.53	0.65	0.69	0.66	0.34	(0.04)	0.06	(0.18)	3.04	3.17	1.00	1.52
Wet (2005)																
ET	0.07	0.13	0.34	0.44	0.55	0.75	0.75	0.54	0.44	0.24	0.13	0.06	4.44	3.59	1.32	1.51
Precip	0.28	0.10	0.10	0.06	0.11	0.01	0.01	0.01	0.03	0.01	0.01	0.37	1.09	0.31	0.27	0.03
NIWR	(0.21)	0.03	0.23	0.38	0.45	0.74	0.74	0.53	0.42	0.24	0.12	(0.31)	3.35	3.28	1.06	1.48

2.6 Water Balance Models

The final step in this Task is to build a water balance model for the major irrigation systems and diversions in each of the valleys. The primary objective of such a model would be to assist in understanding the hydrological impacts of changes in water diversion and consumption that occur as a result of conservation improvements, leasing or other water rights transactions. Constructing such a model relies on the availability of the underlying data and the set of associated assumptions necessary to create a functioning simulation model.

A basic model (a "Valley" model) would treat an entire valley as a single modeling unit and would include the information necessary to understand the following four model elements and changes to them under varying conditions:

1. Water in to the valley, consisting of:
    - Stream inflow; and
    - Precipitation and groundwater recharge.
2. Water out of the valley, consisting of:
    - Evapotranspiration from irrigation and other lands in the valley; and
    - Streamflow leaving the valley.
3. Change in water storage: consisting of the net change in groundwater as the valley stores and releases water in response to the inflows and outflows.

Such a model would be designed to model the water balance over some specified time frame (daily, monthly, seasonal or annual) as pertinent to the information needs. In the case of Antelope and Bridgeport Valleys a "Valley" model should assist with the first objective with respect to the potential of water transactions in Mono County, being to inform an understanding of how water transactions can lead to water that can be delivered to the state line and from there to Walker Lake without adversely affecting other water right uses in the valleys).

With the information available for Antelope Valley, a fairly robust Valley Model is developed below. An additional step is taken of developing a full irrigation water balance model for the majority of the irrigated area in Antelope Valley. This model complements the Valley Model and by fully specifying the irrigation water budget enables a further understanding of how water transactions might affect the water budget and provides more resolution as to what portion of water rights involved in likely water transactions might be marketed to the state line and Walker Lake.

For Bridgeport Valley, data are more problematic. Streamflow inputs and diversions are not "linear" as they are in Antelope Valley and the streamflow input is not well understood over a range of conditions. For this reason, the modeling effort in Bridgeport Valley is limited to a fairly general valley model. As a result, analysis of water transactions in Bridgeport Valley may need to rely more directly on the ET and NIWR figures from the METRIC analysis as cited earlier.

2.6.1 Antelope Valley

Antelope "Valley" Model

The Antelope Valley Model is derived from the following data, most of which is explained in prior Sections of this report:

1. Stream inflow to the valley:
    - Historical gage data above Antelope Valley at the Coleville gage - daily data for 1902 to 2013 is available from the USGS.
2. Precipitation in the valley:
    - Modeled data from PRISM software for Antelope Valley based on available weather station data – average monthly data for January 1995 to September 2011 was provided by DRI.
3. Recharge from precipitation in the valley:
    - Results of modeled sub-watersheds are compiled from a DRI paper prepared expressly for this purpose by Carroll and Pohll (2013) providing an average percent of precipitation routed to recharge of 11%, this represents precipitation less evapotranspiration and is used for the non-irrigated areas of the valley.
4. Evapotranspiration from irrigation:
    - The METRIC results for ET produced by DRI (see Section above) are available for 2002, 2005 and 2010 only, average figures for reference ET are available by crop from NDWR (Huntington and Allen 2010), and crop type is available from DRI for use in estimating average ET for other years (as needed).
5. Streamflow leaving the valley:
    - An unregulated dataset for the Hoye Bridge Gage (located approximately 3.5 miles below the point where the Topaz canal empties into the West Walker River) is constructed using the actual (regulated) Hoye Bridge Gage data and adding back in evaporation from Topaz Lake and storage releases from Topaz Lake, daily data from 1974 to 2013 is available.

While basic characterization of the groundwater system and ancillary groundwater investigations were carried out by various authors (in particular Carroll and Pohll 2013) related to this Mono County RCD project, no detailed historical information has been compiled and analyzed with respect to groundwater levels. Nor is a groundwater model for Antelope Valley available as for Mason and Smith Valleys on the Nevada side of the basin.

The METRIC ET work undertaken by DRI provides spatially disaggregated monthly estimates of actual evapotranspiration in the dry, mid and wet years. When precipitation is subtracted these figures provide initial estimates of Net Irrigation Water Requirements (NIWR). NIWR is effectively the “consumptive use” associated with the application of irrigation water and thus represents a measure of the amount of water that could be leased or transferred to downstream uses, including for instream and environmental purposes. In Antelope Valley, however, there are actually five sources of water that may lead to evapotranspiration from irrigated fields:

1. Precipitation;
2. Diverted decree water;
3. Diverted storage water;
4. Pumped supplemental groundwater; and
5. Transpiration from water stored in the ground.

The irrigation water budget model is developed to track crop demand and the extent to which each of these water sources may contribute to ET on a monthly basis for Antelope Valley. This is carried out for the same three representative years used in the Antelope Valley Model above.

In addition to the input data used for the Antelope Valley Model, a dataset of expected monthly diversion for these years is derived using the water regulation data for Antelope Valley available from the Federal Water Master. The "not bound" data is used for this purpose. This means that the model is using the Water Master's regulation data and is not limiting this to flow available at the Coleville gage. As return flows from irrigation may occur along the stretch of the West Walker in Antelope Valley the Water Master's data should account for any shortages up and down the Antelope Valley reach.

The model is run for the irrigation water rights and fields along the West Walker and excludes Little Antelope Valley and the primary groundwater down gradient from Topaz. The model follows irrigation water that is diverted to the field. Key steps and parameters include:

1. Irrigation water diverted is adjusted downward by a ditch conveyance loss – based on interviews with water managers, this is set at 10% for all but Swauger ditch, which is known to lose substantial amounts of water and, therefore, is set at 40%.

2. Crop water demand at the farm is determined by adjusting the raw crop water demand for the on-farm efficiency, which is in turn calculated based on the amounts of alfalfa and/or pasture, with 80% and 40% efficiencies for sprinkler and flood irrigation assumed.

3. At the farm, precipitation is added to the surface water; if this amount of water is insufficient to meet the crop water demand at the farm then storage and supplemental groundwater are used in proportional fashion to the acres that they can supply.

4. Finally, if these four sources of water are not sufficient the model has a toggle that allows (or does not allow) the crops to access non-consumptive water that is stored in the ground in previous periods (from recharge due to irrigation).

Ideally, the model would be run using a crop demand that represents the maximum crop demand under the conditions present in each month with a "full" water supply; however, such a figure is not available. Instead the model is run in order to use available water supplies to meet the actual evapotranspiration observed in the METRIC models (see the discussion and Tables in Section 2.4 above). The model is first run with the toggle allowing crop demand to pull from the groundwater supply in the "off" position. The results for this run show that irrigation and precipitation alone are not sufficient to generate the METRIC ET measured by DRI. Comparing years also suggests that this crop water deficit is more severe in dryer years (Figure 2-10). This observation very much corresponds with the information provided by local stakeholders. Figure 2-10 also clearly shows that actual evapotranspiration is itself more limited in drier years.

The irrigation water budget model allows the tracking of the different types of irrigation water (decree, storage and supplemental groundwater) and precipitation.
Figure 2-11 charts out the monthly use of each of these types of water across the three representative years. The drop off in decree availability in the dryer years, as opposed to the wet years, is marked, as is the uptick in use of supplemental groundwater in particular to try and meet this deficit. With limited storage and supplemental groundwater rights; however, the large deficit cannot be met through irrigation. Instead it is the filling of the valley water table during the winter and early irrigation season that provides water to sustain crops during that late summer, particularly during the late summer.

Figure 2-10. Model versus METRIC Evapotranspiration without Access to Groundwater

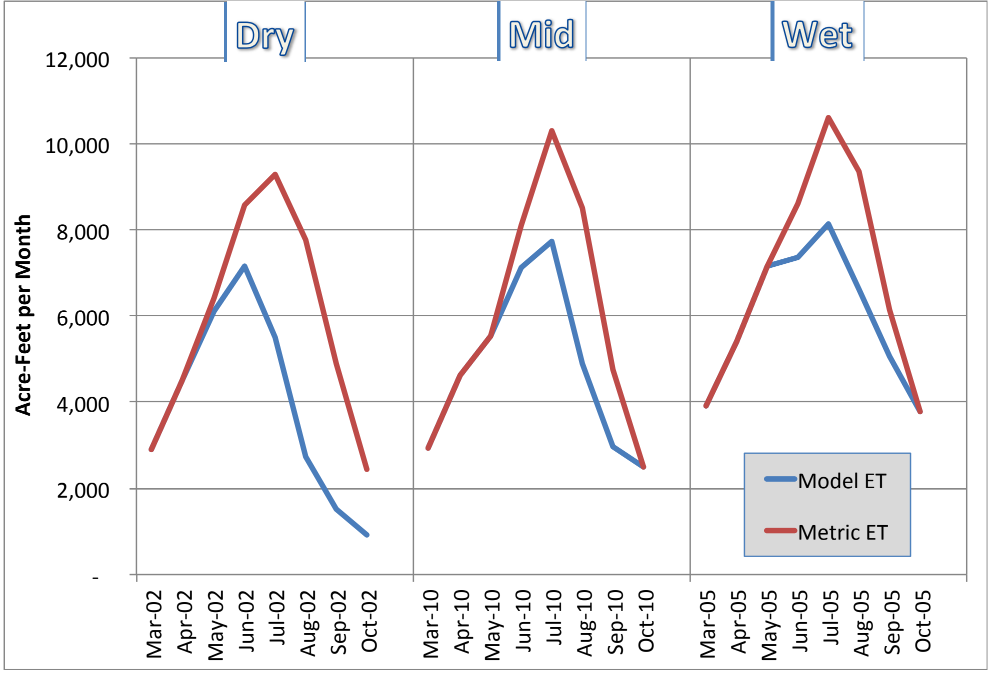
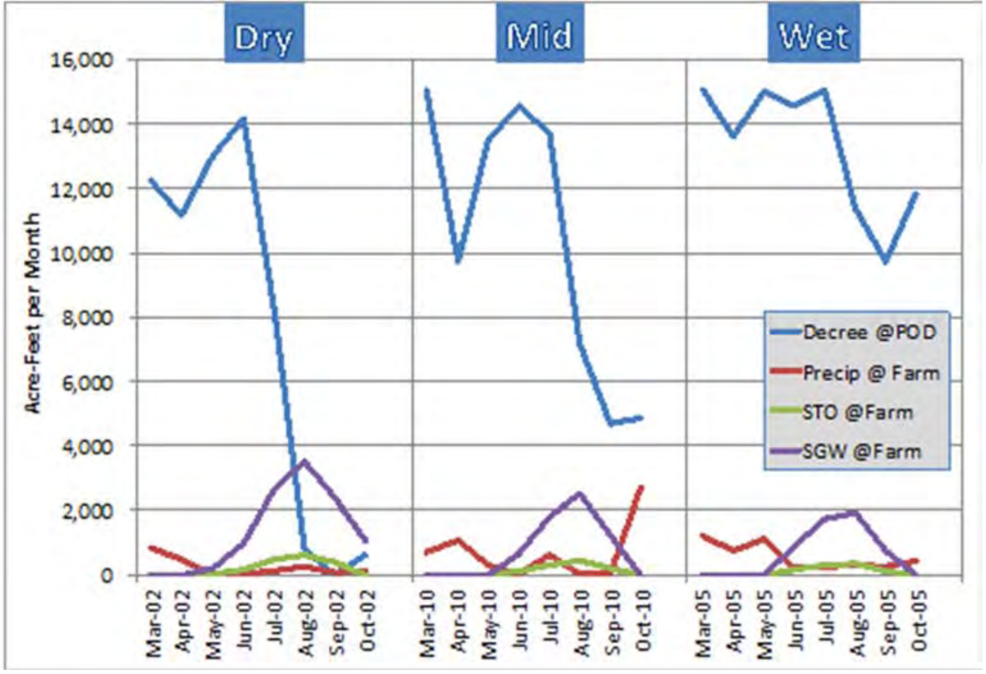


Figure 2-11. Irrigation Water Supply and Precipitation



When access to the irrigation water that is stored in the ground (water table or groundwater) is turned "on" in the model, the crop water demand is filled from the available reservoir of water retained in the ground from irrigation water recharge in prior periods. The model simply accumulates excess water, ditch conveyance loss, and on-farm losses due to irrigation and makes this available to irrigation. Figure 2-12 shows how the different sources of water are stacked one on top of the other to meet the crop water demand. Table 2-15 provides the amounts of ET sourced from each type of water in AF, percentage of total, and feet. Three findings from this analysis are as follows:

1. Irrigation water stored in the water table has an important contribution to crop demand, growth and ET in all years, but particularly in a dry year, in the dry year 33% of total ET comes from groundwater or about 1.08 feet and in the wet year these figures are 14% and 0.53 feet.
2. Irrigation water that is stored in the water table is sufficient to make up for the loss of precipitation and decree diversions in the summer months of dry years – in the dry year this does require that over 35% of the total non-consumptive use for the year be available to plants.
3. The direct contribution of irrigation water to ET in this case is not just ET less precipitation, but ET less precipitation and the water evapotranspired from the water table and will vary significantly:
    a. Year-to-year – with an irrigation water contribution to ET, or NIWR, that varies from 2.14 feet in the dry year to 3.19 feet in the wet year.
    b. Depending on efficiency assumptions that go into the model – increasing water use efficiency means more ET resulting from irrigation and less need to tap groundwater; for example, changing flood irrigation efficiency from 40% to 60% in the model increases the ET due directly to irrigation water from 2.14 to 2.30 feet for dry years, and from 3.19 to 3.46 feet for wet years.

Figure 2-12. Evapotranspiration by Type of Water Consumed

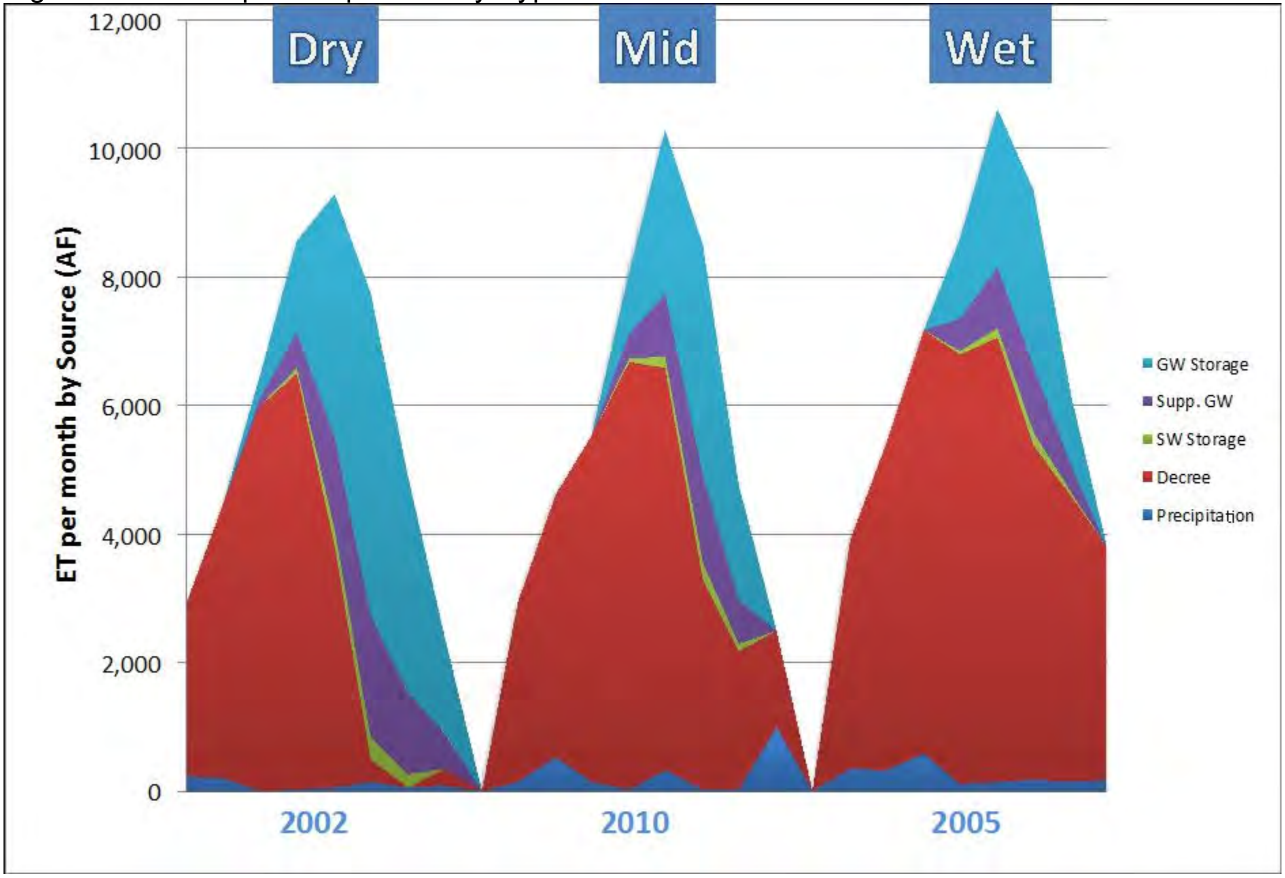


Table 2-15. Irrigation Season Evapotranspiration Amounts by Source and Year Type, Antelope Valley

Sources of ET:	Decree	Storage	Suplemental Groundwater	Subtotal Irrigation Water	Water Table / Groundwater	Precipitation	Total ET
Amounts (AF)							
Dry	23,810	918	5,805	30,533	15,447	762	46,742
Mid	32,171	604	3,363	36,137	8,948	2,185	47,271
Wet	42,100	510	2,840	45,450	7,557	1,981	54,988
Amounts (% of Total)							
Dry	51%	2%	12%	65%	33%	2%	100%
Mid	68%	1%	7%	76%	19%	5%	100%
Wet	77%	1%	5%	83%	14%	4%	100%
Amounts (feet)							
Dry	1.67	0.06	0.41	2.14	1.08	0.05	3.28
Mid	2.26	0.04	0.24	2.53	0.63	0.15	3.32
Wet	2.95	0.04	0.20	3.19	0.53	0.14	3.86

Antelope Valley Findings

The implications of these model findings for water transactions that involve the removal of irrigation water from an irrigated field are as follows for full and partial years (see Table 2-16 for details)

- For a **full year of fallowing / water leasing** the amount of irrigation water (including decree, groundwater and storage) not consumed will vary from 2.14 to 3.19 feet, and from 1.67 to 2.95 feet for decree rights only (Table 2-15), with the following caveats:
  - the figure will be higher the wetter the year, and lower the dryer the year;
  - the figure will be higher for more efficient operations and lower for less efficient operations; and
  - the figure will be lower if evapotranspiration on the field is supported by groundwater storage early in the season (not the late season as the dry year shows that there is a limit to the contribution of groundwater storage).

- For a **sale and transfer of water rights** (i.e., a permanent transaction that fully dries out the property) the ET savings would be the sum of the subtotal for irrigation water and the water table / groundwater component, or a range of from 3.22 to 3.72 feet. If the groundwater is not transferable and the storage is marketed separately the sum of the decree and water table / groundwater component would be 2.75 to 3.48 feet for dry and wet years respectively, with a 2.89 feet figure for the median year.

- For a **partial year late season fallowing/lease** of decree rights (assuming no irrigation after July 1st) the portion of the decrease in decree irrigation water consumed is 0.31 feet in the dry year, 0.93 feet in the median year and 1.42 feet in the wet year, with a midpoint of about 0.8 to 0.9 feet.

- For a **partial year early season fallowing/lease of decree rights** (assuming no irrigation until June 1st) the portion of the decrease in decree irrigation water consumed 0.90 feet in the dry year, 0.86 feet in the median year and 1.07 feet in the wet year, with a midpoint in the 0.9 to 1.0 feet range.

- For a **reduction in water use from wet year levels to dry year levels** the decrease in irrigation water consumed will be about 1.05 feet for all irrigation sources (Table 2-15) and 1.28 feet for decree rights only.

Note that all the caveats to the first bullet above apply to the ensuing bullets.

Table 2-16. Summary of Modeled ET from Decree Source by Month, Antelope Valley

ET from Decree Only	ET Totals in AF/month			ET: Wet less dry (feet)	ET: Wet Less dry Cumul. (feet)	ET by month (feet)		
Month	Dry (2002)	Mid (2010)	Wet (2005)			Dry (2002)	Mid (2010)	Wet (2005)
Mar	2,675	2,781	3,576	0.06	0.06	0.19	0.20	0.25
Apr	4,261	4,110	5,076	0.06	0.12	0.30	0.29	0.36
May	5,962	5,378	6,584	0.04	0.16	0.42	0.38	0.46
Jun	6,488	6,676	6,676	0.01	0.18	0.45	0.47	0.47
Jul	3,775	6,281	6,898	0.22	0.40	0.26	0.44	0.48
Aug	372	3,283	5,216	0.34	0.74	0.03	0.23	0.37
Sep	-	2,157	4,459	0.31	1.05	-	0.15	0.31
Oct	277	1,506	3,615	0.23	1.28	0.02	0.11	0.25
Totals	23,810	32,171	42,100	Subtotal Jul-Oct		0.31	0.93	1.42
				Subotal Mar-May		0.90	0.86	1.07

2.6.2 Bridgeport Valley

Bridgeport "Valley" Model

The modeling effort for Bridgeport Valley is constrained in various ways. The two main data limitations that affect the ability to construct the models deployed above in the case of Antelope Valley are that:

- There is only a four-year period (October 2004 to September 2008) when data from all four creek gages (Buckeye, Green, Robinson and Virginia) is available; and
- There is no regulation data available from the Federal Water Master.

In order to provide an indication of the hydrologic dynamics of Bridgeport Valley along the lines of those put forward for Antelope Valley, two simplifying assumptions are made to construct a valley model and an irrigation water balance model:

- One year of monthly streamflow data (2006 water year) from Swauger Creek is compared with Virginia Creek data for those months in order to generate a full November 2004 to September 2008 data set for Swauger Creek, in order to include this creek's contribution to Bridgeport Valley water supply.
- Dry year irrigation season streamflow for 2002 is approximated by using streamflow data from the 2008 water year based on comparison of flows for these years on Buckeye and Robinson Creek, including the estimated Swauger Creek flows for 2008.Decree diversions are assumed to be the lesser of the total allowed rate per hectare of irrigated land (0.016 cfs/acre under the C-125 decree) summed monthly or the amount of streamflow available.

With these adjustments it is possible to develop the two models for the dry (2002) and wet (2005) years.

The same set of valley model charts as was produced for Antelope Valley are repeated for Bridgeport Valley in the next three Figures below. As is the case with Antelope Valley, there is a large difference (threefold) between wet and dry years in terms of precipitation and streamflow (Figure 2-13). The gap between the stream inflow and the flow leaving the valley roughly follows the same dry/wet year pattern as well. Do note, however, that the difference between inflow and outflow is quite large in the dry year. As shown in Figure 2-14 the shape of the groundwater storage line through the dry and wet years parallels that for Antelope Valley, with the valley gaining water early in the season and discharges water late in the year during the dry year, whereas the wet year shows discharge throughout the year with large amounts leaving the valley early in the season. Presumably, this indicates that during wet cycles that valley "fills" up early in the season, whereas in dry cycles the valley soaks up available water early in the season. The final

Figure 2-15 shows that the artificial constraint imposed on the model means that during the dry year the decree diversions simply equal the streamflow inputs to the valley. And these appear to drive groundwater storage – note the similar shape in the two curves; however, during the wet year streamflow inputs exceeds permitted diversions during most of the summer and streamflow inputs do not appear to drive changes in groundwater storage.

Although it is hard to draw conclusions from only two years of data, it does appear that the model is understating the overall water supply in the valley. The groundwater system appears to be discharging in both dry and wet years (on an annual basis). It is therefore not clear when the system would be recharging the groundwater system to maintain an overall balance between years. Further hydrological assessment of the inflows used in this dataset would be needed to assess where the deficiency lies.

Figure 2-13**.** Inflows and Outflows, Bridgeport Valley

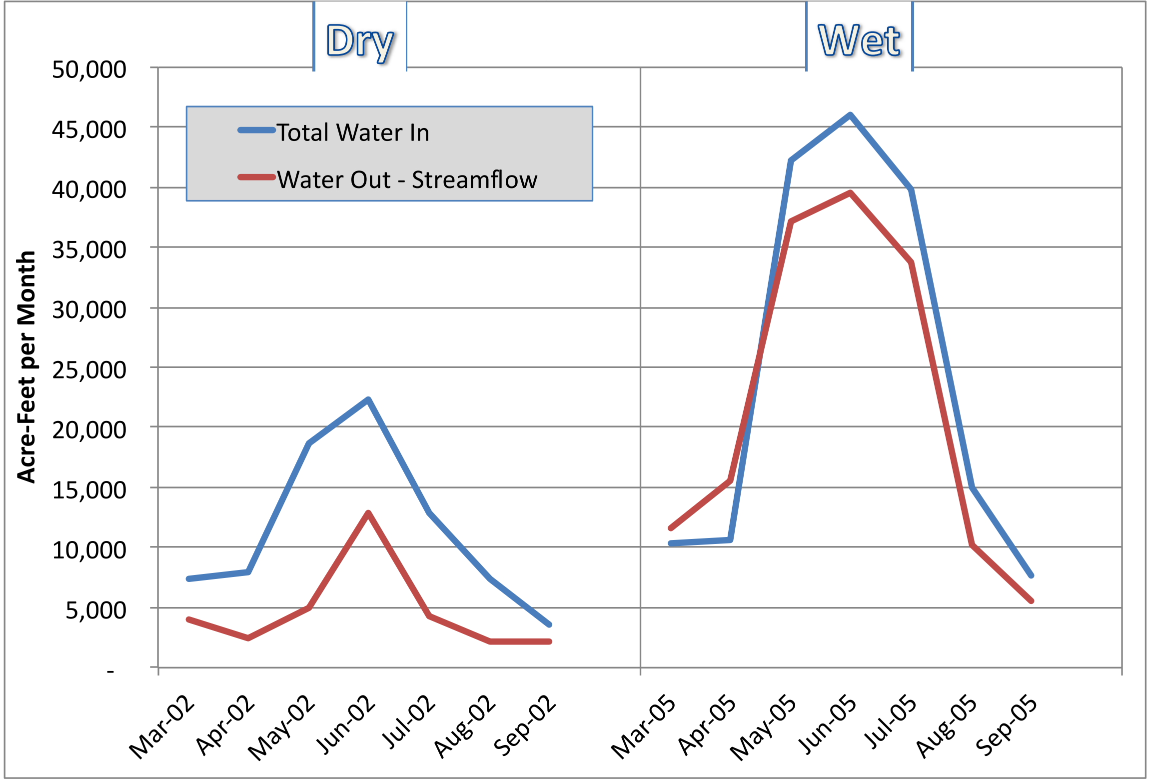


Figure 2-14. Model versus METRIC Evapotranspiration without Access to Groundwater, Bridgeport

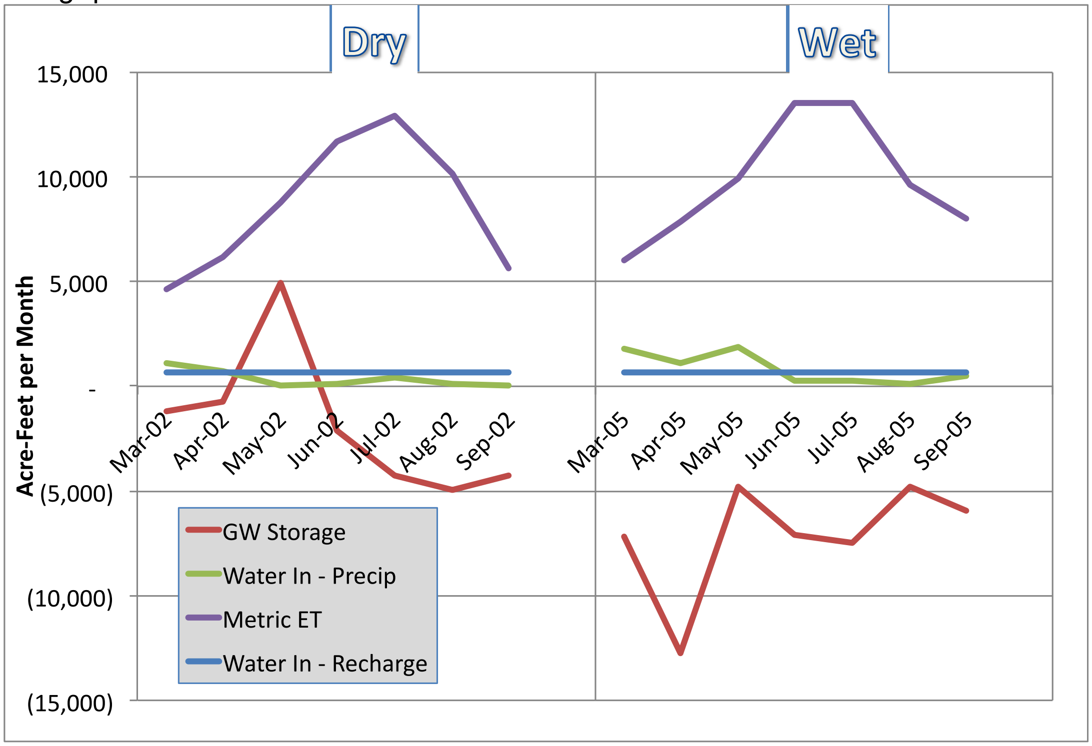
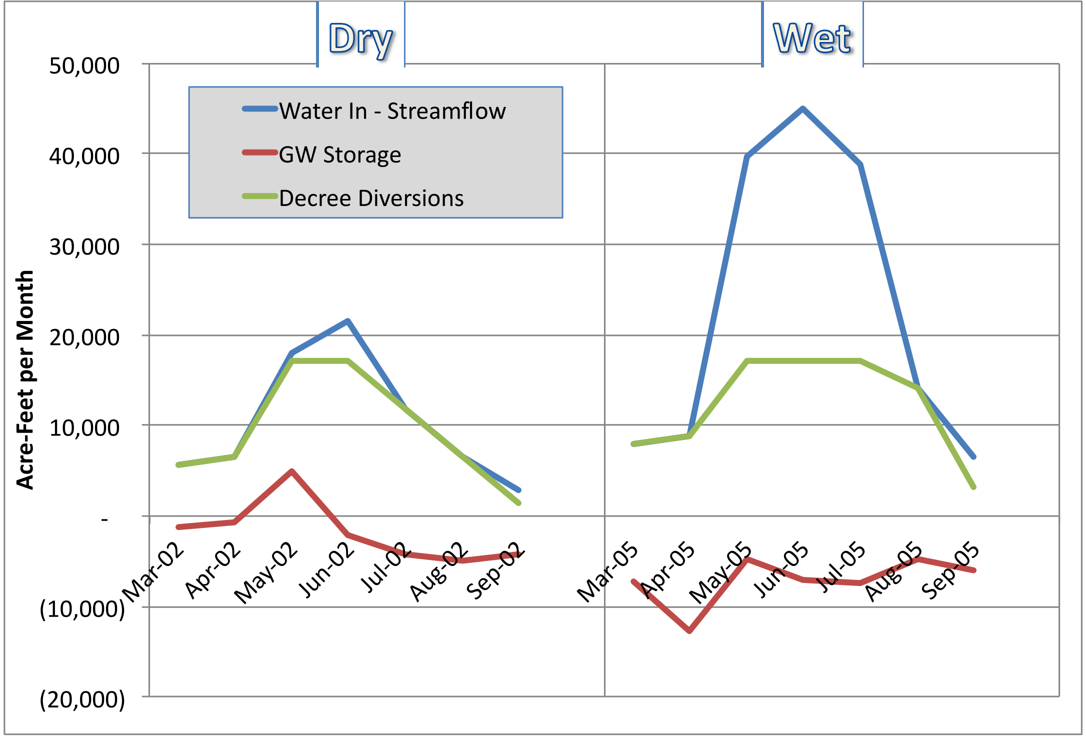


Figure 2-15. Irrigation Water Supply and Precipitation, Bridgeport Valley



The Bridgeport Valley irrigation water budget model follows the same set-up and procedures as the Antelope Valley model. A few of the parameters that differ in the Bridgeport Valley model include:

- Total decree acreage of 17,927;
- No supplemental groundwater rights;
- Storage in the two Twin Lakes on Robinson Creek is 6,100 AF;
- Ditch conveyance loss is set at 10%;
- On-farm efficiency is set to 40% due to the prevalence of flood irrigation in the valley; and
- Beginning of year groundwater storage is set at 3,500 AF.

The low amounts of streamflow for diversion (in the dry year and in all but the snow melt months of the wet year) as noted above, in combination with low efficiency on-farm application, leads to the result that much of the water evapotranspired by crops and pasture in Bridgeport comes from groundwater and not directly from the application of irrigation water. The low proportion of METRIC ET that can be sourced from surface water applications is shown in Figure 2-16. As with Antelope Valley precipitation during the irrigation season is minimal, and insignificant compared to the surface water inflow (Figure 2-17). When the model allows the crop demand to pull from irrigation water previously stored in the water table actual ET can be replicated in the model; however, a very large portion of the ET comes from the plants access to the water table and not directly to the irrigation water as delivered (Figure 2-18 and Table 2-17). Table 2-17 suggests that in the wet year 48% of the ET, or 1.83 feet, comes from the water table and in the dry year this figure is 54% of the total but a similar amount at 1.82 feet. This means that the amount of ET derived directly from the application of irrigation water is quite low at 1.46 feet in the dry year and 1.85 feet in the wet year.

As with the Antelope Valley model it is important to stress that these large figures for the water table component of ET are determined in large part by the water use efficiencies in the water. If the 40% assumed for flood irrigation is changed to the higher 60% efficiency then the amount of ET due directly to irrigation water rises to 2.11 in the dry year and 2.67 in the wet year, a significant increase.

Figure 2-16. Model versus METRIC Evapotranspiration without Access to Groundwater, Bridgeport

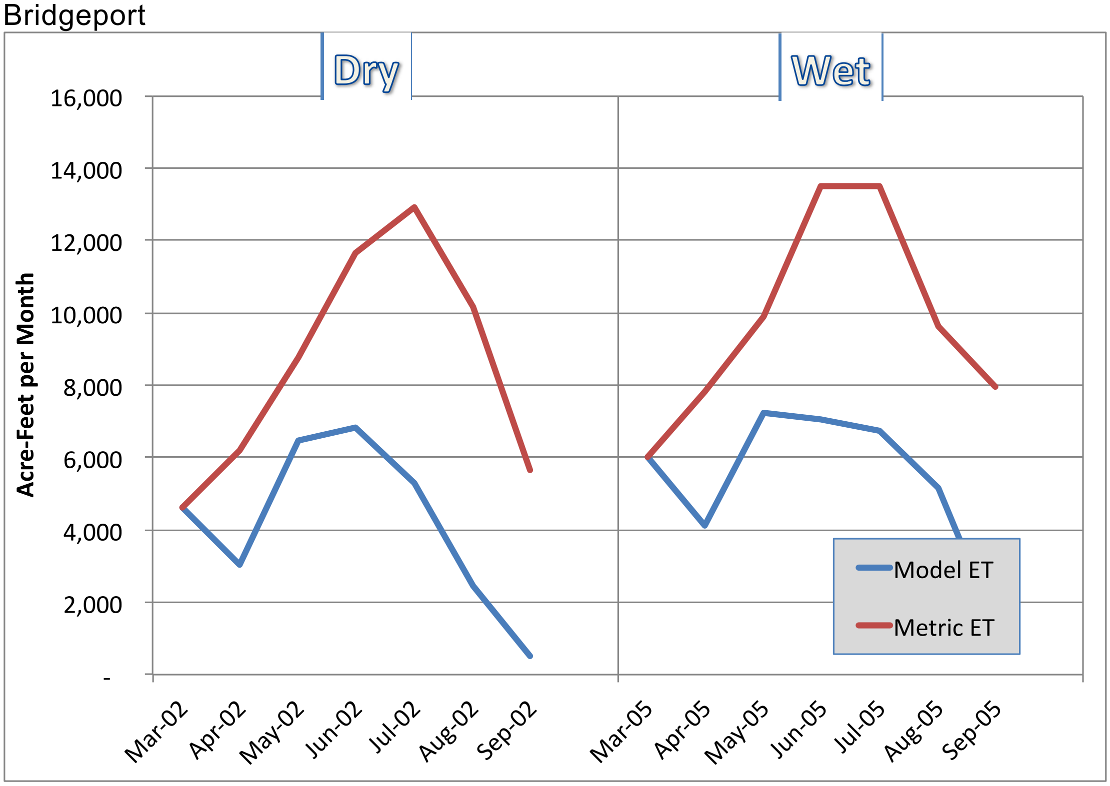


Figure 2-17. Irrigation Water Supply and Precipitation, Bridgeport Valley

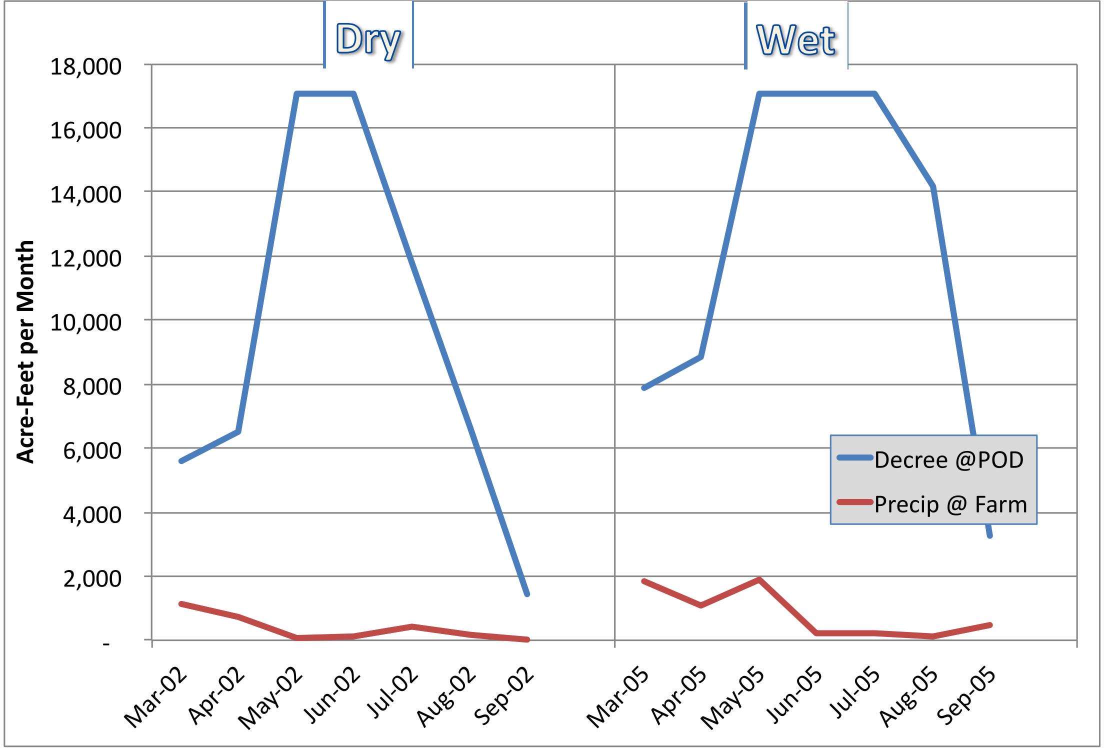


Figure 2-18. Evapotranspiration by Type of Water Consumed, Bridgeport Valley

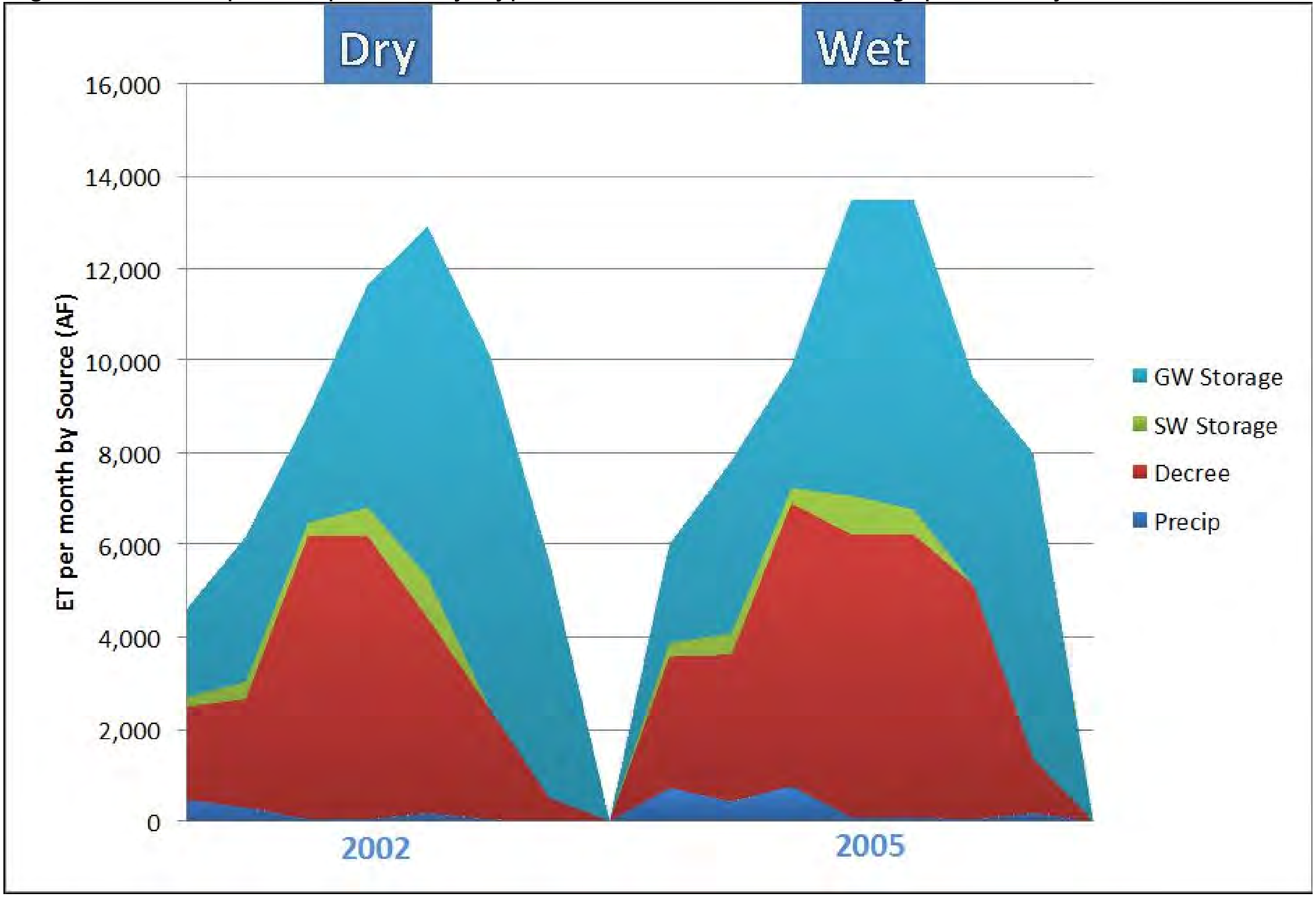


Table 2-17. Irrigation Season Evapotranspiration Amounts, Bridgeport Valley

Sources of ET:	Decree	Storage	Subtotal Irrigation Water	Water Table / Groundwater	Precipitation	Total ET
Amounts (AF)						
Dry	23,804	2,440	26,244	32,603	1,066	59,914
Wet	30,743	2,440	33,183	32,826	2,341	68,350
Amounts (% of Total)						
Dry	40%	4%	44%	54%	2%	100%
Wet	45%	4%	49%	48%	3%	100%
Amounts (feet)						
Dry	1.33	0.14	1.46	1.82	0.06	3.34
Wet	1.71	0.14	1.85	1.83	0.13	3.81

Bridgeport Valley Findings

As in the case of Antelope Valley, the model findings have implications for water transactions that involve the removal of irrigation water from an irrigated field (see Table 2-18 for monthly ET figures for the decree source of water). These implications are as follows, noting that the same caveats apply as in Antelope Valley in terms of the variability of these figures from dry to wet years, the influence of water use efficiency, and the spatial/temporal variability:

- For full year fallowing / lease the amount of irrigation water not consumed will vary from roughly 1.46 to 1.85 feet for all irrigation water and 1.33 to 1.71 for decree water only.
- For a sale and transfer of water rights that fully dries out acreage, the ET savings for all irrigation sources would range from 3.3 to 3.7 feet. If the storage is marketed separately the sum of the decree and water table / groundwater component would be 3.15 to 3.55 feet for dry and wet years respectively.
- For a partial year late season fallowing/lease of decree rights (assuming no irrigation after July 1st) the portion of the decrease in decree irrigation water consumed is 0.40 feet in the dry year and 0.69 feet in the wet year, with a midpoint of about 0.55 feet.
- For a partial year early season fallowing/lease of decree rights (assuming no irrigation until June 1st) the portion of the decrease in decree irrigation water consumed 0.59 feet in the dry year and 0.68 feet in the wet year, with a midpoint of about 0.65 feet.
- For a reduction in water use from wet year levels to dry year levels the decrease in irrigation water consumed will be about 0.4 AF for all irrigation sources (Table 2-17) and for decree rights.

Table 2-18. Summary of Modeled ET from Decree Source by Month, Bridgeport Valley

ET from Decree Only	ET Totals in AF/month		ET: Wet less dry (feet)	ET: Wet Less dry Cumul. (feet)	ET by month (feet)	
Month	**Dry (2002)**	**Wet (2005)**			**Dry (2002)**	**Wet (2005)**
Mar	2,024	2,843	0.05	0.05	0.11	0.16
Apr	2,345	3,192	0.05	0.09	0.13	0.18
May	6,144	6,144	(0.00)	0.09	0.34	0.34
Jun	6,144	6,144	0.00	0.09	0.34	0.34
Jul	4,252	6,144	0.11	0.20	0.24	0.34
Aug	2,380	5,108	0.15	0.35	0.13	0.28
Sep	514	1,167	0.04	0.39	0.03	0.07
Totals	23,804	30,743		Subtotal Jul-Sep	0.40	0.69
				Subotal Mar-May	0.59	0.68

It is important to note that the actual numbers may vary within Bridgeport Valley. Without a full groundwater model, the patterns cannot be determined, but there appears to be a substantial amount of subirrgation from neighboring fields. In general, it might be expected that if a water transaction was done on ground lower in the valley, the amount of consumptive use savings may be limited due to shallow groundwater flow from upgradient meadows and ditches. Upslope areas may result in higher water savings than expected because of no subirrigation, but a lack of return flows over land or subsurface may reduce water available to downslope irrigators. (Moeller, personal communication, 08/20/13)

2.7 Conclusions – Implications for Water Transactions

This paper summarizes existing and newly developed data and models regarding hydrology, water rights and water use for irrigation in Antelope and Bridgeport Valleys. The intent of the effort is to provide information regarding the potential impact on the water budget of a range of water transactions that are to be examined in the RCD study. METRIC ET data and the NIWR figures by DRI, along with the modeling results explained in the preceding Section provide different perspectives on the amounts of evapotranspiration (ET) associated with these transactions under a range of hydrological conditions. Generally, the DRI NIWR figures should be higher than the modeled figures as the modeling attempts to parse out the contribution to ET by source. The advantage of the modeled numbers is that they enable a more refined estimate of the likely amounts associated with specific types of water rights, for example, or decree and the likely effects of temporary transactions that do not fully dry up acreage.

An effort is made in Table 2-19 to summarize the METRIC and the irrigation water budget model results. A brief discussion of the results, and how figures best might be used, is organized by each type of transaction:

- **Full year temporary fallowing** is in the 3.0–3.5 ft range using the METRIC NIWR figures, but from as low as 1.3 ft and up to 3.2 ft using the water budget model figures. Choosing the lower, water budget model numbers would reflect the assumption that small, temporary transactions will not succeed in drying out fields and therefore would not realize the full savings implied by the METRIC NIWR figures.
- Conversely for **full year permanent fallowing** the METRIC NIWR figures of 3.0–3.5 ft seem reasonable as all water would permanently be removed from the property, also the water budget model figures come in very much in this range with values of from 2.8–3.7 ft.
- For the **partial, late season transactions** the METRIC NIWR figures range from 1.4–2.0 ft, whereas the decree only figures from the water budget model range from 0.3–1.4 ft; the decree only figures are quite low but may be more accurate if, as the water budget model suggests, late season ET in these valleys depends in good part on water stored earlier in the season.
- The figures from both data sets with respect to the **early season fallowing** are similar and range from 0.6–1.1 ft; this reflects not so much water stored but the direct contribution of irrigation water (which is usually decree only this early in the season) to early season ET.
- For a **reduction in water use that mimics always irrigating at dry year levels** in the case of Antelope Valley the METRIC NIWR reduction is 0.4 feet, whereas the water budget model suggests a much higher figure of 1.1–1.3 ft; in the case of Bridgeport Valley both approaches yield approximately the same 0.3–0.4 ft figure; these results reflect the much more pronounced variation in decree water right reliability in Antelope Valley which leads to a much higher dry/wet year variation in the water budget model.
- **Storage transactions** are likely to be stand-alone transactions (i.e., not transferred along with the primary decree rights). Due to their unique nature as stored water, already withdrawn from natural flow, they would likely be subject to a different evaluation process with respect to leasing or transfer. Groundwater use is unlikely to be transferrable to an instream surface water right that is protectable downstream. Thus, depending on the case, the decree only figures may be more relevant than the "all sources" figures.

Table 2-19. Summary of METRIC NIWR Results and Irrigation Water Budget Results for Irrigation and Decree Sources for Decree Rights

(all figures in ft of ET)	DRI - METRIC Analysis				Irrigation Water Budget Model							
	Net Irrigation Water Requirement				Antelope Valley				Bridgeport Valley			
	Antelope Valley		Bridgeport Valley		All Sources*		Decree Only		All Sources*		Decree Only	
Transaction Type	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Full Year - Temporary	3.1	3.5	3	3.3	2.1	3.2	1.7	3	1.5	1.9	1.3	1.7
Full Year - Permanent					3.2	3.7	2.8	3.5	3.3	3.7	3.2	3.6
Partial Year - Late Season	1.6	2	1.4	1.5			0.3	1.4			0.4	0.7
Partial Year - Early Season	0.8	0.9	1.0	1.1			0.9	1.1			0.6	0.7
Temporary Full Year Reduction	0.4		0.3		1.1		1.3		0.4		0.4	

Notes: *All sources does not include water table / groundwater for temporary transactions but do include this for permanent transactions

2.8 Climate Change Considerations

Climate change as related to water availability is a real concern in the Sierra Nevada and Great Basin Regions. Measurable shifts in climate trends have already been detected in the Sierra Nevada and Great Basin and are expected to continue into the future. In general both the eastern Sierra Nevada and the Great Basin will experience warmer, drier summers and reduced snowpack in the winter. Over the past century there is observed an increase in temperature by 0.3–0.6 °C and a declining snow pack. Major changes to surface hydrology have resulted, including the timing of spring snowmelt-driven streamflow, which now arrives about 10–15 days earlier than it did in the mid-1900s (Chambers 2008). There is also a substantial increase in inter-annual variability in spring flow *(*Baldwin et al. 2003, Stewart et al. 2004). Another result of the changes in precipitation pattern is increased frequency of rain on snow events and flooding. Beyond water availability these changes in climate will likely alter existing ecosystems and some of the services that they provide. Examples include shifts in fire regimes, ranges of insects and invasive species, and plant and animal diseases and parasites (Joyce 2013). Due to the wide variability and the number of models of emissions projections and general circulation and climate change projections, the Team did not undertake our own analysis to quantify the potential changes in streamflow amounts and timing. The wide range of results we would have produced would not have been specific enough to feed into our models of vegetation, habitat, and economic impacts. Instead we reviewed current literature to determine expected trends.

A recent study (Costa-Cabral et al 2013) analyzed the results of 16 general circulation models under two different emission scenarios to identify climate trends in the Mono Lake and Owens Valley watersheds. Their research revealed projections of:

- Temperature increases of 2–6°C by 2100 (warming at a rate of 1–2°C per 30 years).
- Increases in the fraction of precipitation falling as rain instead of snow, up to 0.5 by 2100.
- A general decline in April 1 snow water equivalency.
- An earlier shift in the date when half of the water volume arrives, up to 1 month earlier than currently.
- There is a wide range in the total amount of precipitation and amount of runoff expected. Projections range from a 24% decline to a 56% increase.

Multiple studies of expected changes in the Lake Tahoe watershed revealed similar projections. Also of note from Lake Tahoe research is that the most extreme hydrologic changes are expected in the latter half of the century, after 2050. In general, changes are relatively minimal before 2030 (Coates et al. 2010).

Although there are differences in elevations in the varied watersheds, trends in the Walker Lake watershed would be expected to be similar to those projected for the Tahoe and Mono regions. Under these scenarios of less snowfall and earlier snow melt, there will be less storage of winter water into the dry summer months making groundwater storage relatively more important. The shift from snow to rain and earlier arrival of the majority of the water will mean less dependable water supplies from mid-summer on. While there may not be a marked decrease in late season water over the next 15 years, within 30 years that change is likely to accelerate. This point bears consideration for both potential water buyers and sellers. The buyer needs to evaluate the current importance of increased water deliveries for Walker Lake or instream needs, and if it is worth purchasing late season rights. The seller may consider the fact that in the future their late season water may not be available, so it might be best to take advantage of a sale opportunity at this point in time. Additionally, landowners should realize that with or without water transactions, in the relatively near future they might need to run their operations with far less water. Participating in water transactions at this time may provide the technical and financial support need to make that transition before it is forced upon them by natural conditions.

3 VEGETATION RESPONSE TO CHANGES IN IRRIGATION MANAGEMENT

Please see Appendix B for a detailed discussion of approach, data, and analysis.

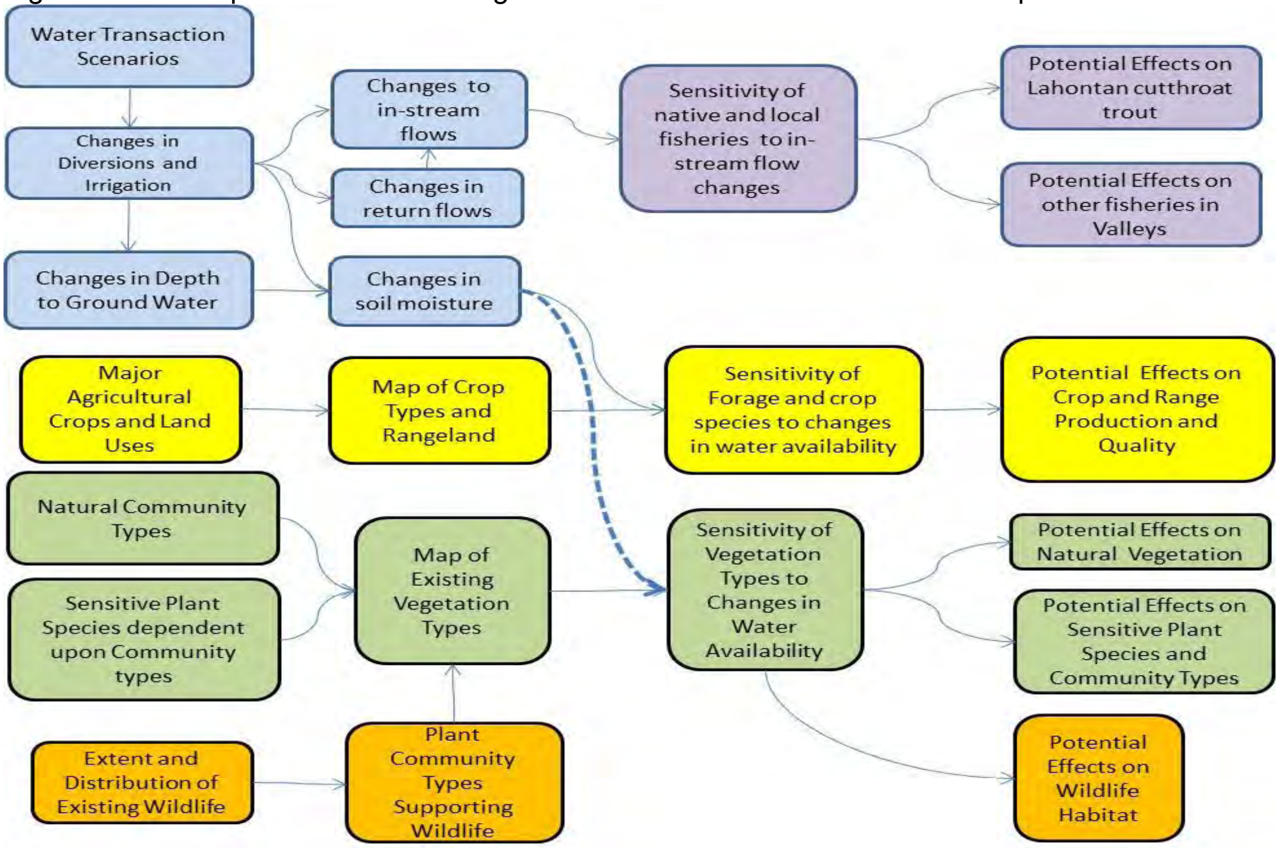
Potential environmental and agricultural impacts of a water transaction program in Antelope and Bridgeport Valleys are described in this report. Overall, a scarcity of quantitative information limited the degree to which conclusions could be made; however we outline basic comparisons among potential water transaction scenarios and their associated potential impacts. An existing general vegetation map of the Walker River riparian corridor was expanded upon and combined with field survey and other information to develop a description and map of local vegetation types in Antelope and Bridgeport Valleys. A conceptual model that articulates linkages among surface water, groundwater, crop production, natural vegetation, fisheries, and wildlife was used to direct this assessment.

3.1 Approach

We use a conceptual linkages model to guide our steps in articulating potential environmental and agricultural impacts associated with changes in water transfers in the California East and West Walker Basins. The model, presented in

Figure 3-1 below, includes three major paths of logic: one that links changes in diversions to consequent changes in instream flows and therefore potential effects on aquatic habitat and fisheries; one that links changes in diversions and irrigation to changes crop production; and a third that links changes in irrigation to changes in groundwater levels which then affect natural (including pastures) vegetation and therefore plant and wildlife habitat.

Figure 3-1 Conceptual Model of Linkages between Scenarios and Potential Impacts



3.2 Study Area

We created Study Area boundaries for the area potentially affected by changes in water transfers in Antelope and Bridgeport Valleys based on several assumptions: (1) all irrigated lands are subject to potential effects; (2) areas of low topographic relief in the irrigated valleys but outside of the designated irrigated areas can also be affected through associated changes in groundwater levels and return flows; and (3) the riparian corridor downstream of the upper-most diversion can be affected by altered in-stream flows. Where active irrigation was not applied, we delineated the edge of the valley floors where surface slopes fell below 5.0%, based on the assumption that areas with steeper slopes would have little or no interaction with the groundwater or irrigation return flows. For both valleys, the excluded steeper lope area includes only a very small percentage (<4.0%) of the valley floor land surface since most of the valley floors are actively irrigated through either flood or pivot irrigation. Thus, irrigated lands are the primary focus of the analysis and are captured in the hydrologic response units described below.

Table 3-1. Hydrologic Response Units in Antelope Valley

Row Labels	Acres total	Percent of Irrigated Lands	Acres <5% slope	Acres > 5% slope
Alkali	206	1.4%	186.40	19.60
Big Slough	9839	65.9%	9,765.51	73.49
Carney	316	2.1%	301.91	14.09
Hardy	57	0.4%	50.06	6.94
Highline	259	1.7%	254.00	5.00
Little Antelope Valley	663	4.4%	187.98	475.02
Lone Company	272	1.8%	267.87	4.13
Main Canal	98	0.7%	96.05	1.95
Powell	181	1.2%	181.08	(0.08)
Rickey and Private	493	3.3%	493.01	(0.01)
Swauger	2271	15.2%	2,257.13	13.87
West Goodnough & Harney	266	1.8%	216.60	49.40
Grand Total	**14,921.00**	100.0%	**14,257.60**	**663.40**

3.3 Existing Soils and Topography

A variety of soil types occur in Antelope and Bridgeport Valleys, most of which are composed of granitic and volcanic derived alluvium. Although textures range from clay to sand, the most common texture in both valleys is fine loam, and the second most common is sand, although some of the loams have high coarse content, and areas of clay soil exist near the reservoirs (Figure 3-2 and Figure 3-3). Bridgeport Valley soils are predominantly poorly to somewhat poorly drained, whereas soils in Antelope Valley are most often considered ‘well drained’ (NRCS Soil Survey Staff 2014). For both Antelope and Bridgeport Valleys, surface slopes generally increase along the valley edges with more sloped areas along the southern valley borders (Figure 3-4 and Figure 3-5). The extent and distribution of different soil textures and surface slope areas in Antelope and Bridgeport Valleys are summarized in Table 3-2 and Table 3-3 below.

Table 3-2. Soil Texture and Surface Slope Classes in Antelope Valley, California

Characteristic	Information Source	Categories	Total Acreage	Percentage of Total
Soil texture class	SSURGO dominant soil texture class	Sands	1,004	4
		Loams and silt loams	16,234	69
		Clay and fine silt	3,345	14
		Unknown	2,809	12
		Total	**23,392**	**100**
Surface slope	30-m^2 DEM	0-3%	18,258	78
		3-5%	5,134	22
		Total	**23,392**	**100**

Table 3-3. Soil Texture and Surface Slope Classes in Bridgeport Valley, California.

Characteristic	Information Source	Categories	Total Acreage	Percentage of Total
Soil texture class	SSURGO dominant soil texture class	Sands	6,428	32
		Loams and silt loams	11,648	58
		Clay and fine silt	50	<1
		Unknown	1,927	10
		Total	**20,053**	**100**
Surface slope	30-m^2 DEM	0-3%	18,255	91
		3-5%	1,799	9
		Total	**20,053**	**100**

Figure 3-2. Surface Soil Textures in Antelope Valley

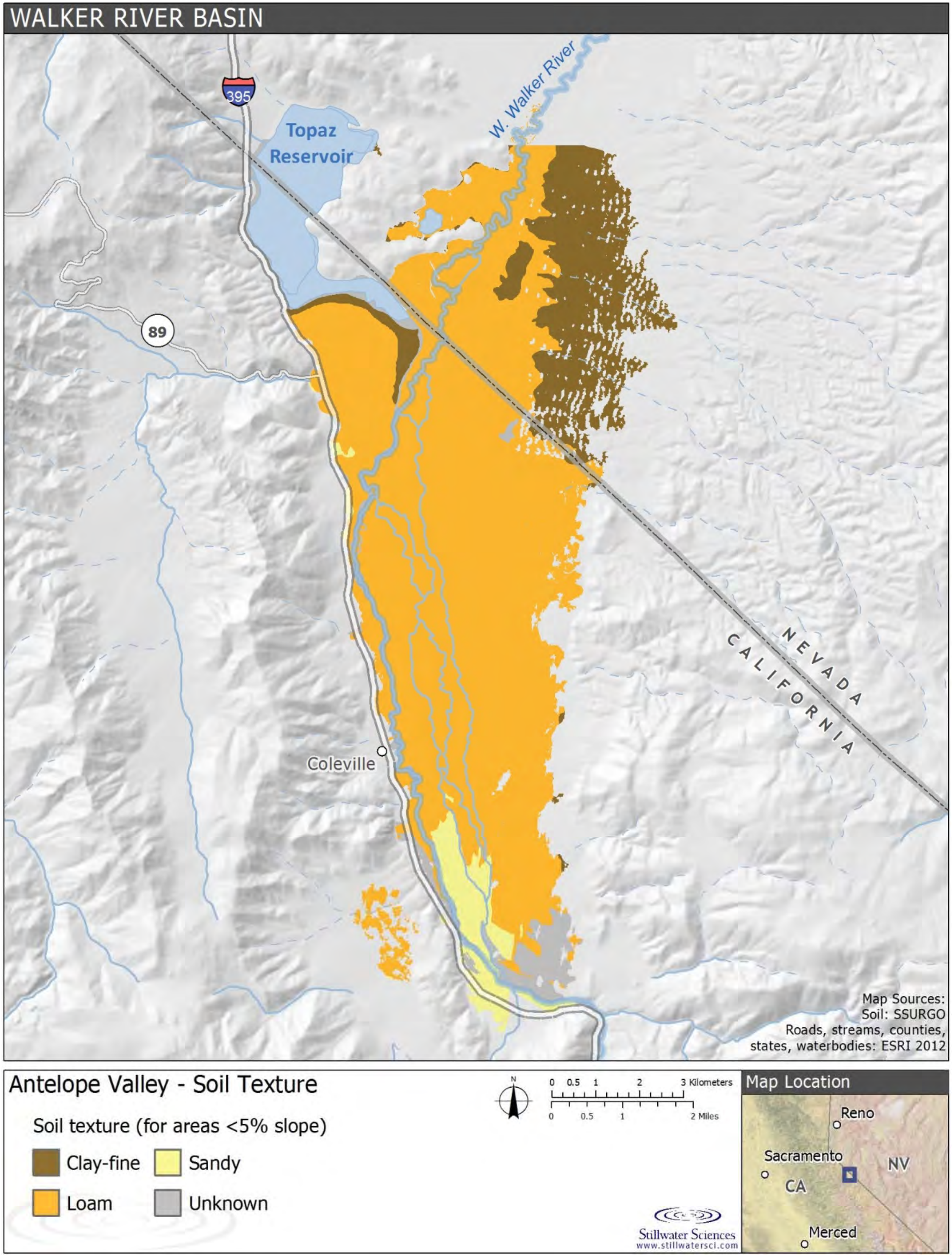


Figure 3-3. Surface Soil Textures in Bridgeport Valley

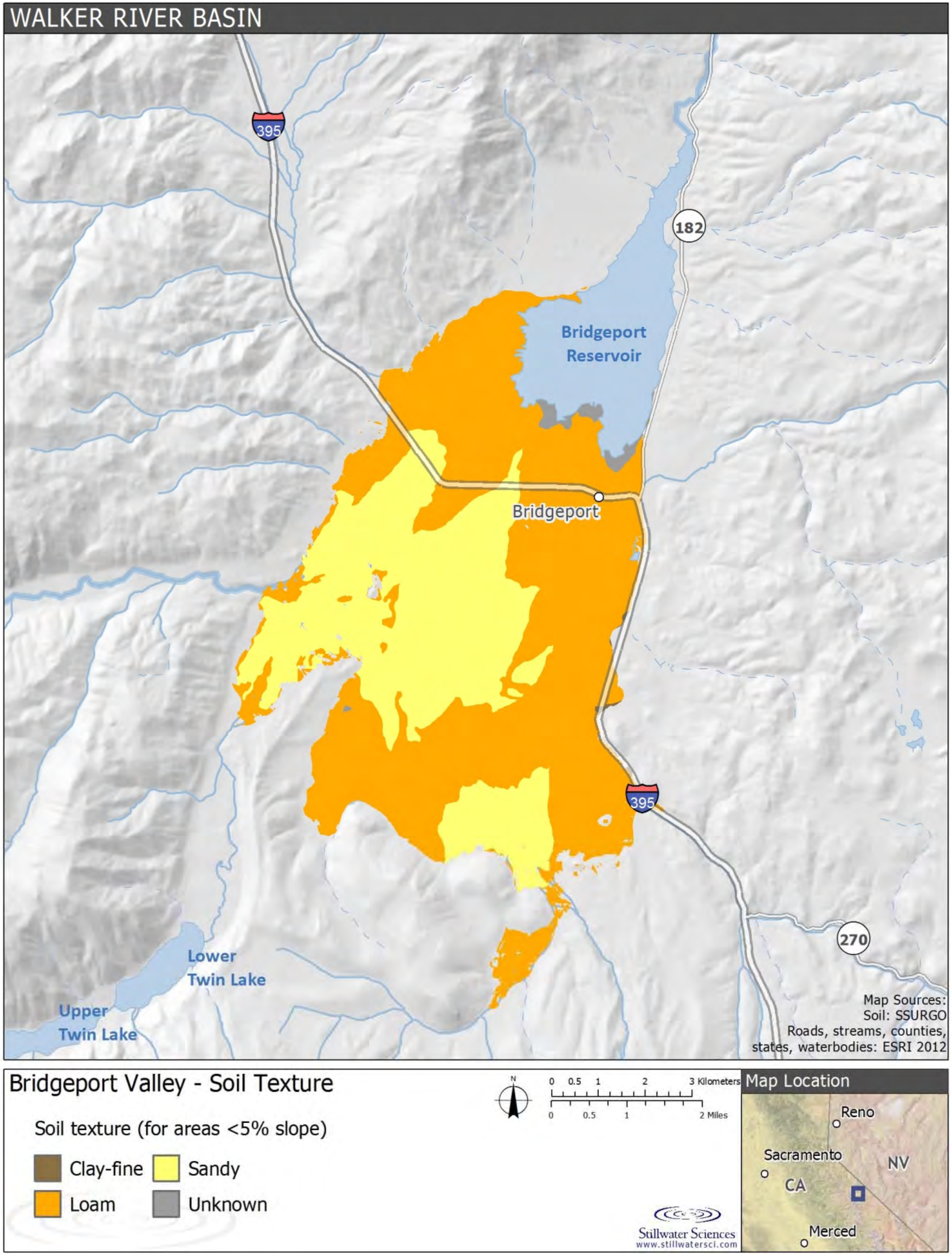


Figure 3-4. Surface Slopes in Antelope Valley

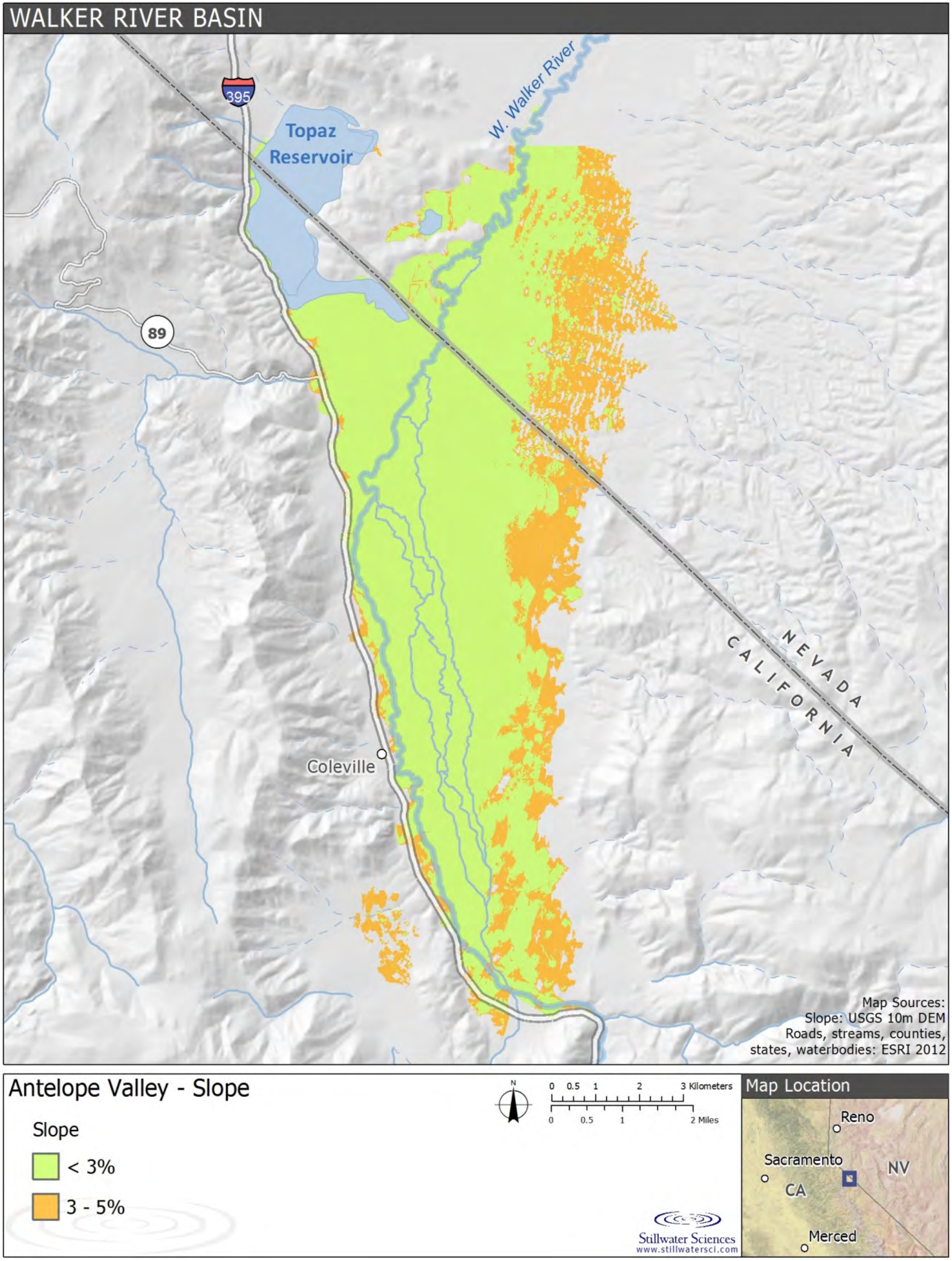
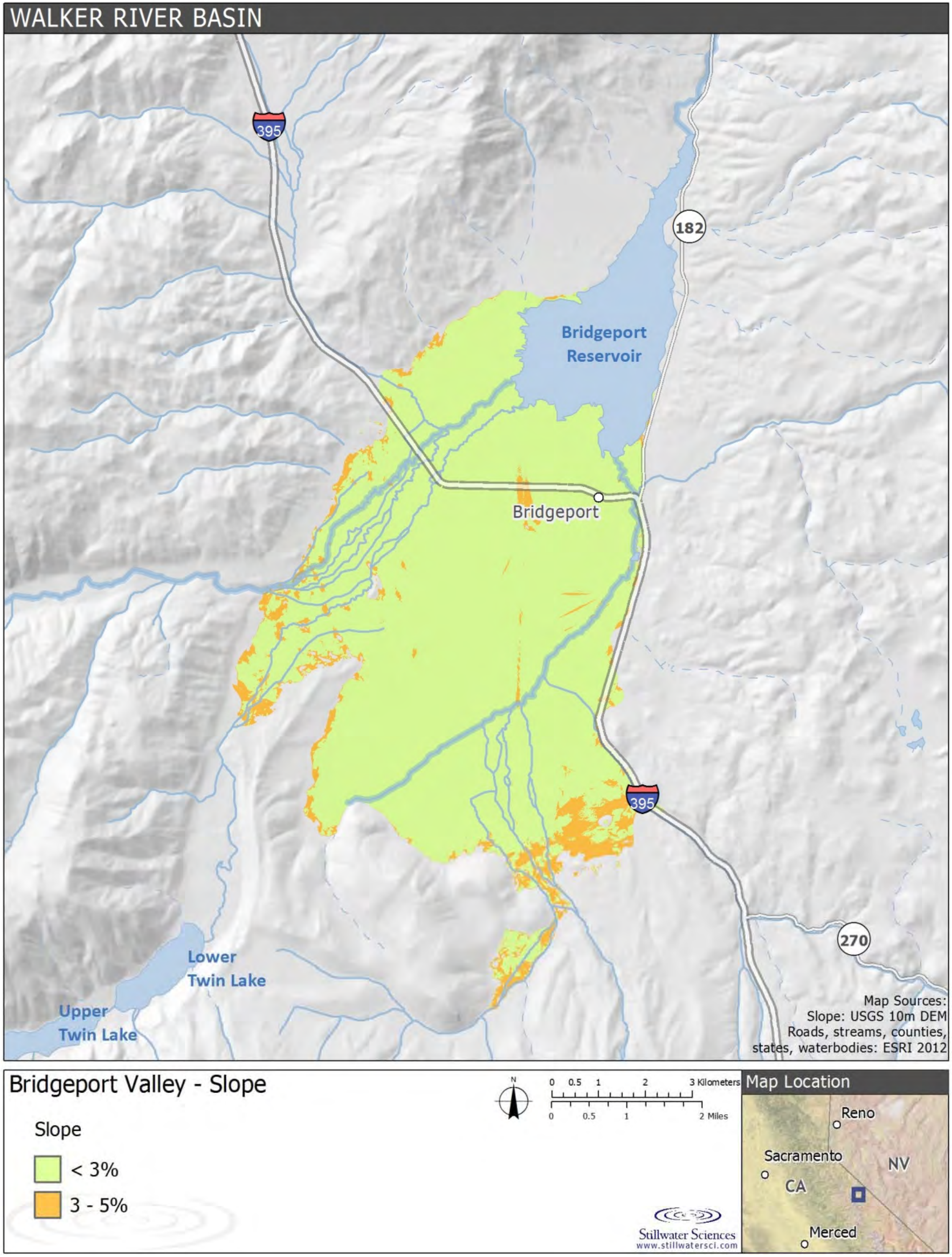


Figure 3-5. Surface Slopes in Bridgeport Valley



3.4 Vegetation in the Study Area

In order to assess likely impacts of a water transactions program on the agricultural, upland, and riparian vegetation, and related sensitive animal and plant species, the following vegetation-related information was needed for the areas in Antelope and Bridgeport Valleys (under 5.0% slope):

- Key species composition for dominant vegetation types in, including riparian corridor, rangelands, other natural lands, and managed crop lands;
- A map of the location and approximate extent of each major vegetation type; and
- Potential vegetation type-specific responses to variations in water availability expected to occur with changes in irrigation.

Using existing information, field surveys, 2012 NAIP imagery, and canonical correlation analysis, Stillwater Sciences developed map of local vegetation types in Antelope and Bridgeport Valleys

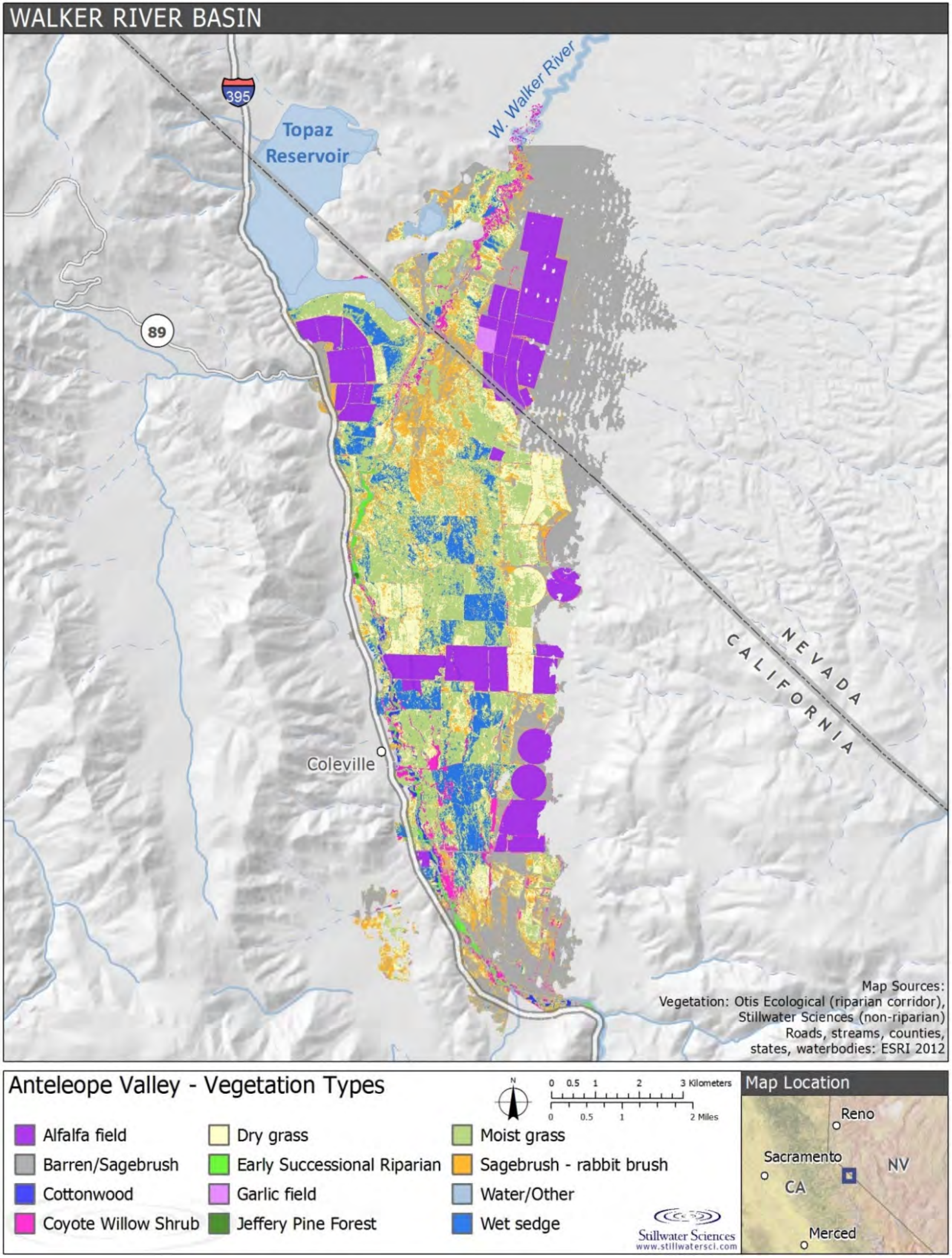
In Antelope Valley, Moist Grass covers the greatest area (30.0%), while irrigated fields of garlic and alfalfa cover a slightly smaller extent (22.0%, see Table 3-4). Barren/sagebrush is similar to the dry grass vegetation type and often the two types form a matrix that together occupies 35.0% of Antelope Valley. Wet sedge occurs in pockets and larger areas distributed throughout the center of the Valley, and makes up over 11.0% of the area. Coyote willow is mapped along many of the irrigation ditches and other low spots in Antelope Valley, but makes up less than 2.0% of the area. Similarly, mature cottonwood and early successional riparian vegetation occupy very small portions of Antelope Valley (both 0.1%) and are clustered along the West Walker River channel.

Bridgeport Valley is larger than the irrigated HRU area in Antelope Valley, based on the extent of land in the HRUs with less than 5.0% slope (20,053 versus 14,257 acres, respectively). Bridgeport Valley appears wetter, with three times the area of wet sedge and somewhat higher fraction of moist grass, but supports none of the alfalfa that covers over one-fifth of Antelope Valley (Table 3-4). Four large tributaries to the East Walker River run through Bridgeport Valley and are mapped as riparian and coyote willow. Along with multiple irrigation ditches, these tributaries distribute surface water widely throughout Bridgeport Valley. The Bridgeport Valley vegetation map would improve with greater ground-truthing since there was very limited private lands access for the maps created for this project. Vegetation in riparian corridors in Bridgeport Valley would especially increase current knowledge of the distribution, condition, and community structure and composition of these critical areas in the landscape. A larger and, therefore, more robust dataset on existing forage quality and quantity, associated with a range of soil moisture levels, would increase the certainty of forage impact estimates associated with a water transaction program.

Table 3-4. Vegetation Type (Number of Acres and Percentage on Lands under 5.0% Slope).

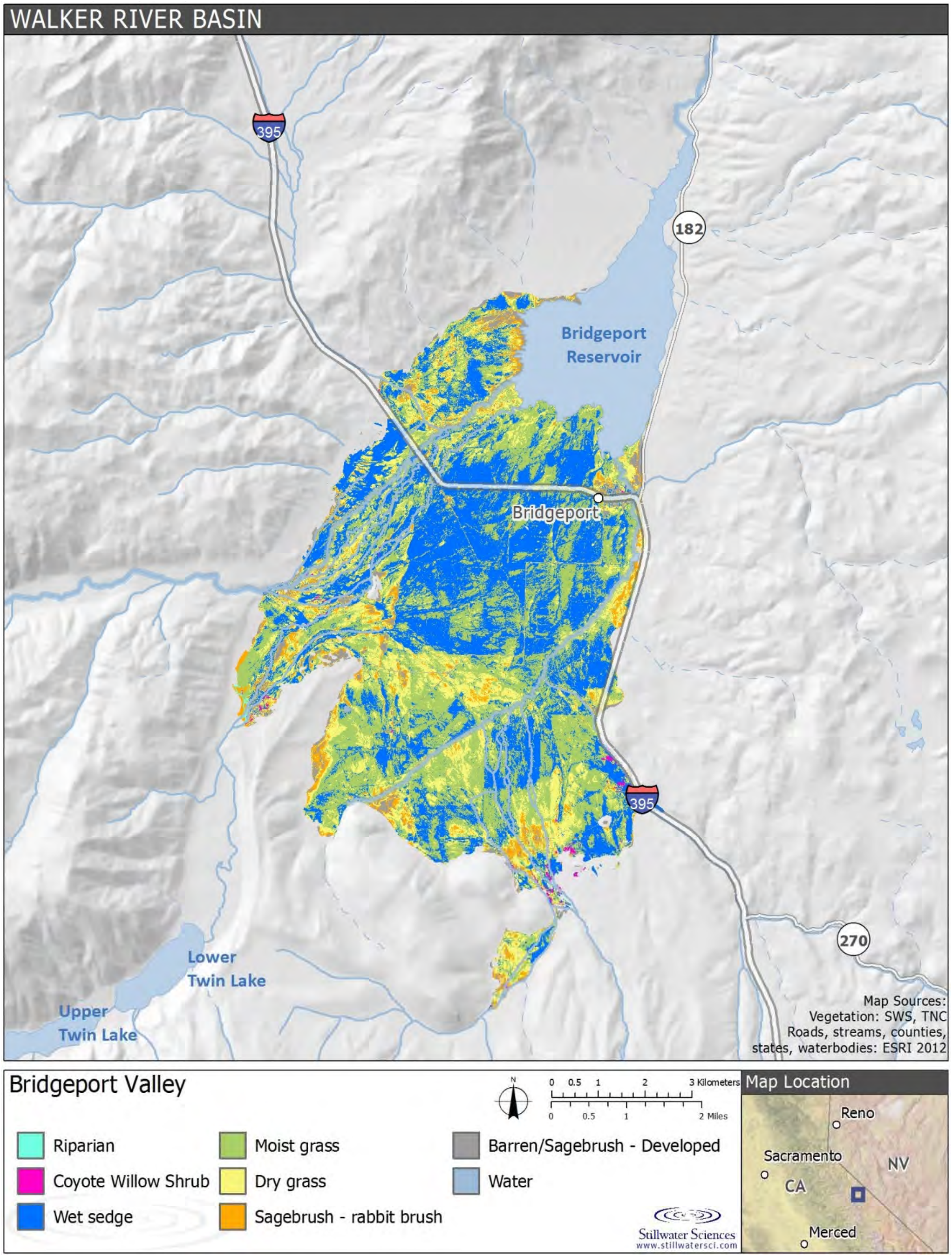
Vegetation Type	Antelope Valley		Bridgeport Valley	
	Acres	**% of Area**	**Acres**	**% of Area**
Alfalfa, Garlic	3,092	22	0	0
Barren/Sagebrush[2]	2,272	16	2,065	10
Coyote Willow	209	2	74	0.4
Dry Grass	2,762	19	3,127	16
Early Successional Riparian	7	0.1	NA	NA
Moist Grass	4,347	30	6,979	35
Wet Sedge	1,513	11	6,285	31
Mature Cottonwood	17	0.1	NA	NA
Riparian	NA	NA	71	0.4
Open Water	38.6	0.3	1,452	7
Total	**14,257**	**100**	**20,053**	**100**

Figure 3-6. Antelope Valley Vegetation Types



Map Sources:
Vegetation: Otis Ecological (riparian corridor), Stillwater Sciences (non-riparian)
Roads, streams, counties, states, waterbodies: ESRI 2012

Figure 3-7**.** Bridgeport Valley Vegetation Types



Map Sources:
Vegetation: SWS, TNC
Roads, streams, counties, states, waterbodies: ESRI 2012

3.4.1 Existing Sensitive Plant Species and Plant Communities

The special-status plant species and natural communities whose geographic distributions overlap with the Study Area were identified by reviewing and querying the following resources:

- The CDFW's California Natural Diversity Database (CNDDB; CDFG 2013); and
- The California Native Plant Society's (CNPS) online Inventory of Rare and Endangered Vascular Plants of California (CNPS 2012).

Altogether, 54 special-status plant species were found to potentially occur within the Study Area (Appendix B, Table A-1). Of these, six are considered seriously rare or threatened in California (list 1B.1 or 2B.1), five of which could occur in moist grass vegetation types, four in wet sedge, and three could occur in the dry grass-sagebrush vegetation type matrix (Table 3-5). Sixteen species are considered moderately rare or threatened in California (list 1B.2 or 2B.2), fourteen of which could occur in the dry grass-sagebrush vegetation type matrix, three in the wet sedge and moist grass, and three species could occur in all three graminoid vegetation types. Actual presence of these plant species within the Study Area is unknown; therefore only the potential to occur and be impacted by altered irrigation regimes can be assessed.

Table 3-5. Vascular and Non-vascular Plant Species with California Rare Plant Rank (CRPR) Rare and Threatened Status Potentially in the Study Area (Marked with a "✓ ")

Scientific Name	Common Name	Status^1: Federal/State/ CRPR	Likelihood of Occurrence in Study Area	Wet Sedge	Moist Grass	Dry Grass/ RB-Sage
Atriplex pusilla	smooth saltbush	–/–/2B.1	Potential habitat in sagebrush-rabbitbrush fields and in wet meadows, ponds	✓	✓	✓
Kobresia myosuroides	seep kobresia	–/–/2B.2	Potential habitat in upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓
Mertensia oblongifolia var. *oblongifolia*	sagebrush bluebells	–/–/2B.2	Potential habitat in sagebrush-rabbitbrush fields, upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓
Polyctenium williamsiae	Williams' combleaf	–/–/1B.2	Potential habitat in sagebrush-rabbitbrush fields and in wet meadows, ponds	✓	✓	✓
Thelypodium integrifolium subsp. *complanatum*	foxtail thelypodium	–/–/2B.2	Potential habitat in sagebrush-rabbitbrush fields and in wet meadows, ponds	✓	✓	✓
Calochortus excavatus	Inyo County star-tulip	–/–/1B.1	Potential habitat in wet meadows	✓	✓	
Mimulus glabratus subsp. *utahensis*	Utah monkeyflower	–/–/2B.1	Potential habitat in wet meadows, ponds	✓	✓	
Ranunculus hydrocharoides	frog's-bit buttercup	–/–/2B.1	Potential habitat in wet meadows, ponds	✓	✓	
Sphaeromeria	alkali tansy-	–/–/2B.2	Potential habitat in wet	✓	✓	

Scientific Name	Common Name	Status[1]: Federal/State/ CRPR	Likelihood of Occurrence in Study Area	Wet Sedge	Moist Grass	Dry Grass/ RB-Sage
potentilloides var. *nitrophila*	sage		meadows, ponds			
Sphenopholis obtusata	prairie wedge grass	–/–/2B.2	Potential habitat in wet meadows, ponds	✓	✓	
Botrychium paradoxum	paradox moonwort	–/–/2B.1	Potential habitat in wet meadows		✓	
Astragalus johannis-howellii	Long Valley milk-vetch	–/CR/1B.2	Potential habitat in sagebrush-rabbitbrush fields			✓
Astragalus monoensis	Mono milk-vetch	–/CR/1B.2	Potential habitat in sagebrush-rabbitbrush fields and upper valley dry meadows, forest edge			✓
Chaetadelpha wheeleri	Wheeler's dune-broom	–/–/2B.2	Potential habitat in sagebrush-rabbitbrush fields			✓
Cusickiella quadricostata	Bodie Hills cusickiella	–/–/1B.2	Potential habitat in sagebrush-rabbitbrush fields			✓
Lupinus duranii	Mono Lake lupine	–/–/1B.2	Potential habitat in sagebrush-rabbitbrush fields and upper valley dry meadows, forest edge			✓
Mentzelia torreyi	Torrey's blazing star	–/–/2B.2	Potential habitat in sagebrush-rabbitbrush fields			✓
Phacelia monoensis	Mono County phacelia	–/–/1B.1	Potential habitat in sagebrush-rabbitbrush fields			✓
Polygala subspinosa	spiny milkwort	–/–/2B.2	Potential habitat in sagebrush-rabbitbrush fields. Documented in assessment area			✓
Tetradymia tetrameres	dune horsebrush	–/–/2B.2	Potential habitat in sagebrush-rabbitbrush fields			✓
Thelypodium milleflorum	many-flowered thelypodium	–/–/2B.2	Potential habitat in sagebrush-rabbitbrush fields			✓
Viola purpurea subsp. *aurea*	golden violet	–/–/2B.2	Potential habitat in sagebrush-rabbitbrush fields			✓

[1]

CRPR Status:

– = None

Federal

FE = Endangered under the ESA

FT = Threatened under the ESA

State

CE = Endangered under the CESA

CR = Rare under the CNPPA

CRPR

1A = Plants presumed extirpated in California and either are or extinct elsewhere

1B = Plants rare, threatened, or endangered in California and elsewhere

2B = Plants rare, threatened, or endangered in California, but more common elsewhere

3 = Plants for which more information is need –a review list

4 = Plants of limited distribution – a watch list

0.1 = Seriously threatened in California

0.2 = Moderately threatened in California

0.3 = Not very threatened in California

3.5 Vegetation – Water Linkages

Overall, plant water availability is expected to vary within Antelope and Bridgeport Valleys based upon:

- Water-year type and associated groundwater consumption (wet, average, dry);
- Down or up-valley location (north or south valley tilt);
- Soil texture and water holding capacity (coarse and sands, loams, clays); and
- Surface slope (>3.0% or <3.0%).

These four important controls on plant water availability were combined to direct focus on areas most likely versus those least likely to experience drought effects under a reduced irrigation scenario.

The potential decline in subsurface water levels with reduced irrigation inputs could importantly affect vegetation response to water transaction scenarios assessed in this report. Therefore, we drew on available information to determine the potential degree of change in groundwater levels (sub-irrigation) with one to multiple-year transactions over a portion or all of Antelope Valley. Groundwater responses were only assessed for Antelope Valley because although groundwater information for Antelope Valley was scarce, it was non-existent for Bridgeport Valley. This assessment is general due to lack of available information on ground water processes in these valleys, and is therefore only meant to provide initial bounds on what is and is not likely to occur in Antelope Valley. To make this same, or a more refined, assessment for Bridgeport Valley, a more involved study with groundwater measurements would be required. Please see Appendix B, Section 2.3 for a complete discussion on groundwater.

Stillwater Sciences combined spatially explicit information on soil water-holding capacity and drainage (surface slope) with plant species vulnerability to water stress in order to roll up, by HRU and vegetation type, potential effects of reduced irrigation. This information is then used to inform the water transaction effects on vegetation and wildlife habitat discussions. Differences in water year type and down versus up-valley location of the HRU are integrated into the assessment of each water transaction scenario.

Based on the information detailed in Appendix B, we ranked the expected vulnerability of each vegetation type to reduced growing season water availability. These vulnerability rankings to drought are listed in Table 3-6.

Table 3-6. Vulnerability by Vegetation Type (0 = not vulnerable 1 = least and 3 = most)

Vegetation type	Vulnerability
Barren	0
Coyote Willow	2
Dry Grass	1
Early Successional Riparian	1
Mature Cottonwood with Riparian Shrub Understory	2
Mature Cottonwood with Xeric Understory	2
Moist Grass	3
Sagebrush	1
Water-Asphalt-Rock	0
Wet Sedge	3

Based on the soil, slope, and groundwater information described in Appendix B - Section3, low-lying lands within Antelope and Bridgeport Valleys were assigned different rankings for potential water stress (high, moderate, low, none). We overlaid soil texture and slope information to identify spatially explicit assessment of water stress (Table 3-7). We multiplied the vegetation vulnerability and location stress rankings per polygon (e.g., stress rank of 3 times vulnerability rank of 1 = effects rank of 3) to create an overall ranking of expected effects of drought on vegetation (Table 3-8). We summarized this information for each HRU in order to identify HRUs with low- to high-expected effects on vegetation associated with altered irrigation schedules. The results from this spatial query are presented by HRU under Scenario 1b. No Irrigation for Full Season: Part of Antelope Valley.

Table 3-7. Stress Rankings by Soil Texture and Slope (1 = least and 3 = most)

Slope/Soil	Sand	Loam	Clay-Fine	Unknown
<3 %	3	1	2	2
3-5 %	3	2	3	2

Table 3-8. Description of Effects Ranking for Vegetation Types Associated with Reduced Water

Rank Name	Rank Description
None	No effect on health or growth expected
Low	Little-to-no effect on vegetation expected
Minor	Some decrease in productivity expected
Moderate	Reduced productivity and possible changes in plant species distribution favoring drought tolerant over intolerant plants
Moderate-High	Pronounced reduction in productivity and percent cover shifts towards drought tolerant plant species
High	Large reductions in productivity and possible change in vegetation type over multiple seasons

3.6 Vegetation – Potential Effects of Water Transactions

In the Sections below, we assess the potential impacts of Transaction Scenarios 1-5 (as described in Section 1.3) on natural vegetation and special-status plant species, forage, and crop production.

3.6.1 Scenario 1a. No Irrigation for Full Season: Whole Valley

Under Scenario 1a, all of the currently irrigated areas are kept out of irrigation for one and possibly multiple growing seasons.

Effects on Forage and Alfalfa Production

Forage is mapped as three graminoid dominated vegetation types in Antelope and Bridgeport Valleys: dry grass, moist grass, and wet sedge. Important changes in forage production and quality could occur where reduced water availability results in effects that are rated as ‘high’ or ‘moderately high’. Based on our mapping of dry grass, moist grass, and wet sedge vegetation types in Antelope and Bridgeport Valleys, and our analysis of potential effects of reduced water availability on vegetation, approximately 10% and 36% of the forage lands in Antelope and Bridgeport Valleys could be importantly affected; with prolonged suspended irrigation, these vegetation types could convert to the next driest graminoid vegetation type (Table 3-9).

Table 3-9. Negative Effects of Reduced Water Availability on Forage Lands

Vegetation type	Effect	Antelope Valley		Bridgeport Valley	
		Acres	% Area	Acres	% Area
Dry Grass	High	-	0	0	0
	Moderate	124	1	1,140	7
	Low/Minor	2,638	31	1,987	12
Moist Grass	High	658	8	3,099	19
	Moderate	3,689	43	3,880	24
	Low/Minor	0	0	0	0
Wet Sedge	High	145	2	2,803	17
	Moderate	1,369	16	3,483	21
	Low/Minor	0	0	0	0
Total		**8,622**	**100**	**16,391**	**100**

Suspended irrigation for one season, with ongoing grazing, is expected to favor pest weed species, including Baltic rush and Missouri iris. These species reduce forage quality and production and become increasingly difficult to remove or control as their populations increase. Seeding with preferred species, such as wild rye, alfalfa, or other grass species could counter these effects.

Overall, forage production is expected to decrease in both valleys. Assuming only the ‘high’ ranked areas undergo type conversion (Table 3-9), approximately 650 acres of moist grass could convert to dry grass with associated large reduction in production rates. Assuming production rates are similar to the average rates reported for meadows for these vegetation types, this could translate into forage reduction of 730 tons of forage. Also, 145 acres of wet sedge could convert to moist grass with an associated 58-ton production increase, and netting an 87-ton decrease in overall forage production in Antelope Valley.

Effects on Bridgeport could be much greater if the natural ground water levels also drop - this important point cannot be adequately addressed with available information. Approximately 2,000 acres of moist grass could convert to lower productivity dry grass, resulting in roughly 2,250-ton drop in forage production, along with conversion of approximately 2,800 acres of wet sedge to moist grass and associated 1,120-ton increase in forage. The net result is roughly estimated to be 1,130-ton drop in forage production for Bridgeport Valley.

Estimates of effects on cattle weight gain include more uncertainty. Findings from Tate et al. (2011) indicate that early season grazing production would be minimally impacted but, as grazing continues into the late season, impacts to cattle weight grain increase dramatically. Changes in forage nutritional quality and associated effects on cattle weight gain per pound of forage produced would exacerbate the changes expected for each valley described above, but are likely within the range of uncertainty and so will not be converted to specific values here.

Effects on Natural Vegetation

Return to the natural annual hydrograph through suspended irrigation withdrawals is expected to positively affect native riparian vegetation along the West Walker River and the four primary tributaries to the East Walker River that run through Bridgeport Valley. Density of understory willows and other native shrub and herbaceous species is expected to increase and overall recruitment of cottonwood and red willow is also expected to increase, bringing diversity to the age profile of the riparian forest stands found in both valleys. Large uncertainties in this assessment could be addressed through a more focused assessment of the existing riparian species composition and extent, the shape of the restored annual hydrograph, and the diversity in the physical structure of the riparian corridors in the study area.

Overall, the extent of natural vegetation outside the riparian corridor affected could be greatest in Bridgeport Valley, depending upon how lack of irrigation affects subsurface groundwater levels during the growing season. The extent of area with expected high to moderately high impacts, in acres and as a percent of the total vegetation type mapped for each valley, is summarized in Table 3-10 below. As emphasized above, there is great uncertainty regarding the degree of impact to the large areas currently mapped as wet sedge and moist grass in Bridgeport Valley that could be impacted under this scenario due to lack of information on natural versus irrigated near surface groundwater response to suspended irrigation.

Table 3-10 Vegetation Type Expected to have 'Moderately High' to 'High' Impacts under Full Season Suspension of Irrigation

Vegetation Type	**Antelope Valley**		**Bridgeport Valley**	
	Acres	**% Area**	**Acres**	**% Area**
Coyote Willow	70	33	16	20
Wet Sedge	145	10	2,800	45
Moist Grass	658	15	1,400	44
Dry Grass	0	0	0	0
Sagebrush-Rabbitbrush	0	0	0	0

3.6.2 Scenario 1b. No Irrigation for Full Season: Part of Antelope Valley

Under this scenario, some areas in Antelope Valley would suspend irrigation while others made no change in the irrigation schedule. Since Bridgeport is being treated as a single HRU, we discuss only Antelope Valley in this Section.

Vegetation effects associated with this scenario are the same by vegetation type as described for Scenario 1a, but applied only to those participating HRUs. The differential effects of all-season suspended irrigation among HRUs are summarized in Table 3-11 and discussed by vegetation type below. In Table 3-11 we present a summary of the extent and potential impacts of limiting growing season water availability on vegetation in each HRU based on the combination of soils, slope, and existing vegetation. Effects ranks are described in Appendix B and are summarized here:

- None: No effect on health or growth expected;
- Low: Limited effect on vegetation expected;
- Minor: Some decrease in productivity expected;
- Moderate: Reduced productivity and possible changes in plant species distribution favoring drought tolerant over intolerant plants;
- Moderate-High: Pronounced reduction in productivity and percent cover shifts towards drought tolerant plant species; and
- High: Large reductions in productivity and possible change in vegetation type over multiple seasons.

Big Slough HRU would experience the greatest effects in alfalfa production, on an acreage basis, were irrigation suspended in this area. On an acreage basis, Big Slough, Swauger, and Rickey and Private HRUs would experience the greatest number of impacted acres in forage production under this scenario. West Goodenough & Harney, Swauger, Powell, and Alkali HRUs have the greatest proportion of their forage production areas that could be importantly affected under this irrigation scenario

Of the HRU's in Antelope Valley, suspending irrigation would have the greatest impact on the overall production in Powell HRU since this area has the greatest proportion of area with high or moderately high negative effects rating (Table 3-11). Coyote willow and set sedge grow in a few areas located primarily in Big Slough and Powell HRU. Moist grass with some likelihood of impact under this scenario occurs primarily in Big Slough and to a lesser amount in Swauger HRU. Moist grass and wet sedge cover a small amount of land in Little Antelope Valley, but this comprises over half of arable land.

Table 3-11 Potential Effects* on Vegetation Types Associated with Reduced Water Availability by HRU in Antelope Valley.

Vegetation Type	Expected Drought Effect	Alkali	Big Slough	Carney	Hardy	Highline	Little Antelope Valley	Lone Company	Main Canal	Powell	Rickey and Private	Swauger	West Goodnough & Harney	Grand Total Acres
Alfalfa field	High		58.0											58.0
	Moderate-high		478.3	82.0		118.9						11.2	19.3	709.7
	Moderate		1452.4	179.6		134.2						556.3	1.4	2323.9
	Total		1988.7	261.6		253.1						567.5	20.7	3091.7
Barren	None	1.2	492.3	20.7	16.8		12.9	28.7	29.1	26.4	1.8	83.2	1.4	714.5
	Total	1.2	492.3	20.7	16.8		12.9	28.7	29.1	26.4	1.8	83.2	1.4	714.5
Willow	Moderate-high		24.4		1.2				0.8	43.7		0.1		70.3
	Moderate	0.1	5.1	5.8	0.1	0.3	0.7	2.4	0.1	2.7	0.1	3.1	3.2	23.5
	Low	0.5	89.4	0.5		0.6	0.5	6.9	0.2		0.4	7.3	8.7	115.0
	Total	0.6	118.8	6.2	1.3	0.9	1.2	9.3	1.1	46.5	0.5	10.5	11.9	208.8
Dry Grass	Moderate		93.5		7.6		0.2	1.2	0.2	15.3		5.8		123.8
	Low	15.2	299.7	2.5	0.5		53.9	27.7	21.4	0.8	1.6	106.1	17.9	547.2
	Minor	29.2	1533.6	0.0			2.5	59.3	7.8	0.4	197.7	243.9	16.5	2090.9
	Total	44.4	1926.7	2.5	8.1		56.6	88.1	29.4	16.5	199.4	355.9	34.4	2761.9
Early Successional Riparian	None	0.0	1.6							3.0	0.6	0.8	1.2	7.1
	Total	0.0	1.6							3.0	0.6	0.8	1.2	7.1
Mature Cottonwood with Riparian Shrub Understory	Moderate	0.1	0.4								0.0	0.1	0.8	1.4
	Low	1.2	0.6								0.0	2.5	1.9	6.2
	Total	1.3	1.1								0.1	2.6	2.7	7.6

Vegetation Type	Expected Drought Effect	Alkali	Big Slough	Carney	Hardy	Highline	Little Antelope Valley	Lone Company	Main Canal	Powell	Rickey and Private	Swauger	West Goodnough & Harney	Grand Total Acres
Mature Cottonwood with Xeric Understory	Moderate-high									1.8		0.2		2.0
	Moderate	1.3								1.6			1.3	4.3
	Low	0.4	0.6									0.7	1.3	3.1
	Total	1.8	0.6							3.4		0.9	2.7	9.3
Moist Grass	High		60.1		1.3		0.0	1.2	0.0	30.0		13.6		106.4
	Moderate-high	30.1	208.3	1.2	0.1		30.8	28.9	6.4	0.7	9.0	199.5	36.5	551.4
	Moderate	47.7	2778.9	0.0			2.0	46.6	2.5	2.1	210.8	560.2	38.4	3689.2
	Total	77.8	3047.3	1.2	1.4		32.8	76.6	9.0	32.9	219.8	773.3	74.9	4347.1
Sagebrush	Moderate		81.0		19.9		0.4	0.8	0.3	21.4		1.4		125.2
	Low	13.0	62.8	9.1	2.4		79.0	22.0	19.8	1.0	2.7	57.7	10.0	279.5
	Minor	12.9	941.4	0.1			3.5	39.4	6.6	0.0	47.7	91.4	9.8	1153.0
	Total	26.0	1085.3	9.2	22.3		82.9	62.2	26.7	22.4	50.4	150.5	19.8	1557.7
Water-Asphalt-Rock	None	0.1	5.1	0.0	0.0		0.1	0.0	0.1	0.1	0.3	32.6	0.2	38.6
	Total	0.1	5.1	0.0	0.0		0.1	0.0	0.1	0.1	0.3	32.6	0.2	38.6
Wet Sedge	High		21.0		0.1			0.0	0.0	26.7		14.5		62.4
	Moderate-high	11.9	7.5	0.4	0.0		1.1	1.6	0.7	0.6	0.2	19.2	39.3	82.4
	Moderate	21.4	1069.5				0.4	1.3	0.0	2.7	20.1	245.6	7.5	1368.5
	Total	33.2	1098.0	0.4	0.1		1.4	2.9	0.7	30.0	20.3	279.3	46.8	1513.2
Grand Total Acres	**Total**	**186.4**	**9765.5**	**301.9**	**50.1**	**254.0**	**188.0**	**267.9**	**96.1**	**181.1**	**493.0**	**2257.1**	**216.6**	**14257.6**

3.6.3 Scenario 2. Late Season Reduction (no irrigation after July 1)

Under this scenario, irrigation continues until July 1, but is shut off for the second half of the growing season.

Effects on Forage and Alfalfa

This may be the best option for the most water savings with minimal impact on alfalfa production. It is often considered a best management strategy to eliminate irrigation late in the season to cause drought-induced dormancy (Shewmaker et al. 2013). Alfalfa production in other regions of California show reduced yields following mid-July suspension of irrigation that average 0.6 tons/acre and range from 0.1–0.8 tons/acre. Based on a conservative interpretation of this available information, potential reduction in alfalfa production with mid-July suspension of irrigation could be represented as ranging from 0, if other water sources are not constrained, to 0.8 tons/acre, which translates to roughly 0–14% of the total annual yield, depending on site-specific conditions. This would be a viable approach to water savings while maintaining alfalfa production, as it is practiced in many regions.

Forage production and quality could decline in areas supporting moist grass in the first year of altered irrigation since many of these species require wet to moist conditions to continue growing and providing high quality forage throughout the growing season (Ganskopp and Bohnert 2001). With multiple years of this irrigation regime, however, cover of mid-summer drought tolerant species, such as wheatgrass and wild rye, would be expected to increase, while that of less drought tolerant species, such as timothy and bentgrass (*Agrostis* spp), would diminish. This adjustment in species composition could reduce the impact of reduced late summer irrigation. Forage production could be reduced for the first year or two but, given appropriate weed and grazing management, production could return to existing levels, or close to it, within several years of ongoing management.

Effects on Natural Vegetation

Minor effects on natural vegetation would be expected with the post July 1 termination of irrigation practices since most species perform the greatest amount of growth and spread in June and early July. Areas in the southern part of Antelope Valley on sandy soils and slightly sloped surfaces could experience drier conditions than other areas; therefore, production in these areas would be somewhat diminished in late summer.

3.6.4 Scenario 3. Early Season Reduction (no irrigation before June 1)

Irrigation does not begin until June 1 throughout the entire Valley.

Effects on Forage and Alfalfa

This irrigation schedule is not recommended as the most efficient way to reach maximum production with water savings. We estimate that yield of first cutting would be at roughly half normal levels, but that the 2nd and 3rd cuttings could reach normal production levels, if they are irrigated with groundwater or storage water after direct diversions are curtailed. It may be difficult to accurately quantify water savings because they would vary by year, depending on existing soil moisture. Forage production is expected to diminish somewhat in Antelope Valley, but will vary depending upon fall precipitation and temperature. Forage production would not be expected to be impacted in Bridgeport Valley under this scenario.

Effects on Natural Vegetation

Some changes in cottonwood and willow tree recruitment would occur under this scenario with possible patches of new recruitment in low elevation areas that lie within the active floodplain.

Since irrigation would commence close to the beginning of the growing season in Bridgeport Valley, no-to-minor changes in vegetation would be expected to occur there. In Antelope Valley, small but potentially noticeable changes could occur. These include some reduction in the health and density of coyote willow with one or several continuous years of this scenario, and similarly, a small reduction in overall density and diversity of vegetation in the moist grass vegetation type. Some changes in the diversity of forb species could occur in the dry grass and sagebrush/ barren vegetation types under this scenario.

3.6.5 Scenario 4. Reduced Irrigation Throughout

Irrigation is performed as if it were a dry water year throughout both Antelope and Bridgeport Valleys. The intent behind this transaction approach is to approximate deficit irrigation where only the minimum water needed is applied. As this is very site-specific management, it was difficult to model for water savings and production impacts with the given information. Instead, the team looked at irrigating during a normal or wet year, using only as much water as was normally available in a dry year.

Effects on Forage and Alfalfa

Using the “irrigate as if a dry year in a normal year” approach would be similar to Scenario 2 in terms of alfalfa response. True deficit irrigation would likely result in higher yields, but it would be difficult to quantify water savings. Effect on forage production would be similar to those described for late summer cessation of irrigation practices described for Scenario 2, with likely minor reductions in the one to two years, followed by some recovery with proper weed and grazing management.

Effects on Natural Vegetation

Responses of natural vegetation types to dry-year irrigation would be similar to those described for Scenario 2, late summer reduction, and therefore are not repeated here.

3.6.6 Scenario 5. End of Season Storage Water Release

Storage water releases would occur after the end of the growing season, and therefore would not affect vegetation.

3.7 Vegetation Response Summary

Water transaction scenarios that suspend irrigation of existing alfalfa stands in Antelope Valley would have significant impacts to overall production rates, cutting production yields to less than two tons/ac per season. Conversion to alfalfa cultivars specific to dryland cultivation would be recommended for alfalfa production under this scenario. Of the twelve areas within Antelope Valley that share an irrigation ditch, those dependent upon Big Slough for irrigation include the greatest amount of land supporting alfalfa production and therefore implementing this transaction scenario to this part of Antelope Valley would result in the greatest negative impact to alfalfa production. Delaying irrigation until after June 1 would have a similarly large effect on alfalfa production since this would sharply impact the first and usually largest cut of the season. Although halting irrigation following July 1 could also reduce alfalfa production, production under this scenario could still be roughly 80% of current levels. This is the recommended approach for alfalfa and is already applied in other regions. Scenario

4 (reduced irrigation throughout season) would have impacts similar to halting irrigation as of July 1, and end of season water releases would be expected to have no impact on alfalfa production.

Under Scenario 1 (no irrigation), forage production is expected to decrease substantially in both valleys. While impacts to forage production in Bridgeport Valley could be important, large uncertainties regarding near-surface groundwater levels and the degree of natural sub-irrigation without diversions make it difficult to determine if there would be significant impacts to rangeland production in this valley. Within Antelope Valley, rangelands irrigated by Big Slough, Swauger, and Rickey and Private would experience the impact on rangeland production. Proportionally, areas irrigated by West Goodenough & Harney, Swauger, Powell, and Alkali would be most impacted. Shutting off irrigation on July 1 (Scenario 2) could reduce forage production for the first one to two years, but given appropriate weed and grazing management, production could return to existing levels, or close to it, within several years of ongoing management. Delaying irrigation until June 1 could have a small impact on forage production in Antelope Valley, but these effects could vary depending upon fall precipitation and temperature. Forage production is not expected to be impacted in Bridgeport Valley if irrigation is delayed until June 1. As with alfalfa, Scenario 4 (reduced irrigation throughout season) impacts would be similar to those described for Scenario 2, and water releases after the growing season (Scenario 4) would have no impact on forage production.

Potential impacts of the water transaction scenarios to existing natural vegetation overlap with the rangelands assessment because many of these areas are the same. Thus, the density, above ground production, and native forb diversity could be impacted in moist grasslands found in both Antelope and Bridgeport Valleys. Smaller impacts to dry grass vegetation found within and separate from areas supporting sagebrush are expected to occur for irrigated areas or areas adjacent to irrigated lands. Several sensitive forb, grass, and moonwort plant species that could occur in the Study Area and that are associated with moist grass or sedge areas could be affected; however surveys have not been performed for these species so their actual occurrence in the Study Area is unknown. Coyote willow and Woods' rose also occurs along many irrigation canals, and in low, wet spots in both valleys. Reduced all-season and early-season irrigation could impact these shrub thickets. Native riparian vegetation along the West Walker River in Antelope Valley includes Fremont cottonwood and several different native willow tree and shrub species. Water transaction scenarios that increase channel flows in a way that is similar to the natural hydrograph could increase recruitment and survival of native cottonwood and willow trees along the riparian corridor. This could increase the density and species richness of the river area, and diversify the age structure of the riparian forests, which are currently skewed towards mature and senescent age classes of cottonwood and red willow.

4 HABITAT RESPONSE TO CHANGES IN IRRIGATION MANAGEMENT

Please see Appendix B for details of the analysis of the habitat response to changes in irrigation management.

4.1 Wildlife – Potential Effects of Water Transactions

There are various common and special-status wildlife species that occur or could occur in the Walker River Basin. The following species were included in this document because of their special-status designation and/or high public interest value, as well as their potential to be affected by water diversions. All of these species are known to currently exist in the general vicinity of the Study Area boundaries; however this is not an exhaustive list of all species that are linked to habitats and ecological processes within Antelope and Bridgeport Valleys.

Table 4-1. Sensitive Wildlife Species and their Associated Vegetation/Habitat Types in the Study Area (* = required habitat)

Common Name (*Scientific name*)	**Status[1]: Federal /State**	**Vegetation types in the Study Area**							
		Wet Sedge	**Moist Grass**	**Dry Grass**	**Sagebrush-Rabbitrush**	**Barren**	**Early Successional Riparian**	**Coyote Willow**	**Mature Cotton-wood**
Greater sage-grouse (*Centrocercus urophasianus*)	FC/SSC	✓	✓	✓	✓*	✓*			
Yellow warbler (*Dendroica petechial*)	–/SSC						✓	✓	✓
Pygmy rabbit (*Brachylagus idahoensis*)	–/SSC				✓*				
Western white-tailed jackrabbit (*Lepus townsendii townsendii*)	–/SSC	✓	✓	✓	✓				
American badger (*Taxidea taxus*)	–/SSC			✓	✓				
Mule deer (*Odocoileus hemionus*)	–/–	✓	✓	✓	✓		✓	✓	✓

[1] Status: FC = federal candidate species; FPE = federally proposed as endangered; ST = state threatened; SSC = state species of special concern

[2] Habitat associations may include one or more of the following: breeding, wintering, migrating, and/or foraging habitat.

Water transactions could affect wildlife by changing the density and distribution of vegetation habitats. In Table 4-1, we provide a summary of habitat associated with sensitive wildlife species known or expected to occur in the Study Area. We use Table 4-1 in combination with the vegetation effects Table 3-9 in order to assess potential wildlife impacts associated with each of the five water transaction scenarios. Section 3 provided a conceptual model linking how changes in diversions may result in changes in groundwater levels, subsequently affecting vegetation and wildlife habitats (

Figure 3-1).

Pygmy rabbit, western white-tailed jackrabbit, and American badger are all species well adapted to living in dry environments with scarce available water. Therefore, no impacts on these species under the various water transaction scenarios are anticipated. The following analyses focus on effects of various water transaction scenarios on greater sage-grouse, yellow warbler, and mule deer.

4.1.1 Scenario 1. No Irrigation for Full Season

There would likely be an increase in the extent and availability sagebrush habitat for greater sage-grouse, with a possible simultaneous impact on adjacent wet areas used for rearing/cover and summer foraging. It is difficult to ascertain whether the increase in amount and extent of sagebrush would offset the loss of moist, irrigated habitats within the valley floors. Clearly, extensive amounts of sagebrush habitat are available in the surrounding uplands adjacent to the valley edges. Since sagebrush-rabbitbrush habitat is currently mapped on less than 20% of the valley bottoms in both Bridgeport and Antelope Valleys, and the Graminoid vegetation types take up most of the remaining area, an increase in sagebrush-rabbitbrush habitat would likely increase the amount of area where a combination of both habitat types are available. One could hypothesize that an increase in the amount of area supporting a combination of moist grass and sagebrush could positively affect the greater sage-grouse. However all of this is predicated on the assumption that there is a population of greater sage-grouse that use areas in Bridgeport or Antelope valleys. Studies to determine the distribution and habitat use of greater sage-grouse in the Study Area would be a first step in identifying where potential changes in vegetation might affect the greater sage-grouse. Once determined, a closer examination of how water transactions might affect vegetation in those areas, and if those changes would affect the greater sage-grouse, would be needed.

Effects of Scenario 1 transactions on yellow warbler is again mixed, since some increase in habitat could occur along the river corridors, but with a potential loss of habitat in patches and along irrigation ditches in other parts of both valleys.

While shifts in the extent and distribution of wet versus dry-adapted species could occur in the Study Area in response to Scenario 1, this is not expected to affect the mule deer because of their diverse diet. In addition, limited effects are expected on sagebrush-rabbitbrush communities, which include shrubs that are part of the mule deer’s diet in this region.

4.1.2 Scenario 1b. No Irrigation for Full Season: Part of Antelope Valley

Big Slough and Powell HRUs have the greatest area ranked to experience high effects on (i.e., reduction of) moist grass and wet sedge due to reduced water availability, and ceasing irrigation for multiple consecutive years could lead to increased replacement of dry grasses with sagebrush or with bare ground in these or other HRUs. Overall, the replacement of dry grasses with sagebrush or to bare ground could result in improved habitat quality for greater sage-grouse. Areas currently with a high proportion of barren/sagebrush vegetation types (e.g., Carney and Hardy ESUs) would be very resistant to effects of prolonged non-irrigation. Subsequently, any potential effects on greater sage-grouse would be less prominent in these areas. As with Scenario 1a (Section 6.1.1), while there would likely be an overall improvement in the extent and availability of required sagebrush habitat for greater sage-grouse, there could be a possible simultaneous impact on adjacent wet areas used for rearing/cover and summer foraging. It is problematic to ascertain whether the increase in amount and extent of sagebrush would offset the loss of moist, irrigated habitats, without information regarding distribution and habitat use of the Study Area by greater sage-grouse.

Effects on yellow warbler habitat in the riparian corridor depend on the timing and amount of water not diverted from the river. Reduced diversions, particularly during the early and late parts of the irrigation period, could have a noticeable positive effect on the extent and structure of riparian vegetation. Big Slough and Powell HRUs both have relatively large areas of coyote willow ranked to have moderately high effects due to reduced water availability; therefore suspended irrigation in these HRUs result in negative effects on yellow warbler habitat associated with non-riparian areas. However, this would be balanced with a potential increased extent of yellow warbler habitat along the river corridor in Antelope Valley.

As with Scenario 1a, little effect is expected on mule deer that may use these areas in winter, since their diet is diverse and changes are not expected to reduce the variety of existing vegetation types used for forage.

4.1.3 Scenario 2. Late Summer Reduction (after July 1)

Overall, late summer reduction in flows is expected to have minor effects on most natural vegetation types and therefore minor or no effect on dependent wildlife species. Specifically, minor effects to greater sage-grouse habitat are expected with the post July 1 termination of irrigation practices. With no changes in early season flows, recruitment of native cottonwood and willow trees is not expected to change, and therefore potential yellow warbler habitat is expected to remain the same. Minor effects to natural vegetation, and therefore to winter herd mule deer forage habitat, are expected with ending irrigation on July 1.

4.1.4 Scenario 3. No Irrigation before June 1

Responses of natural vegetation types (and therefore habitat for special-status species of concern) to delayed irrigation would be minor, since sagebrush-rabbitbrush habitat would experience negligible effects and greater sage-grouse and mule deer are not expected to respond strongly to minor fluctuations in the extent of different graminoid vegetation types. Yellow warbler habitat could increase along the river corridors with increased early season flows expected to support native riparian vegetation.

4.1.5 Scenario 4. Reduced Irrigation Throughout

Responses of natural vegetation types (and therefore habitat for special-status species of concern) to dry-year irrigation would be similar to those described for Scenario 3, late summer reduction.

4.1.6 Scenario 5. End of Season Storage Water Release

Storage water releases would occur after the end of the growing season (whole Valley), and would therefore not affect vegetation. Depending on the site, there may be a decrease or change in irrigation practices as a result of lease or sale of storage water. Storage water is generally used towards the end of the season to replace direct diversion surface water that is no longer available. Thus, if irrigation from storage water is curtailed the impacts would likely be similar to Scenario 2.

4.2 Fisheries – Potential Effects of Water Transactions

Please see Appendix B, Section 7 and 8, for a full discussion of the potential effects of water transactions on the region's fisheries.

The Walker River basin in California currently supports both native and non-native (i.e., introduced) fish species. The native fish species include trout (specifically Lahontan cutthroat trout, [LCT]) and whitefish (Salmonidae), along with non-game fish species such as sucker (Catastomidae), minnows

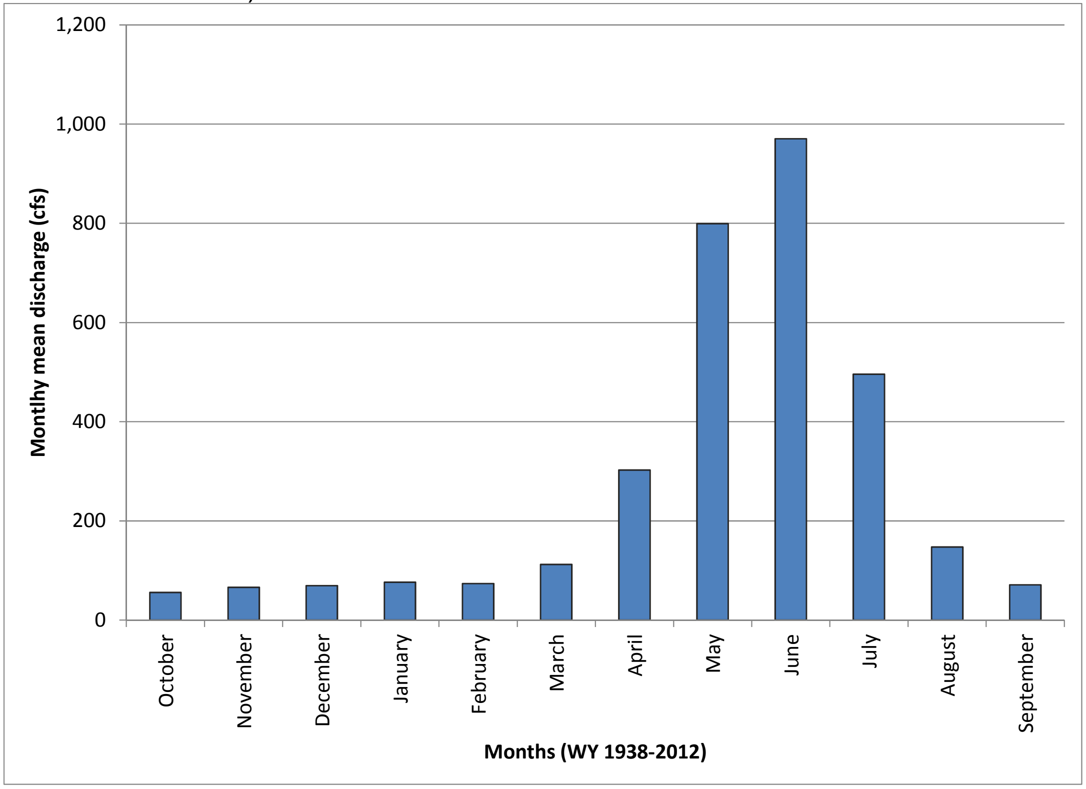
(Cyprinidae), and sculpin (Cottidae). Introduced fish species primarily include non-native trout (brook, brown, and rainbow), which are planted in various lakes, reservoirs, and stream reaches to provide improved recreational fishing opportunities. Other non-native fish species such as bass and hybrid trout have been introduced into reservoirs in the basin (MCCDD 2007), but are not reported to be distributed within stream reaches subject to the effects of water diversions, and will not be discussed here. In this document we focus on fish species in stream reaches likely to be affected by water diversions.

The life-history timing of fish species documented in the Walker River can generally be divided into two groups: (1) fish that spawn in the spring and summer, including rainbow trout and many native non-game species (e.g., Tahoe sucker, Lahontan redside, mountain sucker, Piute sculpin); and (2) fish that spawn in the fall including brown trout, brook trout, and mountain whitefish.

Fish that spawn in the spring and summer (including most native endemic fish species) are generally adapted to take advantage of the snowmelt runoff period, roughly April–July (Figure 4-1). Conditions during this period can offer relatively abundant spawning and rearing habitat and food resources. During the runoff peak, conditions can be unstable with frequently changing flows and habitat conditions. During the receding limb of the snowmelt runoff period, water velocities are on a decreasing trend, and habitat conditions are generally suitable for rearing and growth of early life stages, as well as juveniles and adults.

Fall-spawning fish such as brown trout have fry that emerge during late-winter and early-spring, prior to the peak runoff period. As a result, fry may be susceptible to displacement by high flows occurring during the snowmelt runoff period; however, the tradeoff to their relatively early hatching (and emergence), can give them a longer opportunity to rear and grow compared with spring-spawning fish, and can provide a competitive advantage over other fish of the same age class. This is particularly true for fish that establish hierarchies and actively defend territories; for example, trout species compete with one another for territory.

Figure 4-1. West Walker River Mean Monthly Flow (1938–2012) (USGS gage 10296000 W. Walker River near Coleville)



Native fish resources in the Walker River basin include the Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*), mountain whitefish (*Prosopium williamsoni*), mountain sucker (*Catostomus platyrhynchus*), Tahoe sucker (*Catostomus tahoensis*), Piute sculpin (*Cottus beldingii*), Lahontan tui chub (*Siphateles bicolor*), Lahontan redside (*Richardsonius egregious*), and speckled dace (*Rhinichthys osculus*) (MCCDD 2007).

Non-native trout have been introduced to streams lakes and reservoirs in the Walker River Basin, and continue to be stocked in some locations to improve recreational fishing opportunities (Milliorn et al., 2004, as cited in MCCDD 2007; EWRTC 2008). There is a wealth of information on the life history, regional distribution, and habitat requirements of these trout species, although information on the distribution of non-native trout within specific stream reaches in the Walker River in California is limited.

To assess the potential effects of different water transaction scenarios on fish resources in the Walker River Basin, we consider flow magnitude and timing in relation to the life history timing of fish expected to be present within affected reaches. The general approach is to evaluate changes between current flow conditions and potential future conditions expected under an alternative flow/diversion scenario as they relate to the fish species of interest, during times when habitat conditions are potentially limiting. Stream reaches likely to show substantial changes in aquatic habitat conditions as a result of water transactions are the focus of the assessment. Since the irrigation/diversion season extends from March 1 to October 31 in the Antelope Valley, and March 1 to September 15 in the Bridgeport Valley, we focus this assessment on potential impacts during these periods.

Fish habitat conditions are qualitatively assessed based on the relative quantity and quality of habitat available during key life stages of the focal fish species. Only substantial shifts in estimated habitat quantity and/or quality are considered during the assessment due to uncertainties resulting from data limitations. Note that potential benefits to fish populations resulting from possible water transactions scenarios focus on relative changes to flows and habitat conditions rather than specific habitat or water quality (e.g., temperature and nutrients) conditions. For the purposes of this assessment, we discuss trout (native and non-native) separately from the other native fish species (sucker, minnow, and sculpin), due to the economic importance of trout for recreation, and the similar habitat requirements among trout species (however we note where differences in life history are important).

Note that available data to support the assessment of the potential effects of water transactions on fish resources in the Walker River Basin are sparse. The approach described above, and assessment presented below, is based primarily on (rough) flow estimates, general regional climactic conditions, general life history and habitat requirements of focal fish species from studies mostly done elsewhere, and professional judgment. The information that would be required to make strong informed conclusions about water transactions on fish populations would include: fish sampling (species abundance, size, and age distribution), flow management (diversion timing and volume), streamflow (in-channel and accretion flow), aquatic habitat conditions (habitat frequency, cover, and complexity), flow-habitat relationships for focal fish species and life stages, entrainment (season and flow), and water quality (temperature and nutrients). This data would form the basis of a more comprehensive assessment of the factors controlling fish populations, and could lead to additional information needs such as food availability and bioenergetics modeling to understand key linkages between fish habitat and population abundance.

4.2.1 West Walker System

Based on available information of fish distributions and diversion locations in the West Walker River, we focus this assessment on reaches that extend through Antelope Valley from the Main Canal diversion downstream to Lake Topaz. Focal species for Antelope Valley include rainbow and brown trout and several native fish species. Native LCT distribution does not extend downstream into the main stem Walker River in Antelope Valley, and non-native brook trout are likely in greater abundance in the smaller tributary streams upstream of the valley. Since brook trout have a fall-spawning life history similar to brown trout, the effects of water transactions on habitat quantity and quality for these two species can be considered the same.

In the West Walker Basin, the primary points of diversion are located near the upstream end of Antelope Valley near the town of Walker. Combined, the upper-valley diversions (Main Canal downstream to West Goodnough) account for approximately 75% of the allocated rate of diversion (Ecosystem Economics 2014). From Walker downstream to the town of Coleville (about 4 miles), two diversion ditches (Harney and Alkali) account for approximately 5% of the allocated rate of diversion. The Swauger/Rickey diversion, located about 1 mile downstream of Coleville, and about half way down Antelope Valley between Walker and Lake Topaz (referred to here as the valley reach), accounts for about 15% of the allocated rate of diversion.

Despite issues with the accuracy of estimated flow and diversion values, the results are useful for identifying periods when diversions are most likely to affect habitat quantity and quality for focus fish species. Irrigation returns supply accretion flow to the West Walker River throughout the Antelope Valley reach, resulting in incremental changes to flow and habitat; however, available information is not sufficient to accurately determine spatial differences in accretion within the valley reach. Without this information, it was not possible to discern meaningful spatial differences in habitat quantity and quality along the valley reach; therefore, we focus this assessment on the valley reach as a whole.

West Walker: Scenario 1a. No Irrigation for Full Season: Whole Valley

In this scenario, all areas are kept out of irrigation for the entire growing season.

In general, unregulated flow conditions (i.e., Scenario 1a) would be expected to benefit both native and non-native fish species. Based on the timing and magnitude of diversions and the resulting estimated flow in the West Walker River through the Antelope Valley, benefits to non-native trout and native fish species are expected to be greatest in the summer during the receding limb of the annual hydrograph when water temperatures are expected to be highest (July–August), and in the fall when flow is relatively low and habitat quantity is expected to be correspondingly low (September–October). Available data offers little information on the extent to which diversions might affect habitat quantity and quality early in the irrigation season (March).

Non-native brown and rainbow trout would likely benefit under Scenario 1. Increased base flows during the receding limb of the annual hydrograph (July–August) could increase food production and growth during this period, and improve the general condition of trout going into fall and winter. During August–September (depending on water year), increased base flow would be expected to increase the quantity of available habitat. Under this scenario, the period when water temperatures are favorable for trout growth could also extend later in the year. For example, flows in the 100–500 cfs range could be extended by a few days to a month, depending on flow and water year. Since brown trout spawn in the fall, an extended growing period could improve their condition for spawning. Notably, in dry water years (e.g., 2002), when conditions are likely to be most limiting, diversions might be suspended due to low flow, diminishing the contrast between conditions under this scenario and under existing water management (assuming that in-stream flows are equally affected with late-summer suspended diversions). For example, the water use analysis indicates that diversions would have been suspended from approximately August 18 through October 14, 2002 (Ecosystem Economics 2014).

Entrainment into diversions would presumably be eliminated under Scenario 1. Young fry with relatively poor swimming ability would be particularly vulnerable to entrainment. Therefore, based on their life history timing, rainbow trout fry could possibly benefit a bit more from Scenario 1 compared with brown trout, although all species and age classes could be susceptible to entrainment.

Native fish in Antelope Valley would likely benefit under Scenario 1, primarily during the summer and fall when increased base flows would likely increase the quantity and quality of habitat available for rearing and growth. Entrainment into diversions would presumably be eliminated, and young age classes with relatively poor swimming ability would potentially benefit more compared with older age classes. In general, warm water temperatures are not expected to limit production of native fish due to their relatively high temperature tolerance, with the possible exception of mountain whitefish.

Of the scenarios evaluated and described below, Scenario 1a would be expected to provide the greatest benefit to native and non-native fish species by eliminating the effects of reduced flow in the West Walker River on fish habitat quantity and quality, and eliminating the possibility of entrainment. The greatest benefits to fish are expected during summer and fall (July–October). Potential benefits during the early irrigation season (March–June) are uncertain.

West Walker: Scenario 1b. No Irrigation for Full Season: Part of Antelope Valley

In this scenario, particular areas in Antelope Valley are kept out of irrigation for the entire growing season.

Scenario 1b would likely provide benefits to native and non-native fish in Antelope Valley in-line with those described in Scenario 1a above. However, the relative degree of any potential benefit would presumably be correlated with the volume and location of the diversion (i.e., larger diversion volumes would have a larger effect on habitat quantity (area) and quality, and diversions further upstream would affect a greater linear distance of habitat). Flow-habitat relationships for native and non-native fish species have not been developed for the West Walker in Antelope Valley (or Bridgeport Valley), and therefore, the potential effect of specific water transactions on fish habitat quantity and quality (in general, or for specific subreaches) is not well understood; specifically, the extent to which small volumes of water may provide incremental benefits to habitat quantity and quality is not known. As a result, potential effects from implementing Scenario 1b include a high degree of uncertainty regarding potential incremental benefits that may result from specific water transactions.

To understand the potential for incremental increases in flow to affect habitat quantity and quality would require information on habitat conditions in the West Walker River through Antelope Valley including: flow-habitat relationships for target fish species and life stages, water quality monitoring data, flow management (diversion timing and volume), and streamflow (in-channel and accretion flow).

Scenario 1b would likely provide benefits to native and non-native fish species in Antelope Valley, with the relative level of benefit likely dependent on the volume and location of diversion(s) included. Similar to Scenario 1a, the greatest benefits to fish would be expected during summer and fall (July–October), and the potential benefits during the early irrigation season (March–June) are uncertain.

West Walker: Scenario 2a. Late Season Reduction (no irrigation after July 1): Whole Valley

Irrigation continues through July 1 but is shut off for the second half of the growing season.

Scenario 2a would likely provide the majority of the benefits to native and non-native fish described in Scenario 1a, while maintaining irrigation diversions through the first half of the season. Scenario 2a would affect habitat conditions during those periods most likely to benefit native and non-native fish species; in the summer during the receding limb of the annual hydrograph when water temperatures are expected to be highest (July–August), and in the fall when flow is relatively low and habitat quantity is also likely near its lowest level (September–October). Entrainment potential at diversions in Antelope Valley in relation to flow and fish species life history timing patterns is unknown.

West Walker: Scenario 2b. Early Season Reduction (no irrigation after July 1): Part of Antelope Valley

Irrigation continues through July 1, but is shut off for the second half of the growing season in only part of the valley.

Scenario 2b would likely provide benefits to native and non-native fish in-line with those described for Scenario 2a, with the relative level of benefit likely dependent on the volume and location of diversion(s) included. Available information is insufficient to assess potential incremental benefits to habitat quantity and quality that may result from specific water transactions. As a result, potential effects from implementing Scenario 2b include a high degree of uncertainty. Entrainment potential at diversions in Antelope Valley in relation to flow and fish species life history timing patterns is unknown.

West Walker: Scenario 3. No Irrigation before June 1

Irrigation is shut off for the first half of the growing season in either all or part of Antelope Valley.

Scenario 3 is not likely to provide substantial benefits to native or non-native fish species in Antelope Valley, whether this is implemented across the entire or part of the valley. As stated above, potential benefits to non-native trout and native fish species would be expected to be greatest in the summer when water temperatures are highest, and in the fall when flow is relatively low. Scenario 3 would not affect habitat conditions for fish resources during these critical periods.

There is currently little information on the extent to which diversions may affect habitat quantity and quality early in the irrigation season based on available data, particularly in March. Based on the allocated rate of diversion during our test years (i.e., 2002, 2005, 2010), flows appear to be over allocated during most, if not all, days in March (all days in March were over allocated during test years). Therefore, diversions in March are generally less than the allocated rate of diversion, and likely to be substantially less than the available flow at the Coleville gage. Stream gage data (Coleville gage) indicates that flows generally remain relatively low through March and therefore, habitat limitations resulting from diversions would be possible during this time, depending on the diversion volume. Stream gage data (Coleville gage) also indicate, however, that flows during September–October are generally substantially lower than in March, and therefore, habitat near the end of the irrigation season (September–October) is likely more limiting than it would be in March. In addition, water temperatures (and bioenergetic requirements) are also generally higher late in the season compared with March.

It is possible that early-season flow increases could improve conditions for non-native rainbow trout and other native species that spawn in the spring, by improving their condition prior to spawning, and thus increasing post-spawn survival. Eliminating diversions during March–June would eliminate entrainment during this period. Presumably, early fry would be most susceptible to entrainment due to their poor swimming ability, although entrainment patterns in Antelope Valley are unknown.

West Walker: Scenario 4. Reduced Irrigation Throughout

Under this scenario, irrigation proceeds every year using dry year water allocations. Scenario 4a assumes this occurs across the whole valley while Scenario 4b assumes it occurs in a subset of the valley.

Scenario 4a is likely to provide benefits to native and non-native fish species, however, the relative difference between Scenarios 1 and 4 is unknown, and would depend on available flow and the allocated rate of diversion for each priority water right set by the Federal Water Master on a daily basis. Daily allocated rates of diversion set by the Federal Water Master do not follow a simple approach or formula; therefore, flow for the Walker River under Scenario 4 could not be estimated. Presumably, there would be no difference between Scenarios 1a and 4a, and 1b and 4b, during dry water years. During mid and wet water years, there could potentially be substantial benefits. Based on the average proportion of the allocated rate of diversion (Main Canal-Swauger/Ricky) to flow at Coleville gage to during the irrigation season in test years (33% [dry], 47% [mid], and 39% [wet]), the greatest benefits would potentially occur during mid-water years, which, comprise approximately 50 percent of years.

Scenario 4b would likely provide benefits to native and non-native fish in mid and wet years, with the relative level of benefit likely dependent on the volume and location of diversion(s) included.

West Walker: Scenario 5. End of Season Storage Water Release

Storage water releases occur after the end of the irrigation period (whole Valley).

As stated above, potential benefits to non-native trout and native fish species in the Antelope Valley would likely be greatest in the summer when water temperatures are expected to be high, and in the late-summer and fall when flow is relatively low and habitat availability likely most limiting. Scenario 5 would not affect habitat conditions for fish resources during the critical summer and fall periods.

Therefore other scenarios (Scenarios 1, 2, and 3) have the greatest potential to improve conditions for fish populations in the Antelope Valley.

The extent to which a release of stored water at the end of the irrigation season would improve conditions for native and non-native fish populations is uncertain. The magnitude and duration of such a release would likely be important to the overall benefit to fish populations. Scenario 5 would presumably increase flows above those present under natural (unregulated) conditions for some period of time, depending on available storage volume. Flow in the West Walker at the Coleville gage are typically relatively low at the end of the irrigation season, and average about 70 cfs in November (Figure 4-2), although conditions vary by water year type. Average monthly flows in November during test years were 45 cfs in 2002 (dry), 74 cfs in 2005 (wet), and 57 cfs in 2010 (mid).

Based on flow conditions at the Coleville gage during test years, late-season flow increases can occur naturally. During 2010, approximately three relatively small flow events occurred during October, with daily average flow at the Coleville gage ranging up to about 375 cfs, presumably from storm precipitation. Naturally, such low duration flow events likely bring with them a flush of cool water, and potentially a spike in terrestrial and aquatic food items. In addition, an increase in flow would presumably increase habitat quantity.

Short-duration flow increases from upstream storage of less than a week would likely have a similar effect to a natural freshet by increasing food and habitat availability during the release period. Such an event is not likely to have a great benefit to fish populations due to the relatively short duration, although the extent to which increased food availability could transfer to improved condition prior to spawning could have a benefit to fall spawning fish, particularly in drier years with stressful late-summer and fall conditions.

Long-duration releases of a week to about a month, would likely show a greater benefit compared with a short-duration release, although the effects are uncertain, and likely dependent on the duration of release, water temperature (related to bioenergetics), and when the release occurs in relation to spawning (specifically for fall-spawning species such as brown trout and mountain whitefish).

Mill Creek

A diversion on Lost Canyon Creek (Little Antelope Valley) above its confluence with Mill Creek, provides irrigation supply to Little Antelope Valley, and affects flows in Mill Creek from the confluence with Lost Canyon Creek downstream to the West Walker River near the town of Walker, a distance of approximately 1.8 miles (Figure 2-5). Currently, LCT distribution in Mill Creek extends downstream to just above the confluence with Lost Canyon Creek (USFWS 2009, Figure A1.16); the historic distribution of LCT did not extend into Lost Canyon Creek (USFWS 2009, Figure A1.16). Daily average flows in Lost Canyon and/or Mill Creek were not available, and other information regarding fish habitat quantity and quality, and diversion management were also unavailable. However, entrainment of LCT is not expected since distribution of LCT does not extend into Lost Canyon Creek.

The annual hydrograph in Mill Creek is likely similar to that of the West Walker River, with relatively high flows during the snowmelt runoff period, receding flows during summer, and low flow for the remainder of the year. The irrigation season in Little Antelope Valley is the same as in Antelope Valley and extends from March 1 to October 31. Based on available data, the relative contribution of flow in Lost Canyon Creek to Mill Creek is unknown, and the extent to which flow in Lost Canyon Creek is perennial is uncertain, particularly in dry years.

Fish habitat conditions in Mill Creek are likely quite different from those in the West Walker River through Antelope Valley (and the East Walker in Bridgeport Valley). Mill Creek has a relatively small contributing drainage area compared with the West Walker River at the Coleville gage, and channel size (width) is expected to be much smaller. As a result, riparian vegetation may have a relatively strong influence on habitat complexity, cover, and stream shading. In addition, channel gradient is steep compared with the West Walker River, with differences in channel bed morphology (e.g., step-pool, cascade), and bed substrate coarseness (e.g., cobble/boulder).

Despite differences in habitat characteristics between Mill Creek and the West Walker River in Antelope Valley, we expect that potential benefits to LCT from water transactions would be focused during similar periods: in the summer during the receding limb of the annual hydrograph when water temperatures are expected to be highest (July–August), and in the fall when flow is relatively low and habitat quantity is also likely near its lowest level (September–October). However, since LCT are not currently distributed in the affected reach of Mill Creek (downstream of Lost Canyon Creek) the threshold for improving conditions to a point where habitat conditions allow LCT populations to redistribute and persist, is unknown and highly speculative.

4.2.2 East Walker System

In the East Walker Basin, streams enter Bridgeport Valley from many directions, and diverge into distributary channels and irrigation ditches, which are largely ungauged. Points of diversion within Bridgeport Valley are not well documented, thus making an assessment of water transactions effects on fish resources extremely difficult. In addition, there is no available information on rates of diversion in Bridgeport Valley, thus introducing additional uncertainty regarding when, and to what extent, irrigation diversions (and water transactions) are likely to affect fish habitat conditions.

Due to this lack of information, we did not attempt to evaluate the potential effects of water transactions on fish resources in the East Walker River Basin for specific streams or reaches. Rather we relied largely on the assessment for the West Walker River in Antelope Valley because we believe the potential effects that could be expected as a result of water transactions in Bridgeport Valley would be similar. We attempt to describe where differences between Antelope and Bridgeport Valleys are known or likely, and to summarize how these differences might influence conclusions regarding the effect of water transactions on fish resources. Similarities and differences relevant to this assessment are described below.

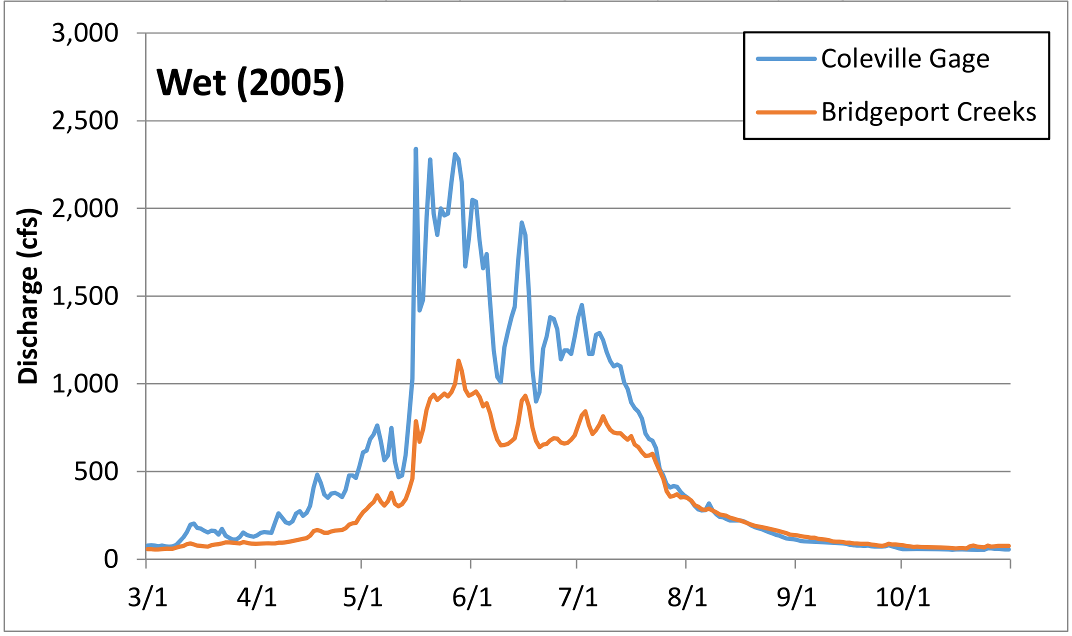
The irrigation season in the Bridgeport Valley extends from March 1 to September 15 and, therefore, is slightly shorter than in Antelope Valley. The shorter irrigation season likely corresponds to a shorter growing season in the Bridgeport Valley. The elevation of Bridgeport Valley is approximately 6,500 ft, which is about 1,500 ft higher than Antelope Valley. This elevation difference generally translates to cooler expected temperatures rear-round in Bridgeport Valley streams. It may also indicate harsher conditions in winter related to snow, ice, and freezing.

The annual hydrograph in the Bridgeport Valley is generally similar to that of Antelope Valley, with low flows persisting from about November through February, flows slowly increasing during March–April as snowmelt begins, relatively high flows resulting from snowmelt runoff during May–July, and flows receding during August–October (Figure 4-2). Overall, differences in flow magnitude between Bridgeport and Antelope valleys are uncertain because the many streams that supply water to Bridgeport Valley are not gaged. A notable difference in fish habitat characteristics between Bridgeport and Antelope valleys is that Bridgeport Valley has four (or more) major natural channels running through the valley whereas Antelope Valley only has one, the West Walker River. As a result, stream channel dimensions in Bridgeport Valley are smaller, and fish habitat characteristics (e.g., pool depth, extent of undercut bank) may differ substantially between the two valleys. Such differences in channel size and flow capacity have a strong influence on sediment transport capacity and bed substrate characteristics, as well as overall channel morphology, which can all influence fish habitat conditions.

Fish resources in Bridgeport Valley were generally considered to be similar to those addressed for the Antelope Valley above, although it is possible that the presence or relative abundance of certain species might be quite different. Based on the hydrology of streams in the Bridgeport Valley, its elevation, and regional climate, we expect the potential benefits to non-native trout and native fish species from water transactions would be greatest in the summer when water temperatures are high, and in the fall when flow is relatively low. The elevation of Bridgeport Valley likely influences water temperatures such that there may be a shorter period of time when water temperatures are not favorable for fish growth (particularly salmonids) during the irrigation season, compared with Antelope Valley. Based on available information, the potential effects of water transactions on fish resources in the Bridgeport Valley would likely be similar, in general, to those outlined above for the West Walker River in Antelope Valley.

There is insufficient information on conditions in Bridgeport Valley to draw different conclusions than those described for Antelope Valley regarding the potential effects of water transactions on fish resources. Therefore, we do not include scenario-specific descriptions. Additional information similar to that described above for Antelope Valley, would be needed to develop strong conclusions regarding the effects of various water transaction scenarios on fish resources in the Bridgeport Valley.

Figure 4-2. Representative Wet Year (2005) Average Daily Flow Hydrograph



Twin Lakes

Twin Lakes provide upper watershed storage for the Bridgeport Valley, and it is possible that water storage here, and other upstream storage reservoirs, could be managed differently if sale incentives for stored water were to change. Twin Lakes also provides a popular recreational fishery, having established resorts and campgrounds near the lakes and along Robinson Creek. Humwell Dam was built on Robinson Creek in 1888 to increase the size and water storage capacity of Lower Twin Lake for stock watering and irrigation in Bridgeport Valley, about 10 miles downstream (Case Study Report #48

No date.). Water storage capacity on Upper Twin Lake has also been increased. Based on available information, upper and lower Twin Lakes would likely maintain mean and maximum depths sufficient to provide suitable water temperatures during the irrigation season for resident trout survival, during years when maximum drawdown is reached (Table 4-2). The long-term effect of annual maximum drawdown on existing fish populations in Twin Lakes and Robinson Creek are uncertain.

Table 4-2. Hydrographic Data, Twin Lakes, Mono County (Table recreated from: (CDFG no date, A progress report of the Twin Lakes kokanee salmon and catchable trout fishery)

	Lower Twin Lake	**Upper Twin Lake**
Elevation at spill level	7,076 feet	7,096 feet
Area at spill level	375 acres	265 acres
Mean depth at spill level	50 feet	50 feet
Mean depth at maximum drawdown	47 feet	36 feet
Maximum depth	149 feet	112 feet
Volume at spill level	18,800 acre-feet	12,455 acre-feet
Estimated average discharge	33.0 cfs	28.0 cfs

Historic information indicates that flows in Robinson Creek downstream of Twin Lakes may reach zero in dry years, however, flow greater than zero is generally maintained to support the recreational fishery and associated businesses (Case Study Report #48, no date). The extent to which stored water sale incentives would change management of flow into Robinson Creek is uncertain; however, it appears that flow could reach zero, which could result in impacts to fish populations in Robinson Creek downstream of Twin Lakes.

Information that would support a stronger understanding of how changes in flow management could affect fish resources in Twin Lakes and Robinson Creek include:

- A summary of existing information on hydrologic conditions and flow management at upper and lower Twin Lakes to document historic management including the effects of historic water supply on flow releases to Robinson Creek, and the frequency of flow releases that could limit fish populations;
- A summary of existing information on fish habitat, populations, and management in upper and lower Twin Lakes and Robinson Creek to provide a background and identify data gaps; and
- An assessment of fish habitat and fish resources in Robinson Creek

4.3 Habitat Response Summary

Antelope and Bridgeport Valleys could provide important habitat for many wildlife species, including the greater sage-grouse, yellow warbler, mule deer, pygmy rabbit, western white-tailed rabbit, and the American badger. Because the pygmy rabbit, western white-tailed rabbit, and American badger are all well adapted to dryland habitats, none of the water transaction scenarios are expected to negatively impact these species. Greater sage-grouse thrives in areas with a mixture of sagebrush, dry grass, and moist grass vegetation. It is difficult to ascertain whether the increase in amount and extent of sagebrush would offset the loss of moist, irrigated habitats within the valley floors. An increase in sagebrush-rabbitbrush habitat would likely increase the amount of area where a combination of both habitat types is available. One could hypothesize that an increase in the amount of area supporting a combination of moist grass and sagebrush could positively affect the greater sage-grouse. However all of this is predicated on the assumption that there is a population of greater sage-grouse that use areas in Bridgeport or Antelope valleys. These habitat changes could occur in both valleys under multiple consecutive years without irrigation (Scenario 1). Other scenarios are expected to have negligible-to-minor effects on the greater sage-grouse. The yellow warbler also occurs in the Study Area and prefers open canopy or deciduous riparian forest and shrubs. Therefore, increases in willow and riparian forest cover that could occur with Scenario 1 and 3 (increased stream flows all or in the early part of the season) could positively affect yellow warbler. On the other hand, decreased extent of coyote willow in other parts of Bridgeport and Antelope Valleys with reduced early season irrigation could negatively affect yellow warbler habitat. Thus, the impacts could be mixed for this species. Mule deer, which have a varied diet that spans the vegetation types in both valleys, are not likely to be affected either way by any of the water transaction scenarios. Yosemite toad, Mt. Lyell salamander, and Sierra Nevada yellow-legged frog were also considered in this assessment but determined not to have potential habitat within the Study Area.

The Walker River Basin in California currently supports both native and non-native fish species. Native fish species include Lahontan cutthroat trout and whitefish, as well as sucker, minnows and sculpin. Introduced fish species include brook, brown, and rainbow trout that have been planted in various lakes, reservoirs, and stream reaches for improved recreational fishing opportunities. Lahontan cutthroat trout occupy less than 3% of their historic range, which formerly included all or most of the Walker River Basin, and are listed as threatened under the Endangered Species Act. Current populations in California are isolated in small headwater streams and do not overlap with the irrigated lower valleys. Thus, the water transaction scenarios are not expected to affect these existing populations of Lahontan cutthroat trout; however, non-native brown and rainbow trout do exist in the river reaches that flow through Antelope and Bridgeport Valleys and could benefit from increased early and late season flows that could occur under Scenario 1, and to a lesser degree, under Scenarios 2 and 3. These benefits to non-native trout are primarily associated with creating cooler stream temperatures due to increased instream flows during critical times of year. Most of the native fish in Antelope and Bridgeport Valleys are less sensitive to stream temperatures but could experience minor benefits from the water transactions due to reduced entrainment in diversions.

Twin Lakes provide upper watershed storage for the Bridgeport Valley, and it is possible that water storage here, and other upstream storage reservoirs, could be managed differently if sale incentives for stored water were to change. Based on available information, upper and lower Twin Lakes would likely maintain mean and maximum depths sufficient to provide suitable water temperatures during the irrigation season for resident trout survival, during years when maximum drawdown is reached (Table 4-2). The long-term effect of annual maximum drawdown on existing fish populations in Twin Lakes and Robinson Creek are uncertain. Historic information indicates that flows in Robinson Creek downstream of Twin Lakes may reach zero in dry years, however, flow greater than zero is generally maintained to support the recreational fishery and associated businesses (Case Study Report #48, no date). The extent to which stored water sale incentives would change management of flow into Robinson Creek is uncertain; however, it appears that flow could reach zero, which could result in impacts to fish populations in Robinson Creek downstream of Twin Lakes.

Of the five scenarios considered, Scenario 1, in which all irrigation is suspended, could have the greatest positive effect on the local fisheries, wildlife, and riparian plant communities. This scenario could have a large impact on alfalfa production and could only be feasible with conversion to more dryland varieties of alfalfa. Impacts to rangeland production could be large, particularly in Bridgeport Valley; however information on surface and groundwater conditions in Bridgeport Valley is needed in order to estimate these effects with any certainty. Impacts to rangeland production in Antelope Valley could be important, particularly in the southern extent of the valley and along the better-drained valley edges. Scenario 1 could affect greater sage-grouse habitat; however more information is needed on the distribution and habitat preferences of the local populations. Native riparian cottonwood and willow forests along the riparian corridors could be positively affected by a return to the natural hydrograph, which could occur with Scenario 1, as would the native fish species in the valley reaches.

Scenario 2, in which diversions continue up to July 1, could have the least effect on forage and alfalfa production, while providing limited benefits to aquatic and wildlife species and negligible effects on native riparian plant communities and other natural vegetation types in the Study Area. By holding off irrigation until June 1, benefits are provided to native riparian willows and cottonwoods and the associated yellow warbler, and to native and non-native fish populations. Impacts on forage production and other natural vegetation types could be minor; however, alfalfa production in Antelope Valley could be importantly reduced if these areas were included in the program. Implementing reduced irrigation levels throughout the irrigation season is expected to have effects similar to those in which irrigation stops as of July 1. Finally, release of storage water after the end of the irrigation season (e.g., in October in Bridgeport or November in Antelope Valley) would have no effect on vegetation but could have a very minor positive effect on aquatic species.

Our ability to clearly and accurately assess potential positive or negative effects associated with a water transaction program in the California Walker River watershed is greatly constrained by gaps in existing information. The greatest information gaps relate to Bridgeport Valley, where stream flows and groundwater conditions are not well quantified. However, the vegetation map created through this effort, and the framework for assessing linkages between water availability and plant, wildlife, and aquatic species represent important steps towards better understanding how changes in water management in the East and West Walker Rivers in California could be made with the least impact to agricultural production.

5 FINANCIAL AND ECONOMIC ANALYSIS OF CHANGES IN IRRIGATION MANAGEMENT

Changes to irrigation water use due to water transactions designed to re-water Walker Lake have the potential to impact individual landowners, local government, and the economy. This Section examines these impacts as follows:

1. **Ranch/Farm Productivity Impacts**. A reduction in water use will reduce agricultural and livestock production leading to a reduction in ranch/farm revenues and the costs of production. A financial model is used to evaluate farm production (i.e., costs and revenues) before and after water transactions and estimate the opportunity costs of engaging in water transactions for farmers/ranchers.

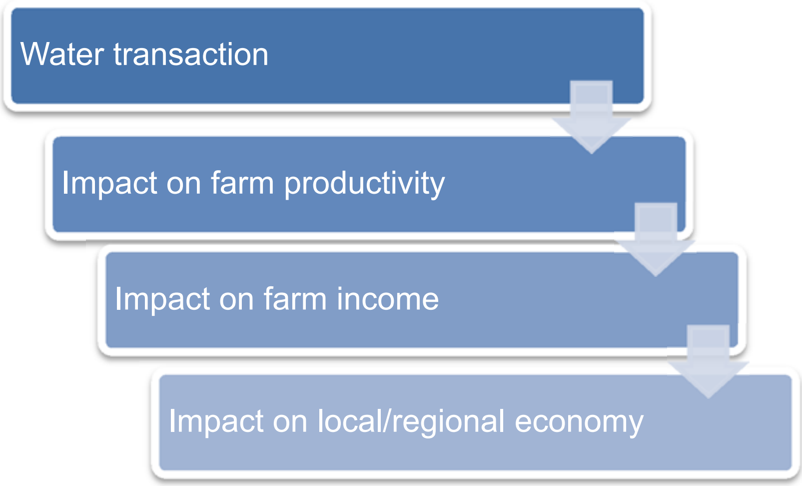
2. **Financial Benefits**. Water transactions between water right holders and the National Fish and Wildlife Foundation for the lease or transfer of water rights for the benefit of Walker Lake will result in cash payments to water right holders. These benefits are quantified using preliminary estimates of what might be the appraised value for such transactions, based on experience in the western U.S. and existing NFWF transactions under the Walker Lake Program in Nevada.

3. **Net Financial Benefits.** A comparison of the financial benefits of engaging in a water transaction with the impacts on production and profitability are an important indicator of the likelihood that water transactions are feasible. The information generated for each water transaction scenario is combined and assessed to identify which, if any, transactions appear beneficial from a purely financial standpoint.

4. **Regional Economic and Fiscal Impacts.** A change in production, expenditure, and land use at the farm/ranch level as water transactions occur could lead to a change in the structure of the regional economy. Secondary economic data and multipliers from Mono County and other studies are used to qualitatively assess the likelihood of significant impacts and the direction of these impacts (positive or negative). Local government may also see a change in its tax base, tax payments, and/or expenditures if water rights are leased or sold. Evidence from other studies and information from Mono County are used to qualitatively assess these impacts

Figure 5-1 shows the general relationship between and sequencing of the assessment of these potential financial impacts.

Figure 5-1. Overview of Economic Model Relations



It should be noted that all economic results derived are estimates only and were based on the best available data at the time of model development. Furthermore, while we believe the results may be useful for decision-making and policy considerations, the analysis was conducted using cost and revenue data for just a few types of "average farms/ranches" in Mono County, and, therefore, results may vary for individual operations.

5.1 Ranch/Farm Productivity Impacts

At present, the primary agricultural production activities in Mono County are beef stock and hay. In 2012, beef stock and hay accounted for 88% and 90% of livestock production and field crop production, respectively (Agricultural Commissioner's Office 2012). Given this, land used for pasture grazing and alfalfa hay is the focus of the analysis. As reported earlier, both types of production occur in Antelope Valley, while Bridgeport Valley is pasture only. While there is some use of pivots for irrigation in Antelope Valley, for simplicity, the analysis assumes that alfalfa hay is irrigated using wheel line and pasture is irrigated using flood.

The model was designed to allow for analysis of the following production types:

1. Full season irrigation with existing water rights (i.e., the before transaction analysis);
2. Full season, permanent dryland production (i.e., the full sale of the water rights);
3. Full season, temporary fallowing (i.e., the lease of the water rights); and
4. Partial Season, late-season diminishment (i.e., partial season lease - starting July 1).

As we could find neither documented experience with early season diminishment, nor any research on the topic, this scenario is not modeled explicitly. The same applies for a scenario involving a small reduction in irrigation throughout the season, as it is unclear whether and to what extent "deficit" irrigation might affect pasture/alfalfa. For both of these transactions, however, the financial benefits can be estimated and this is done in the next Section. The temporary or permanent marketing of storage water is not assessed here as it is expected that any such lease or sale would happen separately from the decree diversion rights. To some extent, per acre-foot productivity impacts may be assumed to apply to storage water as they do for decree water.

5.1.1 Productivity Model

General Assumptions

For simplicity and consistency across analyses, the model required set assumptions for a number of fixed parameters, including values for labor wages, fuel prices, land values, and property taxes, among others.

When possible, county or region specific values were used for these assumptions. Values were either obtained for 2012 or were updated to 2012 dollars.

With respect to pasture, the analysis does not recreate the full costs and benefits of livestock production of the operations, but instead reflects the land and pasture management costs and establishes the benefits of production through the returns in terms of AUMs. More specifically, based on personal conversations with producers in the county, an assumption of 0.66 AUMS per acre per month was used, or 3.96 AUMs per acre across a 6-month season.

The decision not to include livestock production was based on the knowledge that the type of livestock production (i.e., grazing) done in Mono County is heavily dependent on pasture growth/production, which itself is dependent on irrigation water availability. While existing studies for the area describe a direct link between pasture production and water availability, the subsequent link between pasture and livestock production is less clear given that livestock are often moved between multiple pastures during a season in an effort to provide them the greatest level of forage and avoid poor weather conditions.

Irrigation Water/Consumptive Use

The objective of the modeling effort affects the choice of consumptive use to apply as follows:

- For full season irrigation with water rights, the long-term average water availability is used to reflect average returns over time absent water transactions.
- For full season transactions, the assumption is no water is used for irrigation.
- For the late season lease, the assumption is that irrigation water is used only up to July 1, so for months with irrigation the amount is the same as for the before transaction situation.
- For the early season lease, the assumption is that irrigation water is used only after June 1.
- For the full season reduced water use scenario the dry year is taken as the reference point and the difference in water use with the wet year is taken as indicative of potential water savings.

The consumptive use figures are drawn from the METRIC Net Irrigation Water Requirement (NIWR) figures provided by the Desert Research Institute (and are shown in Table 2-13 and Table 2-14). The monthly figures for the midpoint between the dry and wet years for both Antelope Valley and Bridgeport Valley are used in the model to represent long-run average NIWR.

Table 5-1. Monthly Net Irrigation Water Requirement

(inches)	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Antelope	2.00	3.64	5.23	7.13	8.21	6.96	4.51	2.37	40.05
Bridgeport	2.56	4.09	5.59	8.30	8.62	6.53	2.20	n/a	37.88

Note: These figures are taken as the midpoint between wet and dry year figures from Table 2-13 and Table 2-14.

Table 5-2. Net Irrigation Water Requirement by Transaction Type

Transaction	**Antelope Valley**	**Bridgeport Valley**
Full Season		
Permanent	3.34	3.16
Single Year	3.34	3.16
Partial Seasons		
Lease as of July 1	1.84	1.45
Lease to June 1	0.91	1.02
Full Season Reduction	0.39	0.24

Note: The water use reductions all season long are derived from the dry/wet year comparison figures in Table 2-12, all other figures are derived from Table 5-1.

Crop Yield

For full-season leases or permanent purchases, crop yield estimates were determined by a) acquiring estimates from the University of California Cooperative Extension studies (2008; 2012) conducted in the Intermountain Region and the Counties of Inyo and Mono Agricultural Commissioner's Office 2003-12 crop yield reports (2003-12); b) vetting these numbers with active producers in Mono County; and c) adjusting the original numbers as needed based on their feedback.

For full-season water use, annual crop yield was estimated to be 6.50 tons per acre and 3.96 AUMs per acre (i.e., 0.66 AUMs per acre per month for six months) for alfalfa hay and pasture, respectively. Dry land yield for full-season leases was estimated as a proportion of full-water yield based on calculations obtained from WestWater Research.

For permanent purchases, we assume yield for both alfalfa hay and pasture to be zero as anecdotal evidence suggests that common varieties used for both crops under irrigation are not typically suitable for dry land production.

Prices and Revenues

Annual price estimates for alfalfa hay were obtained from the Inyo/Mono Counties Agricultural Commissioner's office (2003-12). For single-season full-season and partial-season transactions, the 2012 price per ton of $235.00 was used. For a permanent purchase, we calculated the 10-year average (2003-12) price after updating all years to 2012 dollars. The resulting price for a permanent purchase was estimated to be $172.00 per ton.

The annual price for pasture obtained through personal communication with farmers/ranchers in the study area and was estimated to be $35.00/AUM or $138.60/acre.

Revenue per acre for both crops was estimated as yield per acre multiplied by price per acre, recognizing that yield per acre varies between the scenarios. Total revenue was then calculated as revenue per acre multiplied by total acreage.

Production Costs

Detailed sample farm production costs for alfalfa hay and pasture were obtained from the University of California Cooperative Extension. While studies specific to Mono County were not available, recent studies for both production activities have been conducted in the Intermountain Region (i.e., Alfalfa Hay - Siskiyou County (2012) and Pasture - Shasta, Lassen and Modoc Counties (2008)). For consistency, values from the 2008 pasture study were updated to 2012 dollars and all costs were calculated as per acre costs.

Fixed and variable costs categories were created in order to account for changes in activity related to water transaction terms and variable cost categories were designed to adjust production costs to reflect the level of irrigation activity chosen (e.g., full-irrigation, split-season lease, full-season lease). Variable production cost categories included:

- Irrigation system and use costs – including labor, power, equipment depreciation & interest, repairs, and water fees;

- Harvest costs – including labor, machine repairs, fuel/lube, equipment depreciation & interest, and custom harvest (if used);
- Other costs – including non-harvest labor, non-harvest machine repair, non-harvest fuel/lube, and fertilizer/herbicide.

Fixed costs included:

- Equipment depreciation;
- Machinery interest, taxes, housing, insurance;
- General overhead;
- Land interest (including farmstead);
- Management fee;
- Land taxes; and
- Establishment costs.

Model Input Choices

The model was designed to allow the user to choose or input some farm-level data, including information on the specifics of the water transaction and farm operations. Table 5-3 shows a brief description of the model input choices by category. For the purposes of this study, some input choices were assumed to be the same for all scenarios run (e.g., all alfalfa is assumed to be custom harvested based on anecdotal evidence and personal communication with producers in the County). These fixed choices are noted in the right-hand column of Table 5-3.

Table 5-3. Description of Model Input Choices

Water Transaction	
Type	Full or partial season (start July 1)
Terms	Single season or permanent purchase
Discount Rate	Permanent purchase only (3%)
Farm Production	
Crop Type – Full Water	Alfalfa or Pasture
Crop Type – Water Transaction	Alfalfa or Pasture
Acreage – Full Water	Enter #
Acreage – Water Transaction	Enter #
Operational Costs	
Harvest Costs	Custom
Owner Labor	No
Owner Irrigation	No
Irrigation System	
Type	Flood, Wheel Line

5.1.2 Financial Returns and Productivity Impacts

The model design required parsing out the presence/absence and/or change in value for revenue and each cost category. A summary of the choices included in the current model is presented in Table 5-4. These choices (and formulae) drive the calculation of financial returns in the business as usual (or before transaction) case and with each of the transaction types.

Table 5-4. Model Parameter Selections with and without Water Transactions

Parameter / Category	Before Transaction	Late Season Lease (on July 1)	Full Season Lease	Full Season Purchase
Production Revenues				
Irrigation ET	full	partial	none	none
Yield: Alfalfa (tons/acre)	6.5 / 6.05	production function	1.00	none
Yield: Pasture (AUMs/acre)	3.96	production function	1.03	none
Price: Alfalfa ($/AUM)	$235 / $172	$235	$235	n/a
Price: Pasture ($/AUM)	$35	$35	$35	n/a
Variable Costs				
Irrigation Costs	full	partial	none	none
Irrigation Power	full	partial	none	none
Irrigation Setup	full	full	none	none
Irrigation Labor	full	partial	none	none
Irrigation Equip. Deprec.	yes	yes	yes	no
Irrigation Equip. Interest	full	full	full	none
Irrigation Repairs	full	partial	none	none
District Assessment	yes	yes	yes	no
Other Costs				
Machinery Repair	yes	yes	yes	none
Fuel and Lube	none	none	none	none
Fertilizer/Herbicide	yes	partial	none	none
Machine Labor	full	partial	none	none
Other Non-Harvest Costs	yes	yes	yes	none
Harvest Costs	alfalfa only	partial	minimal	none
Fixed Costs	full	full	partial	land-related only
Equipment Depreciation	full	full	full	none
Machinery Interest, Taxes, Housing, Insurance	full	full	full	none
General Overhead	full	full	partial	minimal
Land Interest (including farmstead)	full	full	full	full
Management Fee	none	none	none	none
Land Taxes	full	full	full	full
Establishment Costs	full	full	full	none

Results are presented first for the business as usual (before water transaction) situation, in Table 5-5. Under this scenario, returns for alfalfa (~$/acre) were higher than for pasture. Furthermore, returns to pasture in both valleys did not vary much due to the similarity of the model parameters, which differ between the two valleys simply in terms of the NIWR figures. Net returns to pasture were estimated to be slightly negative. This result may be a result of using AUMs as the means for valuing pasture outputs, instead of recreating a full livestock model, as described previously. Nonetheless, it is not surprising to find that alfalfa generates more substantial financial returns.

Table 5-5. Full Irrigation (Pre-Transaction) Estimated Annual Net Return per Acre

Net Annual Returns	**Pasture**	**Alfalfa (1 Season)**	**Alfalfa (Permanent)**
Valley	**$/acre**	**$/acre**	**$/acre**
Antelope Valley			
Revenue	$139	$1,528	$1,041
Variable Costs	-$72	-$521	-$500
Fixed Costs	-$69	-$120	-$119
Net Return	-$2	$887	$422
Bridgeport Valley			
Revenue	$139		
Variable Costs	-$70		
Fixed Costs	-$69		
Net Return	$0		

The model was then used to simulate the impact of the water transaction scenarios on financial returns. In other words, the revenue and cost category assumptions were run through the model for each transaction type, which resulted in a new net financial return estimate for each scenario. When the resulting estimate was compared to the full irrigation returns (Table 5-5), a figure for the change in net returns due to each water transaction was obtained. This estimate (see Table 5-6) is in effect the opportunity cost (or financial loss) due to changes in farm/ranch productivity incurred by the landowner as a consequence of participating in each type of water transaction.

Opportunity cost can be generally defined as the cost associated with forgoing the next best alternative when making a decision. In the context of this analysis, if a landowner would choose to engage in a water transaction, his/her opportunity cost would be the net revenue received with production under full water irrigation.

The estimates in Table 5-6 are annual opportunity costs for the leases and present values for the purchase. The present values were calculated as 30-year cash flows discounted at 3%. These opportunity costs are presented in per acre and per acre-foot of NIWR terms. Per acre-foot figures are used when per acre-foot financial benefits of payments for water transactions are developed in the next Section.

The results suggest that, depending on the crop(s) produced, the opportunity cost of participating in a water transaction may be substantial. Not surprisingly, the opportunity costs was found to be highest for alfalfa, as alfalfa has the highest net revenue in the business as usual case. The results are summarized here:

- For a full season purchase of alfalfa water rights, the opportunity cost to the landowner raising alfalfa was estimated to be approximately $9,500/acre and around $2,500/AF. For pasture in Bridgeport Valley and Antelope Valley, full season purchases of pasture water rights were around $800/acre. These are present values estimates for the sale and transfer of a water right.
- For a full season lease, the net annual opportunity cost to an alfalfa landowner was approximately $850/acre and $250/AF. For pasture, the estimates were similar, but not identical, for the two valleys – $40-41/acre and $12-13/AF.
- For a partial season lease (as of July 1st), the net annual cost was estimated to be $244/acre and $133/AF for alfalfa.

Table 5-6. Opportunity Costs of Engaging in Water Transactions

	Opportunity Cost	
	Pasture $/acre	Alfalfa $/acre
Antelope Valley		
Full Season Purchase (Discounted Present Value)	($819)	($9,499)
Full Season Lease (Annual Value)	($40)	($844)
Partial Season Lease - Start July 1 (Annual Value)	($2)	($244)
Bridgeport Valley		
Full Season Purchase (Discounted Present Value)	($863)	
Full Season Lease (Annual Value)	($41)	
Partial Season Lease - Start July 1 (Annual Value)	$0	

5.2 Financial Benefits of Water Transactions

Landowners entering into leasing or other water rights or water use agreements would normally be compensated for changing their activities and practices. The benefits of program participation are best estimated by using likely prices to be paid for water as part of the Walker Program and/or with reference generally to lease/purchase prices across the western U.S. (for example see Aylward et al. 2010). NFWF has just released its 2014 Program Appraisal Report, which is a particularly useful source of information (Warren 2014).

Lease and purchase rates paid for water are typically based on water rights appraisal that value the water in its highest and best use, which typically means for agricultural purposes. Such appraisals often rely on estimates of “wet” or reliable water that can be provided under the water rights. While a useful indicator of the value of water rights appraisals are typically a starting point for negotiations (Hartwell 2013), the amount actually agreed upon by buyer and seller may vary. For this reason, and for the purposes of this report, we simply select the high value for decree water from the 2014 Warren report of $1,800/AF for wet water. Using a 6.0% implicit capitalization rate based on the WestWater Research analysis of markets in the western U.S. resulted in an estimated lease value of $108/AF/year associated with the decree rights. Warren (2014) also suggested a $1,500/AF figure for storage water measured in nominal volume. Using the capitalization rate mentioned previously results in a $90/AF/year lease price for storage.

Using the quantities of Net Irrigation Water Requirement shown in allowed us to estimate the potential benefits to water right holders in terms of sale and lease payments for the different transactions, as shown in Table 5-7.

Table 5-7. Financial Benefits to Water Right Holders from Water Sales and Leases, Using METRIC NIWR

	Price ($/AF)	**Water Not Consumed - NIWR in AF Available to Sell or Lease**		**Payments ($/Acre)**	
Transaction		**Antelope Valley**	**Bridgeport Valley**	**Antelope Valley**	**Bridgeport Valley**
Permanent Transaction ($/AF)					
Full Season Purchase - Decree	$1,800	3.34	3.16	$6,012	$5,688
Purchase - Storage Water	$1,500				
Single Year Transaction ($/AF/yr)					
Full Season Lease	$108	3.34	3.16	$361	$341
Late Season Lease	$108	1.84	1.45	$199	$157
Early Season Lease	$108	0.91	1.02	$98	$110
Full Season Reduction	$108	0.39	0.24	$86	$32
Storage	$90				

5.3 Financial Net Benefits

The estimated opportunity cost due to lower land productivity under water transactions was then combined with the estimated financial benefits of payments for water transactions to suggest to what extent, given the current figures and prices, these transactions would be seen as profitable by water right holders. The results of this analysis (seen in Table 5-8 below) suggests that water transactions may be financially attractive to landowners engaged in pasture and livestock production, but less so for alfalfa landowners. In the case of alfalfa, the analysis suggests that only the partial season scenario could result in a positive net benefit from engaging in the water transaction. As stated earlier the figures used here are averages only and the results for a particular operation may differ from the results presented here.

Table 5-9 combines a large amount of information into a single estimated net benefit value for each transaction scenario. It is interesting to note that the results suggest that water transactions could be financially feasible in all of Bridgeport Valley, and on most of the ground in Antelope Valley, where there are three times as many acres reported in pasture as in alfalfa.

Storage is not explicitly examined in terms of opportunity cost, but if storage is being used on pasture, which has financial returns on the order of $40/acre, then with over 3.0AF/acre in water use on pasture, that would suggest an estimated financial return of $13/AF on the storage. Storage is typically used only late in the season when other rights are not available, so its marginal productivity may be higher than that, but still a lease price of $90/AF should be an incentive for right holders to engage in leasing storage water.

Table 5-8. Net Financial Benefits to Water Right Holders from Water Transactions, Using METRIC NIWR

	Payments ($/acre)		**Opportunity Costs ($/acre)**			**Net Benefits ($/acre)**		
	Antelope	Bridge-port	Antelope		Bridge-port	Antelope		Bridge-port
Transaction			Alfalfa	Pasture	Pasture	Alfalfa	Pasture	Pasture
Permanent Transaction ($/acre)								
Full Season Purchase - Decree	$6,012	$5,688	-$9,499	-$819	-$863	-$3,487	$5,193	$4,825
Purchase - Storage Water	$1,500/AF							
Single Year Transaction ($/acre/yr)								
Full Season Lease	$361	$341	-$844	-$40	-$41	-$483	$321	$300
Late Season Lease	$199	$157	-$244	-$2	$0	-$45	$197	$157
Early Season Lease	$98	$110						
Full Season Reduction	$86	$32						
Storage	$90/AF							

The caveat here is, while these payments are based on appraised values for reliable water, the Task 1 and Task 2 report suggested alternate approaches to estimating the evapotranspiration associated with decree rights. The comparison between the METRIC NIWR figures used above in the calculations and these alternate approaches is summarized in Table 23 of the Task 1 and Task 2 approach (Appendix A). The question is whether conclusions about the financial feasibility of these water transactions would be affected if these lower numbers were used to represent the water that would be obtained for lease and transfer. This could impact the Program's willingness to pay the appraised prices (from Nevada) if the California decree rights are "worth" less when moved to an instream use for delivery to Walker Lake. For the sake of completeness, the benefits are recalculated using the modeled Figures (for decree rights only) from Table 23 of the Task 1 and 2 Report. These are presented along with the recalculated net financial benefits in the two subsequent Tables (Table 5-9 and Table 5-10). The results suggest lower returns for the temporary transactions, but not for the permanent transactions; however, the only result that changed in terms of direction (i.e., goes from positive to negative net benefits) was the partial season lease for alfalfa in Antelope Valley, which, with the lower modeled decree ET figures, became financially unattractive.

Table 5-9. Financial Benefits to Water Right Holders from Water Sales and Leases, Using Modeled Decree ET

Transaction	Price ($/AF)	Decree Water not Consumed (AF/acre) and Available to Sell or Lease		Payments ($/Acre)	
		Antelope Valley	Bridgeport	Antelope Valley	Bridgeport
Permanent Transaction ($/AF)					
Full Season Purchase - Decree	$1,800	3.15	3.40	$5,670	$6,120
Purchase - Storage Water	$1,500				
Single Year Transaction ($/AF/yr)					
Full Season Lease	$108	2.35	1.50	$254	$162
Late Season Lease	$108	0.85	0.55	$92	$59
Early Season Lease	$108	1.00	0.65	$108	$70
Full Season Reduction	$108	1.30	0.40	$86	$32
Storage	$90				

Note: Decree water figures are the midpoints of the respective figures in Table 2-19, except for the temporary full year reduction which are the wet/dry year differentials from Table 2-15 and Table 2-17.

Table 5-10. Net Financial Benefits to Water Right Holders from Water Transactions, Using Modeled Decree ET

Transaction	Payments ($/acre)		Opportunity Costs ($/acre)			Net Benefits ($/acre)		
	Antelope	Bridge-port	Antelope		Bridge-port	Antelope		Bridge-port
			Alfalfa	Pasture	Pasture	Alfalfa	Pasture	Pasture
Permanent Transaction ($/acre)								
Full Season Purchase - Decree	$5,670	$6,120	-$9,499	-$819	-$863	-$3,829	$4,851	$5,257
Purchase - Storage Water	$1,500/AF							
Single Year Transaction ($/acre/yr)								
Full Season Lease	$254	$162	-$844	-$40	-$41	-$590	$214	$121
Late Season Lease	$92	$59	-$244	-$2	$0	-$152	$90	$59
Early Season Lease	$108	$70						
Full Season Reduction	$86	$32						
Storage	$90/AF							

5.4 Regional Economic and Fiscal Impacts

This Section qualitatively outlines the potential impacts of water transactions on the broader economy, defined here as Mono County. In order to provide context for potential changes, we first broadly characterize the Mono County economy and establish the importance of agriculture (and related industry). Next, we discuss the potential impacts local water transaction may have on relevant economic indicators including employment, county government revenues, and the county-level economy.

5.4.1 County Overview

Mono County is a primarily rural county, with 94% of its 3,049 square miles publically owned. In 2011, the total population of the county was just over 14,000. Due to its proximity to Yosemite National Park and other popular outdoor recreational resources, the largest industry both in terms of employment and economic output is the service industry (see Table 5-11). A recent study (US DOI 2013) estimated that the leisure and hospitality sector of the service industry alone accounted for 49% of all employment in the county. Agriculture, while important for other reasons, accounts for only a small proportion of county-level employment and economic output.

Table 5-11. 2010 Mono County Employment and Economic Output by Industry (as cited in US DOI 2013)

Industry Sector	Individuals Employed	% of Total Employment	Economic Output ($m)	% of Total Output
Service	6,493	61.2%	$682	58.8%
Government	2,136	20.1%	$210	18.1%
Trade	938	8.8%	$70	6.0%
Construction	687	6.5%	$99	8.5%
Manufacturing	113	1.1%	$47	4.1%
Transportation/Utilities	110	1.0%	$20	1.7%
Agriculture	105	1.0%	$27	2.3%
Mining	24	0.2%	$4	0.3%
Total	10,606		$1,159	

Another way to describe the importance of an economic sector to the local economy is by using location quotients, which is basic way to describe how closely the local economy, in this case Mono County, structurally compares to the larger economy (i.e., California). Values between 0.75 and 1.25 suggest that the local economy can closely meet local demand, while a value below 0.75 suggests that local demand is greater than what the local economy can supply and imports are likely needed. The converse is true for values above 1.25. The higher/lower the value above/below one, the more the local economy exceeds or fails to meet local demand.

Comparing a select set of Mono County industries to California, the location quotients suggest that accommodation and food services is a major economic base sector, while agriculture, at least with respect to supporting demand, is not.

Table 5-12. Location Quotients

Industry Sector	California	Mono County
Industry total	1.00	1.00
Accommodation and food services	1.00	5.07
Agriculture, forestry, fishing & hunting	2.97	0.00
Public administration	0.98	1.66
Real estate and rental and leasing	1.14	2.77

5.4.2 Fiscal Impacts

With respect to potential fiscal impacts, the three primary ways water transactions have the potential to affect the local economy are through changes in a) local spending by landowners; and b) property development/taxes; and c) recreation/tourism associated with water-related amenities (e.g., Twin Lakes) and the region more generally. We briefly discuss each of these considerations in turn.

In general, there are two types of local spending by landowners that have the potential to be affected – expenditures to support agriculture production (e.g., fuel, machinery, labor) and expenditures resulting from agricultural revenues accrued by landowners (e.g., restaurants, groceries). With respect to the latter, engaging in a water transaction is unlikely to affect overall post-production expenditures, as, at least in theory, a landowner would not engage in a water transaction unless he/she received at least as much revenue from the transaction as he/she would from full water production.

While not analyzed in this study, as it would greatly depend on the location and specifics of each water transaction, one additional expenditure by landowners engaging in permanent (and potentially full-season) water transactions relates to shared maintenance for the irrigation ditch systems in both valleys. For example, while AVMWC user costs vary by ditch and location, users pay, on average, $1/acre plus a $200 administrative fee per year (Hal Curti, personal communication 2014). It could be possible that if a sufficient number of users chose to participate in water transactions, the remaining users might not be able to afford the costs of maintaining the system. Such an analysis may be useful related to individual transactions.

The former consideration is potentially a bit more complex, however, as the choice to engage in any of the water transaction scenarios considered could have the potential to affect production expenditures, particularly a permanent purchase. That being said, Mono County does not appear to have a large number of agriculture supporting industries – minus labor. With the exception of the general store in Bridgeport, personal communication and anecdotal evidence suggests that the majority of agriculture related purchases are made outside the County, often in Nevada, and that diesel is typically trucked up from Sacramento in order to comply with California standards.

The second consideration is property development/taxes. For information on Mono County's General Plan, please see http://monocounty.ca.gov/planning/page/general-plan. With respect to property taxes, Mono County property tax rates are approximately one percent of the assessed per acre value, with slight variations around the County (1.04% to 1.08%) depending on which tax area a property is located (County of Mono 2013). According to the Mono County Assessor (Personal communication 2014), the tax rate is the same for all property in a given tax rate area, regardless of zoning.

In 2012, property taxes brought in revenues of $53.2 million and were used to support a variety of local services (Table 5-13).

Table 5-13. Property Tax Allocations

Service	**% of Total**
Schools (2 districts)	42.2%
County government	30.0%
Town special districts	16.3%
Town – Mammoth Lakes	4.3%
Other special districts	3.7%

In order to better understand the importance of property taxes to the two largest of these services, we researched the contribution of local property taxes to each of their annual budgets. Local property taxes accounted for 82.3% of the 2011-12 budget for Mammoth Unified School District (Mammoth Schools 2012) and the Mono County 2013-14 government relied on property taxes for 25.2% of its total budget.

While full- or partial-season leases are unlikely to result in changes to property zoning or assessed property values, there may be that potential with permanent purchases; however, there are numerous considerations that have the potential to affect that result. Whether this would result in higher or lower taxes would depend on whether the property lost its agricultural deferral (for more information on the Land Conservation (Williamson) Act, please visit www.conservation.ca.gov/dlrp/lca/Pages/Index.aspx) and the basis and rate for the tax calculations. Furthermore, while it might be expected that less value being generated might reduce taxes, experience in other jurisdictions suggests that tax policies are often designed to subsidize agricultural properties and therefore there is typically no decline in tax paid, and the tax paid potentially could even rise.

According to the Mono County Assessor (Personal communication 2014), irrigated agriculture land is generally zoned agriculture and the maximum density requirements vary depending on the location of the property. With respect to permanent water transactions, if agricultural land, particularly land in pasture, were to no longer be irrigated, the land would likely revert back to high desert sage and scrub brush.

With regards to rezoning of irrigated agriculture land with a permanent water transaction, it appears that land would unlikely be rezoned anything other than agriculture land without a request by the owner for such a change. According to the Mono County Assessor (Personal communication 2014), agricultural land, in general, even when under Williamson Act contracts (i.e., agricultural deferral status), has a higher value than open space land, because of the additional allowable uses. One example is sub-divisions of parcels. Currently, if a property is zoned agricultural, minimum lot sizes generally range from 2.5 to 10 acres, depending on the community, whereas property zoned open space has an 80-acre minimum requirement (Personal Communication 2014). As non-irrigated land would most likely be rezoned open space, which would likely have a negative impact on the property use and value, it is unlikely that any owner would petition for rezoning.

If the owner/developer were looking to develop/subdivide the land in a way different than what is currently allowed, a request would again need to be made for a zoning change, with the planning commission and possibility the Board of Supervisors decided on whether or not to grant the change. (Personal communication 2014).

Of importance is the fact that the rights to subdivide mentioned above for agricultural land are the status quo– so conversion from agricultural to open space status would actually reduce the risk of denser development. Furthermore, while concern has been expressed about additional development of lands transitioning from irrigated to non-irrigated under water transactions, the Mono County Assessor notes “there is virtually no demand for additional development in Mono County at this time” (Personal Communication 2014).

Given the discussion above, it appears that there is incentive for the landowners and the county to maintain the status quo for properties that either continue dryland agriculture or revert back to high desert.

While not considered here, an additional potential impact on property values (and the associated taxes) related to the general aesthetics of the region. Above we discussed the potential impacts to property where water use changes may occur, but it is possible that such changes (i.e., the transition from irrigated landscape to high desert sage and scrub brush landscape) could also have an impact on neighboring property values.

Lastly, we qualitatively consider the potential impact of water transactions on recreation/tourism in the area, as the supporting services currently are the largest industry in Mono County, both in terms of employment and output. A study by Lauren Schlau Consulting (2009) estimated 2008 direct visitor spending in Mono County to be $369.5 million, with an additional $147.8 million in associated indirect spending (using a multiplier of 1.4 for the Mono County tourism industry). In addition, the study estimated Mono County 2008 tax revenues associated with direct visitor spending on lodging and retail to be $16.6 million, with lodging account for 91% of total tax revenue (i.e., $15.1 million).

First, with regards to potential impacts, it is generally believed that the majority of local water-related activities (e.g., fishing, boating, camping/hiking) could benefit indirectly as a result of increased instream flow associated with water transactions; however, the degree to which such indirect benefits may result in changes to recreational use patterns and/or associated local spending was outside the scope of this analysis. One caveat to assumption that the direction of impacts would generally be positive relates to recreational activities occurring on small reservoirs (e.g., Twin Lakes), as there is concern that water transactions could result in decreased water levels in these reservoirs because of early recreation season releases for the benefit of Walker Lake.

We were able to identify eight properties near Twin Lakes that include lodging and/or other recreational support services. Of these, four were Forest Service campgrounds (63 sites total), only two of which charge site fees. Of the other four properties, three have both camping and other lodging (e.g., cabins, motel, resort), while one only has campsites. In total, these four properties have over 350 camping sites and an estimated 50 lodging units of various types. Twin Lakes Resort and Annett's Mono Village also have rentals, general stores and boat storage/marina.

Lauren Schlau Consulting (2009) estimated that in 2008 there were 8,632 total lodging units in 132 properties, with the eight identified properties near Twin Lakes making up less than one percent of the total. This suggests that while changes to lake levels potentially may have impacts on specific businesses such as nearby campground and resorts, the overall impact on the local economy is unlikely to be significant.

More important is that it is likely that any leasing of storage water for delivery downstream to Nevada could be structured as releases at the end of the irrigation season (i.e., in October). The impact of such releases so late in the season likely would be limited in terms of their consequences for the Twin Lakes.

The other potential impact on tourism relates to a change in the general landscape and aesthetics of Antelope and Bridgeport Valleys (e.g., conversion from meadow/pasture to sagebrush) resulting from water transactions. A 2008 study included the following findings that, in addition to the key role of the tourism industry in Mono County, may be of particular relevance to a potential change in the general appearance of the landscape:

- Three of the four primary reasons mentioned for visiting Mono County were for "leisure": vacation/pleasure/to visit (39%); outdoor recreation (29%); and sightseeing/exploring (10%);
- Sixty-five percent of all visitors cited Mono County as their main destination (as opposed to simply passing through on a visit to another location);
- Of all the activities participated in, sightseeing/exploring was the most popular, with 77% of all visitors stating they had done so;
- When asked about their satisfaction with their visit, and, more specifically, the reason for their satisfaction the most popular response was Mono County's "scenic beauty/beautiful area". (LSC 2009)

While by no means conclusive, as the importance of landscape appearance was not specifically addressed, the findings of that study suggest that Mono County is a destination location for many visitors and that those visitors come, in large part, due to the scenic landscape.

5.5 Impacts – Multiplier Effects

The direct effect of an industry is not the only impact that industry has on the economy – frequently creating additional multiplier affects across the broader economy in the form of employment, labor income, and value added.

When considering the broader effect of changes in economic activity, input-output analysis can be used to model the interrelationships of economic sectors and describe the multiplier effect of changes in one sector across a broader economy. While this methodology is commonly used to estimate the impact of a program or initiative that would result in new money entering an economy, it can also be used to understand how decreases in revenue and/or jobs in one industry sector might affect the larger economy.

IMPLAN is perhaps the most commonly recognized input-output model; however, it is proprietary software whose purchase was outside the scope of this study. In order to better understand generally the additional multiplier effects of agriculture in Mono County, we obtained relevant multiplier values from other recent studies in the area.

A recent study by the University of California Agricultural Issues Center (2009) on the value of California agriculture included economic multipliers for agriculture-related industries, with 2002 multipliers of 1.86 and 7.30 for general agriculture and beef/dairy cattle, respectively. A study of agriculture of Lyon County, Nevada used 2004 multipliers of 1.38 and 1.72 for general agriculture and cattle ranching/ farming, respectively (Harris, 2007). A similar study of Douglas County, Nevada used a 2007 multiplier of 1.43 for the agricultural sector (Yolyan, Fadali & Harris 2009).

Given a) the “leaky” nature of county-level economics in general; b) evidence that many agricultural purchases and subsequent income expenditures by ranchers/farmers are done outside Mono County; and c) the assumption that farmers/ranchers would still be compensated if participating in a water transaction, it suggests that changes to the County-level economy are unlikely to be substantial, as are any multiplier effects.

6 ADDITIONAL SUPPORT FOR LANDOWNERS INTERESTED/INVOLVED IN WATER TRANSACTIONS

6.1 Landowner Interest

Upon recommendation from the RCD, the Team did not conduct formal interviews with multiple landowners, but did speak at one public meeting of the Antelope Valley Mutual Water Company, received tours of both Valleys from select landowners, and engaged in multiple conversations with a variety of landowners. As might be expected, there is a range of interest levels and concerns about the possibility of an active water transactions program in Mono County's Walker Basin. The range of opinions voiced include:

- The efforts to restore Walker Lake are misplaced and will inevitably fail.
- Selling agricultural water is inherently a mistake, damaging to the community, and should not be done at any price.
- Landowners should be allowed to sell "excess" water, but those sales should not be tied to requirements for lessening water application to specific ground.
- Short-term leases would be acceptable at the right price, but permanent sales of water would be a mistake.
- For the right price, any short term or permanent water transaction should be considered.

Additionally, it is important to note that some felt it incorrect that water sales were ongoing in Nevada while California landowners were restricted from participation; that the agreement clause stating that no funds could be used in California is illegally limiting their personal rights. At the same time, a few expressed relief that California landowners were not included in the current program, and inclusion would result in a few people profiting from water sales to the detriment of the overall communities.

While not a statistical result from formal interviews, the general impression from interactions with landowners was that the majority of people would like to be allowed the option of participating in water transactions, and some of those people would be interested in leasing a portion of their water rights for the right price, provided there was limited impact on their overall operations. There was very guarded interest expressed in permanent dedication of water rights instream.

These initial concerns are quite common in the realm of agricultural water transactions. If a program moves forward, initial participation might be expected to be limited. Primary interest may be from organized irrigation groups who would have more flexibility with their water management, as well as holders of storage water rights who may be able to enter into deals without contractual obligation to dry up part of their properties. However, experience has shown that participation in water transaction programs tends to increase each year as landowners observe that payments are made and agricultural operations stay viable even with decreased water use. Except in select cases, initial transactions are often limited to short-term (one to five year) agreements. Longer term leases and permanent water acquisitions often come only after short-term leases give landowners the opportunity to learn if and how their individual operations are sustainable with less water.

It is important to note that the Team also encountered concerns from water users downstream from the project area. Downstream users fear that water transactions on the California side would result in more water being protected instream than was actually saved; return flows from California that normally contribute to their water supply would now be considered protected instream, thus diminishing the amount of water they would normally receive and cause injury. Water transactions should only include consumptive use water savings, and all formal transactions require review to assure that there is no injury to other users. The transaction process is intended to guard against downstream injury, but it would be beneficial to landowners participating in California to openly engage the Federal Water Master early in any transaction process to address concerns about potential injury.

6.2 Agricultural Management Changes

Most water transactions will result in decreased irrigation to specific acres, which will reduce productivity; however, there may be other complementary changes in land, livestock, or crop management that could maintain productivity at higher levels than expected. The goal for any landowner participating in a water transaction program should be to reach maximum productivity with minimum water use. The following list is not exhaustive and does not provide explicit details on where and how to implement these changes, but is intended as a general overview to realize that reduced irrigation can be coupled with other management changes to buffer impacts to productivity. Options depend on location, individual operations, and landowner goals.

6.2.1 Cattle Management

One of the most effective approaches to maintain higher stocking rates is to implement a rotational grazing program. While there are more extreme Managed Rotational Intensive Grazing strategies such as those advocated as a tool by the Savory Institute, even a basic program that allows fields a period of rest between grazing intervals will result in a stronger root system, more resilient plants, fewer weeds, and less bare ground. This may require dividing the pasture up into smaller fields and developing new water sources for the additional fields. There is likely technical and financial support available to landowners through NRCS or other avenues to support a change in grazing patterns to protect soil health and reduce water use.

Many of the cattle operations in the area of interest run cow/calf pairs. Pairs tend to be more difficult to manage on a dryland operation as they are generally scheduled by the calendar, and need to stay late into the fall until winter ground is ready. September, October, and November on a dryland or reduced irrigation pasture will likely have limited feed. Other cattle classes, such as lightweight yearlings, can often be transported off the pasture when they reach a target weight. Yearlings could stop grazing in August or September, which is more compatible with a reduced irrigation operation. It may not always be feasible to change the class of cattle raised, especially if the landowner runs their own herd. Operations that lease ground out might be in the best position to move away from cow/calf pairs.

A system akin to “grass banking” could develop working cooperatively with other ranchers in the valley. A cooperation of landowners can determine their livestock and pasture needs, and determine how to share their resources to meet all needs. Different operations will have different abilities to reduce stocking rates. If a landowner wants to participate in a water transaction, but it would be difficult to reduce stocking rates, perhaps other landowners could reduce their stocking rates more and make ground available (for rent) to neighbors. Or someone who normally leases ground to an out-of-town operation may choose to instead lease pasture to neighbors involved in a water transaction. This approach may be especially useful to several landowners who have relatively small properties but would like to implement a rotational grazing strategy to maintain their stocking rates; it is easier to implement rotational grazing on larger properties.

There has been much research done on seeding pastures with dryland forage species. This is a real option if landowners enter into long term or permanent agreements to dedicate irrigation water instream, but would still like to continue grazing. Conditions in both the Antelope and Bridgeport valleys would be favorable to support dryland forage species. There would be cost involved with preparing the pastures and seeding, and care should be taken to determine an appropriate seed mixture and planting method. NRCS and University of Nevada Cooperative Extension can provide technical expertise to help with those decisions. Additionally, there may be financial support through NRCS programs or other avenues to offset the cost of seeding if it is intended to reduce water use.

6.2.2 Alfalfa Production

Alfalfa is well recognized as an ideal crop for water-stressed conditions. It is one of the most water efficient crops when looking at the amount produced per unit of water used. It is perennial, can develop deep roots, and has high yields. There are a variety of different alfalfa cultivars. Cultivars with a higher dormancy rating can generally withstand weeks of drought conditions without damage to the stand. There are also varieties that were developed specifically for full dryland production. Depending on the cultivar in place, landowners may have the ability to improve production or at least minimize production loss when transitioning to reduced irrigation. There is a range of varieties that would likely be appropriate for shorter irrigation seasons that end in mid-summer. Such cultivars could still provide two full cuttings. Producers interested in participating in water transactions should explore alternate alfalfa cultivars when it is time to replant their stand. There may be technical and financial support through NRCS or other outlets to support reseeding with more tolerant cultivars, if the cultivar change was made to complement a reduction in water use.

Changes in irrigation methods are often recommend as an approach to water savings, normally a progression from flood irrigation to gated pipe, pivot, or wheel lines. As discussed in Section 7.4, this could be a standalone water transaction provided there is measurable water savings and the conserved water is dedicated instream under California water law; however, it could also complement a partial season water lease or sale by providing more efficient use and better coverage at the time of irrigation. A partial season water lease or sale may even be combined with a conserved water sale to increase the amount or water sold for instream flow. Conversion to wheel line or pivot may involve significant land preparation, adjustments of water delivery systems, purchase, assembly and maintenance of equipment, and the additional labor that may come with running the new system. There are programs to support all or a share of the cost of irrigation conversion.

A more extreme adaptation would be to change the current land use. This is very dependent on location and interest of the individual producer. Alfalfa could be replaced with a short season high cash vegetable crop, or used as pasture instead. If a producer were interested in a long-term or permanent transition to full dryland, pasture would be more compatible with an extreme reduction in irrigation.

6.3 Existing Programs to Offer Additional Financial / Technical Support

There are a myriad of avenues for landowners to receive technical and financial support related to conservation-based management changes on their property. These programs, in addition to water transaction agreements, may help to offset costs related to productivity and management changes under reduced irrigation. Multiple programs or approaches can be bundled together to enable landowners to make changes they would like to see their property and offset some of the costs of those changes. The following list is not exhaustive and does not provide explicit details, but is intended to serve as a general introduction to the type of programs available. Applicability of each program depends on the individual operations, locations, landowner goals, and program eligibility.

6.3.1 Farm Bill

The Agricultural Act of 2014 (Farm Bill) provides a clear source of both financial and technical assistance. Most support is provided through NRCS or the Farm Service Agency (FSA). NRCS is currently very active in the area, and many landowners are already registered with FSA and have contracted with NRCS. The following is a list of programs that are generally available in the areas of interest, although each one has its own set of priorities and eligibility requirements. Producers should contact NRCS directly to explore opportunities for their individual operations. This report does not include specific lists of approved practices and costs, as they often vary from year to year. Some programs are based on direct individual contracts, while others require a cooperative approach between landowners or involvement of a third-party organization.

The primary program that delivers direct contracts to producers to support management changes is the **Environmental Quality Incentives Program** (EQIP), which is an umbrella program that covers a variety of initiatives. EQIP payments generally provide a portion of the costs of specific approved practices. Applications to EQIP are ranked against each other, with those applications that clearly meet more or higher EQIP priorities receiving higher ranking. There are a variety of initiatives at the local, state, regional, and national levels. Producers should contact the NRCS field office in Minden to determine what specific resource concerns are of high priority at the time they are applying. Initiatives currently support activities that address water conservation, water quality, soil erosion, soil condition, air quality, energy use, and habitat conditions.

The first step in working with EQIP is to develop a **Conservation Activity Plan** (CAP). NRCS supports a Technical Service Provider to work with the landowner to produce a CAP for their property. These plans are specific to certain kinds of land use including grazing or hay, or can also address a specific resource need such as water use management or water quality concerns. Once a CAP plan is developed, producers can then apply for financial assistance to implement the needed conservation practices.

The **Conservation Stewardship Program** (CSP) is an NRCS program that supports the adoption of new conservation practices or maintenance of existing practices. NRCS enters into five-year contracts directly with individual producers and makes payments for specific practices that address soil quality, water quality, water quantity, air quality, habitat quality, and energy concerns. Participants earn CSP payments for conservation performance. CSP could be coupled with long term or permanent water transactions as additional support during the transition period and to allow for other complementary changes to the operation.

The **Working Lands for Wildlife** (WLFW) program is a joint effort between NRCS and the US Fish & Wildlife Service (USFWS) to encourage landowners to implement practices that benefit specific wildlife species. One of the target species is the greater sage-grouse, of which the entire area of interest for this study is currently proposed critical habitat. The program provides technical and financial support for landowners to voluntarily implement specific conservation practices for select species while continuing to manage the habitat as working lands. WLFW participation also provides some regulatory predictability under the ESA. While there is some concern about the impact of reduced irrigation on greater sage-grouse habitat, working with the WLFW program may assist in assuring that greater sage-grouse concerns are addressed and will not impede water transactions.

The **Agricultural Conservation Easement Program** (ACEP) includes easements focused on wetland, grassland, and farm and ranch protection. It provides financial and technical assistance to conserve agricultural lands and wetlands. Landowners can receive payment for land taken out of production for habitat protection, or for release of development and other non-agricultural rights on agricultural land. Easements to protect agricultural land under the Farm and Ranch Protection Program are normally permanent and are implemented through partnering organizations that actually administer the easements. Wetland Reserve easements are contracted directly between NRCS and the producer, and include a 30-year options as well as permanent agreements.

The **Regional Conservation Partnership Program** (RCPP) is an NRCS program that supports partners to work with producers to increase the restoration and sustainable use of soil, water, wildlife, and related natural resources in select areas. RCPP is an opportunity for an organized group of landowners or irrigation districts, state or local government groups, non-governmental organizations, educational institutions or other organized group to apply to NRCS to make the Mono County portion of the basin one of the focal areas for the program. This approach could be made based on water conservation for Walker Lake, water quality, greater sage-grouse habitat concerns, a mix of the above, or other resource concern. This would then bring additional funding through NRCS and help leverage other funding to address management changes that landowners would want to undertake to assist in the conversion to reduced or no irrigation.

Conservation Innovation Grants (CIG) are another opportunity for an organized governmental or non-governmental group to bring funds to the region. The CIG program intends to support new technologies or approaches to address natural resource concerns, while hopefully benefitting agricultural producers. CIG grants have gone towards approaches as varied as irrigation software to animal waste recapture to public-private partnerships to advance irrigation reduction. If there are innovative ideas related to making the transition to reduced irrigation or dryland production easier for landowners, it might be a candidate for a CIG grant.

6.3.2 Conservation Easements

In addition to the conservation easement programs offered through NRCS (as described above), there may be other options to design and fund easements on agricultural property, both to protect agricultural values and/or habitat values. In certain cases such easements may be implemented alongside water transactions. The income from these easements may offset economic impacts from reduced irrigation, and provide income from and protect values of land that may have only marginal agricultural value without irrigation. There is a range of public and private sources of funding that may go toward such easements. Primary groups facilitating easements in the area of interest include the Eastern Sierra Land Trust (ESLT) and Sierra Nevada Conservancy (SNC).

The compatibility of water transactions with conservation easements is very situation-specific. For landowners who already have easements in place, eligibility for a water transaction depends on the existing easement. Some easements specifically include or exclude water rights from the rights governed by the easement. Others may not specifically clarify the ownership of the water rights, but the intent and goals of the easement may still depend on water rights. For instance, many easements focused on protecting agricultural values require that the land stay in agricultural production. Thus, in order to lease or sell water the property would still need to remain productive under no or reduced irrigation. However, the easement holder may still consider dryland agriculture as unacceptable, as it may reduce the chance that production will remain viable on the property into the future under different ownership; or excessively limit the range of agricultural uses possible on the land. If the easement language is not explicit, there may be a difference in interpretation between the landowner and the easement holder as to what would or would not be legal under easement restrictions.

For many easements, landowners may argue that “excess water” would be available for lease or transfer. This “excess” water would be the water above what is necessary to meet the goals of the easement. For example, the easement holder may determine that partial season irrigation is sufficient to maintain the agricultural values protected by the easement, and thus the landowner might enter into a partial season lease or sale, where late-season water is left instream. Or if the easement is not specific to agriculture and is in place only to limit development on a parcel, then perhaps the full water rights might still be available for lease or sale.

It is important to note, however, that water buyers generally only consider water rights that have been actively used for irrigation eligible for lease or purchase. Most water transactions are based on consumptive use savings, not the paper value of water rights. Oftentimes landowners express an interest in selling water rights that they are not using – either not irrigating their full property, or irrigating their complete property using less than their full water rights. Water rights are obviously not eligible for lease or sale if they are subject to abandonment or forfeiture. If valid water rights have not been regularly exercised, it may be difficult to determine the amount of "new" wet water added to the system, or the potential benefit of denied future diversions. While every situation is unique and individual transactions can be creatively structured, the majority of transactions only involve active irrigation water, usually coupled with a reduction in irrigation.

Another potentially ambiguous concern is who receives payment for the water from a property enrolled in a conservation easement. If the easement contract clearly defines that the water rights were transferred to the easement holder, then the transaction would be between the buyer and the easement holder. However, the right of the landowner to approve or disapprove a water sale may differ depending on the contract. If the rights are still clearly held by the landowner, then the landowner could enter into the transaction, provided it did not go against the intent of the easement contract. If it is unclear who holds the water rights, or if rights are split between the easement holder (the amount needed to meet the easement purpose) and the landowner (anything above the amount needed to meet the easement purpose), then that split needs to be determined. Another option besides payment is for the water rights to be donated instream. For an easement holder, it might complement the organization's mission involving habitat restoration. For the landowner, they may enjoy tax benefits from the donation. While the IRS has not issued an official ruling recognizing the value of water right donations, it has been recognized in the past.

Aside from the specific details of each contract, easement holders will likely consider if the overall idea of water transactions fit with their general goals. Some organizations that are focused on agricultural protection might question if selling any irrigation water would be contrary to their mission. There is also the question of selling water rights across state lines – state or local groups may question if water should be kept available for use in California. There are no clear answers to these questions; it is a judgment call to be made by the easement holder.

It is clear that water transactions are becoming an accepted part of the landscape across the west. As such, easement holders in Mono County and elsewhere should clearly incorporate water rights into any new easement contract, clarifying who holds the rights and any required future uses or limitations on the rights.

6.3.3 Restoration Grants

It is clear that there are key habitat values throughout the area of interest, from prize streams to wetlands to meadows and forest. Landowners interested in addressing habitat concerns on their properties have a host of options to turn to for technical and financial assistance. From federal agencies such as the USFWS and US Environmental Protection Agency, to state programs through California Departments of Fish and Wildlife or Water Resources or the Sierra Nevada Conservancy, to local guidance such as the Inyo-Mono Integrated Regional Water Management Program, to private foundations including the National Fish and Wildlife Foundation, opportunities are far too numerous and varied to include in this report. However, it is important to note that participation in water transactions, demonstrating that landowners are concerned with reducing water use, often makes their land more competitive for restoration grants. Restoration activities are often complementary to production goals, and could be another form of support in the transition to a reduced irrigation operation. Application for assistance could be made by a single producer or by an organization on behalf of multiple producers.

An organized group could also apply based on general restoration goals, such as stream corridors or meadows or erosion, which could benefit multiple producers. USFWS is currently dedicating significantly increased resources to address greater sage-grouse concerns in the region. A large portion of this finding will be through the Partners for Fish and Wildlife program, and is intended to be used for voluntary greater sage-grouse restoration on private land. Participating in greater sage-grouse habitat projects would not only improve habitat, but could help assure a reasonable level or regulatory protection related to the ESA, as well as balance concerns related to decreased irrigation harming greater sage-grouse habitat.

6.4 Other Water Transaction Options

While this analysis chose to focus on the five transaction scenarios described for modeling purposes, there are a host of other transaction options that may be beneficial in the area of interest. These options would likely be of interest to the Walker Basin Restoration Program if they resulted in protecting additional water instream. Even if they do not all fit the goals of the Walker Basin Restoration Program, there are opportunities to find funding from other sources to complete transactions. The management changes described below result in some benefit, either providing water or protecting habitat, so are valid and of interest for water transactions. Most would only apply in specific locations.

1. Change in point of diversion in order to:

    - Decrease delivery losses. In some cases water travels a long distance between point of diversion and place of use, which may result in significant water loss. If a change in point of diversion or water source could reduce delivery losses, water conserved may be protected instream under California water law. Payments could be made for the new water protected instream.
    - Increase stream flow in a critical stream reach. There are some stream reaches that are dewatered or become flow limited for habitat purposes due to irrigation diversions. If one or more irrigators upstream of that sensitive reach had the ability to change the point of diversion to a less sensitive reach it could greatly improve habitat conditions. While this may not result in consumptive use water savings, payments have been made for the increased stream flow in the critical reach.

2. Improve efficiency at the diversion point, in conveyance to the irrigation location, or on-field. Increasing efficiency at any point of the irrigation process may result in conserved water that could be protected instream under California Water Law. This could be done by updating the diversion structures; lining or piping open ditches as they pass through areas that are not dependent on sub-irrigation from the ditch; or converting from open flood irrigation to gated pipe or sprinkler systems. Payments could be made for the new water protected instream. The conserved water could likely be protected instream in Nevada as well, provided the Decree Court approved the change to the Decree Rights.

3. Minimum flow agreements. In these agreements irrigators agree to not divert after streamflow reaches a specified low flow level. Irrigators will assure that the minimum flow agreed upon always remains instream. This approach is useful in areas that regularly run dry or low, limiting habitat values of connectivity. Payments are sometimes set by calculations of water that would normally be diverted, or is a set negotiated annual amount, or are only made when the minimum flow is reached and irrigators cease or limit diversions.

4. Rotational sharing. Multiple water users on the same system could coordinate their irrigation practices in a way that would either use less water, or divert less water at any one time. For

example, if irrigation sets were normally set at the same time they could instead stagger them, so that only one user was diverting at any one time. This could assure that there was more water flowing instream. While payments have been made for such agreements on their own based on increases in instream flow, it is likely a better tool to complement a minimum flow agreement.

5. A change in crop type between pasture / alfalfa / hay / or other crops. While this would be a significant adjustment for landowners, there is a difference in water consumption among land uses (depending on specific management choices), and it may be a way to increase economic profits. Payments can be made for the conserved water dedicated instream.

6. Instream flow water right donations. While still in the early stages, there is increasing interest in tax deductions given for water right donations. In some cases the IRS has allowed the value of such donations to be deducted for tax purposes, but as of yet there is no legal Revenue Ruling on the process or value calculation that will be acceptable to the IRS. Such a ruling is expected within the next year or two. If passed, it may be the case that for some water right holders a tax deductible donation instream donation may be of great interest.

7. Water trading or water banking. The Walker Basin Restoration Program has not established a banking approach to water transactions in the Walker Basin, although they or other organizations (including irrigator groups) could if it was deemed a useful tool in the restoration effort. In simple terms it is when one water user buys an irrigation right from another water user. It can be a complex process, especially across state borders or if there is a mix of groundwater and surface water. Such an approach would require full approval from the Decree Court, and likely the California Water Resources Control Board and Nevada State Engineer.

7 LEGAL FRAMEWORK FOR TRANSFERS OF WATER RIGHTS

7.1 Overarching Considerations

The greatest legal obstacles that the proposed water transfers program may confront can be narrowed to essentially three related issues: time for regulatory and court approvals, transaction costs to secure those approvals and the no-injury rule. Additionally, the interstate nature of the proposed transfers adds an additional layer of legal complexity.

As will be discussed, the Decree Court has jurisdiction over changes to decree water rights. The Court may also request recommendation from both state water agencies. As such, if the Decree Court's approval is required, there may be an extended time period before the transaction is finalized. Aside from the simple cost of the actual water, there are often high (50–100%) transaction costs related to research, legal fees, and permitting to complete a transaction. Those fees are often borne by the purchasing party, but there are instances where the seller is asked to contribute to select costs.

In addition to potential impacts on fish and wildlife, the critical issue that the reviewing agency and the Decree Court will analyze when presented with a request to change a California irrigation right to an in-stream flow purpose is whether the proposed change will injure other water users. To avoid injury, only the consumptive use portion of a water right will be approved for an in-stream flow dedication. Since the approval of any change will likely turn on the calculation of consumptive use, the agency and court proceedings will likely be focused on competing expert testimony on that issue.

For the purposes of this report, we have addressed the legal issues that should be considered for the use of California irrigation rights for in-stream purposes so that they will reach WRID's Topaz and Bridgeport Reservoirs. In the event that an in-stream dedication would be approved by the Decree Court and the decree is modified accordingly, we would anticipate that the in-stream flow dedication would be protected into Nevada under the authority of the Decree Court. As directed by RCD, we have not addressed in detail the appropriate contractual or legal mechanism by which such water would pass through WRID's reservoirs into Nevada.

7.2 Nature of the Water Rights

All of the California rights that are currently being exercised on the Walker River are what are known as "pre-1914 rights," meaning that the water was appropriated and put to beneficial use before enactment of California's water code. Generally, such pre-1914 rights are not subject to California regulatory requirements, including the filing of change petitions. Nevertheless, on the Walker River, the California Water Board serves in the role of Special Master to the Decree Court, and any petitions to change the place of use, manner of use or point of diversion or to dedicate water for in-stream purposes in California must be filed in the manner directed by the Water Board. To the extent the proposed place of use is solely Nevada, however, the Decree Court may have exclusive jurisdiction over such change petitions.

This unique regulatory scheme is without precedent and gives rise to many questions as to how the proposed water transfers contemplated by this project will be treated by the Decree Court and/or the Water Board. Some guidance is provided by the Water Board's February 21, 2014 Order Approving Temporary Changes sought by the Walker River Irrigation District. Specifically, to implement the Stored Water Program contemplated by its agreement with NFWF, WRID sought to change the place of use of some of the water rights stored in Topaz and Bridgeport Reservoirs to reaches of the East and West Walker Rivers in California and Nevada, in addition to Walker Lake. In approving WRID's petitions, the Water Board indicated that it processed the petitions in accordance with the Decree Court's Administrative Rules and Regulations, in addition to "applicable California law." *Id.* at p.2.

This report describes the legal framework that governs transfers of California Walker River water rights, analyzes possible transfer scenarios and identifies legal positions that may be advanced in support of those transfers, but does not attempt to predict the outcome of any proposed transfer.

7.3 Guiding Documents

7.3.1 Walker River Decree

The Walker River Decree, as amended on April 25, 1940, is the underlying guiding document for water transfers on the Walker River. For the purposes of the water transfers contemplated in this feasibility study for RCD, the following provisions (in the order in which they appear in the Decree) are pertinent:

1. Rotation of Water Without Injury:

“Nothing herein shall affect the right of any of the parties hereto to rotate the use of water, or to combine or exchange the use thereof, so far as they may do so without injuriously affecting the rights of any of the other parties hereto, and the Water Master, hereinafter mentioned, may permit the said parties to rotate the use of said water or to combine or exchange the use thereof, having due regard to the priorities herein fixed, so far as the same may be done without injuriously affecting the rights of the other parties to this suit.” (Par. XIII).

2. Decree Court Maintains Regulatory Authority Over Change Petitions:

“The Court retains jurisdiction of this cause for the purpose of changing the duty of water or for correcting or modifying this decree; also for regulatory purposes, including a change of the place of use of any water user . . . The Court shall hereafter make such regulations as to notice and form or substance of any applications for change or modification of this decree, or for change of place or manner of use of water as it may deem necessary.” (Par. XIV).

3. Length of Irrigation Season:

The irrigation season extends from March 1 until October 31 each year, except in Bridgeport Valley on the East Walker and at all points above the Coleville Gauging Station on the West Walker, where the irrigation season runs from March 1 to September 15 each year. (Par. XVI, page 75, as amended on p.3 of Amended Decree).

4. Storage in California Reservoirs:

In addition to describing the amount of each direct diversion right, the Decree provides for storage and refill rights in Lower and Upper Twin Lakes, Poore Lake and Black Reservoir and storage rights in East Lake, West Lake and Green Lake. (Pages 52-60 of Document Number 458660 recorded in the records of the Lyon County Recorder). The Decree describes the lands to which the stored water is to be applied and provides: “All of the above stored water is to be used upon the lands above described.” *Id.*

7.3.2 Administrative Rules and Regulations

The United States Board of Water Commissioners issued a document entitled “Administrative Rules and Regulations Regarding Change of Point of Diversion, Manner of Use or Place of Use of Water of the Walker River and its Tributaries and Regarding Compliance with California Fish and Game Code Section 5937 and Other Provisions of California Law, as amended through June 3, 1996 (“Administrative Regulations”). The following provisions are pertinent:

1. **Changes to Water Rights:**

Section 3.1: "Applicants within the State of Nevada shall file a change application with the State Engineer on such forms and in such manner as required by that office."

Section 3.2: "Applicants within the State of California shall file a change application with the Water Resources Control Board on such forms and in such manner as required by that office."

Section 6.1: "The responsible agency shall approve or reject a change application . . . within one (1) year after the date of initial filing, except that the decision may be postponed for an additional time period not to exceed two (2) additional years upon written authorization by the applicant, or in the case of a contested application, where the applicant, protestant, as well as any intervener(s) jointly agree to an extension."

2. **Review of Agency Decisions:**

Section 7.1: "All agency decisions, orders or reports shall be submitted to the Court in the Walker River Action. Any party to an agency administrative proceeding shall be entitled to petition for judicial review thereof in the Walker River Action. Any other entity or individual not a party to the agency proceedings may seek judicial review of the agency decision upon a showing of good cause as to why such entity or individual was not a party to the agency proceedings. With respect to persons who participated in the agency proceedings, the Court shall not consider new or different objections or arguments, without a showing of good cause for failure of that person to present such objections or arguments in the agency proceeding."

Section 7.2: "Proceedings for approval of modifications of the Walker River Decree in accordance with the decision or report of the agency regarding change applications, or for judicial review of any such agency decision or report, may be instituted by the filing of a petition in the Walker River Action by any party to the agency proceedings or upon petition by the agency. . ."

Section 7.5: "The decision or report of the agency regarding a change application shall not take effect unless and until the court having jurisdiction over the Walker River Action finally approves it and enters an order modifying the Walker River Decree accordingly. . ."

Section 7.7: "If before the date set for hearing, application is made to the court for leave to present additional evidence, and it is shown to the satisfaction of the court that additional evidence is material and that there was good cause for failure to present it in the proceeding before the agency, the court may receive additional evidence. The court shall receive such additional evidence in such manner and form as it deems appropriate."

Section 7.8: "The review shall be conducted by the court without a jury. In its review, the court shall consider the administrative record, any additional evidence received by the court, written briefs, and, where deemed appropriate by the court, oral argument. In cases of alleged irregularities in procedure before the agency, not shown in the record, proof thereon may be taken in court."

Section 7.9: "The Court shall conduct a de novo review of all agency decisions regarding change applications which recommend modification of the Walker River Decree, irrespective of whether any party files a formal request for judicial review. Except as set forth in Article VIII, the court may affirm the decision or approve the report of the agency or remand the case for further proceedings. The court may reverse or modify the decision if said decision would impair existing rights under the Walker River Decree, adversely impact some public interest or prejudice substantial rights of the petitioner. Substantial rights of the petitioner may be prejudiced where the administrative findings, inferences, and/or conclusions are:

> (a) Made upon unlawful procedure;
>
> (b) Affected by other error of law;
>
> (c) Erroneous in view of the reliable, probative and substantial evidence on the whole record; or
>
> (d) Arbitrary or capricious or characterized by abuse of discretion or clearly unwarranted exercise of discretion."

> Section 7.10: "In reviewing any report of the Water Resources Control Board, the court in the Walker River Action shall not be limited by the 'clearly erroneous' standard prescribed by Fed.R.Civ.P. 53(e)(2). In the event that no objections are filed to a petition for approval and judicial review of an agency decision or report, the court in the Walker River Action may, in its discretion, accept the agency decision or report regarding a change application without further proceedings."

In addition to these pertinent Sections, the Rules and Regulations set forth a timeline in which the described agency proceedings are to occur following the filing of a change petition/application with the appropriate agency:

Table 7-1. Timeframe of Proceedings for a Change Petition / Application

Activity	Time Frame	Legal Source for Time Frame
Agency's notice of change application	90 days after completed application filed. Published five times in four consecutive weeks	Decree Court Rules and Regs Section 4.1
Filing of proof that notice has been given	30 days after final date of publication of last published notice	Decree Court Rules and Regs Section 4.4
Agency issuance of decision	Within one (1) year after date of initial filing. May postpone for up to additional two (2) years	Decree Court Rules and Regs Section 6.1
Applicant's/petitioner's petition for judicial review to Decree Court	Within 45 days after agency decision is filed or 45 days after decision on rehearing	Decree Court Rules and Regs Section 7.2
Transmittal of administrative record to Decree Court	Within 30 days after service of petition (can be extended by court)	Decree Court Rules and Regs Section 7.6

7.3.3 Order Appointing California as Special Master

On April 9, 1990, the Decree Court entered an order appointing the California Water Board as Special Master. The following provisions are applicable:

> **2.** "The Special Master shall submit a report to this court for each change application, in the form and manner and pursuant to the procedure hereinafter provided, on any and all changes proposed in point of diversion, manner of use, or place of use, in exercise of those rights to the use of waters of the Walker River and its tributaries **within the State**

of California established by the final decree in this action and any decree supplementary thereto (emphasis added)."

4. "In processing all applications to change the point of diversion, manner of use or place of use ('change application'), the Special Master shall follow and require applicants to follow the Administrative Rules and Regulations Regarding Change of Point of Diversion, Manner of Use or Place of Use of Water of the Walker River and Its Tributaries (the 'Administrative Rules and Regulations')."

5. "The Special Master may hold any hearings and conduct any investigations in any part of the State of California or the State of Nevada necessary to carry out its duties pursuant to this Order. For such purposes the Special Master shall have (i) the powers conferred on Masters by the Federal Rules of Civil Procedure, and (ii) the power conferred on it, as California State Water Resources Control Board, by the laws of the State of California and by rules and regulations heretofore or hereafter adopted by it as California State Water Resources Control Board pursuant to such laws, so long as such proceeding affords all parties due process of law, and except as expressly otherwise provided in this Order. It is the duty of the Special Master to proceed with all reasonable diligence."

9. "Effect of Report. The report of the Special Master shall not be final and its findings shall not be given presumptive effect. In review of any report and recommendation as to a change application rendered by the Special Master, the court shall not be limited by the 'clearly erroneous' standard prescribed by Fed.R.Civ.P. 53(e)(2) and all matters referred to the Special Master shall be open for determinations by the court as if no findings had been made."

7.3.4 June 3, 1996 Order of Decree Court

During the prolonged drought in the early 1990's, WRID drained Bridgeport Reservoir, sending water that was high in sediments down the East Fork Walker River, which resulted in a fish die-off. The Water Board brought an administrative action against WRID under the authority of California Fish and Game Code Section 5937, which requires that dams be operated to maintain downstream fish in "good condition." WRID petitioned the Decree Court for review of the administrative fine on the basis that the California agency could not interfere with the exercise of decreed water rights. The parties stipulated to a resolution of that matter, and the Decree Court entered an order on the parties' stipulation on June 3, 1996.

The June 3, 1996 Order contemplated that WRID could file applications to change (1) 2,000 acre feet of its storage rights in Bridgeport Reservoir from irrigation to recreational use; (2) a portion of its Bridgeport Reservoir storage rights from irrigation to instream flow to ensure minimum flows downstream of the dam; and (3) a portion of its Topaz Reservoir storage rights from irrigation to satisfy a continuous minimum bypass of 5 cfs. June 4, 1996 Order ¶¶ 14-17.

In pertinent part, the June 4, 1996 Order provided:

> Because the Administrative Rules deal only with change applications entirely within the boundaries of Nevada or entirely within the boundaries of California and do not address the three change applications referred to in the pr[e]ceeding paragraph, **only the Court has jurisdiction to consider such applications** (emphasis added).

> * * *
>
> The Walker River Irrigation District may file directly with the Court change applications under License Numbers 9407 and 6000 in addition to or in place of the change applications referred to in paragraph 14.
>
> The Walker River Irrigation District may file directly with the Court change applications under License Numbers 9407.

June 3, 1996 Order ¶¶ 17, 19.

During the course of this project, we have not identified any examples in which the Decree Court exercised exclusive jurisdiction over a change petition. To the extent that an applicant might seek to reduce the delay and transaction costs associated with each individual application, filing first in the Decree Court may expedite the process. Alternatively, such a filing could also result in delay should the Decree Court determine that it is not equipped to hear the matter in the first instance or would prefer that the Water Board and/or State Engineer do so. A motion to the decree court for clarification on this issue may be warranted.

The above-described documents, read together, govern any changes that might be made to California Walker River water rights as part of the Walker Basin Program.

7.4 Applicable Substantive Law

Depending upon how a transaction is structured, some or all of the following provisions of law may apply:

7.4.1 Applicable Sections of California Statutory Law

Due to the pre-1914 nature of the California water rights in the Walker Basin, generally, the requirements of the California Water Code would not be implicated by a request to change a pre-1914 irrigation right to instream flow.[1] However, because the decree court, through its rules and regulations, has indicated that a change petition in California should be directed to the Water Board in the form and manner dictated by the Water Board, it appears that the decree court will look to California law and California agency decision making in rendering decisions on any change petition. To the extent that the Water Board, in turn, applies the statutory requirements to these pre-1914 rights, different Sections of the Water Code would be implicated by the proposed scenarios discussed in this report. They are summarized here:

1. **Water Code Section 1011**

> "(a) When any person entitled to the use of water under an appropriative right fails to use all or any part of the water because of water conservation efforts, any cessation or

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[1] The Water Code codified the common law no-injury rule as the standard for changes in pre-1914 rights. *See* Water Code § 1706.

> reduction in the use of the appropriated water shall be deemed equivalent to a reasonable beneficial use of water to the extent of the cessation or reduction in use. **No forfeiture of the appropriative right to the water conserved shall occur** upon the lapse of the forfeiture period applicable to water appropriated pursuant to the Water Commission Act or this code **or the forfeiture period applicable to water appropriated prior to December 19, 1914**.
>
> The board may require that any user of water who seeks the benefit of this Section file periodic reports describing the extent and amount of the reduction in water use due to water conservation efforts. To the maximum extent possible, the reports shall be made a part of other reports required by the board relating to the use of water. **Failure to file the reports shall deprive the user of water of the benefits of this Section.**
>
> For purposes of this Section, the term "water conservation" shall mean the use of less water to accomplish the same purpose or purposes of use allowed under the existing appropriative right. **Where water appropriated for irrigation purposes is not used as a result of temporary land fallowing or crop rotation, the reduced usage shall be deemed water conservation for purposes of this Section.** For the purpose of this Section, "land fallowing" and "crop rotation" mean those respective land practices, involving the nonuse of water, used in the course of normal and customary agricultural production to maintain or promote the productivity of agricultural land.
>
> (b) Water, or the right to the use of water, the use of which has ceased or been reduced as the result of water conservation efforts as described in subdivision (a), **may be sold, leased, exchanged, or otherwise transferred pursuant to any provision of law relating to the transfer of water or water rights**, including, but not limited to, provisions of law governing any change in point of diversion, place of use, and purpose of use due to the transfer.
>
> (c) Notwithstanding any other provision of law, upon the completion of the term of a water transfer agreement, or the right to the use of that water, that is available as a result of water conservation efforts described in subdivision (a), the right to the use of the water **shall revert to the transferor** as if the water transfer had not been undertaken."

Water Code Section 1011(emphases added).

2. Water Code Section 1706

Water transfers of pre-1914 rights are governed by Water Code §1706, which provides:

"The person entitled to the use of water by virtue of an appropriation other than under the Water Commission Act or this code may change the point of diversion, place of use, or purpose of use if others are not injured by such change, and may extend the ditch, flume, pipe, or aqueduct by which the diversion is made to places beyond that where the first use was made."

3. Water Code Section 1707

Water Code Section 1707 authorizes an "in-stream flow dedication" "for purposes of preserving or enhancing wetlands habitat, fish and wildlife resources, or recreation in, or on, the water." Section 1707(a)(1). Such transfers may be made as temporary urgency changes pursuant to Section 1435 (6-

month duration), temporary changes under Section 1725 (1 year or less), or long-term transfers under Section 1735. Any such change is subject to the no-injury rule. *See* Water Code §§ 1435 (change must be made "without injury to any other lawful user of water"); 1702 (change "will not operate to the injury of any legal user of the water involved"); 1736 ("change would not result in substantial injury to any legal user of water and would not unreasonably affect fish, wildlife, or other instream beneficial uses").

a. Temporary Urgency Changes Under Section 1435

California provides for temporary urgency changes under the following circumstances:

1. The permittee or licensee has an urgent need to make the proposed change.
2. The proposed change may be made without injury to any other lawful user of water.
3. The proposed change may be made without unreasonable effect upon fish, wildlife, or other instream beneficial uses.
4. The proposed change is in the public interest.

Water Code § 1435(b). A temporary urgency change order automatically expires 180 days after its issuance unless an earlier date is specified or it has been revoked; however, the Board may renew temporary change orders for a period not to exceed 180 days. Water Code §§ 1440, 1441.

b. Temporary Changes Under Section 1725

Temporary urgency changes are distinct from temporary changes allowed under Water Code § 1725 that are less than one-year duration. Temporary changes under §1725 are limited to the consumptive use portion of the water right, cannot injure another water user, and cannot "unreasonably affect fish, wildlife or other instream beneficial uses." *Id.* The Water Board is required to issue a decision on a temporary change petition no later than 35 days after the date that the Board commenced its investigation of the proposed change or the date that the notice was published, whichever is later. Water Code § 1726(g)(1). If comments are filed, however, the Board may extend the date of its decision for up to 20 days. *Id.* at §1726(g)(2). Additionally, the petitioner may consent to an additional extension so that the Board can hold a hearing. *Id.* at §1726(g)(3). A temporary change under §1725 is exempt from CEQA. *Id.* at §1729. Although both Nevada and California have expedited procedures for temporary changes, the decree still requires amendment for even short-term change applications.

c. Long-Term Transfers Under Section 1736

Water transfers that will last longer than one year are allowed under Water Code Section 1735 et seq. The proposed change can "not result in substantial injury to any legal user of water and "[cannot] unreasonably affect fish, wildlife, or other instream beneficial uses." Water Code § 1736. When considering a petition for a long-term transfer, the Board must provide notice and an opportunity for hearing. *Id.* Additionally, the Board must notify the Department of Fish and Wildlife and provide an opportunity for that agency's review and recommendation. "Following the expiration of the long-term transfer period, all rights shall automatically revert to the original holders of the right without any action by the board." *Id.* at § 1737.

d. Standard for 1707 Dedication

To approve a 1707 petition, the Board must determine that the proposed change:

1. Will not increase the amount of water the person is entitled to use.
2. Will not unreasonably affect any legal user of water.
3. Otherwise meets the requirements of this division.

4. Water Code Section 1745 et seq.

California law provides for the transfer of water made available by the reduction in water usage within an area serviced by a water supplier without compromising the water right. Water Code §1745 et seq. A "water supplier," which by definition includes a mutual water company, may "contract with persons entitled to service within the supplier's service area to reduce or eliminate for a specified period of time their use of water supplied by the water supplier." Water Code § 1745.02. Water can be made available either through conservation measures by individual water users, the fallowing of land or by the elimination or reduction of water use during a given irrigation season. Water Code §1745.05. "The amount of water made available by land fallowing may not exceed 20 percent of the water that would have been applied or stored by the water supplier in the absence of any contract entered into pursuant to this article in any given hydrological year, unless the agency approves, following reasonable notice and a public hearing, a larger percentage." *Id.* at §1745.05(b). A transfer of water made pursuant to Section 1745 will not give rise to "a forfeiture, diminution, or impairment of any water rights [and] is deemed to be a beneficial use by the transferor. . .." *Id.* at §1745.07.

5. Fish and Game Code Section 5937

California Fish and Game Code Section 5937 places certain requirements on WRID to pass water around the dams at Topaz and Bridgeport Reservoirs:

> The owner of any dam shall allow sufficient water at all times to pass through a fishway, or in the absence of a fishway, allow sufficient water to pass over, around or through the dam, to keep in good condition any fish that may be planted or exist below the dam. During the minimum flow of water in any river or stream, permission may be granted by the department to the owner of any dam to allow sufficient water to pass through a culvert, waste gate, or over or around the dam, to keep in good condition any fish that may be planted or exist below the dam, when, in the judgment of the department, it is impracticable or detrimental to the owner to pass the water through the fishway.

After an enforcement action against WRID by the Water Board in the 1990's, WRID is now required to pass certain minimum flows over Bridgeport Reservoir in the East Walker River and around Topaz Reservoir, which is off channel from the West Walker River.

7.4.2 California Common Law for Groundwater and Riparian Rights

Riparian Rights

California recognizes riparian rights and makes those rights subject to the “reasonable use” doctrine. Calif. Const. art. X, §2. In the ongoing litigation in the Decree Court over the Walker River, the issue of how to address “dormant” rights of riparian landowners (meaning riparian rights that remain unexercised but are theoretically cognizable under California law) has arisen. Any applicant seeking to change a decreed California irrigation right to in-stream uses should anticipate a possible challenge from one more dormant riparian owners. California law, however, now requires all water right claimants to file Statements of Diversion and Use with the SWRCB in order to avoid significant daily fines. Such filings should allow a proponent to assess existing claimed rights and anticipate potential challenges.

Groundwater Rights

California follows the correlative rights doctrine for overlying groundwater rights and groundwater appropriations.[2] *Hudson v. Dailey*, 156 Cal. 617, 105 P. 748, 753 (1909). Under this doctrine, each landowner is entitled to pump “a proportionate fair share of the total amount available based on reasonable need.” *Tehachapi-Cummings County Water District v. Armstrong*, 49 Cal.App.3d 992, 1001, 122 Cal.Rptr. 918 (1975). The Water Board, therefore, does not regulate groundwater use and arguably lacks authority to condition any approval of an in-stream flow dedication with a prohibition on groundwater substitution. At most, the Water Board can enforce Water Code §§1745.10 and 1745.11, which provides that replacement of transferred surface water with groundwater cannot contribute to long-term overdraft of the affected groundwater basin.

It is anticipated that any agreement for leasing or purchase of California surface rights by the Program would include as a condition a prohibition on replacement with groundwater. So, groundwater substitution is not likely to be a problem for the proposed transfers.

7.4.3 Environmental Review

California Environmental Quality Act (CEQA)

The statutory authority for the Walker Basin Program requires compliance with the California Environmental Quality Act. Based upon the Water Board’s role as Special Master, any Water Board decision on a change petition arguably is not a discretionary agency action that triggers CEQA. Rather, any Water Board proceeding will merely result in a recommendation to the Decree Court.

Nevertheless, because the legislation that authorized the inclusion of California water rights in the Walker Basin Program requires CEQA review, the CEQA process must be followed before California water transactions can commence. Our understanding is that Mono County is considering being the lead agency and, in that capacity, may accomplish the CEQA process in its upcoming Master Plan revision.

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[2] Groundwater appropriations are junior in priority to overlying groundwater rights under California law.

The MOU between NFWF and Mono County provides:

> NFWF will work with RCD or other parties to develop one or more grant agreements to support development of the California Programs and will not expend, nor authorize the expenditure of, funds appropriated to the Desert Terminal Lakes Fund for the lease or purchase of land, water appurtenant to the land, or related interests within Mono County unless and until the Mono County Board of Supervisors has reviewed, commented upon, and concurred with the scope and nature of the California Programs and complied with its obligations under CEQA.
>
> * * *
>
> As required by CEQA, the Board of Supervisors shall retain discretion to conditionally approve, approve, disapprove, or modify any proposal presented to it pursuant to this agreement for implementation of the California Programs.

MOU paragraph 1 and 4.

In conversations with Water Board representatives at a meeting in Sacramento on September 26, 2013, the Water Board did not express any concerns with Mono County's role as lead agency, particularly since the Water Board would serve only in the limited role of Special Master.

Water Code Section 1729 provides an exemption from compliance with CEQA for temporary water transfers of post-1914 water rights under Water Code Sections 1725 through 1732, dependent on review by the State Water Resources Control Board. The MOU between NFWF and Mono County specifically states that funding for California transactions in the Walker Basin is predicated on Mono County's compliance with its obligations under CEQA. This may be interpreted that if select transactions are legally exempt from CEQA and the parties so choose, those select transactions may proceed without CEQA. It is unclear whether one-year forbearance agreements or pre-1914 appropriative right one-year transfers are exempt from CEQA. The statutory exemption has not been legally tested in forbearance agreements or pre-1914 transfers that are traditionally outside the jurisdiction of the SWRCB. However, a one-year transfer would require approval from the Decree Court, which may involve review by the SWRCB.

National Environmental Policy Act (NEPA)

Reclamation made the decision that the requirements of the National Environmental Policy Act (NEPA) do not apply to NFWF's Walker Basin Restoration Program (WBRP) actions undertaken with Desert Terminal Lakes (DTL) grant funds. This decision applies to WBRP actions undertaken with DTL funds for past and future anticipated future grant funding provided for the same WBRP purposes. Under their grant agreement, NFWF was given the discretion in legislative authorization to make acquisitions and implement associated stewardship and conservation activities that NFWF determines to be the most beneficial to environmental restoration in the Walker River Basin. The legislative authorization on the grant gives NFWF control over decisions on the expenditure of funds under the WBRP. Since Reclamation has no control as to the expenditure of these funds by NFWF, NEPA compliance is not necessary for expenditure of grant funds for activities in NFWF's WBRP.

Endangered Species Act (ESA)

As the funds to purchase water, land, and associated interests under the Walker Basin Restoration Program are federal, implementation of projects with the funds needs to comply with the Endangered

Species Act. Reclamation formally consulted with the FWS under Section 7 related to threatened and endangered species in Nevada, but that consultation does not include any listed species in the California portion of the watershed. Before any transactions are carried out in California, Reclamation will need to consult with the USFWS to determine effects to endangered or threatened species and their critical habitat. If greater sage-grouse, including the bi-state distinct population segment, are listed, a consultation for sage-grouse (and potentially critical habitat) will also be required. As all irrigated ground in the project area may provide essential brood-rearing habitat for greater sage-grouse and may be designated as critical habitat during the ongoing listing process, there is high likelihood that consultation would need to address effects on the critical habitat.

7.4.4 Applicable Nevada Law

Depending on how a transfer of California water rights is structured, Nevada law may apply in some instances. By statute, Nevada requires a permit to change the point of diversion if the point of diversion or a portion of the diversion works is outside the state:

> 1. No permit for the appropriation of water or application to change the point of diversion under an existing water right may be denied because of the fact that the point of diversion described in the application for the permit, or any portion of the works in the application described and to be constructed for the purpose of storing, conserving, diverting or distributing the water are situated in any other state; but in all such cases **where the place of intended use, or the lands, or part of the lands to be irrigated by means of the water, are situated within this state, the permit must be issued as in other cases**, pursuant to the provisions of NRS 533.324 to 533.450, inclusive, and chapter 534 of NRS.
>
> 2. The permit must not purport to authorize the doing or refraining from any act or thing, in connection with the system of appropriation, not properly within the scope of the jurisdiction of this state and the State Engineer to grant.

NRS 533.515 (emphasis added).

In follow up to a June 25, 2013 conversation regarding the proposed California transactions, the Nevada State Engineer indicated that he would not require any Nevada approval for a change from a California irrigation right to in-stream use in Nevada. Noting that the Decree Court and the Water Master will oversee any such change, the State Engineer indicated that he did not anticipate that he would exercise his authority under NRS 533.515 if a California water right were to be put to beneficial use in-situ and flow into Nevada. (Jason King, personal communication, 08/29/13).

To the extent that any California water that, as part of a water rights transaction, is diverted into and stored in Bridgeport or Topaz Reservoirs, this statute could arguably apply because of the statute's reference to "storing." NRS 533.515. Likewise, if a Nevada irrigator purchases a California irrigation right to replace water that the Nevada irrigator sold or leased for in-stream purposes, a permit from the Nevada State Engineer will be required. *See id.* If the California water's presence in Topaz or Bridgeport Reservoirs is simply incidental to moving it downstream to Walker Lake, it is unlikely that a Nevada approval would be needed. *See id.*

7.5 Types of Potential Water Transactions

For the California transaction program anticipated, there are essentially three primary legal mechanisms for making water available to augment in-stream flow: (1) forbearance agreements; (2) dedications of water under the authority of Section 1707 of the California Water Code; and (3) an interstate change application to move the place of use of the water into Nevada only. These mechanisms can be used alone or in concert with one another, as described below.

7.5.1 Forbearance Agreements

Overview of Forbearance Agreements

A forbearance agreement is a contract between a landowner/water user and the entity interested in keeping the water in-stream (in this case NFWF), in which the water user agrees to forego withdrawals of water pursuant to certain contractual terms and conditions. The main advantage of a forbearance agreement is its relative simplicity and efficiency. No formal change in the point of diversion, place of use or manner of use is sought, so there is no need for agency proceedings, Decree Court approval or modification of the Decree.

For that reason, however, a forbearance agreement will not legally protect the water that voluntarily goes unused by the irrigator against downstream diversions. Downstream appropriators (who have not exceeded the quantity of their appropriative rights), as well as riparian landowners, can legally use the extra flow that results from a forbearance agreement if they are not a party to the forbearance agreement. As a result, in any forbearance agreement scenario, a separate agreement in which any potential downstream diverter agrees not to divert the increased flow would likely be necessary. Water Code Section 1011 should protect from forfeiture any water rights holder who enters into a forbearance agreement so long as the in-stream proponent can demonstrate that the in-stream dedication has resulted from water conservation actions – like land fallowing or improved irrigation or conveyance efficiency.

Use of Forbearance Agreements to Move California Water into Nevada

The California reaches of the Walker River system have potential opportunities for the use of forbearance agreements, particularly on the West Walker River, where the Antelope Valley Mutual Water Company has the decreed right to a large amount of water and there are few downstream diverters before the water reaches Topaz Reservoir. The Program could enter into a forbearance agreement with AVMWC and separate agreements with any other diverter or riparian owner downstream of AVMWC's point of non-diversion who might have the opportunity to make use of the increased flow from the consumptive use portion of AVMWC's rights that are left instream.

While these types of contractual arrangements could benefit in-stream values of the West Walker upstream of Topaz Reservoir, they alone are likely insufficient to protect the water into Nevada and to Walker Lake. Forbearance to increase in-stream flows may create a contractual right against the party to the forbearance agreement, but it does not affirmatively create a legal protection against diversion that can be managed by the Water Master and enforced through the Decree Court. Once the water flows downstream of the last point of diversion against which it has contractual protection, it can be appropriated by a downstream user according to priority.

To the extent there are distinct river reaches in California that might benefit from increased flows during certain times of the year, a forbearance agreement might be effective. For example, the West Walker River reach below AVMWC's diversion points is a prized fishery that might benefit from instream flows. Moreover, a forbearance agreement may, under certain river conditions, be valuable to enhance flows in the Topaz Reservoir "by-pass" channel, which is actually the natural channel of the West Walker River, or downstream of Bridgeport Reservoir. The storage rights for the reservoirs are relatively junior to the direct diversion rights of many downstream appropriators (License 6000 for Topaz Reservoir has a February 21, 1921 priority while License 9407 for Bridgeport Reservoir has an August 8, 1919 priority). Under conditions where WRID is unable to divert and hold water in the reservoirs because that water is being sent downstream to satisfy a more senior right, the water that is subject to a forbearance agreement may increase downstream flows in the West Walker by-pass around Topaz Reservoir and downstream of Bridgeport Reservoir on the East Walker. As a practical matter, however, it is not clear if there are any circumstances in which such conditions might exist.

7.5.2 Section 1707 Dedications

Three primary iterations of a Section 1707 dedication could be used to further the purposes of the Walker Basin Restoration Program. In approving a 1707 in-stream flow dedication, the Water Board will recognize a place of use that includes both California and Nevada. *See* Order Approving Temporary Changes, *In re Licenses 6000 and 9407 of Walker River Irrigation District*, February 21, 2014. The Water Board has an independent obligation, however, to consider the effect of a proposed change in use on California public trust resources and to protect those resources where feasible. *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419. The Water Board considers the evaluation of public trust resources as part of its evaluation of impacts to fish, wildlife, or other instream beneficial uses under Water Code Sections 1435, 1727, and 1736.

For that reason, although a goal of the Walker Basin Restoration Program is to enhance in-stream conditions in Nevada, it will be important to include a Walker River reach that is in California in order for the Water Board to fulfill its public trust obligation. Beneficial use in Nevada alone is unlikely to be sufficient. To that end, in a September 26, 2013 meeting, Water Board representatives suggested that any petition for a 1707 dedication include at least 100 yards of California as the place of use so that Nevada is not the exclusive place of use.

Dedication for In-Stream Purposes in California

To the extent that one or more forbearance agreements would not be effective in increasing river flows in California and, in particular, the Topaz Lake by-pass, a 1707 dedication would be an effective device to do so. The Water Board decision approved by the Decree Court, and the subsequent modification of the Decree, would constitute the necessary legal protection to ensure that the water that is subject to the 1707 dedication is not diverted by other users.

Dedication for Storage in Topaz or Bridgeport Reservoirs for Use in Stored Water Program

The 1707 process can also be used to augment the water available for NFWF's Stored Water Program. The consumptive use portion of a natural flow right acquired from a California irrigator could be dedicated for in-situ use in the Topaz and Bridgeport Reservoirs and for further in-stream use in Walker River and Walker Lake within the scope of the Water Board's February 21, 2014 Order on WRID's temporary change petition or any future similar approval. In addition to enhancing in-stream conditions in the Walker River and its two branches, this scenario would also improve reservoir levels for recreational purposes.

Dedication for In-Stream Purposes in California and Nevada without Storage

A 1707 dedication of a California irrigation right could include as its place of use portions of California and Nevada river reaches, in addition to Walker Lake, without a storage component. In this way, the water would flow through the natural channel on the West Walker River; however, the Program would not necessarily have the benefit of controlling the timing of the water release during later periods in the season when the water might be needed the most.

7.5.3 Interstate Change Application to the Decree Court

Another possible procedural mechanism for moving water to Nevada would be the filing directly with the Decree Court of an application to change the point of diversion, place of use and manner of use. The Decree Court's June 3, 1996 Order contemplated such an application. While seemingly bypassing any proceedings before the Water Board, an application directly to the Decree Court raises questions regarding which state's law to apply. Since this type of change could implicate NRS 533.515, as well as various Sections of the California Water Code, the Decree Court could order proceedings before both of those agencies before it would review an interstate change application. It might be of value to file a motion with the Decree Court for clarification regarding the process an applicant would follow for an interstate application. Ultimately, however, the Decree Court is likely to want input for the agencies, so no efficiencies would be gained from this procedure.

7.5.4 Two-Step Transactions, or Water Exchanges

Another possible way to structure a transaction is to engage in a two-step process that involves the following:

Step 1: Transfer of an existing WRID storage right ("Right A") to instream use under the Stored Water Program already in place and

Step 2: the purchase of a California decreed irrigation right ("Right B") by the Nevada seller of "Right A" to irrigate the land previously irrigated by Right A.

Under this type of two-step transaction, the agency approval for "Step 1" above has already been obtained from the Water Board (Feb. 21, 2014 Order).

However, "Step 2" would likewise require a petition to change the point of diversion and manner of use, which could be submitted to the Decree Court in the first instance as described above. The Decree Court may order that the administrative process of both the Water Board and the Nevada State Engineer be followed, followed by a motion to the Decree Court to amend the decree. As a result, it is not clear what a multi-step transaction would gain over a 1707 petition.

Possible benefits include: (1) storage opportunity for release of in-stream right at times when the water is most needed; (2) incentive of stored water users to participate in the Stored Water Program due to the opportunity to purchase senior direct diversion rights from California; and (3) less consumptive use reduction due to the fact that the stored water rights place of beneficial use is further down in river system with less reliance on return flow.

7.5.5 Short-Term Transactions

As noted in Section IV above, short-term transactions require the amendment of the decree. Nevertheless, temporary urgency changes under Water Code §1435 and temporary changes under Water Code §1725 could be used to facilitate a temporary instream flow dedication. Both efforts would require a petition process with the SWRCB and both require meeting the SWRCB petition criteria as noted above.

The benefits of the short-term water transactions would be to demonstrate the feasibility of engaging the water transfer process through the SWRCB and the decree. Such a precedential effort would allow the proponent to understand opposition to and pitfalls of a proposed transaction as well as determine the effectiveness of the proposed transaction in meeting project objectives that may translate into a future permanent transaction.

7.6 Analysis of Specific Management Changes

The above analysis regarding forbearance agreements, 1707 dedications and change petitions addresses the scope of legal mechanisms that might be used to achieve the transfer of California water rights to Nevada in-stream flow purposes. To the extent that any additional legal considerations might be posed by the specific management changes described in this report, they are discussed here:

7.6.1 Full-Season Dryland on Specific Ground

The irrigation season for the Walker River extends from March 1 to October 31 of each year, except that in Bridgeport Valley on the East Walker River, and at all points above the Coleville Gauging station on the West Walker River, the irrigation season extends from March 1 to September 15 each year. Decree ¶ XVI. Because the irrigation season for all Sections of the Walker River exceeds six months, full-season dry-land management would be achieved either through a temporary change under Sections 1725 or 1736 and 1707 dedication or by way of a forbearance agreement.

Rotational agreements so that different ground is left dry each year may create an opportunity for more of a programmatic approach that could reduce the time and transaction costs associated with administrative and court approval. For example, the Antelope Valley Mutual Water Company is the record title owner of the decreed rights that service the irrigated lands within the AVMWC's boundaries. AVMWC would be considered a "water supplier" under Water Code §1745.02 such that water can be made available for transfer either through conservation measures by individual water users, the fallowing of land or by the elimination or reduction of water use during a given irrigation season. Water Code §1745.05. Moreover, the decree allows for rotation of water among the lands within AVMWC's boundaries. Decree Par. XIII. As a result, the approval process could entail one 1707 petition filed by AVMWC to dedicate the consumptive use portion of what it would have diverted for irrigation but for the rotational dry land management.

7.6.2 Diminishment in Length of Irrigation Season

The legal analysis for seasonal diminishment is similar to that for full-season dryland. In addition, however, because the proposed changes would last less than six months, a temporary urgency change can be sought under Water Code Section 1435.

7.6.3 Reduced Irrigation Throughout the Entire Season

To the extent that water savings under this scenario are difficult to quantify, it is unlikely that reduced irrigation throughout the season could be achieved through a permanent dedication. For the purposes of its injury analysis, the Water Board would need to be able to quantify the actual amount of water that is being dedicated in-stream. To that end, a year-to-year analysis might be necessary. If the Water Board would be comfortable with what modeling shows to be the most conservative amount of water saved as what gets passed downstream, this scenario could result in a water give away to downstream users because the 1707 dedication would not protect the full amount of water that actually is passed downstream.

7.6.4 Storage Management Changes

The decree grants storage and refill rights in Upper and Lower Twin Lakes under Claims 186-189, 191-192, 197-198 and 201-203. The refill rights have more junior priority dates than the original fill right and are subordinate to an irrigation diversion right in the East High Line Ditch. The decree also grants storage rights without the right to refill in Poore Lake, Black Reservoir, East Lake, West Lake, and Green Lake under Claims 220 and 230. The stored water must be used on the lands described in the decree with reference to the respective claims.

In a meeting in Sacramento on September 26, 2013, Water Board representatives made clear that the release of stored water prior to commencement of the irrigation season to augment flows in Nevada could not be followed by a refill other than as allowed under the Decree. Otherwise, the release and refill would expand the water right.

For that reason, we have evaluated the feasibility of a post-irrigation season release of stored water. Depending on interpretation, this change in storage management could still be subject to challenge as an expansion of the water right. Presumably, at the end of the irrigation season, the water right holder has exercised the entirety of the irrigator's direct diversion rights. So, release of the stored water could not otherwise occur to serve the direct diversion rights. Even though the irrigation season has ended, the water released at the end of the season would have offset the amount diverted to storage the following season. If a judgment of expansion or injury to downstream users is reached, stored water releases at the end of the irrigation season, it may result in the need to forego refill during the following season and run the risk of whether natural river flows are adequate to serve its direct diversion rights. It appears that post-season releases of storage water by WRID may be approved, however, which might set precedence for such transactions to occur with other storage rights under the Decree.

7.7 Legal Framework Conclusion

This Section is intended to examine the legal mechanisms that may be employed to meet the instream flow objectives of this project. Identifying the exact legal mechanism to use in meeting the project objective depends upon the specific facts related to the identified water right, the location of the water right, and the precise instream flow objective to be achieved. This framework does not provide this specific recommendation and instead provides the mechanisms that may be considered in framing the factual situation.

Below is a chart that can be used to help identify the appropriate legal mechanism to use in light of the factual situation chosen to meet the project objectives:

Table 7-2. Legal Mechanisms Applicable to Water Transactions in the Mono County Portion of the Walker River Basin

Legal Mechanism	Initial Step	Benefit and Burden	Time
Decree	Petition Decree Court directly under its "exclusive jurisdiction" over interstate transfers to dedicate water for instream beneficial uses under the identified adjudicated water right	Decree Court sanction of dedication. Significant procedural action to modify decree.	9 months to 1.5 year to complete
Forbearance	Engage water user and downstream users to forbear from using water.	Must engage a large number of potential diverters in order to secure water for desired objectives	3 months to 3 years to complete (if there are protracted negotiations with multiple landowners)
Water Code §1707	File petition with SWRCB in order to dedicate a water right to instream purposes	Decree Court would still need to modify the decree in order for 1707 right to be protected.	2 to 5 years to complete
Water Code §1435	File petition with SWRCB for a temporary urgency change.	Under Decree Court Rules and Regs, temporary change must be ratified by the Decree Court.	Up to 6 months based on state requirements; then dependent on Decree Court involvement
Water Code §1725	File petition with the SWRCB to dedicate water for instream purposes	Temporary change must be ratified by the decree court	6 months based on state requirements; then dependent on Decree Court involvement
Water Code §1736	File petition with the SWRCB to dedicate existing water right for instream purposes	Permanent change must be ratified by the decree court	2 to 5 years

Before any transaction can move forward in the California portion of the basin, two other activities need to be complete:

1. Under the Mono County / NFWF Memorandum of Understanding, funding for California transactions in the Walker Basin is predicated on Mono County's compliance with its obligations under CEQA. Mono County will need to complete a CEQA analysis before approval of overall program participation. One-year transfers and forbearance agreements may be exempt from CEQA under California law, in which case NFWF and Mono County may agree to move forward with select transactions concurrent with (and perhaps to inform) CEQA.

2. A Section 7 ESA Consultation on the effects to listed or candidate species and their habitat must occur. Bureau of Reclamation would be the lead agent on the Consultation.

8 POTENTIAL IMPACTS OF CONCERN TO MONO COUNTY

Based on the analysis and interviews completed as part of this study, we have identified potential impacts that may be in conflict with policies and goals identified in the Mono County General Plan. The potential impacts are listed below, with considerations to mitigate for or minimize the negative effects.

Please note that this discussion covers all potential impacts of concern as identified by this assessment. This includes concerns raised by residents and County officials, even if the assessment did not explicitly study them. At the request of RCD the Team is providing insight into all concerns raised, even if there is not data specific to those impacts. There may be other impacts not identified under this assessment. Additionally, some of these potential impacts may not come to fruition, or the County may determine that they are not points of concern. It is important to note that for many of these concerns there are regulations in place that would already provide protection, including under California water law, the Walker River Decree, and existing County policies. The County may or may not decide if it is in their interest to add an extra layer of protection by including certain limits or regulations as part of their discretionary approval of water transactions. This discussion presents ideas for the County to consider based on information gathered, but by no means intends to convey that these are all certain impacts, or that all or any of the mitigation or minimization steps are necessary for a functional program.

The impacts analysis addresses the following aspects of a water transactions program, as described previously:

- Temporary reduction of irrigation;
- Permanent reduction of irrigation;
- Temporary cessation of irrigation;
- Permanent cessation of irrigation; and
- Release of storage water for instream needs.

And, where possible, it also identifies the spatial scale at which there may be a significant impact.

8.1 Maintain Current Agricultural Land Use of the Region

Mono County's General Plan specifically identifies the need to avoid conversion to non-agricultural land use, unless it enhances other critical resource values. Agricultural and grazing lands should be preserved and protected in order to promote both the economic and open space values of these lands.

No aspect of this project on its own would directly result in the conversion of farmland to non-agricultural use. However, while ***permanent cessation of irrigation*** would still allow for dryland ranching or farming, landowners who permanently transfer irrigation water rights instream may be more inclined to use the property for non-agricultural purposes.

Short-term cessation of irrigation may temporarily remove a property from agriculture, if the landowners choose to not practice dryland ranching. A short-term lease may lead to interest in a permanent water sale, but as a standalone transaction it would have a limited impact on scenery, open space, or rural character. Additionally, short-term leases may provide insight into the potential for changing conditions under permanent cessation.

While a ***permanent reduction in irrigation*** would easily enable agriculture to continue, landowners may also be interested in preserving a portion of the water intending to change the purpose of use to allow for other development in the future. A t***emporary reduction in irrigation*** is not expected to encourage a conversion to non-agricultural use, although concerns have been raised that it may be the first step in landowners implementing more extreme land-use changes.

Recommendations to minimize or mitigate for impacts.

The primary concern with conversion to non-agricultural use is the loss of open space and parcel subdivision for development. Mono County already has guidelines in place limiting parcel sizes and requiring extensive processes to allow for additional development or conversion from agricultural zoning to other zoning. These guidelines can help to maintain the open space and rural character of the region as they are intended to do with or without a water transactions program.

It may benefit the County, however, to implement additional safeguards targeted specifically at acreage under water transaction agreements. The County may state clearly as part of the agreement to participate in the water transactions program that the program should not undermine the agricultural economy, advance development, or contribute to the loss of open space. However, care must be taken to not be overly restrictive of private property rights. Landowners currently have the ability to sell water rights and/or make changes to their land use within existing County regulations regardless of the Walker Basin Restoration Program. This assessment did not include consideration of the legal implications of private property rights and County regulations.

Limits may be placed on the ability of landowners to subdivide their properties through county zoning or planning regulations, transfer of development credits, or conservation easements. (Please see Section 6.3.2 for further discussion on conservation easements). These may be done in conjunction with the water purchase, or through separate parties. Mono County already requires a full impacts assessment if development activities will reduce agricultural productivity. While this regulation doesn't specifically fit a water transaction, as the activity is simply diminishing normal irrigation, the County could extend such a regulation to cover permanent cessation of irrigation.

8.2 Maintain Scenic Qualities and Aesthetic Character of the Region

As noted in the General Plan, outstanding scenery is one of Mono County's significant attributes. Aside from being part of the identity for those who live there, it also plays a large role in attracting visitors to the region and supporting tourism, which is the County's largest economic sector. A 2009 study noted that Mono County is a destination location for many visitors and that those visitors come, in large part, due to the scenic landscape; the most common reason for tourist's satisfaction with their visit was Mono County's "scenic beauty/beautiful area". This holds true for the green meadows ringed by mountains found in the Walker portion of Mono County. Thus a potential change in the general appearance of the landscape may be a concern.

This concern differs from Section 8.1 in that the properties do not necessarily have to stay in agriculture, as long as the scenic values remain.

Permanent cessation of irrigation may lead to a transition from meadows to drier / sagebrush vegetation. The areas at greatest risk for this transition include approximately 6,000 acres on sandy soils with moderate to high-ranking species vulnerability in the central western portion of Bridgeport Valley and about 1,300 acres scattered across Antelope Valley, with the most notable impacts in Powell and Big Slough HRUs (see Section 3.6)

Short-term cessation and short term and permanent reduction in irrigation would likely not have a permanent impact on aesthetics. There may be changes during the one to five year time frame of a short-term lease, but those would be reversed with a return to normal irrigation practices.

See Appendix B, Section 4 for complete discussion of vegetation response to changes in irrigation management.

Recommendations to minimize or mitigate for impacts

To reduce the impact of irrigation cessation on the scenic vista and visual character of the area, the extent of high-risk acres entered into transactions for permanent cessation of irrigation may be limited. There is an expressed concern that the County should place limitations on the Program before agreeing to participate, as once that agreement has been made it might be more difficult to protect local interests. These limitations may be set through overall County policy or could be considered as thresholds set on the extent of the program as a condition of the County's participation. The County will have to explore the legal ramifications of limiting the number of acres allowed to participate in specific transactions, and the approach used. This assessment did not consider legal standing of landowners who might then be excluded due to those limitations.

In Bridgeport Valley, there are about 6,000 acres of ground identified as potentially high-risk, out of almost 18,000 irrigated acres on the Valley floor. In Antelope Valley, the Big Slough HRU encompasses just under 10,000 acres across most of the Valley floor. Mixed within are 1,300 acres of high to moderate risk of conversion to dryland species. If only a percent of those high-risk acres could be taken out of irrigation, then the impact on the visual character of the areas would be minimal. It is important to note that there is no current information on groundwater response to decreased irrigation. Especially in Bridgeport there may naturally be a high water table in early season, and thus reduced irrigation might not change the visual character of the valley. If monitoring or observance shows no conversion to sagebrush due to naturally high water levels, then a limit may not be necessary.

It is also important to note that acreage that experiences greater changes as a result of decreased irrigation management often has the most water savings. Acreage identified as "high-risk" may be of greater benefit to the streams and lake if included in the Program.

This assessment is not able to make recommendations for what specific acreage limitations should be. Specific thresholds may be identified as part of an in-depth CEQA analysis; however even with extensive background data it may be difficult to determine appropriate controls. Vegetation transitions can take years to occur and are dependent on numerous factors. As such, the County may explore options to assure the ability to exercise adaptive management, enacting or changing any limitations as necessary as program participation progresses. NFWF currently operates the Water Transactions Program with extensive attention to vegetation changes. Suggestions from the existing program include detailed monitoring on participating ground for a better understanding of those changes, revegetation plans implemented when needed, and the potential dedication water to be used as needed for revegetation of native or forage plants. Water Transactions that have been carried out under the program thus far include vegetation management plans.

8.3 Protect Habitat Values and Species of Concern

As noted in the General Plan, Mono County's fish and wildlife populations and plant communities contribute substantially to the tourist based economy, recreation, and aesthetic enjoyment. While a shift to a more natural irrigation regime is expected to help native habitat conditions overall, there are potential concerns.

8.3.1 Vegetation

This assessment identified 11 plant species under the California Rare Plant Ranks that might be present in the project area, and thus may potentially be impacted by irrigation cessation. It is important to note that these are not plants listed as rare or threatened under the Federal or State Endangered Species Acts (see Appendix B, Table 4-5); however, a rare plant survey was not conducted, and none of these species was actually identified within the project area.

While it depends on the species and the habitat conditions needed, ***irrigation cessation***, both short-term and permanent, is the most likely to have a detrimental impact on a select vegetation species or community (see Appendix B, Section 4).

Recommendations to minimize or mitigate for impacts

While none of the identified species are listed under the California Endangered Species Act, their status on the CRPR list means that they must be considered under CEQA. The County can mandate that if there are suspected special status plants present on specific ground involved in a full dryland (complete irrigation cessation) water transaction, then surveys should be conducted before the transaction is in place at the applicant’s expense. If protected plants are present, the transaction will be subject to all legal requirements related to protection of the species.

8.3.2 Wildlife

This assessment highlighted ten species because of their special-status designation and/or high public interest value, as well as their potential to be affected by water diversions (see Appendix B Section 5). Of these species, the yellow warbler and the greater sage-grouse were determined to have the potential of being affected by a change in irrigation regime. Yellow warbler might be benefited by an improvement in riparian vegetation, but could lose some habitat if willow decreases within the fields. Greater sage-grouse could be negatively impacted if there is a loss in moist grass vegetation, although they use a mix of sagebrush, dry grass, and moist grass habitats.

Changes in irrigation application – ***temporary and permanent, reduction and cessation* -** is a point of concern related to greater greater sage-grouse habitat. The entire study area is proposed critical habitat, but within the program area further study is needed to identify actual presence and timing of habitat use.

Recommendations to minimize or mitigate for impacts

If the bi-state population of greater sage-grouse is officially listed with the proposed critical habitat, then federal law would require an ESA Section 7 Consultation under USFWS. This Consultation might include a biological assessment with more detailed determination of presence and timing of habitat use in the program area. Before any transactions are carried out, Reclamation will consult with the USFWS on potential effects to endangered or threatened species and their critical habitat. Ideally, a programmatic-level ESA (section 7) consultation would be completed to cover the entire Program and all necessary listed species/critical habitat. Any water transactions would be subject to limitations imposed by the Consultation.

Landowners working cooperatively (such as within the AVMWC) or as part of a County-led effort may develop a Habitat Conservation Plan (HCP), Safe Harbor Agreement (SHA), or Natural Community Conservation Plan (NCCP) for the greater sage-grouse which would protect the bird while potentially providing more flexibility in land and water management. Water transactions would be subject to the requirements of the Plan. Such plans are best developed over large areas with multiple landowners, to avoid a piecemeal approach to mitigation and management. All plans would be developed working closely with the California DFW, USFWS, or NRCS.

8.3.3 Fisheries

A timed ***release in storage water*** may lower water levels in small reservoirs or their outflows to the point that it would have a detrimental impact on the fisheries in the reservoirs. While normal irrigation may lower water levels to the same extent, there is the potential that it would happen more often as part of a water lease. There may be added incentive to do a complete fill and drawdown for multiple years or to abbreviate the release timeline.

The primary reservoirs of concern are Twin Lakes. Twin Lakes provide upper watershed storage for the Bridgeport Valley. It is possible that water storage in Twin Lakes and other reservoirs could be managed differently if sale incentives for stored water were to change. Twin Lakes also provides a popular recreational fishery, having established resorts and campgrounds near the lakes and along Robinson Creek. Based on available information, upper and lower Twin Lakes would likely maintain mean and maximum depths sufficient to provide suitable water temperatures during the irrigation season for resident trout survival during years when maximum drawdown is reached. However, the long-term effect of annual maximum drawdown on existing fish populations in Twin Lakes and the outflowing Robinson Creek are uncertain.

Historic information indicates that flows in Robinson Creek downstream of Twin Lakes may reach zero in dry years; however, flow greater than zero is generally maintained. The extent to which stored water sale incentives would change management of flow into Robinson Creek is uncertain. If flows reach zero it could result in impacts to fish populations in Robinson Creek downstream of Twin Lakes.

See Appendix B Section 8.3.1 for further discussion.

Recommendations to minimize or mitigate for impacts

Limits may be placed on the timing of the storage releases, and/or the extent of drawdown in Twin Lakes, and/or minimum flows in Robinson Creek. These limits could be arranged either through the initial agreement for County participation in the Program, and/or per agreement between the water right holder and purchaser.

The maximum existing drawdown in Twin Lakes appears to maintain sufficient habitat for resident fish; however, the impact of multiple years of maximum drawdown is unknown. Further study could determine if this is a worthy concern, especially in consecutive dry years. The County might want to suggest that under a water transaction agreement full drawdown cannot occur in consecutive dry years, and in every other consecutive dry year a certain amount (10%, for example) of the storage water right needs to remain in reservoir. The water right holder may need to receive compensation for this water left in-lake, as they would legally have the right to withdraw it. Any appraisal of the value of the water rights should include this aspect.

Timing of the drawdown for instream purposes could be limited to outside of the recreation season and critical time periods for fish of concern. If approved under the Decree Court, releases immediately post-irrigation season would meet these requirements.

Such a storage water transaction could also be coupled with a minimum flow agreement for the outflow stream – such as Robinson Creek. As part of the transaction a portion of the water could be released when needed to maintain instream flows during the irrigation season. While this water might not be protectable past other water users, it would serve the purpose of supplying instream flow in a critically low flow reach. The water right holder may need to receive compensation for this water left instream, as they would legally have the right to store it. Any appraisal of the value of the water rights should include this aspect.

Since these limitations on the amount and timing of water released are beyond limitations set by the Decree rights and water law, they would need to be incorporated into the agreement in which Mono County agrees to participation in the Water Transaction Program, or in agreement between the water purchaser and seller.

8.4 Protect Wetland Values

Antelope and Bridgeport Valleys, as well as the Swauger Creek region, have extensive areas identified as wetlands. Some are naturally occurring wetlands, while others are irrigation-induced. Mono County adopted a specific goal of protecting wetland values.

This assessment did not include wetland delineations within the project area, but did include comprehensive vegetation mapping. Reduction or cessation in irrigation will result in drier pastures in many areas, reducing wetland conditions in irrigation-induced wetlands, but will likely improve natural wetlands and riparian corridors. For example, coyote willow / shrub communities are artificially supported along canals and in drainage areas. These communities may decline after multiple years of non-irrigation, but are expected to increase in riparian areas. See Appendix B, Section 4 for further discussion on vegetation response to irrigation changes. It is important to note there is very limited information on shallow groundwater behavior across these meadows. In Bridgeport especially there are questions that remain about the shallow groundwater response to decreased irrigation. There is the potential that some parcels would remain wet in early season without irrigation.

A caveat to the statement on decreased irrigation only affecting irrigation-induced and not natural wetlands is that the landscape has been significantly altered from natural conditions. Thus, a natural wetland may have been present and is currently maintained by irrigation, but if irrigation is reduced these natural wetlands may be drained by canals and ditches constructed as part of the irrigation infrastructure.

Permanent cessation of irrigation would clearly have the greatest impact on irrigation-induced wetland conditions.

Short-term cessation may reduce irrigation-induced wetland conditions for the term of the transaction agreement, but wetland conditions would likely recover if normal irrigation were resumed. Depending on habitat values of the specific site, this short-term impact may or may not be of concern.

Many of the natural wetlands in meadows used for agriculture were likely seasonally wetted in spring and early summer, but drier into the season. Thus, ***irrigation reduction in the early season*** would have the greater impact on wetland conditions than with late season curtailment. Reducing late-season irrigation would more closely follow the natural hydrology. As stated above, short-term reduction would likely not result in permanent changes, but the short-term loss of wetland conditions may still be of concern.

Recommendations to minimize or mitigate for impacts

Multiple layers of protection for wetlands currently exist at the federal, state, and county levels. This protection is typically aimed at activities that would disturb or drain wetlands, such as digging, filling, or construction. Halting the artificial application of water often does not trigger wetland protection measures unless there is a specific species of concern involved. It is important to note that irrigation can't be required to maintain non-natural wetlands created by irrigation.

Additional information could be collected to provide a better understanding of the extent of the impact of reduced irrigation on wetland conditions. Currently, only portions of Bridgeport have a wetland delineation complete. A more complete delineation should include 1) determination between irrigation-induced and natural wetlands; 2) if the natural wetlands are dependent on irrigation; and 3) identification of areas that may be significantly important to wildlife. As this exercise would be quite burdensome to complete across all irrigated ground, it may be more practical to require site-specific wetland delineation only for properties considering irrigation cessation for longer than three years.

8.5 Protect Groundwater Resources

The Mono County General Plan identifies the importance of ensuring the availability of adequate surface and groundwater resources to meet current and future demands. It also states that activities cannot degrade or deplete surface or groundwater resources or interfere substantially with groundwater recharge.

There are three potential concerns related to groundwater resources and a water transactions program:

- The leasing or selling of groundwater;
- Exploitation of groundwater as a substitute for surface water irrigation when water users enter into water leases or sales; and
- Reduced irrigation would decrease water recharge into the deep aquifer.

<u>Recommendations to minimize or mitigate for impacts</u>

It is not recommended to include groundwater in a water transactions program at this time. This is due to limited and new regulation on California groundwater extraction, the absence of groundwater in the Walker River Decree, and general concerns about the transfer and depletion of groundwater resources. Mono County and the Program can specifically state that groundwater is not eligible for transactions at this time.

There are examples across the west of leasing or purchasing surface water and allowing groundwater as a substitute irrigation water source. However, this practice raises some points of concern. First, there may not be a net savings of water in the system depending on connectivity between the surface and groundwater. While there may be increased streamflow, if the vegetation is irrigated there will still be the same amount of water consumptively used. Second, this can lead to excessive aquifer drawdown depending on the amount of groundwater extracted, especially if groundwater use is not closely regulated. As this option is not considered a fit for the California side of the Walker Basin, and there is a lack of groundwater information, it was not considered in this assessment. Mono County and the Program may both wish to explicitly disallow the substitution of groundwater (or storage water) for direct diversion surface water in any agreement related to Mono County's approval of participation in the program. This prohibition can be included in the County's overall agreement to participate in the program, as well as a non-rewatering clause in every lease or sale agreement. Where necessary, participants can be required to provide records of past groundwater use (pumping, diesel, or other records) and agree to monitoring of field conditions, diversions, and pumping activity during the lease.

It is currently common practice to irrigate with storage or groundwater towards end of the season after surface water from a direct diversion is no longer available due to low flows. Thus, if landowners who normally use surface water or permitted groundwater to supplement a direct diversion right enter into a water transaction that prohibits source substitution, they would also not be able to use the storage water or groundwater in the acreage included. The water purchaser may or may not consider increased payments to account for the supplemental water saved.

There is currently very limited information on aquifer interactions with irrigation water and shallow groundwater. This assessment does not have the information to comment on any potential impacts on groundwater recharge.

8.6 Maintain Economic Stability for Individuals and Communities

Changes to irrigation water use due to water transactions designed to increase flows to Walker Lake have the potential to impact the economic standing of individual landowners and the community. Please see Section 5 for a complete discussion of economic impacts.

In terms of individual landowners, the analysis demonstrates that transactions would be beneficial for only a portion of water right holders. It is expected that only landowners for whom a transaction would be beneficial, either while continuing agriculture or undergoing a transition to alternate uses, would participate.

The three primary ways water transactions have the potential of affecting the community economy are through changes in a) local spending by landowners; b) property taxes; and c) recreation/tourism associated with water-related amenities. As discussed in Section 5.4, changes in local spending by landowners are expected to be negligible. Property taxes and the recreation economy are discussed below.

8.6.1 Changes in Property Taxes

While ***temporary agreements / water leases*** are unlikely to result in changes to property zoning or assessed property values, there may be that potential with ***permanent purchases***. Whether a permanent water sale would result in higher or lower taxes would depend on whether the property lost its agricultural deferral and the basis and rate for the tax calculations. Furthermore, while it might be expected that less value being generated might reduce taxes, experience in other jurisdictions suggests that tax policies are often designed to subsidize agricultural properties and therefore there is typically no decline in tax paid, and the tax paid potentially could even rise.

A landowner entering into a ***permanent irrigation reduction*** or a ***permanent sale of storage water*** may continue to use the property for agriculture, unless they are moving towards a transition in land use. After a ***permanent cessation of irrigation*** the land could still be used for dryland grazing (or alfalfa under specific conditions), but landowners may be choosing to sell the irrigation water specifically to halt agricultural practice. These changes may or may not have a limited impact on property taxes. If the landowner continues operating the property for dryland agriculture, they could request a reassessment of the property value in hopes of lowering property taxes. If there are no longer water rights associated with the property, the property value and thus taxes may decrease. However, some landowners might also balk at the idea of lowering their property value and would argue that the land value would hold constant even with reduced water availability. With regards to rezoning of irrigated agricultural land, it appears that land would unlikely be rezoned anything other than agriculture land without a request by the owner for such a change. If the landowner intends to develop/subdivide the land, which would likely increase the value of the property, a request would again need to be made for a zoning change, with the Planning Commission and possibly the Board of Supervisors deciding on whether or not to grant the change.

If the owner were looking to develop/subdivide the land, which would likely increase the value of the property and thus taxes, a request would again need to be made for a zoning change, with the Planning Commission and possibly the Board of Supervisors deciding on whether or not to grant the change.

Given the discussion in Section 5.2, there does not seem to be a high likelihood of an overall drop in property tax revenue for the County as a result of participation in a water transactions program.

Recommendations to minimize or mitigate for impacts

There are already specific policies in place to address zoning changes, requiring thorough review and approval from the County. These policies should assure that changes in land use, and thus related tax income, are within County guidelines with or without a water transactions program. This analysis suggests that a significant drop in tax income is not likely. However, it is understandable that the County may want to assure some level of protection.

The County may wish to consider how to directly or indirectly affect the pace and extent of permanent transactions to sell water rights through agreement with the Program or through county policies governing land and water use. Through a MOU with the Program the County could reserve their future right to consider the amount of acreage permitted to permanently cease irrigation if it appears to be having a detrimental impact on tax income. As discussed in 8.1, limits may be placed on the ability of landowners to subdivide their properties through county zoning or planning regulations, transfer of development credits, or conservation easements.

The County should work closely with the purchasing party (currently NFWF) when determining what the best options are for managing the extent of permanent water sales. The goal of the Walker Basin Restoration Program is to permanently increase flows to Walker Lake, and thus the program has a strong interest in permanent dedication of water instream. If limits are too restrictive, then the effort needed to expand the program to California may not have merit to the purchasing party. Early discussion with the likely purchasing party will determine if program constraints based on County concerns are compatible with program benefits expected from the purchasing party; this would avoid either side moving too far forward if the approach will not work for both. Especially given that the extent of change and true impacts would not be known until initial transactions are actually done, it may be best for the County to reserve their right for future consideration of the extent of permanent water sales, instead of setting strict limitations at the outset.

8.6.2 Maintain Recreational Economic Benefits

As noted in the County's general plan, natural resource based outdoor recreation is and will likely continue to be the foundation of Mono County's economy. Supporting services to recreation and tourism are the largest industry in Mono County, both in terms of employment and output.

It is generally believed that the majority of local water-related activities (e.g., fishing, boating, camping/hiking) could benefit indirectly as a result of increased instream flow associated with water transactions; however, the degree to which such indirect benefits may result in changes to recreational use patterns and/or associated local spending was outside the scope of this analysis. One possible exception to the assumption that the direction of impacts would generally be positive is related to recreational activities occurring on small reservoirs (e.g., Twin Lakes). There is concern that the ***lease or sale of storage water*** could result in decreased water levels in these reservoirs and their outflows, thus limiting recreational attractions. While currently water is diverted from the storage facilities for irrigation, the full water right is often not completely drawn down every year. There is concern that a lease or sale of the storage right would result in a full drawdown of the right every year. Or the drawdown might occur at a different time to benefit downstream needs at the expense of upstream needs. While this is within legal bounds, it may result in flow or water level changes that might be detrimental to local habitat or economic considerations.

As discussed in 8.3.3, a release in storage water may lower water levels in small reservoirs. While normal irrigation may also lower water levels to the same extent, there is the potential that it would happen more often as part of a water lease. These low water levels have the potential to impact the recreational use of the lakes and businesses dependent upon them. Around Twin Lakes there are four properties, which have over 350 camping sites and an estimated 50 lodging units of various types between them. There are also equipment rentals, general stores and boat storage/marina.

Recommendations to minimize or mitigate for impacts

As discussed in Section 8.3.3, limits may be placed on the timing of the storage releases, and/or the extent of drawdown in Twin Lakes as part of a water transaction. These limits could be arranged either through the initial agreement for County participation, and/or per agreement between the water purchaser and irrigator. The easiest approach to assure that the reservoir recreation facilities are not impacted by a water lease or sale is to only allow the drawdown after the height of the recreation season. The approach recommended per this assessment is to target the water release at the end of the irrigation season, which is after the recreation season.

8.7 Protect Cultural Resources

Mono County's General Plan recognizes that the region's cultural heritage is a valuable resource, with Native American, mining, ranching, and recreational historical sites. This assessment did not include identification of cultural resources. No significant impacts would be expected as the program would simply keep water instream, but this assessment did not explicitly consider these impacts.

Recommendations to minimize or mitigate for impacts

Mono County has policies in place to identify and protect cultural resources. These existing policies should be sufficient to address cultural resources as related to a water transactions program.

8.8 Protect Other Water Users from Injury as a Result of a Water Transaction

If one water user decides to participate in a water lease or sale, California water law and the Walker River Decree both provide protection to other water users, so that they are not injured by the change. If a formal instream dedication is done through the California Water Code Section 1707 for short-term, long-term, or permanent transactions, then the state needs to ascertain that there is no injury caused. As part of the process other users can bring claims of injury forward. Also, as the pertinent water rights are all under the Walker River Decree, the Decree Court and Federal Water Master also have jurisdiction to assure that no other water users are injured. Water users or the County may raise their concerns to the state or the court as part of the application to change the water right. If another user is found to be injured then a water transaction cannot go forward or needs to be adjusted until there is no injury.

There are four aspects to changes in irrigation that often cause concern to neighbors that may not be considered legal injury. These are 1) delivery of other's irrigation water on a shared ditch; 2) maintenance costs on a shared ditch system; 3) noxious weed control; and 4) dust management and air quality.

8.8.1 Delivery of Remaining Water on a Shared Ditch System

In gravity flood irrigation systems with shared delivery ditches, the loss of a portion of the water in a ditch may impact the water delivered to other users. Ditches generally carry more water more efficiently than less water. If two water users share a delivery ditch, and User 1 leases or sells their water through ***any type of transaction***, then User 2 may receive less water as more of it will be lost during conveyance in the ditch. Please note that this assessment did not include a detailed review of the internal water delivery system, and as such cannot identify if or where the loss of carry water might actually be of concern to other users. It is included in this report because it was a common concern in discussions with irrigators. It is not expected to be of concern within the Antelope Valley Mutual Water Company; As the AVMWC holds the water rights and is tasked with delivering water to all users, they would be expected to structure transactions in such a way that continued water delivery of their remaining rights is possible.

The loss of carry water is generally not recognized as legal injury under state law; it is not the responsibility of one neighbor to provide another's water; however, the County may want to assure that shared delivery water users should have protections that there are sufficient means by which their water can reach their point of diversions.

<u>Recommendations to minimize or mitigate for impacts</u>

The County can include in the agreement to participate that carry water is a point of concern and needs to be considered when structuring transactions. There are various ways transactions can be structured to protect other users on a shared ditch system, including piping sections of a ditch or transferring only the consumptively used portion of a right, and allowing the continued diversion of the remainder. The approach to assuring full water delivery to others will depend upon the individual transactions.

Additionally, the Federal Decree Board has more flexibility within the limits of the Decree to address concerns about water use than under basic California water law. Water users and the County may approach the Federal Decree board with concerns about adverse impacts from specific transactions. It would likely be preferable for all parties to resolve transaction issues outside of the legal process, and results tend to be more positive when decisions are made without court orders. The County should realize, however, that the Decree Court would serve to protect water users from detrimental impacts of changes to the Decree.

8.8.2 Maintenance Costs on a Shared Ditch System

Many of the irrigation systems are shared between several landowners. There are concerns that as some water users enter into water transactions they will no longer contribute to system maintenance and others will need to bear increased costs. As discussed in Section 5, it could be possible that if a sufficient number of users chose to participate in water transactions, the remaining users might not be able to afford the costs of maintaining the system. The AVMC conveyed that they would expect water users involved in water leasing to continue to pay their dues to cover maintenance, but if water rights were permanently sold they would no longer contribute. If this practice could also be applied to individual water right holders on shared systems, then it would only be *permanent transfer of water rights* that would impact shared costs.

<u>Recommendations to minimize or mitigate for impacts</u>

As described above, lease agreements could include requirements that all normal shared costs would continue to be paid. For this to be successful, payment rates for the leases would have to be sufficient to cover these costs without resulting in a monetary loss for the lessor. Mono County could include such a requirement in the overall agreement to participate in the Program.

While possible, it may not be reasonable to require continued support of shared maintenance costs under a permanent water right sale. Under the AMVC the water rights are all in the Company's name, so it is expected that the Company would self-regulate and not sell water rights to the point that it would harm their overall management. This self-regulation would not occur with individual water users. Mono County can identify this concern in their agreement to participate in the overall Program, and require that it be taken into consideration when approving permanent water right sales. While parties will likely be able to reach acceptable compromises to address these needs, one landowner cannot be required to continue irrigating to support a neighbor.

8.8.3 Noxious Weed Control

Noxious weed control may be a point of concern as irrigation management changes on neighboring properties. While the individual involved in the transaction has made the decision willingly, an increase in weeds may result in easier spread to neighboring properties. ***Temporary or permanent irrigation cessation*** with continued grazing is expected to favor pest weed species, including Baltic rush and Missouri iris. See Appendix B, Section 4 for further discussion.

Recommendations to minimize or mitigate for impacts

The County may mandate that water transaction agreements include a requirement that landowners maintain weed control within a set distance from neighboring properties. The County may wish to establish a weed control program with NFWF under a joint MOU, to avoid any adverse impacts from cessation of irrigation. There may exist programs to help with weed management (See Section 6).

8.8.4 Dust Management and Air Quality

Temporary or permanent irrigation cessation may result in fields with less ground cover, and the potential for creating increased dust to the point it may be an air quality concern. Maintaining ground cover or allowing watering of fields during windy conditions may minimize this impact.

Recommendations to minimize or mitigate for impacts

The County may mandate that water transaction agreements include a requirement that landowners develop a plan for dust management, which could be integrated into the vegetation management plans for each transaction. NFWF currently operates the Water Transactions Program with extensive attention to vegetation changes. There may be existing programs to help with dust management (See Section 6).

8.9 Transferring Water across State Lines

Transferring water out of basin or across state lines is a controversial practice. Water is a highly valued resource, and Mono County already struggles with large volumes of water being exported for use outside the county. There is concern about water availability for future growth. The Mono County General Plan specifically identifies the need to protect water users and biological resources from the adverse effects of out of basin transfers. Water transfers under the water transactions program of the Walker Basin Restoration Program would remain in the same basin, but the water would cross state lines. These transactions would benefit instream flows in Mono County, as well as flows in Nevada and into Walker Lake. Water permanently transferred under the transactions program would no longer be available for use within Mono County.

Recommendations to minimize or mitigate for impacts

There is no clear way to mitigate for the export of water from the County, but there are ways to limit the extent. While leaving natural flow instream is not the typical “water exportation” project, similar concerns surround the instream transfers because water that was previously permitted for irrigation in Mono County would now be permanently dedicated for instream use in Nevada and would no longer be available for any out-of-stream use in Mono County. Out-of-basin extractive transfers currently require permits from the Mono County Planning Commission. While these permanent instream transfers are not out-of-basin transfer, the County could consider applying the same rules and requirements.

Another option is to set a limit for the amount of water that could be permanently dedicated to instream uses in Nevada. This limit could be set under a few different approaches:

- Beneficial instream flow targets for the East and West Walker systems, as determined by further analysis of instream habitat conditions;
- A percentage of the amount of water targeted for increased flow into Walker Lake, currently under development by NFWF. This percentage could be based on:
    - California’s percentage of irrigated acreage within the basin; or
    - California’s percentage of consumptive use of water within the basin.

It is worth giving consideration to the interests of the purchasing party when setting limits. The goal of the Walker Basin Restoration Program is to permanently increase flows to Walker Lake, and thus the program has a strong interest in permanent dedication of water instream. If limits are set below the amount of water that the program hopes to engage in California, then the effort needed to expand the program to California may not be merited to the purchasing party.

8.10 Conflict with Existing Conservation Plans

Concerns have been raised about the water transaction program conflicting with existing conservation plans, including conservation easements or Habitat Conservation Plans; however, there is no expected conflict with any existing conservation plans. All such plans take precedence over a water transaction, and land on which such irrigation changes are not compatible with existing plans would not be eligible for the program. There may be specific parcels that are not compatible with the program – such as ground with a conservation easement that requires continued irrigation – but there is no overall conflict.

Recommendations to minimize or mitigate for impacts

None. Regulations from existing plans, easements, or other agreements take precedence over water transactions. All applicants should be made aware of this limitation early in the process.

8.11 Beneficial Impacts

This assessment emphasized potential impacts of concern as the feasibility of participation in the program may depend on the County’s consideration of the risk of these impacts and the ability to minimize or mitigate those risks. However, it is equally important to highlight that many of Mono County’s objectives would also be addressed through participation in the program. There are aspects of the program that could deliver clear benefits to the County.

Outdoor recreation and the fisheries found in the East and West Walker systems are a critical part of the identity and economy of the region. Mono County policies recognize the value of these resources, and specifically support efforts to regulate instream flows, support riverine and riparian habitats, and increase wild trout populations.

A detailed description of the fisheries as related to a potential water transactions program is in Appendix 2 Section 7. Although a complete stream habitat assessment was not within the scope of this effort, it is evident that habitat is limited by low flows in many stream reaches. Leaving irrigation water instream, especially throughout the season or in late season, would clearly improve habitat conditions and connectivity. Anecdotal evidence suggests that Slinkard, Mill, Swauger, ByDay, Summers, Robinson, and Buckeye Creeks all run critically low in many years. Current populations of Lahontan cutthroat trout in California are isolated in small headwater streams and do not overlap with the irrigated lower valleys. Thus, the water transaction scenarios are not expected to affect these existing populations in the near term. However, restoring flow and connectivity is the first step towards expanding the population in the future. Additionally, non-native brown and rainbow trout do exist in the river reaches that flow through Antelope and Bridgeport Valleys and would benefit from increased early and late season flows.

Determination of habitat benefits as a result of increased flow or minimum flow requirements to maintain viable habitat depends on specific characteristics of each stream reach. A survey to collect this information requires access to the streams and was not completed as part of this effort. However, Mono County could work with California Department of Fish and Wildlife to conduct an assessment. This information would identify the most critically flow limited stream reaches and might suggest minimum flow targets.

Participating in the water transactions program would not give the County the legal ability to mandate minimum instream flows, but the County could set flow targets as part of their participation in the program. Flow targets at specific gage sites could be used as minimum targets, where transactions that would contribute water up to that point might be considered higher priority or be streamlined through County approval. Or they could be set as maximums, where transactions that would contribute water above the target flow might be lower priority or might proceed through a more rigorous process to determine the cost or risk versus benefit.

8.12 Outstanding Points

1. Settling on a reasonable estimate of water savings in different locations for individual transactions.

The potential amount of water saved remains an open question. The accepted methodology in Nevada and elsewhere is to use the Net Irrigation Water Requirement, essentially evapotranspiration minus precipitation; however, the Team repeatedly encountered concerns about the amount of subirrigation and return flow from Antelope and Bridgeport. To address that concern, Ecosystem Economics developed a model to account for shallow groundwater contribution to consumptive water use. It is important to stress that the model results in estimates based on incomplete information. Without a detailed picture of flow regimes and groundwater dynamics many assumptions were made. Throughout the process the most conservative assumptions were used. The true consumptive use savings are likely somewhere between NIWR and the model results, depending on location and time of season. Refer to Table 2-19.

2. The time, effort, and expense required to move a water right change through the Decree Court.

As described in Section 7, the Decree Court has jurisdiction over all water right changes, and will likely involve the California Water Board and the Nevada State Engineer in consideration of any change applications. It will likely be a complex and time-consuming process. While some approaches, such as Forbearance Agreements, may not legally require Court approval, if any concerns are raised about injury to others the Court can step into the process, As such, the recommendation is that water leasing and sales are done on a larger scale cooperative or programmatic manner. In Antelope Valley this could entail the AVMWC serving as the coordinator for all transactions, even for those involving rights that are not part of the Company. In Bridgeport this could involve individual landowners cooperating with neighbors and putting forth transaction interests as a block. Another consideration to explore may be for California water right holders to participate under a transaction structure developed by WRID. While it is not clear that either party has an interest in such a collaboration, it may serve to reduce protests from WRID. In addition, the regulatory requirements related to CEQA and the ESA should be met in a programmatic fashion, approving the transaction program in California as a whole instead of by individual lease or sale.

3. Addressing concerns about reduced irrigation on greater sage-grouse habitat.

The entire area of interest for this study is proposed critical habitat for the greater sage-grouse, which require a mosaic of habitat, including large expanses of sage brush and wet meadows. Greater sage-grouse are known to use irrigated areas adjacent to sagebrush habitats, since meadows can provide an abundance of succulent forbs for foraging during summer. These areas are especially important during drier summers. In addition to food, herbaceous vegetation also provides cover during the nesting and early brood-rearing seasons. Thus, a water transaction scenario that suspends all water delivery to irrigated areas or wet meadows may reduce the availability and/or quality of nesting, brood-rearing, and summer foraging habitats. However, since sagebrush habitat is currently mapped on less than 20% of the land in both Bridgeport and Antelope Valleys, and the meadow vegetation types take up most of the remaining area, an increase in sagebrush habitat would likely increase the amount of area where a combination of both habitat types are available, potentially benefiting the greater sage-grouse. Additionally, maintaining instream flows is intended to benefit another listed species, the Lahontan cutthroat trout. This creates a struggle between two important species for the same resource, and it is unclear how USFWS might balance the needs in an ESA consultation for the Water Transactions Program. While it is true that the government cannot compel a private landowner to irrigate if they do not want to, and that restoring natural habitat should take precedence over artificially created habitat, if a water transaction is determined to harm the greater sage-grouse then there may be limits on how federal funds can be spent on the purchase or lease. It seems clear that there will be middle ground and certain irrigation changes can be made in most locations without detriment to the greater sage-grouse. It is recommended that a more detailed assessment of greater sage-grouse distribution and habitat use throughout the area of interest take place as a precursor to water transactions.

9 NEXT STEPS

The intent of this assessment is to provide Mono County RCD with objective information to assist in the County's decision regarding participation in the water transactions component of the Walker Basin Restoration Program.

This assessment is only one contribution to the County's decision-making process. At this point Mono County may conduct further studies, and/or initiate a CEQA analysis, or decide against participating. While data gaps remain, there is substantial information to move forward with a CEQA analysis. However, Mono County may need a more complete picture of groundwater interactions with surface water and vegetation, and Water Transactions Program managers may want a better understanding of flow regimes. Another complementary approach is to conduct select trial water leases that would inform both program managers and participants. Short-term trial transactions would demonstrate the realities of the administrative process as well as provide a better understanding of short-term environmental impacts. The actual leases as part of the trial transactions would be for one year, but the process would likely stretch over several years.

Details of these potential next steps are provided below.

9.1 Information Gaps and Opportunities for Further Study

Summarized below are information gaps identified though this analysis.

- Complete water budgets based on real flow measurements for both Bridgeport and Antelope Valleys, including diversion and return flow timing, location, and volume.
- Shallow groundwater elevations, movement, and interactions in both Bridgeport and Antelope Valleys.
- Irrigation effects on deep groundwater recharge.
- Detailed accounting of East Walker River flow and tributaries on the Bridgeport Valley floor, including diversions and the acreage they serve.
- Diversion regulation data from the Federal Water Master for both Valleys.
- Site-specific rare and endangered plant surveys.
- Greater sage-grouse population, presence, and seasonal habitat usage.
- Seasonal fish presence and habitat surveys, including flow-habitat relationships.
- Water quality conditions.
- Decree Court / State Water Board determinations related to transactions, including storage refill, injury, and consumptive use water savings.
- Methods for protecting instream flows into Nevada and through to Walker Lake.

It is not suggested that all or any of this additional information is needed to move forward with a Water Transactions Program. Some of this information (diversion records and water quality data) does exist but wasn't available for or included in this assessment. Other information (fish surveys and specific greater sage-grouse habitat usage), may fall under the purview of State or Federal agencies and could be gathered through those channels. Some of the studies above (water budgets and groundwater) would require significant time and financial investment, as well as permission to conduct monitoring on private lands. The legal and regulatory questions might only be answered during the transaction process.

Throughout the development of this assessment continued concern was raised about shallow groundwater interactions and sub-irrigation, most often related to Bridgeport Valley. A clearer picture of shallow groundwater levels, dependence on irrigation, and movement could be gained from a groundwater modelling effort. Such an effort might include installation and monitoring of piezometers across the valley floors, geologic well logs from shallow and deep wells, flow gaging on all natural waterways and irrigation diversions, aquifer tests, and geophysical surveys to define the geometry of the basin-fill sediments. There is question about the feasibility of the development of a complete model, with concerns about private landowners' interest in sharing well logs and allowing monitoring wells and flow measurements. It is, of course, possible to design a lesser monitoring scheme around monitoring locations that are more easily accessible, but the fewer data points and more assumptions that need to be made weaken the accuracy of the model. The practicality of moving forward with such a study would depend on the ability to collect hydrogeologic data. Time required for the overall study would likely be at least two years, including study design and establishment, data collection, and data processing / modeling.

An outstanding question of interest to the Transaction Program managers is how river flows would be affected downstream as a result of these water transactions; how much water would travel how far through the system? In the Lower Walker Basin there is a Decision Support Tool (DST) operated by the Desert Research Institute. The DST captures the "spatial and temporal complexity of important relationships among climate, evapotranspiration, river flows, groundwater-surface water exchange along the river, irrigation practices, groundwater pumping, lake volume, and total dissolved solids levels in Walker Lake." (http://www.dri.edu/walker-lake-basin). It predicts the amount of new water delivered to various stream reaches and Walker Lake as a result of a water transaction. The DST does not currently extend into the California side of the basin. Expansion of the DST would require additional hydrogeologic information as described above. Integrating the model into the DST would take another year, resulting in a three-year effort to complete.

In addition to scientific data, unknowns remain about the actual transaction process. As is often the case in legal questions, the outcome is unsure until tested and considered by the legal or regulatory agencies. Outstanding topics include:

- Undetermined ESA restrictions;
- Ability to exercise storage refill rights after release of storage water for beneficial instream use;
- Instream protection of leased water into Nevada under both simple forbearance agreements and legal instream dedications;
- The timeline and process that the Federal Decree Court will require for legal instream dedications;
- Federal Decree Court involvement in forbearance agreements without a California legal instream dedication; and
- Legal and physical restraints related to passing leased water through Bridgeport Reservoir and the main stem West Walker River past the Topaz Reservoir diversion.

9.2 Trial Transactions

Another approach, which can be used in conjunction with or separate from additional research, is to implement trial transactions – one year temporary water leasing ("Trial Transactions"). The best way to understand the process and impacts of transactions is to actually carry them out on the ground. Trial Transactions in the project area would serve to inform the process, provide monitoring sites, and be an overall test to gauge how realistic different transactions might be. It is important to note that under a Trial Transaction, a valuable but limited amount would be learned about groundwater and vegetation response to irrigation management changes. Also, as discussed in Section 7.4.3 Trial Transactions might be exempt from CEQA with approval from the California Water Resources Control Board. Trial Transactions could occur parallel with a CEQA analysis to continue consideration of potential program participation.

The ability to carry out trial transactions would primarily be driven by private landowner interest. It would be ideal to implement both a storage right lease and direct surface diversion Decree right lease on each of the East and West Walker systems. If only one of each transaction could occur, from a learning standpoint a storage water transaction in the West Walker system might be most valuable because of the ability to test if and how to pass water though the main stem river or Topaz Reservoir. Equally, a direct diversion water lease might be of most interest in the Bridgeport area because of questions around vegetation response and shallow groundwater levels under decreased irrigation; however, either transaction type in either location, or only one trial transaction, would be an invaluable process.

9.2.1 Trial Lease of Storage Rights

Structure

This assessment suggests that a storage lease be structured for water release at the end of the irrigation season, to avoid repeated disruptions to recreational use of the water and diversion by downstream users. This transaction might be carried out through a simple water user agreement. However, the water may need to be legally dedicated to instream beneficial use to allow the exercise of refill rights, to protect the flow instream if released during the irrigation season, or if needed to protect flows into Nevada. A storage water lease would not be tied to on-the-ground irrigation management changes, but there would be a need for assurance that groundwater is not used to replace storage water irrigation. Ideally a significant amount of water should be included in the trial lease for maximum benefit and measurability. The actual quantity of water needed for a worthwhile trial transaction would depend on the location.

Questions Addressed by the Trial Transaction

- What is the appropriate timing of the storage release - during or after irrigation season?
- How do water users retain their ability to exercise refill rights after the release of leased storage water for instream use?
- On the East Walker River, how is leased water passed through Bridgeport Reservoir and into Nevada?
- On the West Walker River, can leased water be kept instream past the Topaz diversion? If necessary, can leased water be passed through Topaz Reservoir?
- If applicable to the Trial Transaction, what is the best method to assure that storage water is not replaced with groundwater for irrigation?
- As a result of the lease, what are the increased flows instream and into Walker Lake?

Monitoring

Monitoring design of a trial storage water lease would depend on the location. It would likely involve flow measurement through select reaches. Depending on the site and time frame (during or after the irrigation season), established gages may be sufficient or additional gages might be necessary. It would also be necessary to detect groundwater substitution, potentially through satellite images or historic and current electric or diesel records.

9.2.2 Trial Lease of Direct Surface Diversion Decree Rights

Structure

A trial lease of surface diversion rights would be tied to a specific change in irrigation management on specific acreage. Irrigation would be reduced on the given acreage, most likely either no irrigation for the full season, or no irrigation after a certain date. A full-season lease would be preferable for a trial transaction both because potential impacts would be more evident, and to avoid the risk that a dry year might result in no water available in late season. Such a transaction could be completed with either an individual irrigator, or an irrigator under a management district. Assurances against groundwater or storage water substitution would be developed. The structure of such an agreement – forbearance or a legal instream flow dedication - might depend upon the location and lessor. For a trial transaction, a full instream dedication would be most informative related to questions of regulatory process; however, even a basic single user forbearance agreement would be beneficial. The State Water Resources Control Board would need to be notified of the forbearance agreement in order for the temporary water transfer to be exempt from CEQA.

Questions Addressed by the Trial Transaction

- What are potential short-term impacts of the lease and change in irrigation management? Long-term impacts on vegetation and groundwater will not be revealed by a one-year lease.
- What is the quantity and timing of increased flows at points of interest?
- What approaches assure continued delivery of remaining water rights to other users on the system?
- What are the best tactics to pass water past or through Topaz and Bridgeport Reservoirs?
- How to assure downstream users do not divert leased water?
- How to structure forbearance agreements with the lessor and downstream users, if necessary?
- What is the timeframe and steps to the entire process through the state water agencies and the Federal Decree Court?
- What are the best approaches to assure no groundwater or storage water substitution?
- While one year of data is limited, how do evapotranspiration rates under partial or no irrigation compare to evapotranspiration under full irrigation?

Monitoring

Monitoring design will depend on the specific locations of the trial transactions. It would likely involve flow measurement through select reaches. Depending on the site established gages may be sufficient or additional gages might be necessary. The METRIC evapotranspiration analysis could be repeated to provide a comparison of ET rates under normal irrigation (existing 2002, 2005, 2010 analysis) and one year of decreased irrigation. Although these would be limited results, it would provide an approximation of expected water savings. A monitoring approach to detect groundwater or storage water substitution might be necessary. Installation of shallow wells or piezometers to monitor shallow groundwater levels and potential subirrigation from neighboring fields would provide real information on these interactions. This will not however, reveal long-term impacts of the program on shallow groundwater levels. If a trial lease is carried out on pasture ground, then vegetation transects or releve plots could be established to track plant communities and percent of ground cover, as well as monthly growth clippings and forage quality analysis. Again, one year of new management and monitoring would not provide insight to longer-term impacts. As such, monitoring vegetation and groundwater may be outside the realm of interest at this early stage, but the data would be useful if irrigation management changes continue at that site or others, as it would provide early data and establish initial monitoring protocols.

9.3 Endangered Species Act (ESA)

Water transactions under the Walker Basin Restoration Program (Program) are federally funded and, therefore, must comply with the ESA. The Bureau of Reclamation (Reclamation) administers the funds that would be expended on California’s Walker Basin water transactions. Before any such transactions are carried out, Reclamation will consult with the USFWS on potential effects to endangered or threatened species and their critical habitat.

Ideally, a programmatic-level ESA (section 7) consultation would be completed to cover the entire Program and all necessary listed species/critical habitat; however, there is value in differentiating between temporary leasing and permanent acquisition of water rights, as potential impacts on listed species and critical habitat may vary greatly depending on time frame. As information gaps related to critical habitat remain, it may be best to complete an initial ESA consultation on the first few leases – such as Trial Transactions - individually. At the point trial transactions would occur the County would not yet have determined if there was interest in full program participation or what the structure and limitations to that program might be. A program-wide consultation would not be reasonable at that stage. Experience and information learned from the initial transactions may help inform the program-wide consultation if and when the County moves forward.

9.4 California Environmental Quality Act (CEQA)

As described in Section 7, a CEQA impacts analysis must be carried out by Mono County before water transactions, beyond pilot projects, can commence in California. While there is significant information available towards an environmental impacts analysis, depending on the scope of the overall program there may be interest in further research to fill information gaps described in Section 9.1; however, the County could select to move forward with CEQA, adjusting the project scope so the analysis will fall within the bounds of existing information.

As noted throughout this assessment, impacts from permanent water transfers and irrigation management changes may be magnitudes greater than from temporary transfers. Most if not all impacts from temporary leases could likely be reversed by a return to full irrigation. Mono County might consider scaling the initial program to include only temporary water leasing and conduct a CEQA analysis based upon that limited scope. Permanent water right acquisitions could be omitted from the program and CEQA analysis at this point. Alternately, a tiered CEQA approach could include permanent acquisitions, with the analysis identifying any information gaps that would need to be addressed. If gaps for permanent acquisitions are identified the complete analysis of permanent acquisition could be completed at a later date tiering of the initial CEQA document.

Temporary water transfers (such as a trial transaction) are expected to be exempt from the CEQA process, provided the Water Resources Control Board is notified. Therefore trial transactions can move forward before or in conjunction with a CEQA analysis on the overall Program if the appropriate parties agree.

9.5 Summary

At this juncture Mono County may choose to:

- Conduct further research to fill the "information gaps" identified in this assessment, and/or
- Move forward with one year trial transactions to gain a better understanding of the process and potential impacts, to help inform CEQA, and/or
- Move forward with a CEQA analysis, or
- End or pause consideration of participation in the Walker Basin Water Transactions Program.

These activities are not exclusive and may occur simultaneously. If the County would like to continue considering program participation, initiating an appropriate CEQA analysis and allowing for select one year trial leases would provide the most direct experience and information to further inform the decision-making process.

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APPENDICES

A. Water Use in Walker Basin, Mono County, California.

Prepared by Ecosystem Economics, LLC

B. Walker River Basin, California. Potential Environmental Impacts of a Water Transaction Program

Prepared by Stillwater Sciences, Inc.

Task 1 Report:
Water Use in Walker Basin, Mono County, California

a report for Mono County Resource Conservation District

as part of study of Water Transactions in the Walker River Basin, California

Final Draft: May 2014

Erik Borgen

Bruce Aylward

Ecosystem Economics LLC
Bend, Oregon

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1. Introduction

Shannon Peterson Ciotti Consulting and partners are conducting a study of the potential impacts of water transactions in the California side of the Walker River Basin, including the possibilities for avoiding, minimizing, or mitigating for those impacts. The work is a project of the Resource Conservation District (RCD) of Mono County. The RCD wishes to determine the potential risks, benefits, and procedural considerations involved in the establishment of a water transactions program within the California portion of the basin; to complement the ongoing water leasing and sales efforts in Nevada currently led by the National Fish and Wildlife Foundation (NFWF). This study will provide recommendations regarding the potential development and implementation of a water transactions program for the California portion of the Walker River Basin, aimed at meeting ecological goals and protecting/sustaining communities and livelihoods in the basin.

This report focuses on Task 1 of the larger study—an effort to understand irrigation water use in Antelope and Bridgeport Valleys— and includes compilation of available data and information on water use and hydrology in these two valleys. The report also includes an effort to model the water balance and irrigation water use in each valley. The modeling effort is intended to assist in understanding the potential hydrological impacts of water transactions and feed into subsequent analyses under this study of ecological and economic impacts of such transactions.

The report begins by setting the stage for the report by discussing the overall purpose of the RCD study and the manner in which this report seeks to inform study outputs. The remainder of the reports provides a compendium of technical information organized in the following order: hydrology, water rights, irrigation water use, and evapotranspiration. The report closes with a presentation and discussion of the water balance models and how they might inform the discussion about the lease or transfer of water rights to assist in the restoration of Walker Lake.

2. Background, Overview and Rationale

As outlined in the RCD study proposal, there are three cascading outcomes that could result from water transactions in Bridgeport and Antelope Valleys. Each of these outcomes results from the changes to water use and/or water management that are incentivized by particular types of water transactions. A change in water use and/or water management likely will change the hydrology of the fields and streams, which in turn would affect both stream and field ecology and species. Subsequently, these changes may have financial, social and/or economic impacts on residents, producers and tourists in the Valleys.

The analysis of outcomes (or impacts) is driven by a set of three potential objectives for water transactions in Mono County:

Objective 1: *Provide water to the state line for delivery to Walker Lake.* The driving force behind the analysis of the impacts of water transactions is NFWF's Walker Basin Restoration Program, which is working to improve flows to Walker Lake and promote sustainable land and water management in the Walker Basin. In the case of Bridgeport and Antelope Valley, it is likely that in order to qualify for incentives from NFWF landowners would need to offer water that would otherwise have been consumed in the Valleys. Analysis of the impacts of potential water transactions will therefore generally rely on analysis of how changes in the timing and amount of water diverted to and used on irrigated fields affect the evapotranspiration of water from these fields.

Objective 2: *Improve productivity for fish and wildlife in area waterways.* At present, the storage and release of reservoir water and the diversion and return of stream flow for irrigation water are actions that subtract water from area creeks and streams (at diversions) and adds water to area creeks and streams (at points of return flow). Reduced flows in streams may be a limiting factor for the survival, health and productivity of fish and wildlife. To the extent that water transactions move water through these valleys in the form of additional stream flow at times when low flows are a limiting factor, then water transactions would improve instream hydrological conditions with resulting improvements in passage, connectivity and habitat for aquatic species, particularly fish.

Objective 3: *Improve, or minimize, impacts on pasture and crop productivity.* Providing water for Objectives 1 and 2 will mean changes to on-site water use and management. Ideally, the changes in water use and/or water management would be consistent with increasing productivity. If not, then any decrease in productivity and reduction in financial returns to livestock and cropping would need to be more than compensated for by payments received by producers for entering into water transactions.

In order to assess the impacts of water transactions in terms of these three objectives, a series of hydrological, ecological and economic questions need to be analyzed by the RCD study. The primary goal of Task 1 is simply to understand how potential water transactions that meet Objective 1 would alter the pattern of water use and management in the two valleys. Generally speaking, water transactions may change:

1. The amount of storage water assigned for diversion and use in irrigation;
2. The point at which water is diverted from the stream to the field;
3. The source that is used (i.e., switching from surface water to groundwater);
4. The efficiency with which water is diverted and conveyed to the field;
5. The efficiency with which water is used on the field;
6. The amount of ground that is irrigated; and/or
7. The proportion of the season that fields are irrigated.

Any of these approaches has the potential to improve instream conditions in the two valleys and fulfill Objective 2. Without being conclusive at this stage, it would be reasonable to hypothesize that only Approaches 1, 6 and 7 would qualify as means to reduce consumptive use in irrigation, thereby providing savings that could potentially be carried through to Walker Lake, and fulfilling Objective 1.

Changes to the timing and location of storage releases and diversions are likely to pass water by diversions and on downstream, resulting in raised stream flow in downstream reaches. Reducing diversions and the use of irrigation water may then impact crop evapotranspiration as well as the infiltration of excess water into the water table. Changes to infiltration will affect groundwater levels, which in turn may also affect the ability of plants to access the water table for the purposes of transpiration and growth. Changes to groundwater levels and the extent to which plants draw from groundwater for transpiration will then affect the rate and amount of water that moves through the subsurface geology of the valleys and back to the streams. So, changes in water use and/or water management likely will also affect stream flow below diversions where the water would have returned to the streams, but for the water transaction.

The relationship between surface water, plants, and the groundwater system are complex. Typically, they can be addressed conceptually, analytically and numerically. For example, for the Walker River below Topaz and Bridgeport and down to the US Geological Survey (USGS) gage at Wabuska, scientists at the University of Nevada Reno and the Desert Research Institute have developed combined surface water distribution and groundwater models that provide numerical analysis of potential water transactions (Boyle *et al*. 2009, 2013; Minor *et al*. 2009). In the Lower Walker River below the Wabuska gage, the

USGS has prepared a groundwater model (since surface water distribution is straightforward) to simulate stream flow through to Walker Lake (Allander *et al*. Forthcoming).

These modeling efforts have taken years and millions of dollars. However, these studies and models have involved only minimal efforts to characterize and describe the headwater valleys in California. In this study, therefore, such precision cannot realistically be attained. Rather, this study, and Task 1 more specifically, represent an initial attempt to gather relevant information and examine how it can be deployed to create a simple water balance model that will describe how water moves through the system and how water transactions may alter the status quo.

It is important to note that Task 1 is designed to provide information that can be used in subsequent tasks to examine the hydrological, ecological and economic impacts of potential water transactions. In other words, the overall intent of the RCD study is to assess whether any particular transactions meet any or all of the three objectives above, and, if so, what the associated positive or negative impacts are. Analysis of higher level ecological and economic outcomes, however, relies on first documenting the potential hydrological changes that may occur as a result of water transactions and the changes they cause in water use and/or water management. Thus, Task 1 is critical to the utility of the overall results from the study.

In this effort Ecosystem Economics was fortunate enough to benefit from parallel efforts at data collection and analysis made by researchers from the Desert Research Institute. In particular, Task 1 has relied considerably on the following work:

- Tim Minor worked with the RCD members and Ecosystem Economics to digitize relevant features from Bridgeport and Antelope Valley, including but not limited to points of diversion and irrigated fields, grouped into “hydrologic response units.”
- Tim Minor and Justin Huntington developed and processed information on meteorological conditions and Landsat images to provide spatial information on evapotranspiration
- Greg Pohll and Rosemary Carroll carried out a preliminary assessment of recharge in the two valleys (Carroll and Pohll 2013).

While much of this information is integrated into this report all errors and omissions in the report below remain the property of the report authors.

3. Hydrology

Antelope Valley sits at the base of the Sierras and feeds the West Walker River. Located to the South, Bridgeport Valley collects water from a number of creeks emerging from the Sierras and feeds the East Walker River. First surface water and then groundwater hydrology of the two valleys is discussed below, separating the discussion between the two valleys.

3.1 Surface Water: West Walker River

The West Walker River drains portions of the eastern slope of the Sierra, primary in Mono County. Discharge is largely from snowmelt, with over two-thirds of annual flow volume occurring in three months (May-July). Flows are highly variable from year to year and the "average" discharge usually does not occur.

The USGS gaging network for the West Walker River is presented in Figure 1 and Table 1, and the gages specifically located in Antelope Valley are presented in Figure 2. A majority of the surface water flow entering the valley is measured by USGS location 10296500—West Walker River near Coleville, CA

(Coleville Gage, #4 in Figure 1); however, there are some small streams (including Mill Creek) that discharge into the West Walker below the Coleville Gage. Irrigation diversions begin just below the Coleville Gage, with a majority of diversions in the upper portion of the Valley.

Figure 1. USGS Schematic of West Walker River Gages

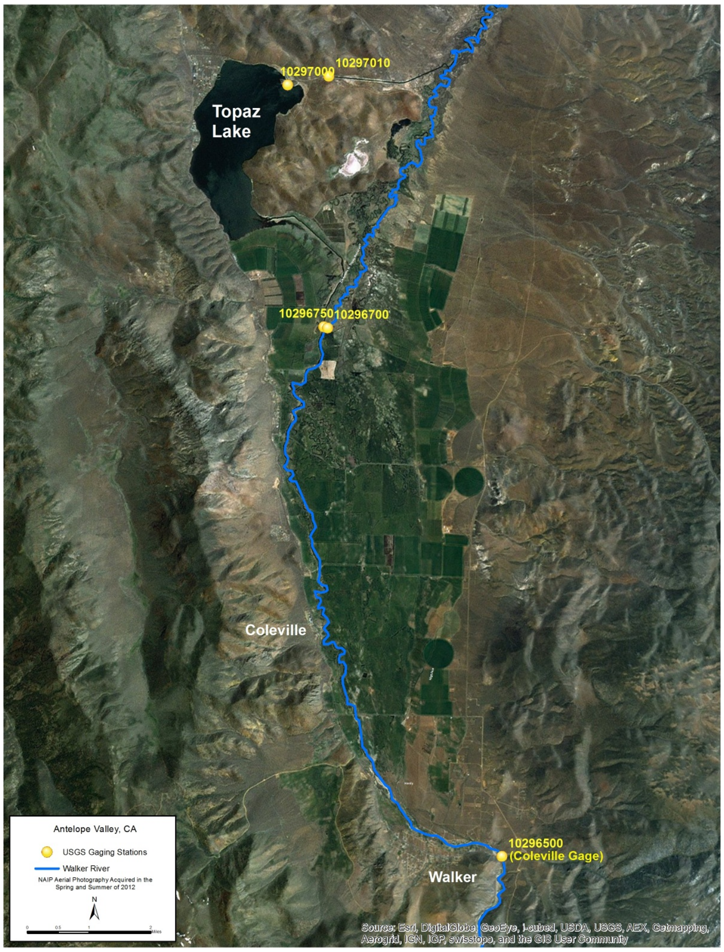
Source: USGS, http://nevada.usgs.gov/walker/swdata_westwalker.htm, captured 6/25/2013

Table 1. West Walker River Gages

West Walker River Active Stations		
Map Number	**USGS Site Identification**	**Site Name**
2	10295500	Little Walker River near Bridgeport CA
3	10296000	West Walker River below little Walker River near Coleville CA
4	10296500	West Walker River near Coleville CA
7	10297000	Topaz Lake near Topaz CA
11	10297500	West Walker River at Hoye Bridge near Wellington NV
14	10299100	Desert Creek near Wellington NV
18	10300000	West Walker River near Hudson NV

West Walker River Inactive Stations		
Map Number	**USGS Site Identification**	**Site Name**
1	10295300	West Walker River at Hwy 108 bridge below Pickel Meadows CA
5	10296580	Mill Creek above Lost Cannon Creek near Walker CA
6	10296650	West Walker River above Topaz Lake at Topaz CA
8	384131119325101	Nevada Creek at Highway 395
9	384142119321901	Topaz Lake at Marina
10	384049119324000	Topaz Lake sample site near California Creek near Topaz
12	10298000	Saroni CA near Wellington NV
13	10298500	West Walker River near Wellington NV
15	10299102	Desert Creek at Desert Creek Ranch Bridge near Wellington NV
16	384250119190000	Desert Creek at State Highway 22 NV
17	10299120	Obanion Canyon near Wellington NV

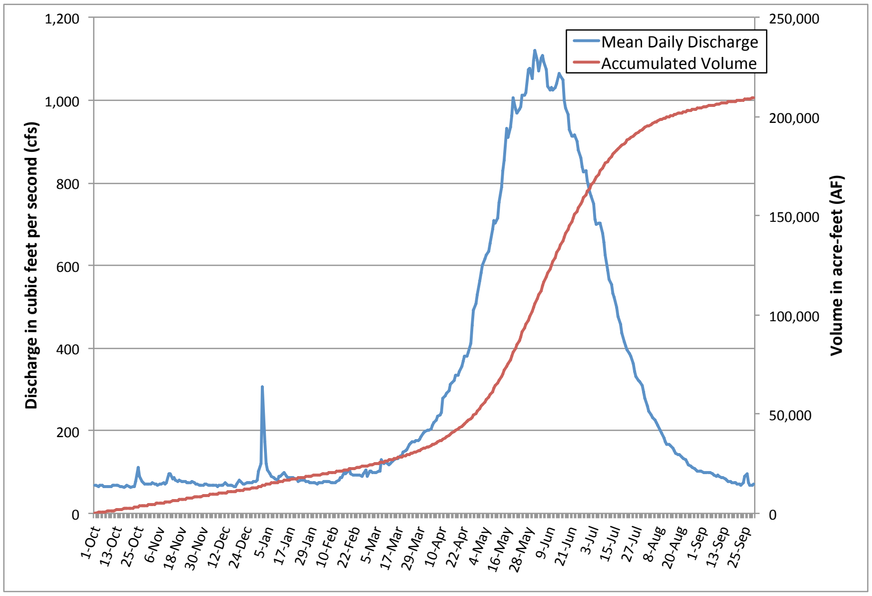
Figure 2. Map of Antelope Valley Gages



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

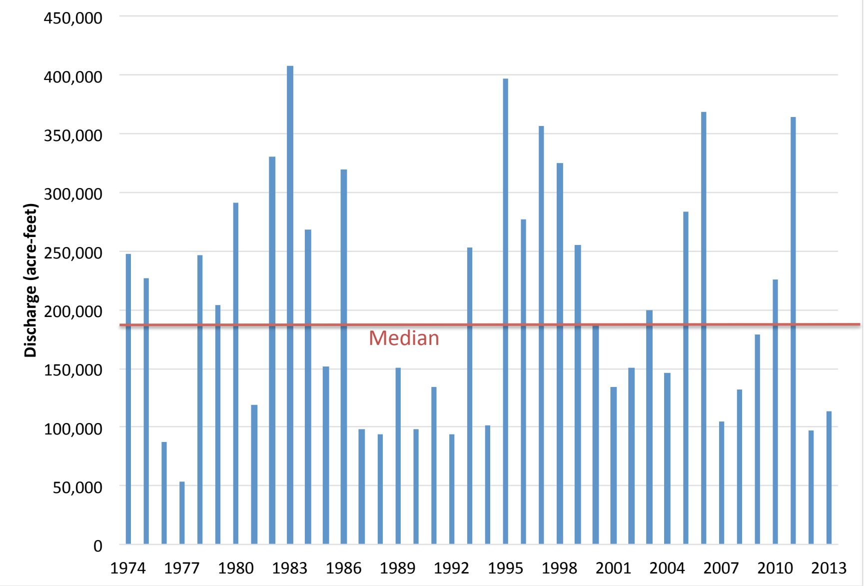
Surface water entering Antelope Valley, as measured at the Coleville gage, was analyzed to understand the variability of surface water supply within the irrigation season and from year to year. Mean daily discharge for water years 1973–2013 was collected from the USGS website. To understand the general distribution of flows during a water year (October 1 to September 30), mean daily discharge for each day was averaged (i.e., all October 1's from 1973–2013 were averaged to determine average flow on October 1) and then plotted (see Figure 3). Note that the majority of flow occurs between April and July.

Figure 3. Seasonal Distribution of Flow, Coleville Gage



Variability between years was also examined. Total discharge in acre-feet (AF) for each water year was summed and plotted (see Figure 4). Note the large difference between peak flow years and dry years as well as many successive dry years.

Figure 4. West Walker River Discharge By Water Year



Variability in discharge entering Antelope Valley by water year was also ranked, assigned percentiles and classified by “dry”, “mid” and “wet” (see Table 2). All years in the 25th percentile and lower were classified as “dry”, between 25th and 75th as “mid”, and 75th and above as “wet.” The last two irrigation seasons ranked as dry, which is consistent with anecdotal evidence gathered via landowner interviews.

Table 2. West Walker River Discharge by Water Year and Classification

Water Year	Discharge by Gage (AF)			Water Year Based on Coleville		
	Coleville	Hoye Br. Raw	Hoye Br. Unreg.	Rank	Percentile	Year Type
1974	247,523	225,369	245,614	26	65	Mid
1975	227,327	218,500	229,149	24	60	Mid
1976	87,774	90,666	81,738	2	5	Dry
1977	53,935	44,136	44,836	1	3	Dry
1978	246,345	185,424	224,187	25	63	Mid
1979	203,930	202,057	190,559	22	55	Mid
1980	291,658	281,897	305,431	32	80	Wet
1981	119,006	118,080	108,590	11	28	Mid
1982	330,659	294,950	342,049	35	88	Wet
1983	407,685	448,557	457,814	40	100	Wet
1984	267,792	290,670	265,138	29	73	Mid
1985	151,456	138,548	143,885	18	45	Mid
1986	319,066	301,333	321,992	33	83	Wet
1987	97,892	101,839	91,941	6	15	Dry
1988	93,722	76,529	80,830	3	8	Dry
1989	150,560	121,009	132,895	16	40	Mid
1990	98,362	79,727	81,528	7	18	Dry
1991	134,394	86,955	93,173	14	35	Mid
1992	94,103	67,596	74,650	4	10	Dry
1993	252,694	181,681	205,470	27	68	Mid
1994	101,071	92,036	85,030	8	20	Dry
1995	396,662	329,715	374,561	39	98	Wet
1996	276,661	271,718	263,627	30	75	Wet
1997	356,647	354,808	355,734	36	90	Wet
1998	324,701	278,765	308,189	34	85	Wet
1999	255,362	251,680	235,544	28	70	Mid
2000	186,366	151,823	153,917	20	50	Mid
2001	133,964	96,025	106,821	13	33	Mid
2002	150,611	103,908	107,439	17	43	Mid
2003	199,846	131,782	145,794	21	53	Mid
2004	146,412	127,398	122,913	15	38	Mid
2005	283,964	246,349	277,783	31	78	Wet
2006	368,459	321,154	326,537	38	95	Wet
2007	104,227	90,723	84,236	9	23	Dry
2008	131,500	100,353	106,895	12	30	Mid
2009	178,584	122,033	139,478	19	48	Mid
2010	226,167	183,337	190,960	23	58	Mid
2011	364,075	305,253	329,689	37	93	Wet
2012	96,747	105,961	86,277	5	13	Dry
2013	113,938	82,865	88,281	10	25	Dry

Surface water that is not diverted, return flows from irrigation diversions and storage releases from Topaz Lake comprise the surface water leaving Antelope Valley. Measuring water leaving the valley is complicated by Topaz Lake storage operations. The USGS added three gages in 2010 to aid in management by measuring: 1) water diverted to Topaz; 2) water left in the West Walker River; and 3) water released from Topaz Lake. Because of the short history of these gages, an alternative method for estimating water flowing out of Antelope Valley was used.

The Hoye Bridge gage on the West Walker River is located below the Topaz Lake return canal (in Nevada), but above inflows (e.g., Sweetwater Creek) or diversions in the upper end of Smith Valley. In addition, the Federal Water Master has traditionally used Hoye Bridge as a major measurement point. Therefore, Hoye Bridge was used in this analysis to measure water leaving Antelope Valley. The raw data for this gage, however, is highly influenced by Walker River Irrigation District (WRID) storage operations at Topaz Lake. For example, if WRID is storing water in Topaz Lake, Hoye Bridge will show less water than is actually leaving Antelope Valley. Conversely, if WRID is releasing stored water from Topaz Lake, Hoye Bridge will show more water than what is leaving Antelope Valley. To convert the raw Hoye Bridge gage data to "unregulated flow," the change in storage (a release is negative) at Topaz Lake (from the USGs) and the estimated evaporation from Topaz Lake (based on lookup tables used by the FWM) was added to Hoye Bridge discharge. This estimate of unregulated flow at Hoye Bridge is therefore the best estimate of flow leaving Antelope Valley (see Table 2).

3.2 Surface Water: East Walker River

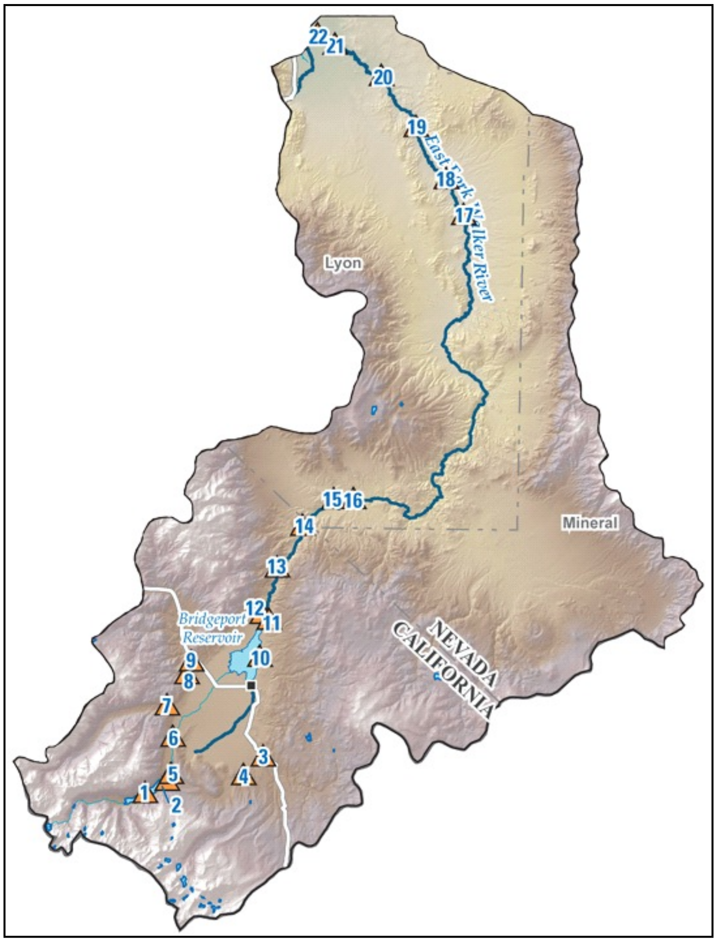
The East Walker River also drains portions of the eastern Sierra and, like the West Walker, experiences its greatest flows from April-July. The USGS gages on the East Walker are described in Figure 5 and Table 3. Gages in Bridgeport Valley are presented in Figure 6. Unlike Antelope Valley, Bridgeport Valley has numerous small streams that provide inflow to the Valley, many of which are neither gaged nor regularly measured. All outflow from the valley, however, leaves through the outlet of Bridgeport Reservoir, which is measured.

Bridgeport Valley inflows and outflows were substantially more difficult to estimate for two primary reasons: lack of gage data and many inflows. There are four primary creeks (i.e., Buckeye, Green, Robinson and Virginia) gaged by the USGS and many ungaged smaller creeks (including By Day, Log Cabin, Swauger and others) that enter Bridgeport Valley, eventually discharging in Bridgeport Reservoir. Furthermore, the four primary gaged creeks only have four years of overlap. A few of the other creeks have been gaged at various times by the USGS. For example Swauger Creek was gaged from June 2005 through the end of September 2006.

Bridgeport Reservoir is an in-channel reservoir so, like Antelope Valley, unregulated flow was estimated by backing out storage operations and evaporation from flow at the East Walker River Gage at Bridgeport (below the reservoir).

Despite the lack of stream gages and history for the gages in place, the sum of discharge from the four primary creeks do provide some valuable information, particularly when plotted along with the estimated unregulated flow below Bridgeport Reservoir (see Figure 7). The figure shows that, as might be expected, outflows more closely follow inflows during wet years, whereas the "top" of the inflow peak is carved off during the dryer years. As storage in the Bridgeport Reservoir is already accounted for this suggests that much of the inflow water is being stored or consumed in the valley. This topic is returned to in the water balance model discussion later in Section 7.4. The other point worth mentioning is that these four creeks probably do not account for the full amount of water supply during the irrigation season. Evapotranspiration from irrigated fields should likely cause a more pronounced difference between inflows and outflows in the wet years.

Figure 5. USGS Schematic of East Walker River Gages



Source: USGS, http://nevada.usgs.gov/walker/swdata_ewalker.htm, captured 6/25/2013

Table 3. East Walker River Gages

West Walker River Active Stations		
Map Number	**USGS Site Identification**	**Site Name**
2	10295500	Little Walker River near Bridgeport CA
3	10296000	West Walker River below little Walker River near Coleville CA
4	10296500	West Walker River near Coleville CA
7	10297000	Topaz Lake near Topaz CA
11	10297500	West Walker River at Hoye Bridge near Wellington NV
14	10299100	Desert Creek near Wellington NV
18	10300000	West Walker River near Hudson NV

West Walker River Inactive Stations		
Map Number	**USGS Site Identification**	**Site Name**
1	10295300	West Walker River at Hwy 108 bridge below Pickel Meadows CA
5	10296580	Mill Creek above Lost Cannon Creek near Walker CA
6	10296650	West Walker River above Topaz Lake at Topaz CA
8	384131119325101	Nevada Creek at Highway 395
9	384142119321901	Topaz Lake at Marina
10	384049119324000	Topaz Lake sample site near California Creek near Topaz
12	10298000	Saroni CA near Wellington NV
13	10298500	West Walker River near Wellington NV
15	10299102	Desert Creek at Desert Creek Ranch Bridge near Wellington NV
16	384250119190000	Desert Creek at State Highway 22 NV
17	10299120	Obanion Canyon near Wellington NV

Figure 6. Map of Bridgeport Valley Gages

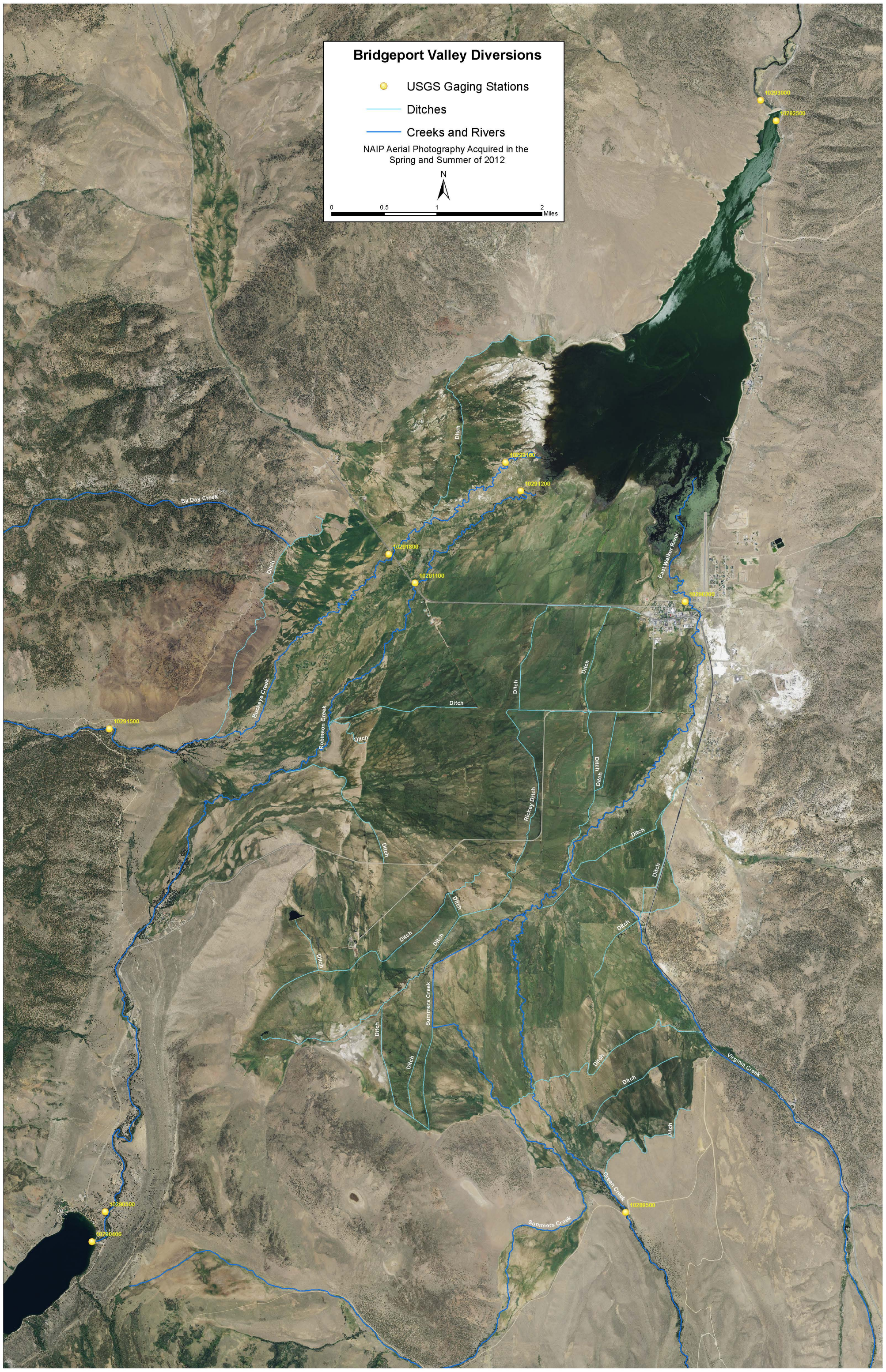
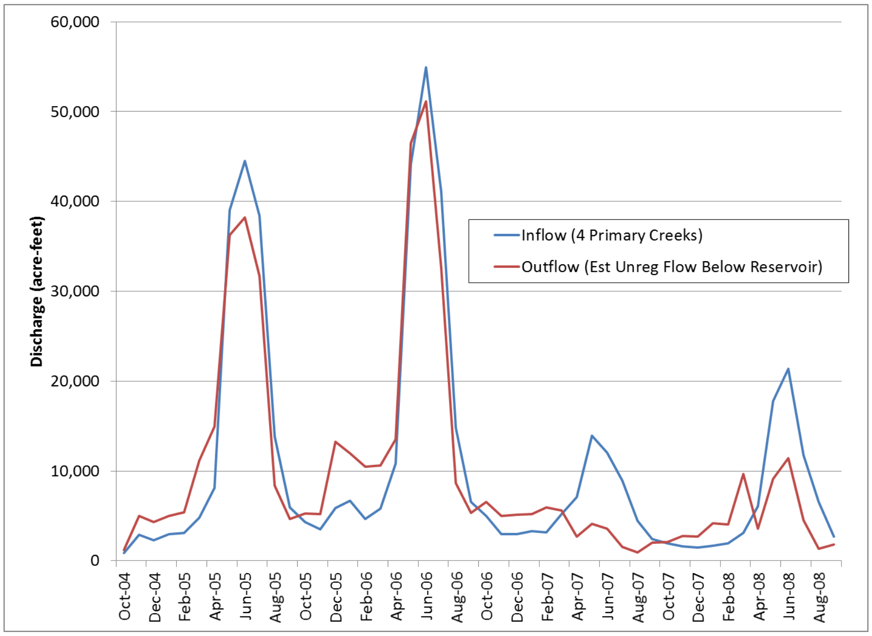


Figure 7. Bridgeport Valley Inflows and Outflows



3.3 Groundwater

Dr. Greg Pohll of DRI, along with his DRI colleague Dr. Rosemary Carroll, prepared a short report on groundwater recharge in Antelope and Bridgeport Valleys (Carroll and Pohll 2013). This report is available upon request and only a brief summary of the results is reproduced here, although a number of the results are picked up and used in the models in Section 7.

Dr. Pohll also provided Ecosystem Economics with a brief analysis of groundwater levels based on data from USGS well monitoring stations in Antelope and Bridgeport Valley. This information is summarized below based on communications with Dr. Pohll, along with the results of the recharge analysis.

3.3.1 Antelope Valley

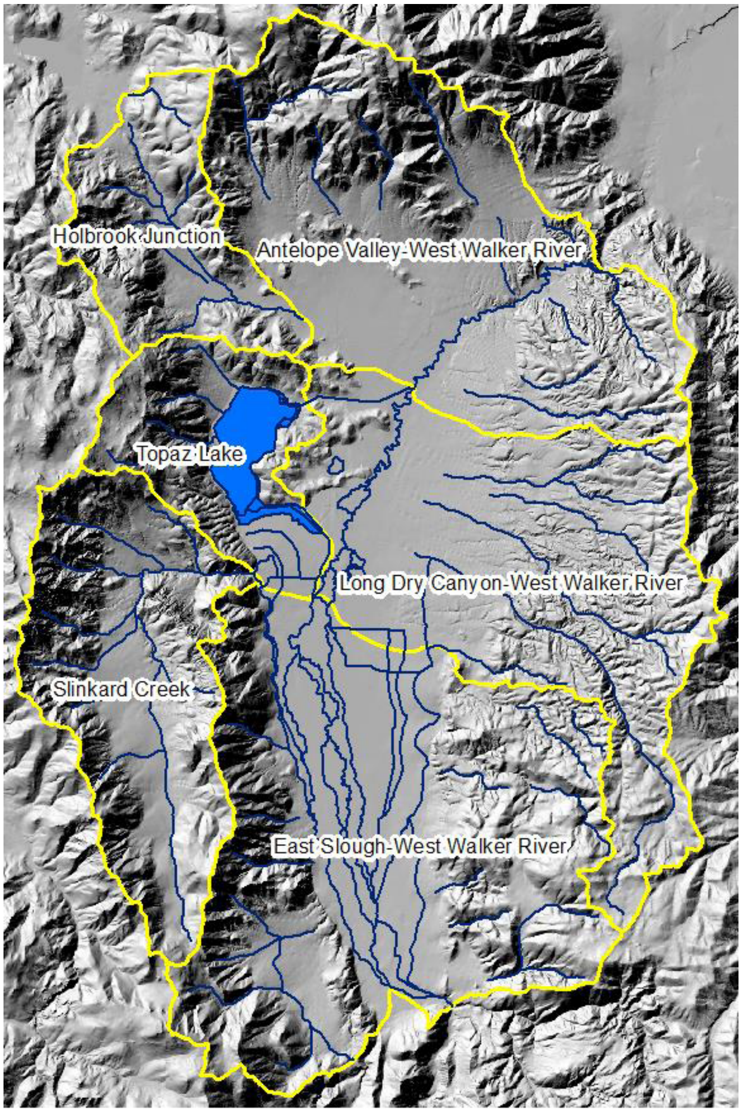
Dr. Pohll identified six HUC-12 sub-watersheds in Antelope Valley (Figure 8). Using 1981-2010 PRISM data total annual average precipitation of 175,700 AF, with zones ranging from 8 to 34 inches per year. Thus, it is concluded that all areas contribute to groundwater recharge. Dr. Pohll employs three different methods to estimate recharge: the Maxey-Eakin approach commonly used in Nevada, the Nichols approach, and Epstein's BBRM (bootstrap brute-force recharge model). For Antelope Valley the models yield recharge estimates that range between 15,600 AF (9%) from the BBRM approach to 22,800 AF (13%) from the Max-Eakins approach.

With respect to groundwater Dr. Pohll concludes that it is evident that water levels are highest in the south and northwest of Antelope Valley. Water from the south generally flows parallel to the river until just south of the state line. At that point, there is a groundwater divide with some water flowing toward Topaz Lake and the remainder flowing northeast along the riparian corridor. Dr. Pohll notes a few additional interesting findings:

- There is no evidence of significant inflow from the western mountains. These are relatively of high elevation so it would be expected that more pronounced inflow would be seen, which would cause contours that are U-shaped with the tips pointing north. To some degree this is a function of the location of the wells, with many located on Highway 395, but few located up-gradient. The conclusion is that groundwater is likely flowing into the valley from the west, but the flux may be less than originally thought, perhaps due to low permeability rock on the margins.

- There seems to be evidence that groundwater pumping is occurring because of the drawdown cones that occur in the west-central portion of the valley.
- The data are a bit too coarse along the river channel in the center of the valley to ascertain with certainty gaining or losing reaches. Topaz Lake is likely receiving groundwater. Above Topaz Lake, the water levels indicate that, on average, the river is most likely gaining, but data are fairly limited. The river may actually be losing in the lower reaches due to groundwater pumping, but one cannot tell with much certainty.

Figure 8. Sub-Watersheds for Antelope Recharge Analysis



Source: Carroll and Pohl (2013)

3.3.2 Bridgeport Valley

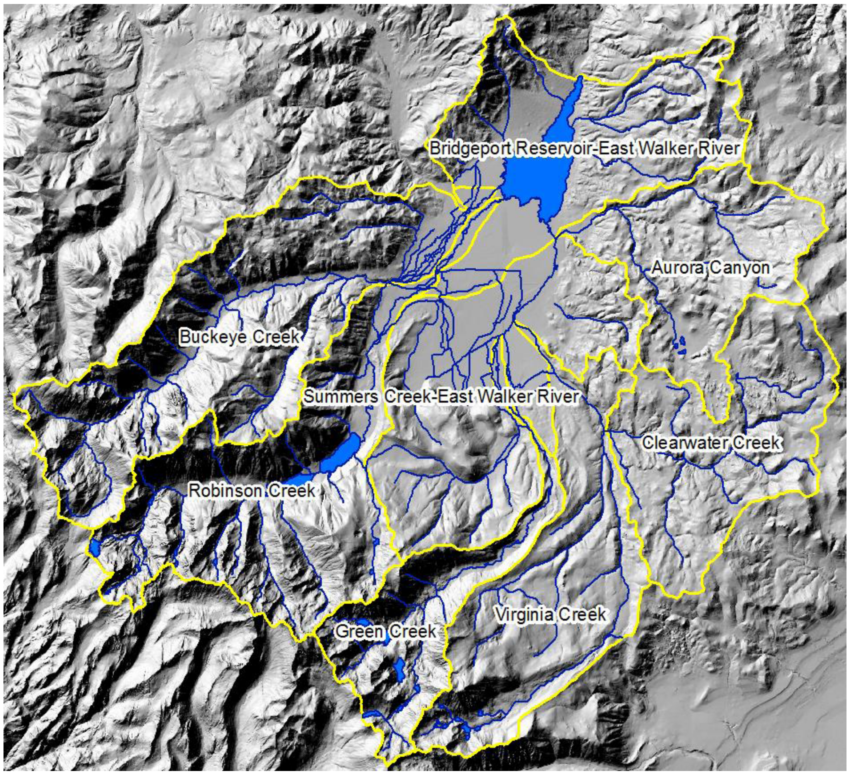
For Bridgeport Valley, Dr. Pohll identified eight HUC-12 sub-watersheds (Figure 9). Precipitation was twice that of Antelope valley at 380,000 AF/yr, with the same range as observed in Antelope Valley. completed the same analysis for Bridgeport Valley. Estimated recharge varies from 68,600 AF (18%) using the Nichols approach through to the BBRM which had a mean value of 128,700 (35%).

Dr. Pohll drew the following conclusions regarding the Bridgeport Valley groundwater system:

- Groundwater flow is generally from the southwest to the northeast.
- The U-shaped water level contours indicate that recharge is likely entering the valley from all sides, and from the braided stream structure in the southwest (exact locations of gains and losses cannot be determined from the map).
- Hydraulic gradients are quite large in the southwest portion of the valley, suggesting that the sediments are most likely not very deep in this region. The gradients decrease in the northeast suggesting higher transmissivities and perhaps deeper sediments.
- The limited spatial data and braided nature of the stream system in Bridgeport Valley makes it more difficult to determine if the river is gaining or losing, but it appears that the streams are mostly gaining, except for the areas in the south and southwest.

In summary, groundwater recharge is mostly from the adjacent uplands with perhaps an additional component from stream losses as the streams enter each valley. Groundwater flow is generally parallel to the streams and on the downstream end the streams are most likely gaining. Bridgeport Reservoir appears to be receiving groundwater.

Figure 9. Sub-Watersheds for Bridgeport Recharge Analysis



Source: Carroll and Pohl (2013)

4. Water Rights

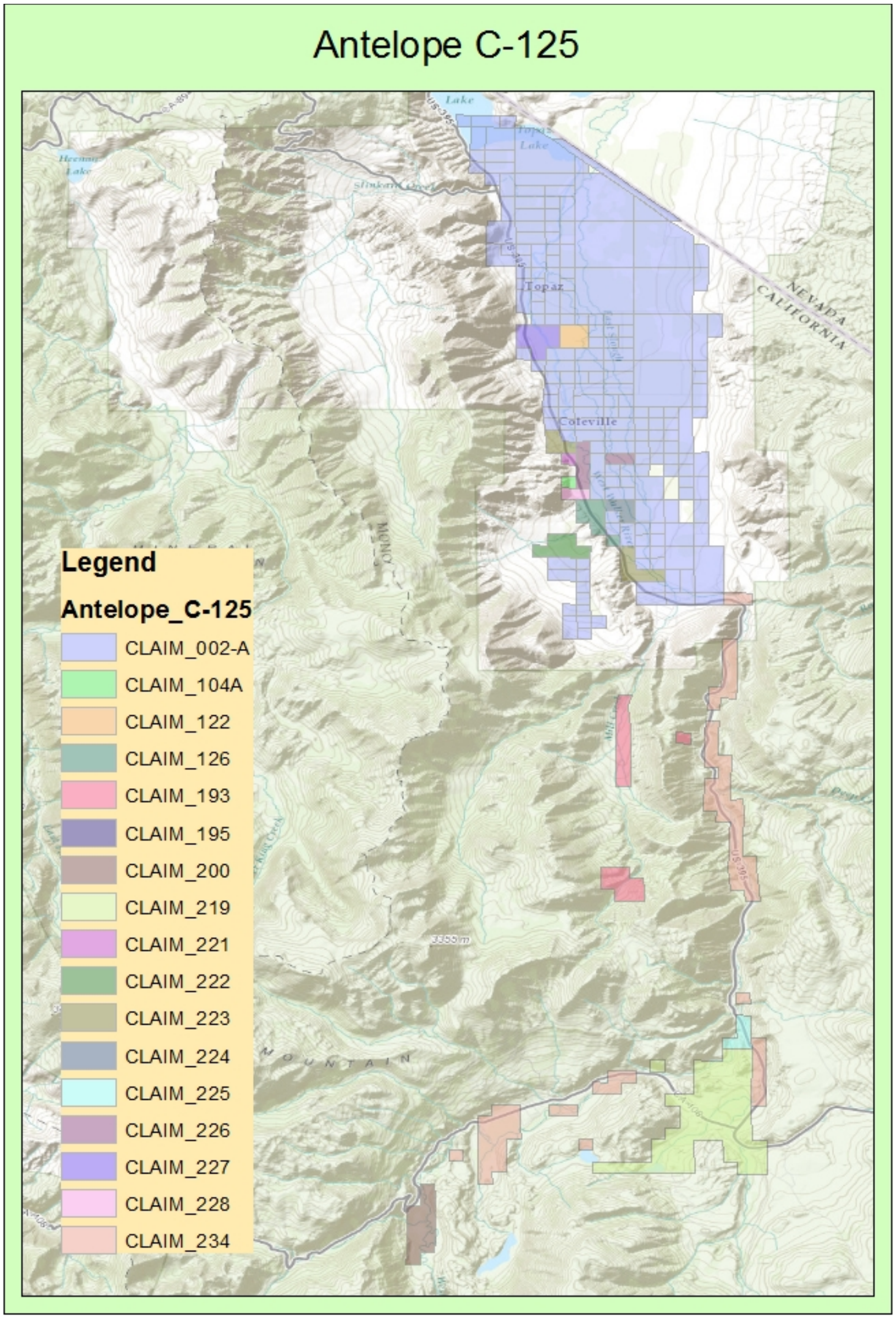
Water rights in the Walker Basin consist of both surface water and groundwater rights. Surface water rights comprise the majority of water rights in Antelope Valley and are primarily made of up appropriative rights adjudicated by a federal court decree. There are also groundwater rights in Antelope Valley, largely used to supplement decreed surface water rights.

4.1 Decree

The oldest water rights in the Walker River system are for the direct diversion of the natural flows (including return flows) of the Walker River and its tributaries as set forth in Decree C-125, the federal Walker River Decree. Issued initially in 1919 as Decree 731, and then re-adjudicated by the federal District Court in 1936, Decree C-125 was issued in final amended form in 1940.

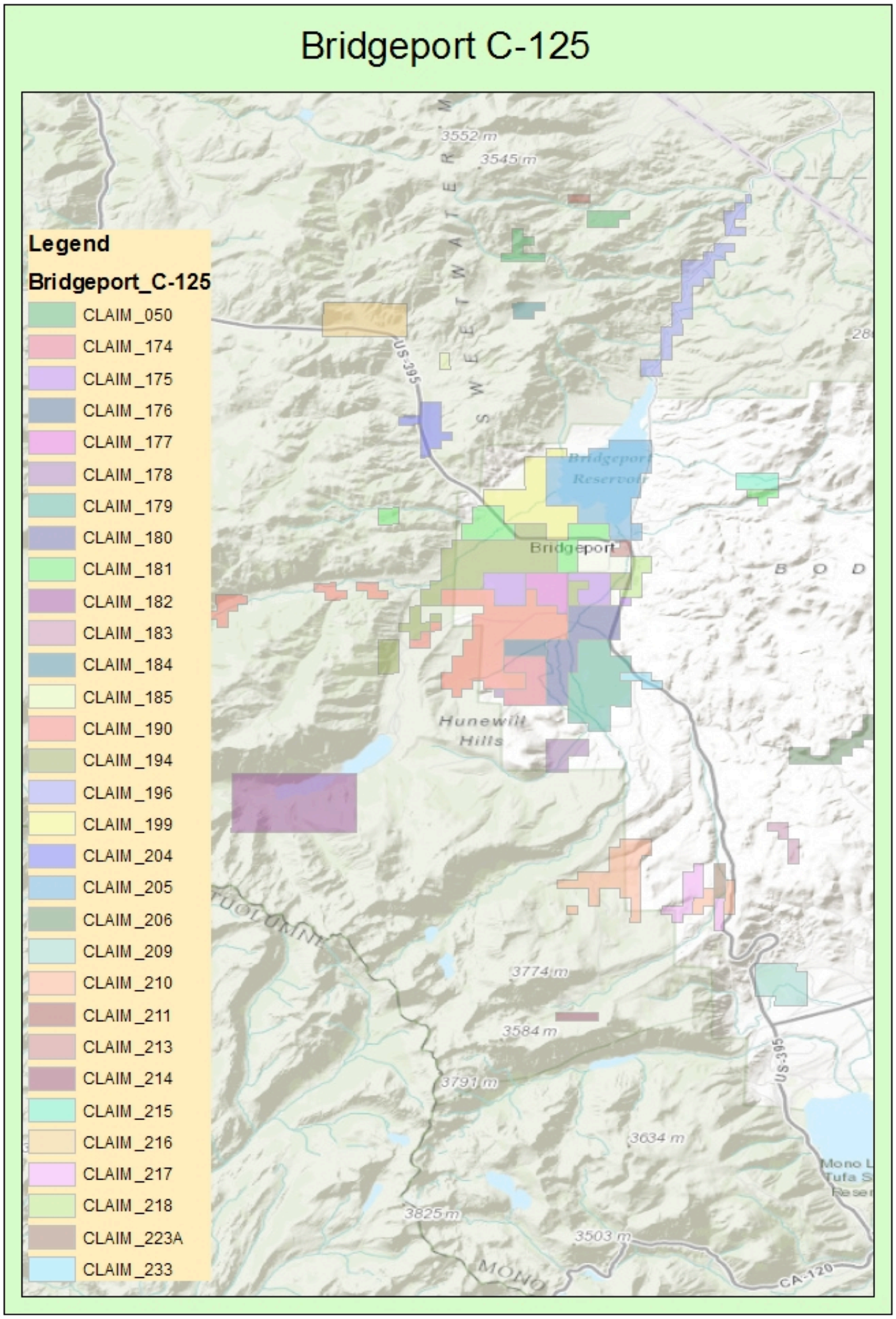
Under the decree, Antelope Valley rights were generally granted 0.016 cfs per acre and an irrigation season of 245 day (March 1 to October 31). Bridgeport Valley rights were also generally granted 0.016 cfs per acre; however, the irrigation season is only 199 days (March 1 to September 15). Total decreed irrigation water rights in California under the C-125 decree are 41,811 acres, of which 23,669 acres on the East Walker drainage and 18,142 on the West Walker drainage. A portion of these rights are found outside Antelope and Bridgeport Valleys proper, but the vast majority are in these valleys (see Figure 10 and Figure 11) The tables that follow provide current information as provided by Historical Mapping Service and DRI on the quantities of water rights within and outside the valleys.

Figure 10. Map of West Walker River C-125 Decree Water Rights by Claim



Source: Desert Research Institute

Figure 11. Map of East Walker River C-125 Decree Water Rights by Claim



Source: Desert Research Institute

Table 4. C-125 Decree Water Rights in Antelope Valley

Ditch	Acres	Diversion Rate (cfs)	Maximum Annual Diversion (AF)
Alkali	428	6.72	3,266
Big Slough	9,928	154.80	75,225
Carney	1,112	17.41	8,461
Hardy	210	3.36	1,633
Harney	426	6.64	3,227
Little Antelope	456	7.19	3,496
Main	360	5.61	2,727
Powell	159	2.54	1,234
Ricky	463	7.30	3,547
Swauger	2,183	34.03	16,537
West Goodnough	343	5.47	2,656
Totals	16,067	251.07	122,009

Notes: The maximum diversion based on diversion for all 245 days of the irrigation season

Table 5. C-125 Decree Water Rights from West Walker Upstream from Antelope Valley

Claim	Name	Acres	Diversion Rate (cfs)	Notes
219	Junction Range	1,150	18.40	between Junction Creek and Little Walker River; 12 miles above Antelope Valley
225	Adams, R & V	40	0.64	near confluence of Little Walker and West Walker; 11 miles above Antelope Valley
200	USFS/Tholke, R	485	7.76	off Wolf Creek (14 miles above Antelope Valley) and west Walker in vicinity of Poore Lake
195	Dressler, M	80	1.28	from Hot Creek, trib to the Little Walker; 14 miles above Antelope valley
193	Cal F&G	320	5.12	up Mill Creek; likely forfeited/abandoned due to non-use
Totals		2,075	33.20	

Table 6. C-125 Decree Rights in the East Walker Drainage

Claim No.	Acres	Diversion Rate (cfs)	Maximum Annual Diversion (AF)
174	971.0	15.53	6,130
175	1,855.5	29.76	11,747
176	468.0	7.49	2,956
177	280.0	4.48	1,768
178	540.0	8.64	3,410
179	1,875.0	30	11,841
180	1,544.0	24.71	9,753
181	1,540.0	24.64	9,726
182	290.0	4.64	1,831
183	240.0	3.84	1,516
185	80.0	1.28	505
190	3,660.0	58.56	23,115
194	3,530.0	56.48	22,294
199	1,870.0	26.72	10,547
204	800.0	12.8	5,052
206	640.0	10.24	4,042
207	160.0	2.56	1,010
208	480.0	7.68	3,031
209	375.0	6	2,368
210	1,680.0	27.08	10,689
213	100.0	1.6	632
214	40.0	0.64	253
216	100.0	1.6	632
217	100.0	1.6	632
218	130.0	2.08	821
223B	160.0	2.56	1,010
233	160.0	2.56	1,010
Total	23,668.5	375.77	148,323

4.1.1 Decree Priority Dates

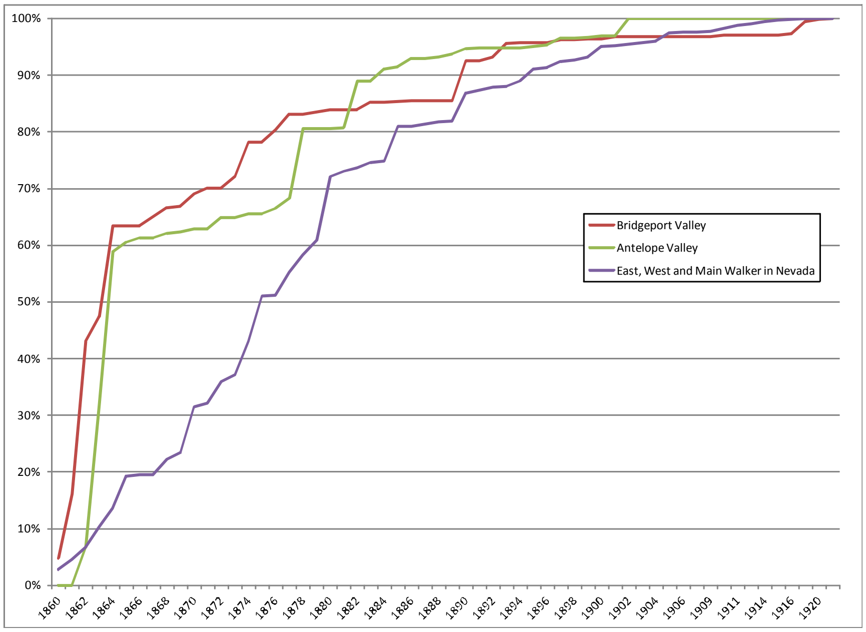
Since Walker Basin water rights are governed by the doctrine of prior appropriation, the priority date of a water right (typically the date first put to beneficial use) is very important. The older the water right, the more senior that right is. In the event the river does not yield enough water to satisfy the demand of all water rights (nearly every year in the Walker Basin, to some extent), the most junior water right is cut off first, then the next most junior, and so on until there is no shortage.

Between Antelope and Bridgeport Valleys, there are 45 different priority dates ranging from 1860 to 1925. The priority dates in each Valley, along with their corresponding acreage, diversion rate and maximum annual diversion are presented in Appendix 1 in Table 24 and Table 25.

To visualize the relative priority of water rights in different valleys or reaches, it is helpful to plot "accumulation" curves. With the priority date on the x-axis and the most senior date nearest the origin, the cumulative percentage (that is, the percent of the total volume of rights for that priority date and more senior dates) is plotted for each priority date. The curve increases on the y-axis until it reaches 100%.

Figure 12 below shows these accumulation curves for Bridgeport Valley, Antelope Valley and the remaining downstream decree rights in Nevada. This figure shows that the California decree rights are substantially more senior than the Nevada decree rights. The accumulation curve for both valleys increases rapidly. Over 60% of the California decree rights have an 1864 or more senior priority date whereas the corresponding figure for Nevada rights is just 12%. The implication of this finding is that the California rights are far more reliable on average (as explored further below) and therefore would be of higher value, other things equal.

Figure 12. Walker River Decree Rights Seniority Accumulation Chart

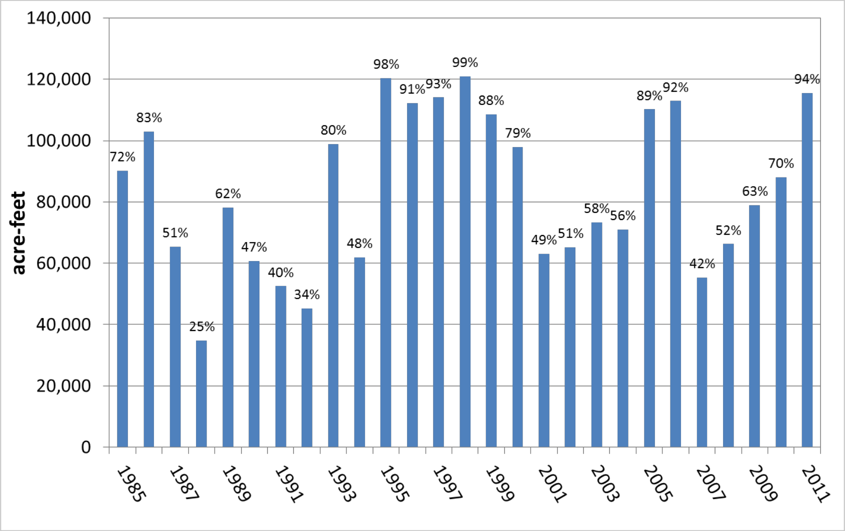


4.1.2 Reliability of Decree Rights

The Federal Water Master (FWM), also known as the Chief Deputy Water Commissioner of the U.S. Board of Water Commissioners, is appointed by the federal decree court and administers the delivery of water to authorized points of diversion on the Walker River. In Antelope, Smith and Mason Valleys, the FWM office receives orders for water, and determines what priority dates can be served by the water available. If, for example, the priority date being served in Antelope Valley is 1864, then that means only decree rights with an 1864 priority date and earlier (more senior) can divert water, and any right with an 1865 priority date or later (more junior) may not divert. There are no provisions under the current FWM to allow partial diversion for the most immediate junior right (1865 in the example above). The FWM does not have gages in Bridgeport Valley and generally relies on the cattle operators in the Valley to work among themselves in times of water shortage.

FWM regulation data for Antelope Valley (1985-2011) is publicly available as evidentiary materials on the first Nevada transfer of water rights by NFWF in front of the Nevada State Engineer under Application No. 80700. These data were compiled and applied to the C-125 water rights information for Antelope Valley, presented above. The volume of water in priority each year as well as its percentage of the maximum face value is presented Figure 13. The FWM does not provide regulation data for Bridgeport Valley, although the East Walker regulation data would likely be a good indicator of reliability. However, the Antelope Valley figure provides a sufficient indication of the annual variation in reliability of the California water rights. The principal message is that even senior decree rights are subject to considerable variability in their water supply, even if on average they receive more water than junior rights. In this regard it is worth mentioning that the junior Nevada rights (1874 priority date and junior) have access to supplemental storage water from Bridgeport Reservoir and Topaz Lake. This supplemental supply tends to even out somewhat the variability in supply and the apparent mismatch in seniority between Nevada and California rights. Nevertheless, as storage rights are separable from decree rights for the purposes of water transactions it remains the case that the California decree rights will have a competitive advantage purely in terms of reliability.

Figure 13. Antelope Valley Water Reliability by Year in Volume and Percent of Face Value



4.2 Storage

Many agricultural communities in the American West have stored irrigation water available so as not to rely solely on the availability of natural surface flow during the irrigation season. In contrast to Mason and Smith Valley, located downstream from Mono County in the Walker Basin, Antelope and Bridgeport Valleys have, in comparison, very little storage water. The volumes, locations and priority dates for these limited storage resources are presented in Table 7 and Table 8. In the case of Lobdell Lake the storage right is specified as a diversion rate with no reported storage capacity. Actual capacity is reported as 640 AF.

Table 7. Antelope Valley Storage Rights

Reservoir Name	Water Source	Decreed Right	Priority	Place of Use	Claim No.
Lobdell Lake	Deep Creek	6 cfs	1864	S. Smith Valley	172
Black Reservoir	Black Creek	350 AF	1907	Sonora Junction	220
Poore Lake	Poore Creek	1200 AF	1901	Antelope Valley	201-203

Table 8. Bridgeport Valley Storage Rights

Reservoir Name	Water Source	Priority Date	Decreed Storage Right (AF)	Refill Right (AF)	Refill Priority Date
Green Lakes	Green Creek	1895	400		
Lower Twin Lake	Robinson Creek	1888	4,050	4,050	1905
Upper Twin Lake	Robinson Creek	1905	2,050	2,050	1906

4.3 Groundwater

No groundwater permits or certificates were located, due to how the State of California deals with groundwater rights. Based on interviews with Antelope Valley irrigators, there are some irrigators who use groundwater to supplement their decree rights. Details and estimates from the interviews are presented in the next section under water use.

5. Water Use

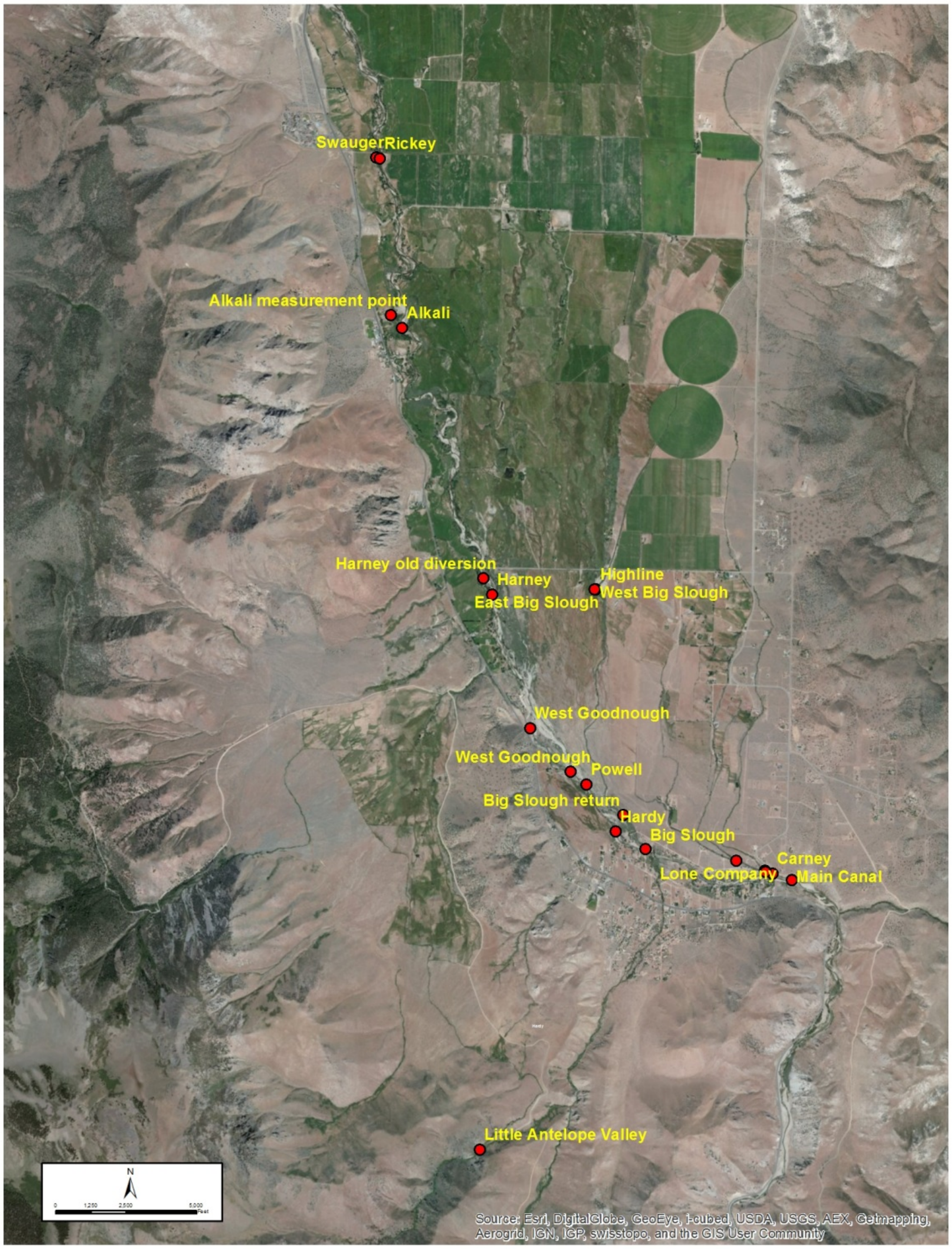
This section examines water use in Antelope and Bridgeport Valleys. Generally, Antelope Valley has a mix of pasture and hay crops while Bridgeport Valley is nearly all pasture. Application of water in Antelope Valley includes flood, wheel-lines and pivots, while Bridgeport Valley is nearly all flood application. Antelope Valley has mostly surface water with some supplemental groundwater, while Bridgeport Valley does not appear to utilize any groundwater.

To quantify water use, the first item needed was diversion records. Permission for use of Antelope Valley’s diversion records was sought, but not approved by the water users. Diversion records are not maintained in Bridgeport Valley An alternative method for estimating Antelope Valley diversions is outlined below.

5.1 Irrigated Fields and Hydrologic Response Units (HRUs)

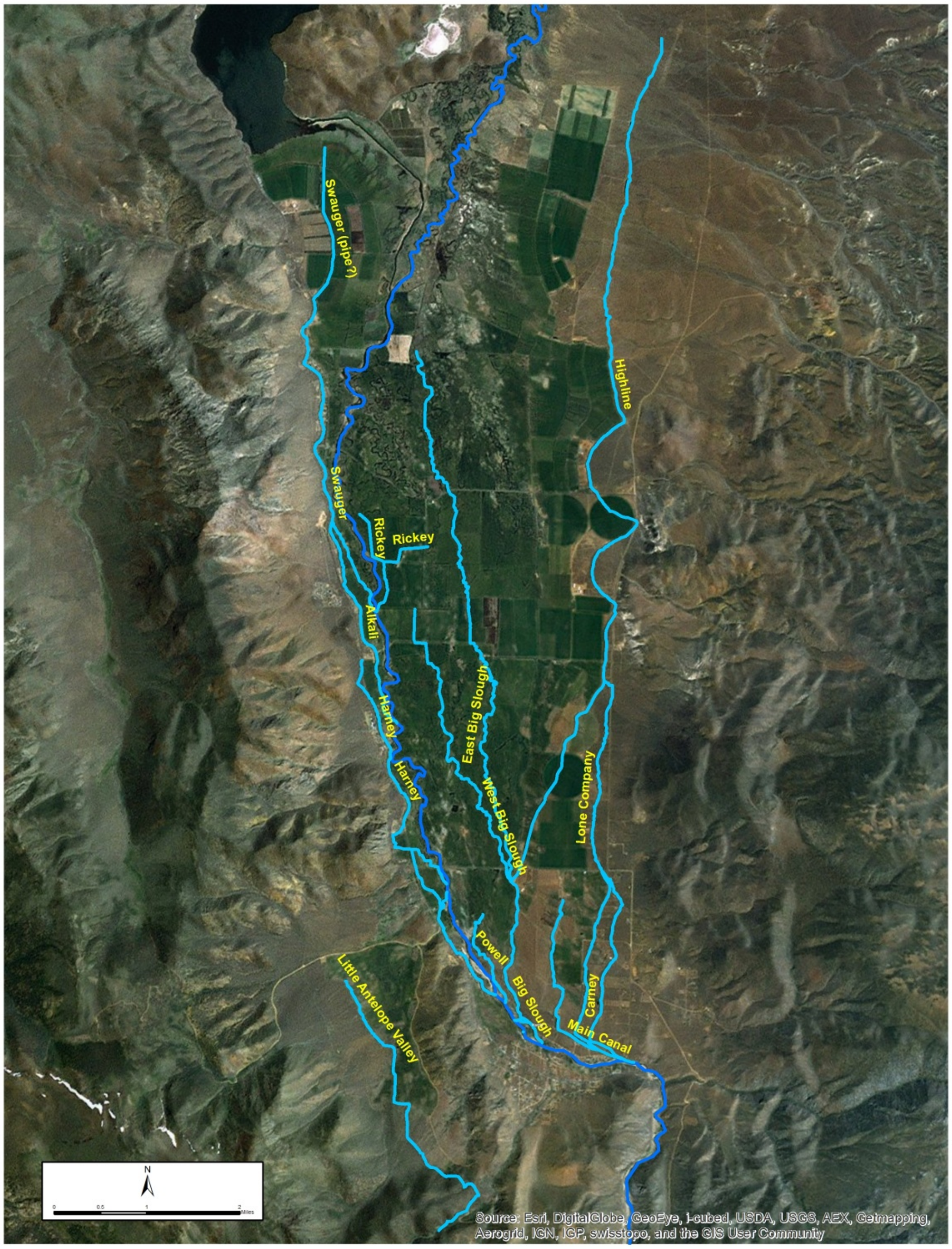
To assess spatial variability of water use, agricultural practices and specifically evapotranspiration (ET) within Antelope Valley, Hydrologic Response Units (HRUs) were defined based on the fields served with surface water via the major points of diversions and ditches. Tim Minor at DRI delineated irrigated fields through interpretation of aerial photos and interviews with Antelope Valley irrigators. The HRU boundaries were also determined based on interviews with Antelope Valley irrigators and personnel of Antelope Valley Mutual Water Company (AVMWC), which serves most of the irrigators in Antelope Valley. The results are shown in Figure 16. Minor then calculated the corresponding acreage of each field using GIS and summed these by HRU (see Table 9). Over 65% of the irrigated acreage in Antelope Valley is associated with a single HRU, the Big Slough. According to information gathered from landowners somewhat less than one-third of the acreage uses groundwater to supplement surface water. The irrigated acreage derived from the field mapping is very close to the acres derived from the Antelope Valley Mutual Water Company's "share sheet" (see Table 10) and the acres derived from the C-125 decree (see Table 4). As the crop type for each field was also assigned in the GIS, Table 11 provides the totals for each crop by HRU.

Figure 14. Map of Antelope Valley Surface Water Points of Diversion



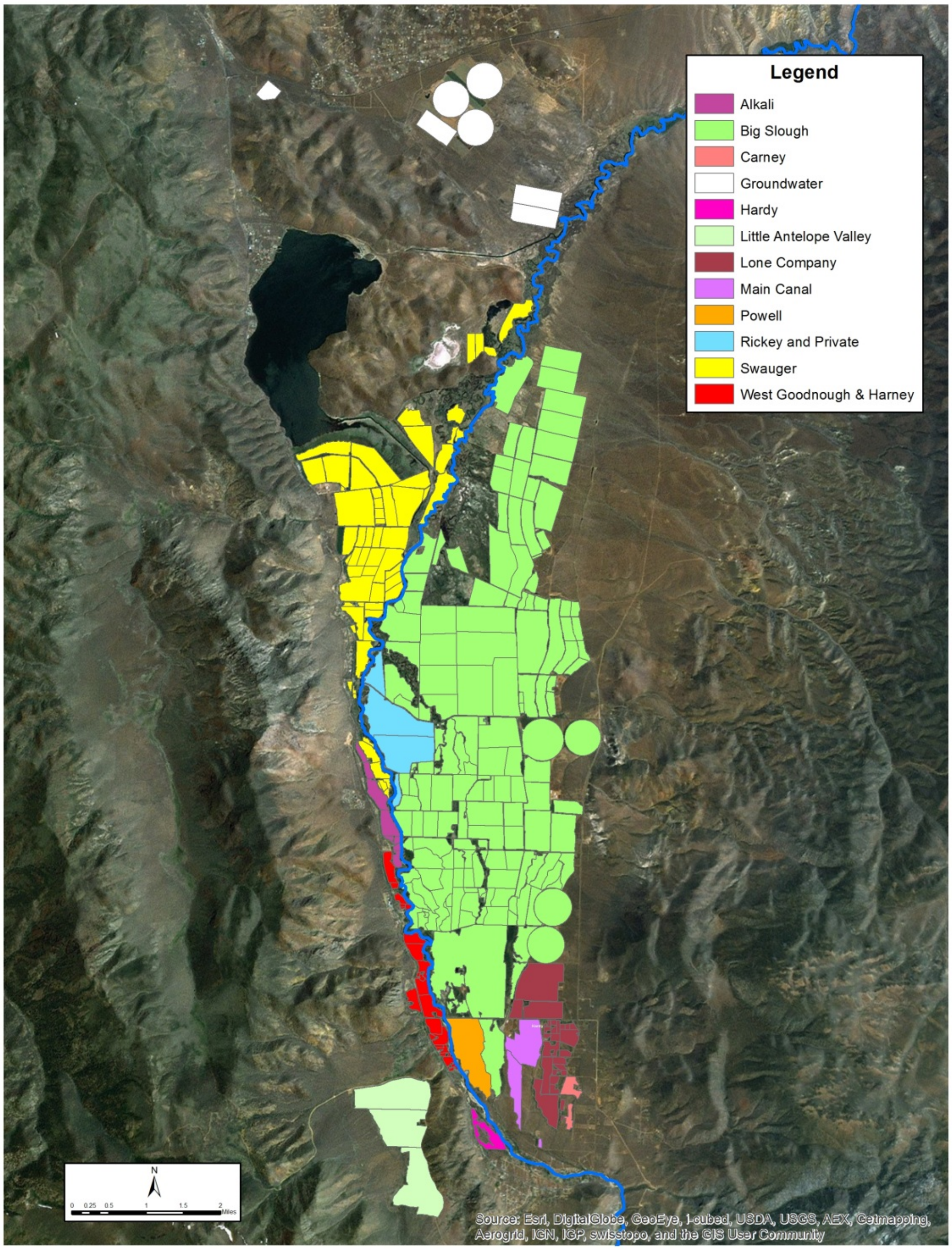
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 15. Map of Antelope Valley Ditches



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 16. Map of Antelope Valley Hydrologic Response Units (HRUs)



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Table 9. Antelope Valley Irrigated Acreage by Ditch and Type

HRU	Acres	Diversion Rate (cfs)	Maximum Annual Diversion (AF)	Acres with Supplemental Groundwater
Alkali	206	3.30	1,605	0
Big Slough	9,839	157.43	76,503	2,641
Carney	316	5.06	2,459	0
Hardy	57	0.91	443	0
Highline	259	4.14	2,012	259
Little Antelope Valley	663	10.61	5,158	0
Lone Company	272	4.36	2,119	0
Main Canal	98	1.56	760	0
Powell	181	2.90	1,408	0
Rickey and Private	493	7.89	3,833	214
Swauger	2,271	36.34	17,659	781
West Goodnough & Harney	266	4.26	2,072	0
Totals	14,923	238.77	116,031	3,895

Notes: *cfs derived from acres multiplied by 0.016 cfs/acre

Table 10. Antelope Valley Water Rights from AVMWC "Share Sheet"

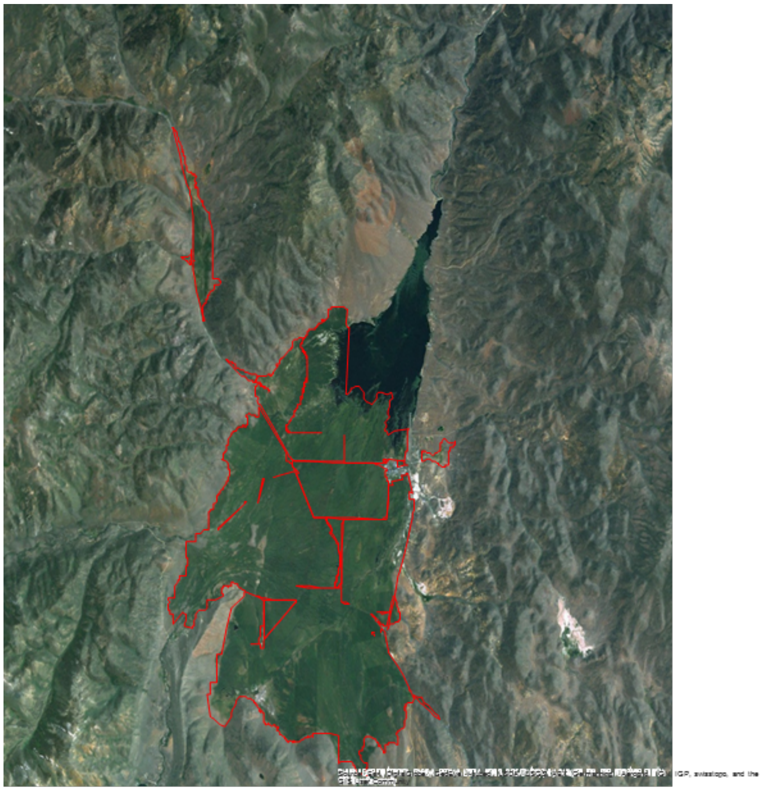
Ditch	Acres	Diversion Rate (cfs)	Maximum Annual Diversion (AF)
Alkali	363	5.80	2,819
Big Slough	9,942	159.07	77,300
Carney	987	15.79	7,673
Hardy	210	3.36	1,633
Little Antelope	450	7.19	3,496
Lone Company	415	6.64	3,227
Main	351	5.61	2,727
Powell	159	2.54	1,234
Ricky	485	7.77	3,774
Swauger	2,029	32.47	15,780
West Goodnough	342	5.47	2,656
Totals	15,732	251.71	122,320

Table 11. Antelope Valley Irrigated Acreage by Ditch and Crop

HRU	Alfalfa	Grains	Hay	Pasture	Totals
Alkali			100	106	206
Big Slough	1,982	55	1,862	5,940	9,839
Carney	277			40	316
Hardy				57	57
Highline	259				259
Little Antelope Valley				663	663
Lone Company			76	197	272
Main Canal				98	98
Powell				181	181
Rickey and Private			214	279	493
Swauger	572		44	1,656	2,271
West Goodnough & Harney	25		82	159	266
Totals	3,115	55	2,377	9,376	14,923

HRUs were not developed for Bridgeport Valley because specific information regarding which ditches serve which fields could not be obtained and because water rights by ditch could not be verified. However, based on field delineation of Bridgeport Valley by Minor (see Figure 17), an irrigated area of 17,926.8 acres was calculated. The calculated area actually irrigated is far less than the total decree acres of 23,669 referenced in Table 6. This difference likely is due to the C-125 decree including acreage outside Bridgeport Valley proper (such as Upper Summers, Lower Summers, and Sinnamon meadows), and likely some area no longer irrigated. The face value of the water rights associated with the calculated acreage equals 286.83 cfs and a maximum annual diversion of 113,216 AF.

Figure 17. Map of Bridgeport Irrigated Area



5.2 Diversion Estimates

The AVMC share sheet outlined in Table 10 breaks down the diversion rights by ditch and by priority date. This information was used, along with the daily regulation data from the FWM (1985-2011), to estimate daily diversions based on what irrigators could have diverted (see Figure 18, Estimated Diversions (not bound)). At total of almost 82,000 AF is the average figure for potential diversions during this time period.

Based on feedback obtained at a meeting of the Antelope Valley Mutual Water Company, diversion estimates were also calculated to account for times when the face value of rights in priority exceeded the flow available. In doing so, the face value of rights in priority was compared to the flow available at the Coleville gage and the lesser of the two values was tabulated, on a daily basis. Figure 18 provides the results of the original estimates, not bound by flow (in blue) and the new estimates (bound by flow), limited by West Walker River flow coming into the Antelope Valley. Table 12 provides the same estimates in numerical format, and as percentages. The bound by flow approach yields an average of 69,000 for the period which is on average 15% lower than the unbound value. Differences between the two methods appear to be larger in wetter years. The difficulty with the bound by flow approach is that it ignores the return flows that accrue back from irrigated lands downstream from Coleville. In practice the FWM's regulation of the river would accommodate these return flows, effectively allowing for water to be diverted more than once as it passes through the valley.

Figure 18. Antelope Valley Diversion Estimates

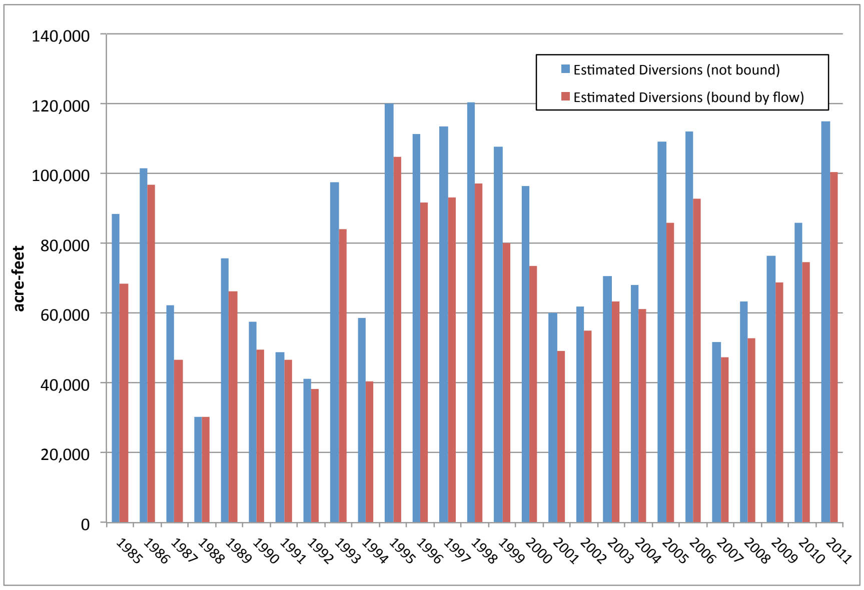


Table 12. Antelope Valley Diversion Estimates

Year	Estimated Diversion (not bound)		Estimated Diversion (bound by flow)		Difference	
	(AF)	% of maximum	(AF)	% of maximum	(AF)	%
1985	88,360	72%	68,678	56%	19,682	22%
1986	101,748	83%	96,813	79%	4,935	5%
1987	62,446	51%	46,852	38%	15,595	25%
1988	30,269	25%	30,163	25%	105	0%
1989	75,882	62%	66,482	54%	9,399	12%
1990	57,564	47%	49,586	41%	7,978	14%
1991	48,937	40%	46,624	38%	2,314	5%
1992	41,282	34%	38,278	31%	3,004	7%
1993	97,582	80%	84,051	69%	13,531	14%
1994	58,773	48%	40,434	33%	18,338	31%
1995	119,994	98%	104,895	86%	15,099	13%
1996	111,554	91%	91,803	75%	19,751	18%
1997	113,463	93%	93,251	76%	20,211	18%
1998	120,598	99%	97,267	80%	23,331	19%
1999	107,698	88%	80,317	66%	27,380	25%
2000	96,456	79%	73,479	60%	22,977	24%
2001	60,043	49%	49,393	40%	10,651	18%
2002	62,158	51%	54,892	45%	7,266	12%
2003	70,718	58%	63,566	52%	7,153	10%
2004	68,229	56%	61,414	50%	6,816	10%
2005	109,409	89%	85,923	70%	23,485	21%
2006	112,229	92%	92,758	76%	19,471	17%
2007	51,926	42%	47,517	39%	4,409	8%
2008	63,345	52%	52,821	43%	10,525	17%
2009	76,571	63%	68,798	56%	7,773	10%
2010	86,143	70%	74,525	61%	11,618	13%
2011	114,949	94%	100,569	82%	14,380	13%
Average	81,790	67%	68,931	56%	12,858	15%
Median	76,571	63%	68,678	56%	11,618	14%

Note: The maximum annual diversion used is 122,320

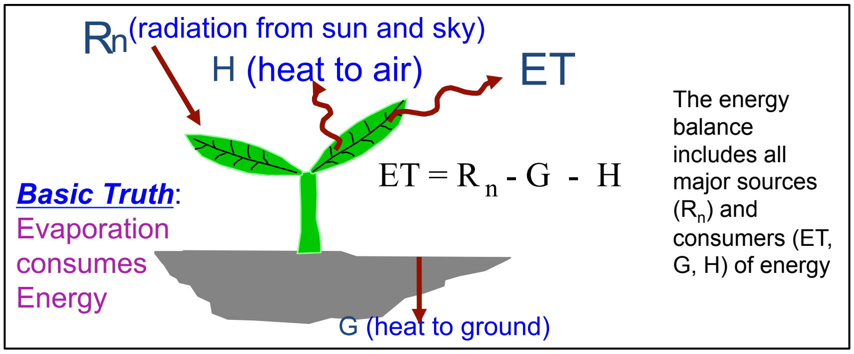
6. Irrigation Water Use

6.1 METRIC

Mapping Evapotranspiration at high Resolution using Internalized Calibration (METRIC) is a state-of-the-art and widely accepted method of using remote sensing and model to estimate evapotranspiration (ET) from vegetation. DRI carried out a METRIC study of Antelope and Bridgeport Valleys as an input to the RCD study and the results are presented below.

METRIC calculates ET as a "residual" of the energy balance, as satellites do not recognize water vapor well (Figure 19 below). The primary inputs for the model are satellite images from the Landsat Platform, a digital elevation model, ground-based weather data measured within or near the area of interest, and land cover classification data for the study area. METRIC ET results are used to refine estimates of crop consumptive use and provide information towards refining perennial yield throughout the western United States. METRIC results are used to estimate historical plant water use (ET) from agricultural and groundwater discharge areas. METRIC is used in an operational capacity by numerous western states to estimate total consumption by irrigated agriculture (Idaho), evaluate water rights (New Mexico, Colorado, Nebraska, Montana), monitor groundwater recharge (Idaho, Nevada), and develop water budgets for water transfers (Oregon, Nevada, Idaho, California).

Figure 19. METRIC Infographic



Source: Allen et al. (2005)

Due to the complexity and time involved in calculating METRIC results for any given year, the DRI team selected just three years for analysis in cooperation with the RCD study team. The three years were chosen based on aerial photograph and meteorological data availability as well as the extent of flow conditions (dry, normal/mid or wet): 2002 (dry), 2005 (wet) and 2010 (median or “mid”) (see Table 2 for year classifications and percentiles).

6.2 Evapotranspiration

In addition to calculated ET the tables below present figures for reference ET. Reference ET (or ETr) is an indicator of potential evapotranspiration that is derived based on weather variables. There are many different methods for calculating reference ET. In this case, due to data limitation in Bridgeport and Antelope Valleys, DRI used data from near Bishop, CA and from Carson Valley, NV to calculate reference ET for the respective valleys. This reference ET is based on weather station data and therefore is a single value for the valley. In the discussion below, it is employed as a useful indicator of how potential evapotranspiration varied across years and the two valleys.

Results of the Antelope Valley METRIC analysis are presented in Table 13. Actual ET results are provided for each HRU, as defined earlier. The reference ET for the valley is provided at the bottom of the first table. Both calendar year and March to October totals are provided. The March to October ET figures are the actual measured ET that are related to irrigation water use for each of the three years. The dry year ET for the the irrigation season (3.26 ft) is less than that for the wet year (3.72 ft), As the reference ETs are similar it is not surprising that there is a higher ET in the wet year when more irrigation water is available. In the median year the reference ET is less than either dry or wet year but the actual ET is almost the same as in the dry year. This suggests that the median years ET might have been higher, and more similar to the wet year, had the weather conditions that drive ET not been so dissimilar from the other two years. So it does appear that on the dry to wet year continuum that ET is higher under wetter conditions, although there appears to be more of a difference between the dry and median years than between the median and wet years. Another way to understand this is shown in the last row in Table 13 which subtracts the ET from the reference ET. This shows that the gap between reference ET and actual

ET declines in a fairly continuous fashion as years moved from dry to median to wet. Table 14 uses the ET rates and the acreages to derive total ET for the Antelope Valley HRUs.

The corresponding figures for ET rates and total ET for Bridgeport Valley are shown in Table 15. As described earlier, HRUs were not established for Bridgeport so the totals are for the entire Bridgeport Valley. In the case of Bridgeport irrigation ET increases as the years change from dry (3.18 ft), to median (3.38 ft), to wet (3.59 ft). Note that the sequence for reference ET is the reverse, suggesting more evapotranspirative demand in the dry as opposed to the wet year.

Comparing results for the two valleys in Table 13 and Table 15, suggest slightly higher calendar year ET in Bridgeport than Antelope Valley (by around 0.4 ft on average). However, for the irrigation season the ET figures in Antelope Valley are approximately the same, most likely due to the longer irrigation season in Antelope Valley.

Table 13. Antelope Valley METRIC Results

(all figures in feet)	Calendar Year			March-October		
HRU	Dry (2002)	Mid (2010)	Wet (2005)	Dry (2002)	Mid (2010)	Wet (2005)
Alkali	3.22	3.30	4.10	3.02	3.11	3.88
Big Slough	3.51	3.55	4.10	3.36	3.34	3.95
Carney	3.25	3.53	3.92	2.98	3.29	3.70
Hardy	1.38	2.57	2.84	1.16	2.37	2.65
Little Antelope Valley	2.63	2.96	3.32	2.33	2.76	3.09
Lone Company	2.15	2.63	2.58	1.93	2.44	2.43
Main Canal	1.56	1.82	2.01	1.35	1.66	1.89
Powell	3.45	3.17	3.98	3.12	2.97	3.74
Rickey and Private	3.75	3.76	4.37	3.69	3.71	4.23
Swauger	3.63	3.69	4.13	3.46	2.62	2.94
West Goodnough & Harney	3.73	3.69	4.24	3.48	3.53	4.13
Total Actual ET	3.48	3.51	4.02	3.28	3.18	3.72
ETr	5.67	5.18	5.49	4.91	4.63	4.94
ETr less Actual ET	2.19	1.67	1.47	1.63	1.45	1.23

Table 14. Antelope Valley METRIC Total ET

		March-October ET (AF)		
HRU	Acres	Dry (2002)	Mid (2010)	Wet (2005)
Alkali	206	623	643	801
Big Slough	10,097	33,924	33,755	39,930
Carney	316	944	1,040	1,169
Hardy	57	66	135	151
Little Antelope Valley	663	1,546	1,828	2,049
Lone Company	272	526	666	661
Main Canal	98	132	162	184
Powell	181	564	538	678
Rickey and Private	493	1,818	1,827	2,083
Swauger	2,271	7,857	5,945	6,666
West Goodnough & Harney	266	927	942	1,099
Total Actual ET	14,922	48,926	47,481	55,473
w/out L Antelope Valley	14,259	47,381	45,653	53,424

Table 15. Bridgeport Valley METRIC results

(figures in feet unless noted)	Acres	Calendar Year Total			Mar-September 15 Total		
		Dry (2002)	Mid (2010)	Wet (2005)	Dry (2002)	Mid (2010)	Wet (2005)
Total Actual ET		3.82	4.05	4.44	3.18	3.38	3.59
Total Actual ET (AF)	17,927	68,523	72,603	79,644	57,096	60,512	64,364
ETr		5.25	5.02	4.86	3.99	3.87	3.62
ETr less Actual ET		1.43	0.97	0.42	0.81	0.50	0.03

6.3 Precipitation and Net Irrigation Water Requirement

Precipitation data from each valley was prepared by DRI from the PRISM Climate Group's 800m dataset, employing a centroid place in the center of each valley. Results were multiplied by the acres in each HRU for Antelope Valley and by the delineated irrigated acreage in Bridgeport Valley. The monthly totals for the three years used in the METRIC analysis are presented in the tables below.

Actual ET less precipitation for a given period is generally accepted as a measure of the water that is evapotranspired due to the application of irrigation water. In the DRI work this is referred to as the net irrigation water requirement (NIWR). NIWR is as accepted approach for determining the consumptive use of irrigation water. NIWR is also generally used as a measure of the water that can be leased or transferred to points downstream without causing conflict or injury with other water users. NIWR can be estimated directly if actual ET and precipitation data are available. Otherwise, ET can be estimated for particular crops by developing the reference ET, then adjusting this general ET to crop-specific ET estimates according to coefficients developed for each crop, and then subtracting out precipitation. In Nevada, the Department of Water Resources has developed such NIWR figures for every basin in the state.

The month-by-month calculations for the two valleys for ET, precipitation and NIWR by year are provided below in Table 17 and Table 18. Totals are provided for the calendar year, for the full irrigation season and for two periods of interest for the study: March through May and July through the end of the irrigation season. A summary of the findings of these tables is presented in Table 16. The results suggest comparable NIWR levels in the two valleys. The annualized total volume difference in NIWR between wet and dry years for the irrigation seasons are in the 4,000 to 6,000 AF range with Bridgeport Valley seeing the lowest variation.

In the case of Bridgeport Valley the wet to mid to dry years show small decreases in NIWR as might be expected due to lower availability of water supply. In Antelope Valley the mid year is an outlier as NIWR is lower than for the dry year. An important contributor to this result is a large batch of precipitation in October of 2010. Whether or not all of this precipitation contributed to crop ET is unknown, but its contribution is expected to be minimal, as much vegetation has already shutdown in October due to colder temperatures. Where large rainfall events occur they may not all go to crop ET. This suggests the difficulty with calculating NIWR simply as if it is ET net of precipitation. For example in the winter months negative NIWR numbers result from this procedure (as seen in the tables below). These numbers are of no value for the current purpose, of course, as these months are outside the irrigation season. The issue of the potential sources of ET is pursued further in the modeling effort in the next section.

Table 16. Summary of NIWR for Antelope and Bridgeport Valleys

Valley and Year	NIWR (feet)	NIWR (AF)	ETr (feet)
Antelope Valley (Mar-Oct)			
Wet (2005)	3.53	52,676	4.94
Mid (2010)	2.93	43,723	4.63
Dry (2002)	3.14	46,856	4.91
Wet/Dry Difference	0.39	5,820	0.03
Bridgeport Valley (Mar-Sep 15)			
Wet (2005)	3.28	58,752	3.62
Mid (2010)	3.17	56,867	3.87
Dry (2002)	3.04	54,430	3.99
Wet/Dry Difference	0.24	4,321	(0.37)

Table 17. Antelope Valley Net Irrigation Water Requirement

(feet)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals	Irrigation Subtotals		
														Season	Mar-May	Jul-Oct
Dry (2002)																
ET	0.05	0.10	0.20	0.31	0.45	0.60	0.65	0.54	0.34	0.17	0.07	0.05	3.55	3.28	0.97	1.71
Precip	0.02	0.01	0.06	0.03	0.00	0.00	0.01	0.02	0.01	0.01	0.22	0.18	0.57	0.14	0.09	0.04
NIWR	0.03	0.09	0.14	0.28	0.45	0.60	0.64	0.53	0.34	0.16	(0.16)	(0.12)	2.98	3.14	0.87	1.67
Mid (2010)																
ET	0.04	0.08	0.21	0.32	0.39	0.57	0.72	0.60	0.33	0.17	0.08	0.04	3.54	3.32	0.92	1.83
Precip	0.19	0.16	0.05	0.07	0.02	0.00	0.04	0.00	0.00	0.19	0.10	0.37	1.21	0.39	0.15	0.24
NIWR	(0.16)	(0.09)	0.16	0.25	0.36	0.57	0.68	0.59	0.33	(0.02)	(0.02)	(0.34)	2.33	2.93	0.77	1.59
Wet (2005)																
ET	0.02	0.07	0.27	0.38	0.50	0.60	0.74	0.66	0.43	0.27	0.11	0.04	4.10	3.86	1.16	2.10
Precip	0.31	0.10	0.08	0.05	0.08	0.01	0.02	0.02	0.02	0.03	0.03	0.40	1.16	0.32	0.22	0.09
NIWR	(0.29)	(0.03)	0.19	0.33	0.42	0.59	0.72	0.63	0.41	0.23	0.09	(0.35)	2.95	3.53	0.94	2.00

Note: This includes the 14,922 acres of HRUs using surface water in Antelope Valley

Table 18. Bridgeport Valley Net Irrigation Water Requirement

(feet)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals	Irrigation Subtotals		
														All	Mar-May	Jul-Sep 15
Dry (2002)																
ET	0.07	0.15	0.26	0.35	0.49	0.65	0.72	0.57	0.31	0.14	0.08	0.04	3.82	3.18	1.09	1.44
Precip	0.04	0.03	0.06	0.04	0.00	0.01	0.02	0.01	-	0.01	0.13	0.14	0.50	0.15	0.11	0.03
NIWR	0.03	0.12	0.19	0.30	0.49	0.64	0.70	0.56	0.31	0.13	(0.06)	(0.10)	3.32	3.04	0.98	1.41
Mid (2010)																
ET	0.05	0.10	0.24	0.34	0.55	0.68	0.71	0.67	0.38	0.17	0.11	0.05	4.05	3.38	1.14	1.56
Precip	0.15	0.14	0.03	0.08	0.03	0.03	0.01	0.01	0.04	0.21	0.05	0.23	1.01	0.20	0.14	0.04
NIWR	(0.09)	(0.05)	0.21	0.26	0.53	0.65	0.69	0.66	0.34	(0.04)	0.06	(0.18)	3.04	3.17	1.00	1.52
Wet (2005)																
ET	0.07	0.13	0.34	0.44	0.55	0.75	0.75	0.54	0.44	0.24	0.13	0.06	4.44	3.59	1.32	1.51
Precip	0.28	0.10	0.10	0.06	0.11	0.01	0.01	0.01	0.03	0.01	0.01	0.37	1.09	0.31	0.27	0.03
NIWR	(0.21)	0.03	0.23	0.38	0.45	0.74	0.74	0.53	0.42	0.24	0.12	(0.31)	3.35	3.28	1.06	1.48

7. Water Balance Models

The final step in Task 1 as envisioned in the proposal for the Study is to build a water balance model for the major irrigation systems and diversions in each of the valleys. The primary objective of such a model would be to assist in understanding the hydrological impacts of changes in water diversion and consumption that occur as a result of conservation improvements, leasing or other water rights transactions. Constructing such a model relies on the availability of the underlying data and the set of associated assumptions necessary to create a functioning simulation model.

Such a model can be constructed at one of two levels of resolution. The most basic model (a "Valley" model) would treat an entire valley as a single modeling unit and would include the information necessary to understand the following four model elements and changes to them under varying conditions:

1. Water in to the valley, consisting of:
    - stream inflow; and
    - precipitation and groundwater recharge.
2. Water out of the valley, consisting of:
    - evapotranspiration from irrigation and other lands in the valley; and
    - streamflow leaving the valley.
3. Change in water storage: consisting of the net change in groundwater as the valley stores and releases water in response to the inflows and outflows.

Such a model would be designed to model the water balance over some specified time frame (daily, monthly, seasonal or annual) as pertinent to the information needs fulfilled by the model. In the case of Antelope and Bridgeport Valleys a "Valley" model should assist with the first objective with respect to the potential of water transactions in Mono County (as explained above in Section 2), being to inform an understanding of how water transactions can lead to water that can be delivered to the state line and from there to Walker Lake without adversely affecting other water right uses in the valleys).

A second, more refined model (an "HRU" model) would partition the valley into identifiable hydrologic response units (HRUs) that can be modeled much as the entire valley would be modeled in the basic model. The advantage of such a model is that it can address with some specificity the question of how transactions might affect instream flows through the valley (the second objective as explained in Section 2 of this memo), as explained above. For example, with the Valley model it is not possible to say anything about stream flow within a valley. All that is known are stream flow inputs above the valley and the outflow below the valley. This will be sufficient for examining water transactions that meet the first objective. However, in order to assess stream flow within the valley and the potential benefits of water transactions on fish and wildlife a more refined model is needed. Such a model would involve breaking land area out into HRU and the stream into segments (based on irrigation points of diversion). Diversions of water from particular points allow the simulation of outflows from streams. The conveyance and application of water on fields within the HRUs allow simulation of evapotranspiration, groundwater storage and the return of flow to the stream.

In an HRU model, in addition to the inflows and outflows to the valley (as per items 1 and 4 for the Valley Model) it is necessary to estimate the following parameters for each of the HRUs:

- Amount of water diverted to the HRU at the point of diversion, noting that this may depend on the priority of the water rights on the diversion and the availability of surface water
- Conveyance water net of any immediate returns of water to the stream
- Transmission Efficiency; or the inverse of the conveyance loss from the point of diversion to fields
- On-Farm Efficiency; the water use efficiency on the field based on the water application technology (e.g. flood, wheel line, etc)
- Crop evapotranspiration;
- Other returns from tailwater to the stream

For the streams in an HRU model the following features along the stream need to be identified in terms of their location and amount of inflow/outflow to/from the stream.

- tributary inputs (+)
- irrigation diversions (-)

- irrigation returns, typically towards the upper end of ditches (+)
- groundwater discharge from canal seepage (+)
- groundwater discharge from on-farm seepage (+)
- tailwater at the end of the main irrigation canals (+)

With the information available for Antelope Valley a fairly robust Valley Model is developed below. Development of a full HRU model is not attempted for Antelope Valley due to the lack of sufficient streamflow data within the valley. Information from fixed gages or a streamflow seepage campaign would be necessary to be able to calibrate such a model. As such information does not exist an HRU model is not attempted. However, an intermediate step is taken of developing a full irrigation water balance model for the majority of the irrigated area in Antelope Valley. This model complements the Valley Model and by fully specifying the irrigation water budget enables a further understanding of how water transactions might affect the water budget and provides more resolution as to what portion of water rights involved in likely water transactions might be marketed to the state line and Walker Lake.

For Bridgeport Valley data is more problematic. Streamflow inputs and diversions are not "linear" as they are in Antelope Valley and the streamflow input is not well understood over a range of conditions. For this reason, the modeling effort in Bridgeport Valley is limited to a fairly general valley model. As a result, analysis of water transactions in Bridgeport Valley may need to rely more directly on the ET and NIWR figures from the METRIC analysis as cited earlier in this memo.

7.1 Antelope "Valley" Model

The Antelope Valley Model is derived from the following data, most of which is explained in prior sections of this report:

1. Stream inflow to the valley:
    - Historical gage data above Antelope Valley at the Coleville gage is available - daily data for 1902 to 2013 is available from the USGS (see Table 2).
2. Precipitation in the valley:
    - Modeled data from PRISM software for Antelope Valley based on available weather station data – average monthly data for January 1995 to September 2011 was provided by DRI.
3. Recharge from precipitation in the valley
    - Results of modeled sub-watersheds are compiled from a DRI paper prepared expressly for this purpose by Carroll and Pohll (2013) providing an average percent of precipitation routed to recharge of 11%, this represents precipitation less evapotranspiration and is used for the non-irrigated areas of the valley.
4. Evapotranspiration from irrigation
    - The METRIC results for ET produced by DRI (see section above) are available for 2002, 2005 and 2010 only, average figures for reference ET are available by crop from NDWR (Huntington and Allen 2010), and crop type is available from DRI for use in estimating average ET for other years (as needed).
5. Streamflow leaving the valley
    - An unregulated dataset for the Hoye Bridge Gage (located approximately 3.5 miles below the point where the Topaz canal empties into the West Walker River) is constructed using the actual (regulated) Hoye Bridge Gage data and adding back in evaporation from Topaz Lake and storage releases from Topaz Lake (as explained in Section 3.1 above and shown in Table 2), daily data from 1974 to 2013 is available.

While basic characterization of the groundwater system and ancillary groundwater investigations were carried out by various authors (in particular Carroll and Pohll 2013) related to this Mono County RCD project, no detailed historical information has been compiled and analyzed with respect to groundwater levels. Nor is a groundwater model for Antelope Valley available as for Mason and Smith Valleys on the Nevada side of the basin.

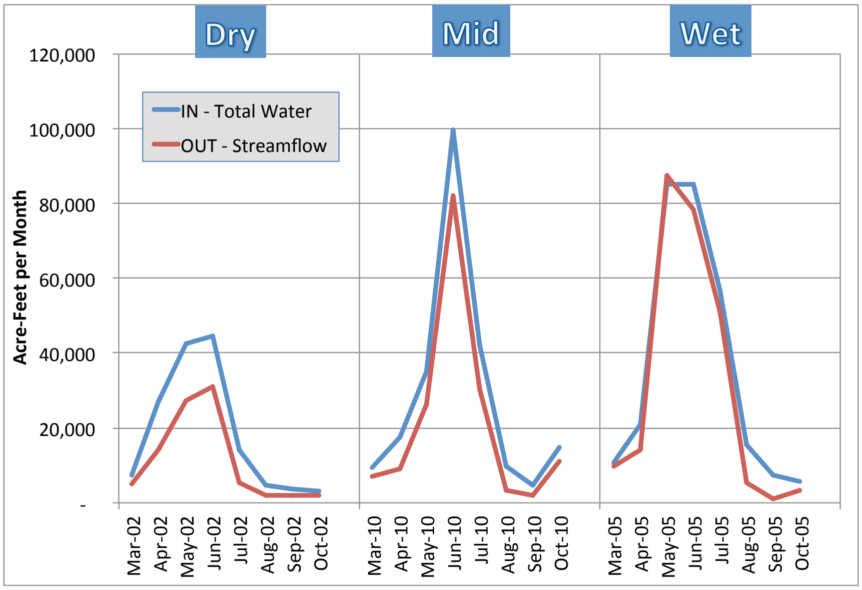
The Antelope Valley Model is constructed so as to impute the change in groundwater storage once inflows and outflows are specified. In order to adapt the data available the model largely separates out the irrigated and non-irrigated portions of the Valley. For the purposes of the model Little Antelope Valley (or Slinkard watershed) are lumped in with the non-agricultural portion of the valley (as they are non-contiguous with the bulk of the Antelope Valley HRUs. Precipitation (P), recharge (RCH), and evapotranspiration (ET) are derived separately for so-called “agricultural” and “non-agricultural” portions of the basin. So a net recharge figure is derived for the non-agricultural part of the basin. This is derived by subtracting the non-irrigated lands and Topaz Lake surface area from total valley area and multiplying this areal percent by precipitation and the portion of precipitation going to recharge (as per Carroll and Pohll 2013 as cited above). The delay in precipitation routing to the stream is not known, but a trailing 12-month moving average of precipitation is used as the precipitation input in the calculation.

In the model then, the change in groundwater storage, GW, for each monthly time step is computed as follows:

$$GW = SF_{in} + RCH_{non\text{-}ag} + P_{ag} - ET_{ag} - SF_{out}$$

The inflow and outflows in the model are shown below for the three years for which Metric data are available, being a dry year (2002), a “mid” or median year (2010), and a wet year (2005). The chart shows that in a dry year total inflows and outflows peak at just over 40,000 AF/month, whereas in the other two years they peak at two times that amount. Examining the inflows and outflows it can also be seen that outflows are always below inflows and sometimes significantly so early in the irrigation season in the dry year. In the mid year outflows are below inflows but consistently to a minor degree. In other words in these years the major trend is to be increasing groundwater storage. In the wet year, early in the season outflows exceed inflows and thus the system is discharging water on net.

Figure 20. Inflows and Outflows, Antelope Valley



The change in groundwater storage can be observed more directly in Figure 21. Again note that the progression from dry to wet years leads to a reversal of the groundwater storage pattern. Also note that while ET is progressively higher going from dry to wet years, this change in ET is clearly not sufficient to drive such large swings in storage. The figure also charts out the recharge from non-agricultural lands and the precipitation input. These would also appear to not be driving groundwater storage. Figure 22 however charts groundwater storage against streamflow and the diversion of surface water decree rights (as explained in Section 5.2 and further below in the monthly model). Here a relationship can be seen between the two measures of hydrologic availability and the change in groundwater storage. As expected storage then appears to be driven by the availability of streamflow, which itself translates into the availability of surface water irrigation, which in turn refills the water table in the valley. This observation confirms the views of long-term farmers and ranchers as expressed in meetings with the project team. These stakeholders emphasized the importance of "filling the bathtub" to sustaining irrigation late in the season and in dry years.

Figure 21. Change in Groundwater Storage, Antelope Valley Model

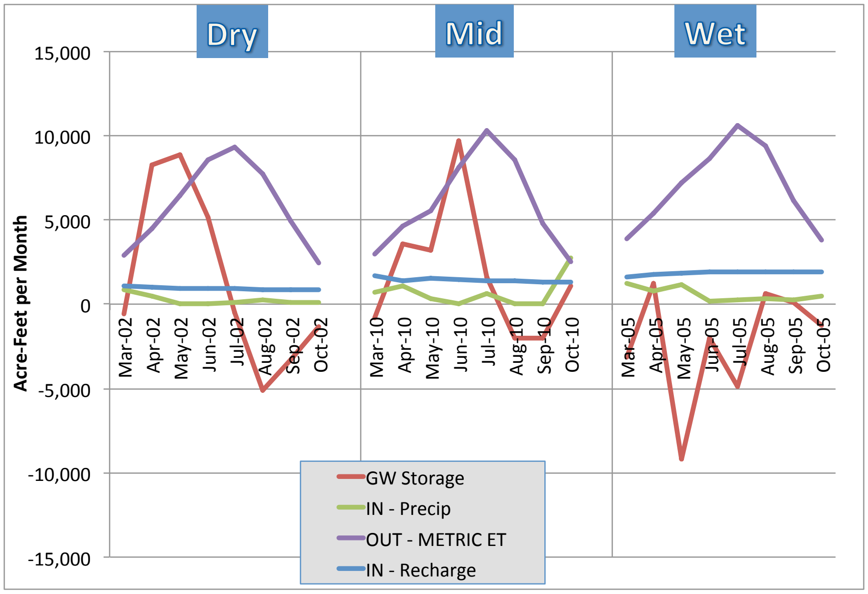
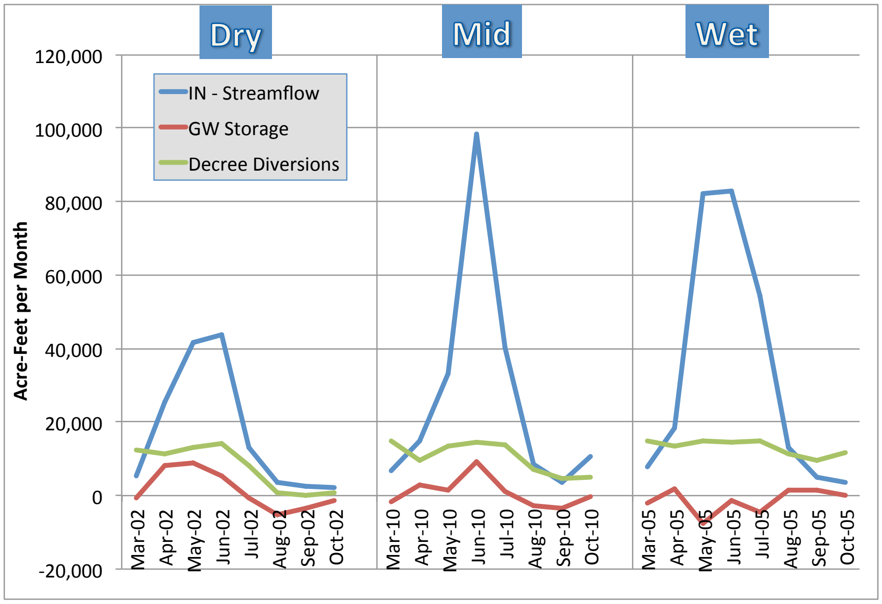


Figure 22. Groundwater Storage, Streamflow and Irrigation Diversions



7.2 Antelope Valley Irrigation Water Budget Model

The Metric ET work undertaken by DRI as reviewed in Section 6 above provides spatially disaggregated monthly estimates of actual evapotranspiration in the dry, mid and wet years. When precipitation is subtracted these figures provide initial estimates of Net Irrigation Water Requirements (NIWR). NIWR is effectively the "consumptive use" associated with the application of irrigation water and thus represents a measure of the amount of water that could be leased or transferred to downstream uses, including for instream and environmental purposes. In Antelope Valley, however, there are actually five sources of water that may lead to evapotranspiration from irrigated fields:

1. Precipitation
2. Diverted decree water
3. Diverted storage water
4. Pumped supplemental groundwater
5. Transpiration from water stored in the ground

The irrigation water budget model is developed to track crop demand and the extent to which each of these water sources may contribute to ET on a monthly basis for Antelope Valley. This is carried out for the same three representative years used in the Antelope Valley Model above.

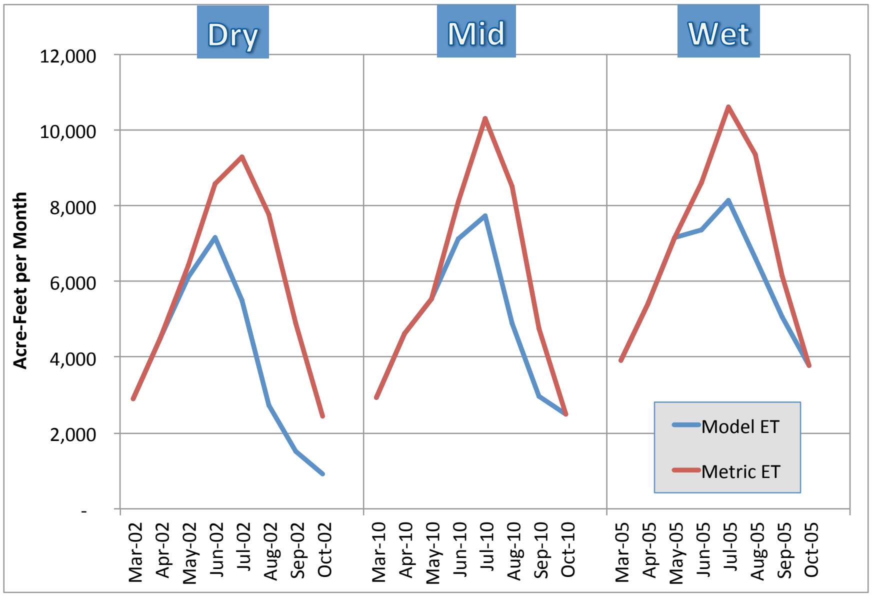
In addition to the input data used for the Antelope Valley Model a dataset of expected monthly diversion for these years is derived using the water regulation data for Antelope Valley available from the Federal Watermaster. The "not bound" data from Table 12 is used for this purpose. This means that the model is using the Watermaster's regulation data and is not limiting this to flow available at the Coleville gage. As return flows from irrigation may occur along the stretch of the West Walker in Antelope Valley the Watermaster's data should account for any shortages up and down the Antelope Valley reach.

The model is run for the irrigation water rights and fields along the West Walker and excludes Little Antelope Valley and the primary groundwater down-gradient from Topaz. The model follows irrigation water that is diverted to the field. Key steps and parameters include:

1. Irrigation water diverted is adjusted downward by a ditch conveyance loss – based on interviews with water managers this is set at 10% for all but Swauger ditch which is known to lose a lot of water and is set at 40%
2. Crop water demand at the farm is determined by adjusting the raw crop water demand for the on-farm efficiency, which is in turn calculated based on the amounts of alfalfa and/or pasture with 80% and 40% efficiencies for sprinkler and flood irrigation assumed.
3. At the farm, precipitation is added to the surface water; if this amount of water is insufficient to meet the crop water demand at the farm then storage and supplemental groundwater are used in proportional fashion to the acres that they can supply
4. Finally, if these four sources of water are not sufficient the model has a toggle that allows (or does not allow) the crops to access non-consumptive water that is stored in the ground in previous periods (from recharge due to irrigation)

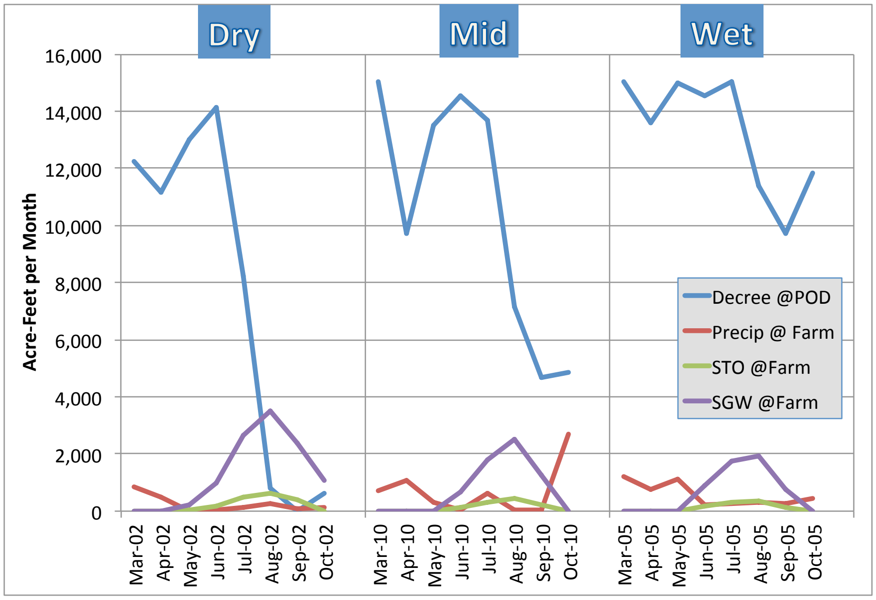
Ideally the model would be run using a crop demand that represents the maximum crop demand under the conditions present in each month with a "full" water supply. However, such a figure is not available. Instead the model is run in order to use available water supplies to meet the actual evapotranspiration observed in the METRIC models (see the discussion and tables in Section 6.1 above). The model is first run with the toggle allowing crop demand to pull from the groundwater supply in the "off" position. The results for this run show that irrigation and precipitation alone are not sufficient to generate the METRIC ET measured by DRI. Comparing years also suggests that this crop water deficit is more severe in dryer years (see Figure 23). This observation very much corresponds with the information provided by local stakeholders. The figure also clearly shows that actual evapotranspiration is itself more limited in drier years.

Figure 23. Model vs METRIC Evapotranspiration without Access to Groundwater



The irrigation water budget model allows the tracking of the different types of irrigation water (decree, storage and supplemental groundwater) and precipitation. Figure 24 charts out the monthly use of each of these types of water across the three representative years. The drop off in decree availability in the dryer years, as opposed to the wet years is marked, as is the uptick in use of supplemental groundwater in particular to try and meet this deficit. However, with limited storage and supplemental groundwater rights the large deficit cannot be met through irrigation. Instead it is the filling of the valley water table during the winter and early irrigation season that provides water to sustain crops during that late summer, particularly during the late summer.

Figure 24. Irrigation Water Supply and Precipitation



When access to the irrigation water that is stored in the ground (water table or groundwater) is turned “on” in the model, the crop water demand is filled from the available reservoir of water retained in the ground from irrigation water recharge in prior periods. The model simply accumulates excess water, ditch conveyance loss and on-farm losses due to irrigation and makes this available to irrigation. Figure 25 shows how the different sources of water are stacked one on top of the other to meet the crop water demand. Table 19 provides the amounts of ET sourced from each type of water in AF, % of total, and feet. Three findings from this analysis are as follows:

1. Irrigation water stored in the water table has an important contribution to crop demand, growth and ET in all years, but particularly in a dry year, in the dry year 33% of total ET comes from groundwater or about 1.08 feet and in the wet year these figures are 14% and 0.53 feet.
2. Irrigation water that is stored in the water table is sufficient to make up for the loss of precipitation and decree diversions in the summer months of dry years – in the dry year this does require that over 35% of the total non-consumptive use for the year be available to plants.
3. The direct contribution of irrigation water to ET in this case is not just ET less precipitation, but ET less precipitation and the water evapotranspired from the water table and will vary significantly:
    a. Year-to-year – with an irrigation water contribution to ET, or NIWR, that varies from 2.14 feet in the dry year to 3.19 feet in the wet year.
    b. Depending on efficiency assumptions that go into the model – increasing water use efficiency means more ET resulting from irrigation and less need to tap groundwater; for example, changing flood irrigation efficiency from 40% to 60% in the model increases the ET due directly to irrigation water from 2.14 to 2.30 feet for dry years, and from 3.19 to 3.46 feet for wet years.

Figure 25. Evapotranspiration by Type of Water Consumed

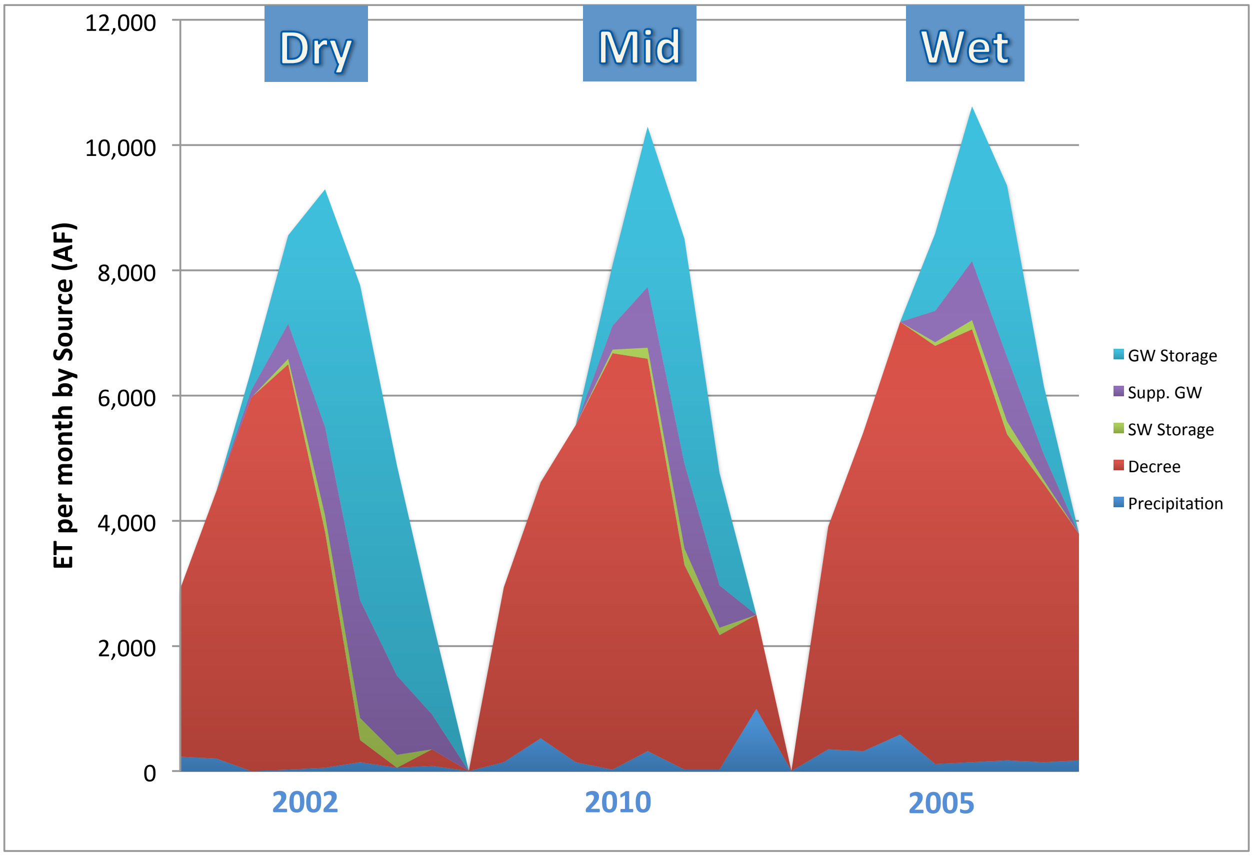


Table 19. Irrigation Season Evapotranspiration Amounts by Source and Year Type, Antelope Valley

Sources of ET:	Decree	Storage	Suplemental Groundwater	Subtotal Irrigation Water	Water Table / Groundwater	Precipitation	Total ET
Amounts (AF)							
Dry	23,810	918	5,805	30,533	15,447	762	46,742
Mid	32,171	604	3,363	36,137	8,948	2,185	47,271
Wet	42,100	510	2,840	45,450	7,557	1,981	54,988
Amounts (% of Total)							
Dry	51%	2%	12%	65%	33%	2%	100%
Mid	68%	1%	7%	76%	19%	5%	100%
Wet	77%	1%	5%	83%	14%	4%	100%
Amounts (feet)							
Dry	1.67	0.06	0.41	2.14	1.08	0.05	3.28
Mid	2.26	0.04	0.24	2.53	0.63	0.15	3.32
Wet	2.95	0.04	0.20	3.19	0.53	0.14	3.86

7.3 Antelope Valley Findings

The implications of these model findings for water transactions that involve the removal of irrigation water from an irrigated field are as follows for full and partial years (see Table 20 for details):

- For a full year of fallowing (or water leasing) the amount of irrigation water (including decree, groundwater and storage) not consumed will vary from 2.14 to 3.19 feet, and from 1.67 to 2.95 feet for decree rights only (see Table 19), with the following caveats:
    - the figure will be higher the wetter the year, and lower the dryer the year
    - the figure will be higher for more efficient operations and lower for less efficient operations
    - the figure will be lower if evapotranspiration on the field is supported by groundwater storage early in the season (not the late season as the dry year shows that there is a limit to the contribution of groundwater storage).
- For a sale and transfer of water rights, i.e. a permanent transaction that fully dries out the property, the ET savings would be the sum of the subtotal for irrigation water and the water table / groundwater component, or a range of from 3.22 to 3.72 feet. If the groundwater is not transferable and the storage is marketed separately the sum of the decree and water table / groundwater component would be 2.75 to 3.48 feet for dry and wet years respectively, with a 2.89 feet figure for the median year.
- For a partial year late season fallowing/lease of decree rights (assuming no irrigation after July 1st) the portion of the decrease in decree irrigation water consumed is 0.31 feet in the dry year, 0.93 feet in the median year and 1.42 feet in the wet year, with a midpoint of about 0.8 to 0.9 feet.
- For a partial year early season fallowing/lease of decree rights (assuming no irrigation until June 1st) the portion of the decrease in decree irrigation water consumed 0.90 feet in the dry year, 0.86 feet in the median year and 1.07 feet in the wet year, with a midpoint in the 0.9 to 1.0 feet range.
- For a reduction in water use from wet year levels to dry year levels the decrease in irrigation water consumed will be about 1.05 feet for all irrigation sources (see Table 19) and 1.28 feet for decree rights only.

Note that all the caveats to the first bullet above apply to the ensuing bullets.

Table 20. Summary of Modeled ET from Decree Source by Month, Antelope Valley

ET from Decree Only	ET Totals in AF/month			ET: Wet less dry (feet)	ET: Wet Less dry Cumul. (feet)	ET by month (feet)		
Month	Dry (2002)	Mid (2010)	Wet (2005)			Dry (2002)	Mid (2010)	Wet (2005)
Mar	2,675	2,781	3,576	0.06	0.06	0.19	0.20	0.25
Apr	4,261	4,110	5,076	0.06	0.12	0.30	0.29	0.36
May	5,962	5,378	6,584	0.04	0.16	0.42	0.38	0.46
Jun	6,488	6,676	6,676	0.01	0.18	0.45	0.47	0.47
Jul	3,775	6,281	6,898	0.22	0.40	0.26	0.44	0.48
Aug	372	3,283	5,216	0.34	0.74	0.03	0.23	0.37
Sep	-	2,157	4,459	0.31	1.05	-	0.15	0.31
Oct	277	1,506	3,615	0.23	1.28	0.02	0.11	0.25
Totals	23,810	32,171	42,100	Subtotal Jul-Oct		0.31	0.93	1.42
				Subotal Mar-May		0.90	0.86	1.07

7.4 Bridgeport "Valley" Model

The modeling effort for Bridgeport Valley is constrained in various ways. Two main data limitations that affect the ability to construct the models deployed above in the case of Antelope Valley, including:

- There is only a four-year period (October 2004 to September 2008) when data from all four creek gages (Buckeye, Green, Robinson and Virginia) is available

- There is no regulation data available from the Federal Watermaster

In order to provide an indication of the hydrologic dynamics of Bridgeport Valley along the lines of those put forward for Antelope Valley, three simplifying assumptions are made to construct a valley model and an irrigation water balance model:

- One year of monthly streamflow data (2006 water year) from Swauger Creek is compared with Virginia Creek data for those months in order to generate a full November 2004 to September 2008 data set for Swauger Creek, in order to include this creek's contribution to Bridgeport Valley water supply.
- Dry year irrigation season streamflow for 2002 is approximated by using streamflow data from the 2008 water year based on comparison of flows for these years on Buckeye and Robinson Creek, including the estimated Swauger Creek flows for 2008.Decree diversions are assumed to be the lesser of the total allowed rate per hectare of irrigated land (0.016 cfs/acre under the C-125 decree) summed monthly or the amount of streamflow available

With these adjustments it is possible to develop the two models for the dry (2002) and wet (2005) years.

The same set of valley model charts as was produced for Antelope Valley are repeated for Bridgeport Valley in the next three figures below. As is the case with Antelope Valley, there is a large difference (threefold) between wet and dry years in terms of precipitation and streamflow (see Figure 26). The gap between the stream inflow and the flow leaving the valley roughly follows the same dry/wet year pattern as well. Do however note that the difference between inflow and outflow is quite large in the dry year. As shown in Figure 27 the shape of the groundwater storage line through the dry and wet years parallels that for Antelope Valley, with the valley gaining water early in the season and discharges water late in the year during the dry year, whereas the wet year shows discharge throughout the year with large amounts leaving the valley early in the season. Presumably, this indicates that during wet cycles that valley "fills" up early in the season, whereas in dry cycles the valley soaks up available water early in the season. The final figure shows that the artificial constraint imposed on the model means that during the dry year the decree diversions simply equal the streamflow inputs to the valley. And these appear to drive groundwater storage – note the similar shape in the two curves. However, during the wet year streamflow inputs exceeds permitted diversions during most of the summer and streamflow inputs do not appear to drive changes in groundwater storage.

Although it is hard to draw conclusions from only two years of data, it does appear that the model is understating the overall water supply in the valley. The groundwater system appears to be discharging in both dry and wet years (on an annual basis). It is therefore not clear when the system would be recharging the groundwater system to maintain an overall balance between years. Further hydrological assessment of the inflows used in this dataset would be needed to assess where the deficiency lies.

Figure 26. Inflows and Outflows, Bridgeport Valley

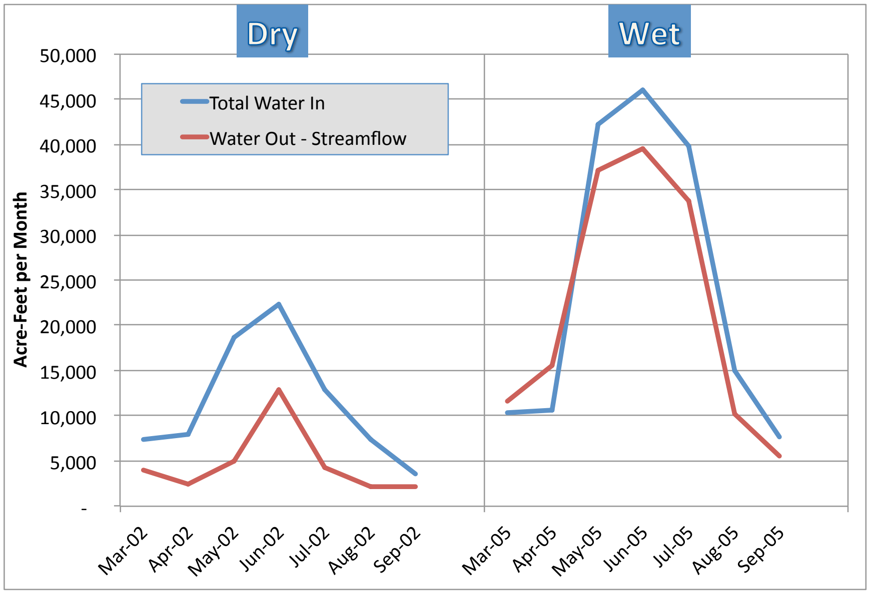


Figure 27. Model vs METRIC Evapotranspiration without Access to Groundwater, Bridgeport Valley

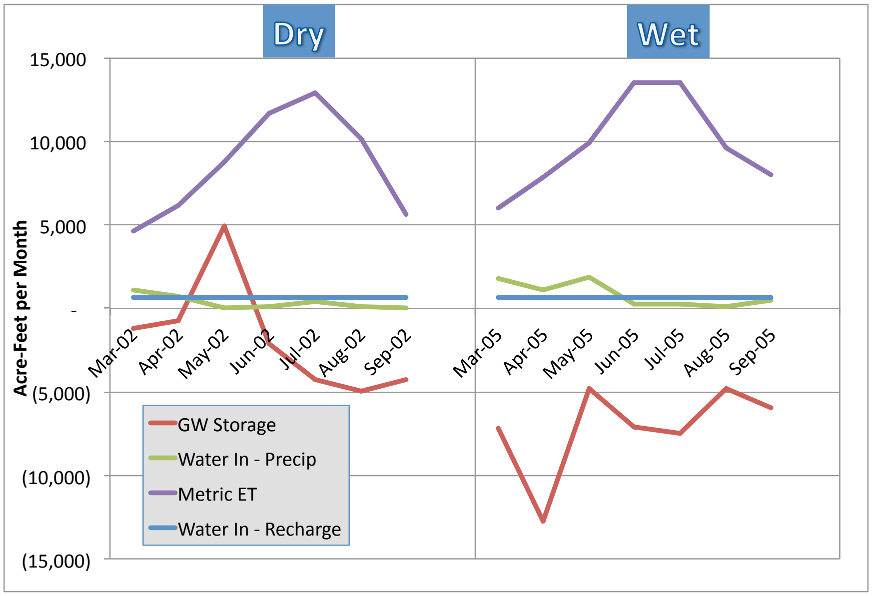
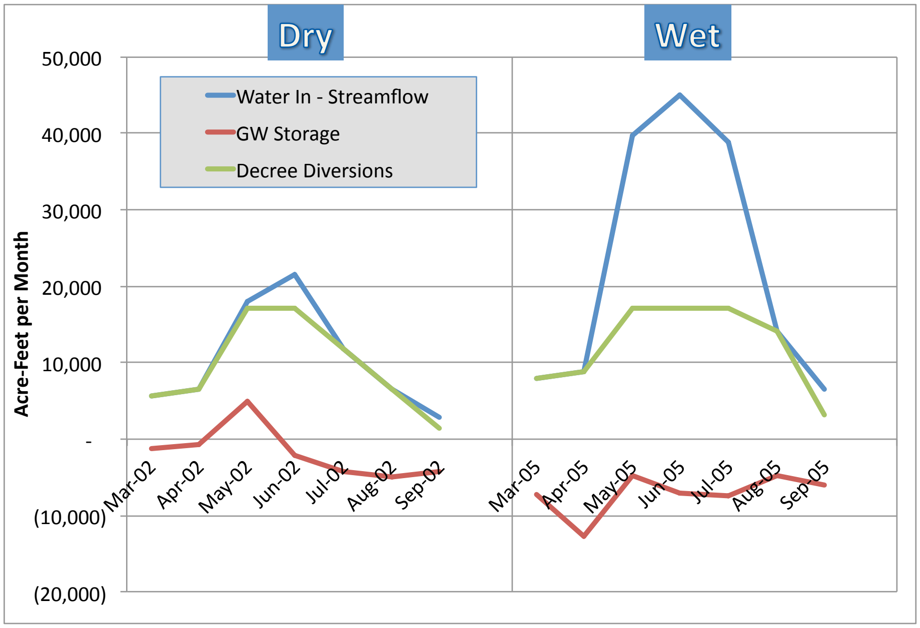


Figure 28. Irrigation Water Supply and Precipitation, Bridgeport Valley



7.5 Bridgeport Valley Irrigation Water Budget Model

The Bridgeport irrigation water budget model follows the same set-up and procedures as the Antelope Valley model. A few of the parameters that differ in the Bridgeport model include:

- Total decree acreage of 17,927
- No supplemental groundwater rights
- Storage in the two Twin Lakes on Robinson Creek is 6,100 AF
- Ditch conveyance loss is set at 10%
- On-farm efficiency is set to 40% due to the prevalence of flood irrigation in the valley
- Beginning of year groundwater storage is set at 3,500 AF

The low amounts of streamflow for diversion (in the dry year and in all but the snow melt months of the wet year) as noted above, in combination with low efficiency on-farm application, leads to the result that much of the water evapotranspired by crops and pasture in Bridgeport comes from groundwater and not directly from the application of irrigation water. The low proportion of METRIC ET that can be sourced from surface water applications is shown in Figure 29. As with Antelope Valley precipitation during the irrigation season is minimal, and insignificant compared to the surface water inflow (see Figure 30). When the model allows the crop demand to pull from irrigation water previously stored in the water table actual ET can be replicated in the model. However, a very large portion of the ET comes from the plants access to the water table and not directly to the irrigation water as delivered (see Figure 31 and Table 21). The table suggests that in the wet year 48% of the ET, or 1.83 feet, comes from the water table and in the dry year this figure is 54% of the total but a similar amount at 1.82 feet. This means that the amount of ET derived directly from the application of irrigation water is quite low at 1.46 feet in the dry year and 1.85 feet in the wet year.

As with the Antelope Valley model it is important to stress that these large figures for the water table component of ET are determined in large part by the water use efficiencies in the water. If the 40% assumed for flood irrigation is changed to the higher 60% efficiency then the amount of ET due directly to irrigation water rises to 2.11 in the dry year and 2.67 in the wet year, a significant increase.

Figure 29. Model vs METRIC Evapotranspiration without Access to Groundwater, Bridgeport Valley

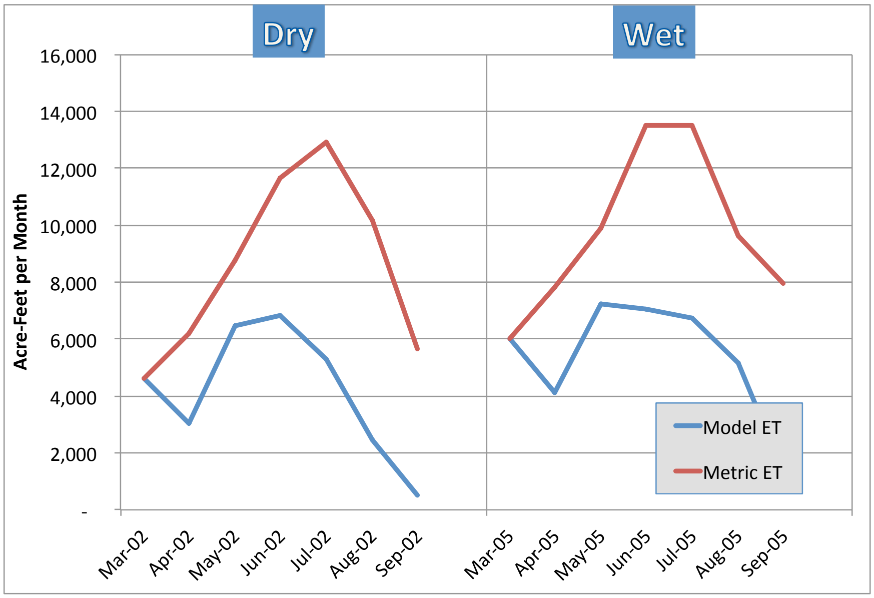


Figure 30. Irrigation Water Supply and Precipitation, Bridgeport Valley

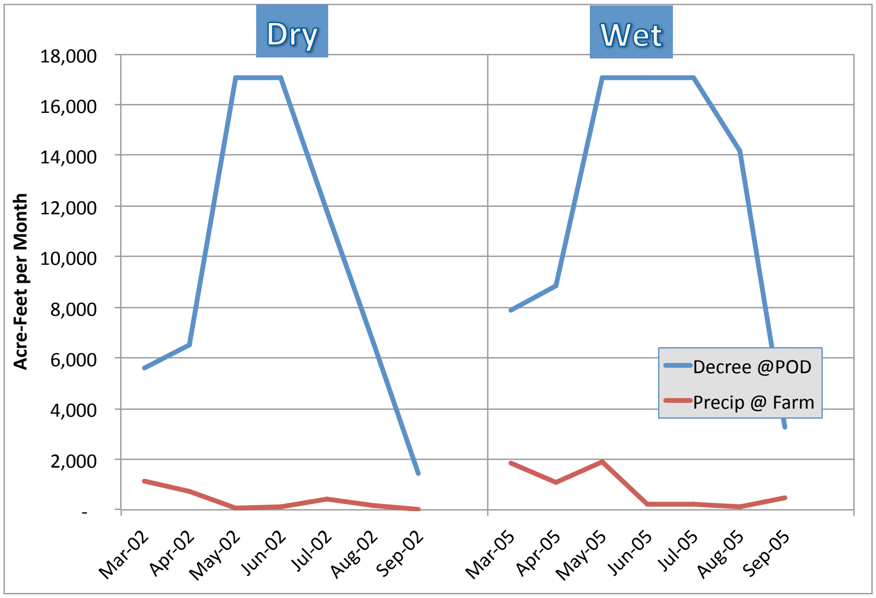


Figure 31. Evapotranspiration by Type of Water Consumed, Bridgeport Valley

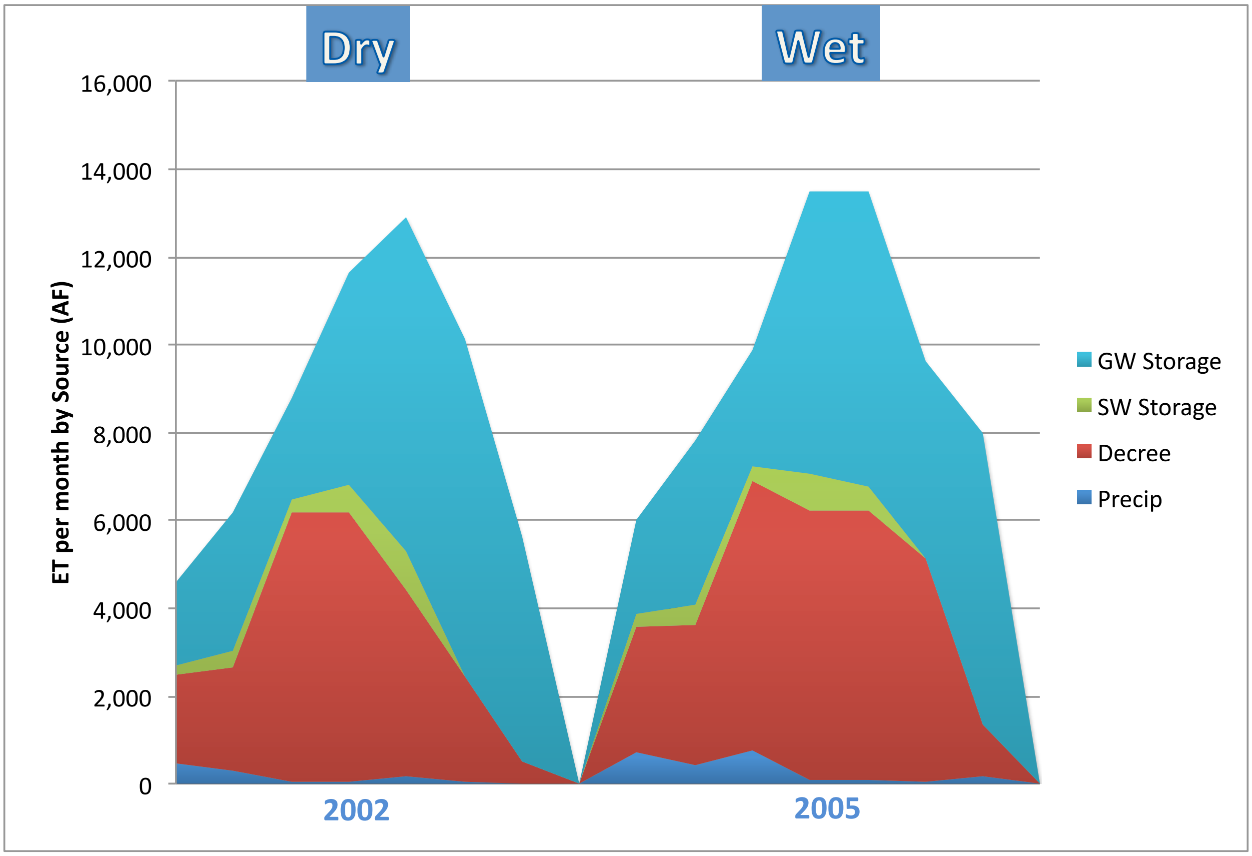


Table 21. Irrigation Season Evapotranspiration Amounts by Source and Year Type, Bridgeport Valley

Sources of ET:	Decree	Storage	Subtotal Irrigation Water	Water Table / Groundwater	Precipitation	Total ET
Amounts (AF)						
Dry	23,804	2,440	26,244	32,603	1,066	59,914
Wet	30,743	2,440	33,183	32,826	2,341	68,350
Amounts (% of Total)						
Dry	40%	4%	44%	54%	2%	100%
Wet	45%	4%	49%	48%	3%	100%
Amounts (feet)						
Dry	1.33	0.14	1.46	1.82	0.06	3.34
Wet	1.71	0.14	1.85	1.83	0.13	3.81

7.6 Bridgeport Valley Findings

As in the case of Antelope Valley, the model findings have implications for water transactions that involve the removal of irrigation water from an irrigated field (see Table 22 for monthly ET figures for the decree source of water). These implications are as follows, noting that the same caveats apply as in Antelope Valley in terms of the variability of these figures from dry to wet years, the influence of water use efficiency, and the spatial/temporal variability:

- For full year fallowing the amount of irrigation water not consumed will vary from roughly 1.46 to 1.85 feet for all irrigation water and 1.33 to 1.71 for decree water only.
- For a sale and transfer of water rights that fully dries out the property, the ET savings for all irrigation sources would range from 3.3 to 3.7 feet. If the storage is marketed separately the sum of the decree and water table / groundwater component would be 3.15 to 3.55 feet for dry and wet years respectively.
- For a partial year late season fallowing/lease of decree rights (assuming no irrigation after July 1st) the portion of the decrease in decree irrigation water consumed is 0.40 feet in the dry year and 0.69 feet in the wet year, with a midpoint of about 0.55 feet.
- For a partial year early season fallowing/lease of decree rights (assuming no irrigation until June 1st) the portion of the decrease in decree irrigation water consumed 0.59 feet in the dry year and 0.68 feet in the wet year, with a midpoint of about 0.65 feet.
- For a reduction in water use from wet year levels to dry year levels the decrease in irrigation water consumed will be about 0.4 AF for all irrigation sources (see Table 21) and for decree rights.

Table 22. Summary of Modeled ET from Decree Source by Month, Bridgeport Valley

ET from Decree Only	ET Totals in AF/month		ET: Wet less dry (feet)	ET: Wet Less dry Cumul. (feet)	ET by month (feet)	
Month	Dry (2002)	Wet (2005)			Dry (2002)	Wet (2005)
Mar	2,024	2,843	0.05	0.05	0.11	0.16
Apr	2,345	3,192	0.05	0.09	0.13	0.18
May	6,144	6,144	(0.00)	0.09	0.34	0.34
Jun	6,144	6,144	0.00	0.09	0.34	0.34
Jul	4,252	6,144	0.11	0.20	0.24	0.34
Aug	2,380	5,108	0.15	0.35	0.13	0.28
Sep	514	1,167	0.04	0.39	0.03	0.07
Totals	23,804	30,743	Subtotal Jul-Sep		0.40	0.69
			Subotal Mar-May		0.59	0.68

8. Conclusions: Implications for Water Transactions

This paper summarizes existing and newly developed data and models regarding hydrology, water rights and water use for irrigation in Antelope and Bridgeport Valleys. The intent of the effort is to provide information regarding the potential impact on the water budget of a range of water transactions that are to be examined in the RCD study. METRIC ET data and the NIWR figures by DRI, along with the modeling results explained in the preceding section provide different perspectives on the amounts of evapotranspiration (ET) associated with these transactions under a range of hydrological conditions. Generally, the DRI NIWR figures should be higher than the modeled figures as the modeling attempts to parse out the contribution to ET by source. The advantage of the modeled numbers is that they enable a more refined estimate of the likely amounts associated with specific types of water rights, for example, or decree and the likely effects of temporary transactions that do not fully dry up acreage.

An effort is made in Table 23 to summarize the METRIC and the irrigation water budget model results. A brief discussion of the results and how the figures might be used is best organized by each type of transaction:

- Full year temporary fallowing is in the 3 to 3.5 foot range using the METRIC NIWR figures, but from as low as 1.3 feet and up to 3.2 feet using the water budget model figures. Choosing the lower, water budget model numbers would reflect the assumption that small, temporary transactions will not succeed in drying out fields and therefore would not realize the full savings implied by the METRIC NIWR figures.
- Conversely for full year permanent fallowing the METRIC NIWR figures of 3 to 3.5 feet seem reasonable as all water would permanently be removed from the property, also the water budget model figures come in very much in this range with values of from 2.8 to 3.7 feet.
- For the partial, late season transactions the METRIC NIWR figures range from 1.4 to 2 feet, whereas the decree only figures from the water budget model range from 0.3 to 1.4 feet; the decree only figures are quite low but may be more accurate if, as the water budget model suggests, late season ET in these valleys depends in good part on water stored earlier in the season.
- The figures from both data sets with respect to the early season are quite similar and range from 0.6 to 1.1 feet; in this case this reflects not so much water stored but the direct contribution of irrigation water (which is usually decree only this early in the season) to early season ET.
- For a reduction in water use that mimics always irrigating at dry year levels in the case of Antelope Valley the METRIC NIWR reduction is 0.4 feet, whereas the water budget model suggests a much higher figure of 1.1 to 1.3 feet; in the case of Bridgeport Valley both approaches yield approximately the same 0.3 to 0.4 feet figure; these results reflect the much more pronounced variation in decree water right reliability in Antelope Valley which leads to a much higher dry/wet year variation in the water budget model.

Storage transactions are likely to be stand-alone transactions, i.e. not transferred along with the primary decree rights. Due to their unique nature as stored water, already withdrawn from natural flow, they would likely be subject to a different evaluation process with respect to leasing or transfer. Groundwater use is unlikely to be transferrable to an instream surface water right that is protectable downstream. Thus, depending on the case the decree only figures may be more relevant than the "all sources" figures.

Table 23. Summary of METRIC NIWR Results and Irrigation Water Budget Results for Irrigation and Decree Sources for Decree Rights

(all figures in ft of ET)	DRI - METRIC Analysis				Irrigation Water Budget Model							
	Net Irrigation Water Requirement				Antelope Valley				Bridgeport Valley			
	Antelope Valley		Bridgeport Valley		All Sources*		Decree Only		All Sources*		Decree Only	
Transaction Type	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Full Year - Temporary	3.1	3.5	3	3.3	2.1	3.2	1.7	3	1.5	1.9	1.3	1.7
Full Year - Permanent					3.2	3.7	2.8	3.5	3.3	3.7	3.2	3.6
Partial Year - Late Season	1.6	2	1.4	1.5			0.3	1.4			0.4	0.7
Partial Year - Early Season	0.8	0.9	1.0	1.1			0.9	1.1			0.6	0.7
Temporary Full Year Reduction	0.4		0.3		1.1		1.3		0.4		0.4	

Notes: *All sources do not include water table / groundwater for temporary transactions but do include this for permanent transactions

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Appendix 1. Water Right Priorities

Table 24. Antelope Valley Decree Rights, by priority date

Priority Date	Irrigated Acres	Diversion Rate (cfs)	Max Annual Volume (AF)
1862	1,152	18	8,810
1863	4,181	65	31,738
1864	4,742	74	36,005
1865	218	3	1,652
1866	153	2	1,166
1868	142	2	1,089
1869	41	1	311
1870	103	2	777
1872	172	3	1,302
1874	139	2	1,050
1876	152	2	1,166
1878	2,141	33	16,221
1882	1,451	23	10,992
1885	65	1	515
1886	164	3	1,244
1888	41	1	311
1889	108	2	816
1890	154	2	1,166
1891	41	1	311
1895	41	1	311
1896	41	1	311
1897	205	3	1,555
1899	21	0	156
1900	41	1	311
1902	359	6	2,721
Totals	16,067	251	122,009

Table 25. Bridgeport Valley Decree Rights, by priority date

Priority Date	Irrigated Acres	Rate (cfs)	Volume (AF)
1860	1,120	17.92	7,073
1861	2,850	42.40	16,736
1862	6,300	100.80	39,787
1863	1,035	16.56	6,537
1864	3,775	60.40	23,841
1867	400	6.40	2,526
1868	360	5.76	2,274
1869	80	1.28	505
1870	490	7.84	3,095
1871	240	3.84	1,516
1873	480	7.68	3,031
1874	1,448	23.17	9,146
1876	500	8.00	3,158
1877	640	10.24	4,042
1879	100	1.60	632
1880	80	1.28	505
1883	305	4.88	1,926
1885	40	0.64	253
1886	40	0.64	253
1890	1,656	26.56	10,484
1892	140	2.24	884
1893	560	8.96	3,537
1894	40	0.64	253
1897	120	1.92	758
1899	40	0.64	253
1901	100	1.60	632
1910	50	0.80	316
1916	80	1.28	505
1918	480	7.88	3,110
1920	80	1.28	505
1921	40	0.64	253
Grand Total	23,669	375.77	148,323

TECHNICAL MEMORANDUM ◦ MAY 2014

Walker River Basin, California, Potential Environmental Impacts of a Water Transactions Program: Task 3 Report

PREPARED FOR

Resource Conservation District of
Mono County
Post Office Box 327
Coleville, CA 96107

PREPARED BY

Stillwater Sciences
2855 Telegraph Ave., Suite 400
Berkeley, CA 94705

Stillwater Sciences

For more information contact:
Amy Merrill, amy@stillwatersci.com

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Cover photos:
Clockwise from upper left: looking down West Walker River; small farm and pasture in Bridgeport Valley, hay field in Antelope Valley; garlic field in Antelope Valley (photos by A.G. Merrill).

EXECUTIVE SUMMARY

Potential environmental impacts of a water transaction program in Antelope and Bridgeport Valleys are described in this report. Overall, a scarcity of quantitative information limited the degree to which conclusions could be made; however we outline basic comparisons among potential water transaction scenarios and their associated potential impacts. An existing general vegetation map of the West Walker River riparian corridor was expanded upon and combined with field survey and other information to develop a description and map of local vegetation types in Antelope and Bridgeport Valleys. A conceptual model that articulates linkages among surface water, groundwater, crop production, natural vegetation, fisheries, and wildlife was used to direct this assessment. In-stream effects on native and non-native fish species were assessed, again with limited quantitative information particularly in Bridgeport Valley. For either all or part of Antelope Valley and for all of Bridgeport Valley, potential impacts associated with five water transaction scenarios are considered: (1) no irrigation for full season; (2) late summer reduction in irrigation (July 1); (3) no irrigation until June 1; (4) reduced irrigation throughout the irrigation season; and (5) end of season storage water release.

Alfalfa is grown in roughly one-fifth of the irrigated area in Antelope Valley and therefore is an important agricultural crop in this area. Both Antelope and Bridgeport Valleys include rangelands, which cover over 80% of Bridgeport Valley and approximately 60% of Antelope Valley. Garlic is also grown on a small portion of Antelope Valley. Water transaction scenarios that suspend irrigation of existing alfalfa stands in Antelope Valley would have significant impacts to overall production rates, cutting production yields to less than two tons/ac per season. Conversion to alfalfa cultivars specific to dryland cultivation would be recommended for alfalfa production under this scenario. Of the twelve areas within Antelope Valley that share an irrigation ditch, those dependent upon Big Slough for irrigation include the greatest amount of land supporting alfalfa production and therefore implementing this transaction scenario to this part of Antelope Valley would result in the greatest negative impact to alfalfa production. Delaying irrigation until after June 1 would have a similarly large effect on alfalfa production since this would sharply impact the first and usually largest cut of the season. Although halting irrigation following July 1 could also reduce alfalfa production, production under this scenario could still be roughly 80% of current levels. This is the recommended approach for alfalfa and is already applied in other regions. Scenario 4 (reduced irrigation throughout season) would have impacts similar to halting irrigation as of July 1, and end of season water releases would be expected to have no impact on alfalfa production.

Under Scenario 1 (no irrigation), forage production is expected to decrease substantially in both valleys. While impacts to forage production in Bridgeport Valley could be important, large uncertainties regarding near-surface groundwater levels and the degree of natural sub-irrigation without diversions make it difficult to determine if there would be significant impacts to rangeland production in this valley. Within Antelope Valley, rangelands irrigated by Big Slough, Swauger, and Rickey and Private would experience the impact on rangeland production. Proportionally, areas irrigated by West Goodenough & Harney, Swauger, Powell, and Alkali would be most impacted. Shutting off irrigation on July 1 (Scenario 2) could reduce forage production for the first one to two years, but given appropriate weed and grazing management, production could return to existing levels, or close to it, within several years of ongoing management. Delaying irrigation until June 1 could have a small impact on forage production in Antelope Valley, but these effects could vary depending upon fall precipitation and temperature. Forage production is not expected to be impacted in Bridgeport Valley if irrigation is delayed until June 1. As with alfalfa, Scenario 4 (reduced irrigation throughout season) impacts would be similar to those described for Scenario 2, and water releases after the growing season (Scenario 4) would have no impact on forage production.

Potential impacts of the water transaction scenarios to existing natural vegetation overlap with the rangelands assessment because many of these areas are the same. Thus, the density, above ground production, and native forb diversity could be impacted in moist grasslands found in both Antelope and Bridgeport Valleys. Smaller impacts to dry grass vegetation found within and separate from areas supporting sagebrush are expected to occur for irrigated areas or areas adjacent to irrigated lands. Several sensitive forb, grass, and moonwort plant species that could occur in the Study Area and that are associated with moist grass or sedge areas could be affected; however surveys have not been performed for these species so their actual occurrence in the Study Area is unknown. Coyote willow and Woods' rose also occurs along many irrigation canals, and in low, wet spots in both valleys. Reduced all-season and early-season irrigation could impact these shrub thickets. Native riparian vegetation along the West Walker River in Antelope Valley includes Fremont cottonwood and several different native willow tree and shrub species. Water transaction scenarios that increase channel flows in a way that is similar to the natural hydrograph could increase recruitment and survival of native cottonwood and willow trees along the riparian corridor. This could increase the density and species richness of the river area, and diversify the age structure of the riparian forests, which are currently skewed towards mature and senescent age classes of cottonwood and red willow.

The wildlife impact assessment is closely tied to our understanding of potential impacts to natural vegetation as wildlife habitat. Antelope and Bridgeport Valleys could provide important habitat for many wildlife species, including the greater sage-grouse, yellow warbler, mule deer, pygmy rabbit, western white-tailed rabbit, and the American badger. Because the pygmy rabbit, western white-tailed rabbit, and American badger are all well adapted to dryland habitats, none of the water transaction scenarios are expected to negatively impact these species. Greater sage-grouse thrives in areas with a mixture of sagebrush, dry grass, and moist grass vegetation. It is hypothesized that an increase in the amount of interface between these vegetation types could positively affect greater sage-grouse, but the importance of this is unknown, as is the extent and distribution of any greater sage-grouse populations in the Study Area. Any assessment of potential effects on greater sage-grouse associated with changed vegetation in the valley bottoms would need to be centered upon the current distribution of greater sage-grouse in the valley(s). Only Scenario 1, implemented for multiple years, is expected to have a significant effect on the amount of interface between sagebrush and moist meadow vegetation. Other scenarios are expected to have negligible-to-minor effects on the greater sage-grouse that might occupy one or both valleys.

The yellow warbler also occurs in the Study Area and prefers open canopy or deciduous riparian forest and shrubs. Therefore, increases in willow and riparian forest cover that could occur with Scenario 1 and 3 (increased stream flows all or in the early part of the season) could positively affect yellow warbler. On the other hand, decreased extent of coyote willow in other parts of Bridgeport and Antelope Valleys with reduced early season irrigation could negatively affect yellow warbler habitat. Thus, the impacts could be mixed for this species. Mule deer, which have a varied diet that spans the vegetation types in both valleys, are not likely to be affected either way by any of the water transaction scenarios. Yosemite toad, Mt. Lyell salamander and Sierra Nevada yellow-legged frog were also considered in this assessment but determined not to have potential habitat within the Study Area.

The Walker River basin in California currently supports both native and non-native fish species. Native fish species include Lahontan cutthroat trout and whitefish, as well as sucker, minnows and sculpin. Introduced fish species include brook, brown, and rainbow trout that have been planted in various lakes, reservoirs, and stream reaches for improved recreational fishing opportunities. Lahontan cutthroat trout occupy less than three percent of their historic range, which formerly included all or most of the Walker River Basin, and are listed as threatened under the Endangered Species Act. Current populations in California are isolated in small headwater streams and do not overlap with the irrigated lower valleys. Thus, the water transaction scenarios are not expected to affect these existing populations of Lahontan cutthroat trout. However, non-native brown and rainbow trout do exist in the river reaches that flow through Antelope and Bridgeport Valleys and could benefit from increased early and late season flows that could occur under Scenario 1, and to a lesser degree, under Scenarios 2 and 3. These benefits to non-native trout are primarily associated with creating cooler stream temperatures due to increased in-stream flows during critical times of year. Most of the native fish in Antelope and Bridgeport Valleys are less sensitive to stream temperatures but could experience minor benefits from the water transactions due to reduced entrainment in diversions.

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1 INTRODUCTION

1.1 Overview and Project Goals

In this report, we describe the potential environmental and agricultural impacts associated with scenarios to alter water deliveries in Antelope and Bridgeport valleys. To this end, we identify and characterize existing conditions and habitat needs for listed and sensitive species such as Lahontan cutthroat trout (LCT), important habitat for birds, amphibians and other wildlife, sports and other resident fisheries, natural wetlands, and other native plant communities and sensitive plant species. Linkages between these environmental and agricultural resources and changes in hydrologic conditions, including groundwater levels, irrigation and in-stream flows, are articulated in a conceptual model developed for this project. We use this linkages model to assess the distribution and potential vulnerability to changes in hydrologic conditions of habitats and different crops grown in Antelope and Bridgeport valleys.

We use a water-budgeting spreadsheet model described in the associated Task 1 Report (Ecosystem Economics 2014) as input on potential monthly changes in in-stream and in-irrigation ditch flows to different areas of Antelope Valley and to Bridgeport Valley as a whole for four potential sales/lease scenarios. We use the linkages model described in Section 1.2 Approach: Linkages between Water Use and Environmental Benefits to estimate potential effects of different water sales/lease scenarios on aquatic and terrestrial resources relative to existing conditions for each Valley. Resources we assess include existing and native vegetation, crop and forage production, wildlife and fisheries.

1.1.1 Water transfer scenarios considered

Five potential water transfer scenarios are considered for this report to help outline the broad potential ecological and economic implications of implementing a water transfer program. These scenarios are summarized below.

1. **No Irrigation for Full Season:** Keep all areas out of irrigation for the entire growing season. This scenario is considered for all of both Bridgeport and Antelope Valleys (Scenario 1a) and for some subset of Antelope Valley (Scenario 1b).
2. **Late Summer Reduction (after July 1):** Irrigation continues through July 1 but is shut off for the second half of the growing season. Again this scenario is considered for all of Bridgeport and Antelope Valleys (Scenario 2a) and for some subset of Antelope Valley (Scenario 2b);
3. **No Irrigation before June 1:** No irrigation before June 1 in either valley (Scenario 3a); or in part of Antelope Valley (Scenario 3b).
4. **Reduced Irrigation Throughout:** Using the dry year irrigation rates as an estimate for closer water management. as applied in all of both valleys (Scenario 4a); or in part of Antelope Valley (Scenario 3b).
5. **End of season Storage Water Release:** storage water releases after the end of the normal irrigation (whole Valley).

Although a water transfer program could include any combination of these scenarios implemented variously in different parcels, for the purposes of describing the overall potential degree, extent, and distribution of these effects, each scenario was applied to Bridgeport Valley as a whole, and to areas supported by common irrigation ditches in Antelope Valley. Thus, we assess all five scenarios for all or a part of Antelope Valley and apply all five scenarios to Bridgeport Valley only as a whole.

1.1.2 Description of Antelope and Bridgeport valleys

The Walker River Basin drains from the high Sierras in California south of Lake Tahoe to a terminal lake in the Great Basin area of Nevada (Figure 1-1). Antelope and Bridgeport valleys are two large and wide valleys that occur in California along the western and eastern forks of the Walker River. These areas, which have rich soils and ample water provided from the high mountains to the west, have supported agricultural production for over 150 years. The climate in Antelope and Bridgeport valleys is humid continental, in that most of the precipitation occurs during long cold winters. Temperatures are moderate: commonly in the 60-70^{o}F range in the summer, and in the 20-30^{o}F range in the winter. Located in the rain shadow of the Sierra Nevada crest, both Antelope and Bridgeport valleys receive the overwhelming majority of their water as runoff that descends from the adjacent mountains and direct precipitation is a far less critical hydrologic input than surface flows from upstream and subsurface groundwater inputs. Annual precipitation within the valleys themselves ranges from 8 to 12 inches, while precipitation in the headwater reaches of Bridgeport and Antelope Valleys range from 35 to 40 inches. Brief summer monsoon rainstorms can occur, but the majority (roughly 75%) of precipitation falls from October through April. Snowmelt in the upper watershed and associated run off remain high from May through July, depending on the water-year. The bottoms of both valleys can be considered impermeable (Carroll and Pohll 2013) so that subsurface recharge comes from the valley sides, and primarily from the western slopes. Elevations of the contributing areas range from 10,007 to 6,000 feet for Antelope Valley; the valley itself lies at 5,000 to 5,800 feet. Bridgeport Valley is a little higher, at 6,450 to 6,750 feet, and with a contributing area that reaches 12,303 feet along the Sierra Crest.

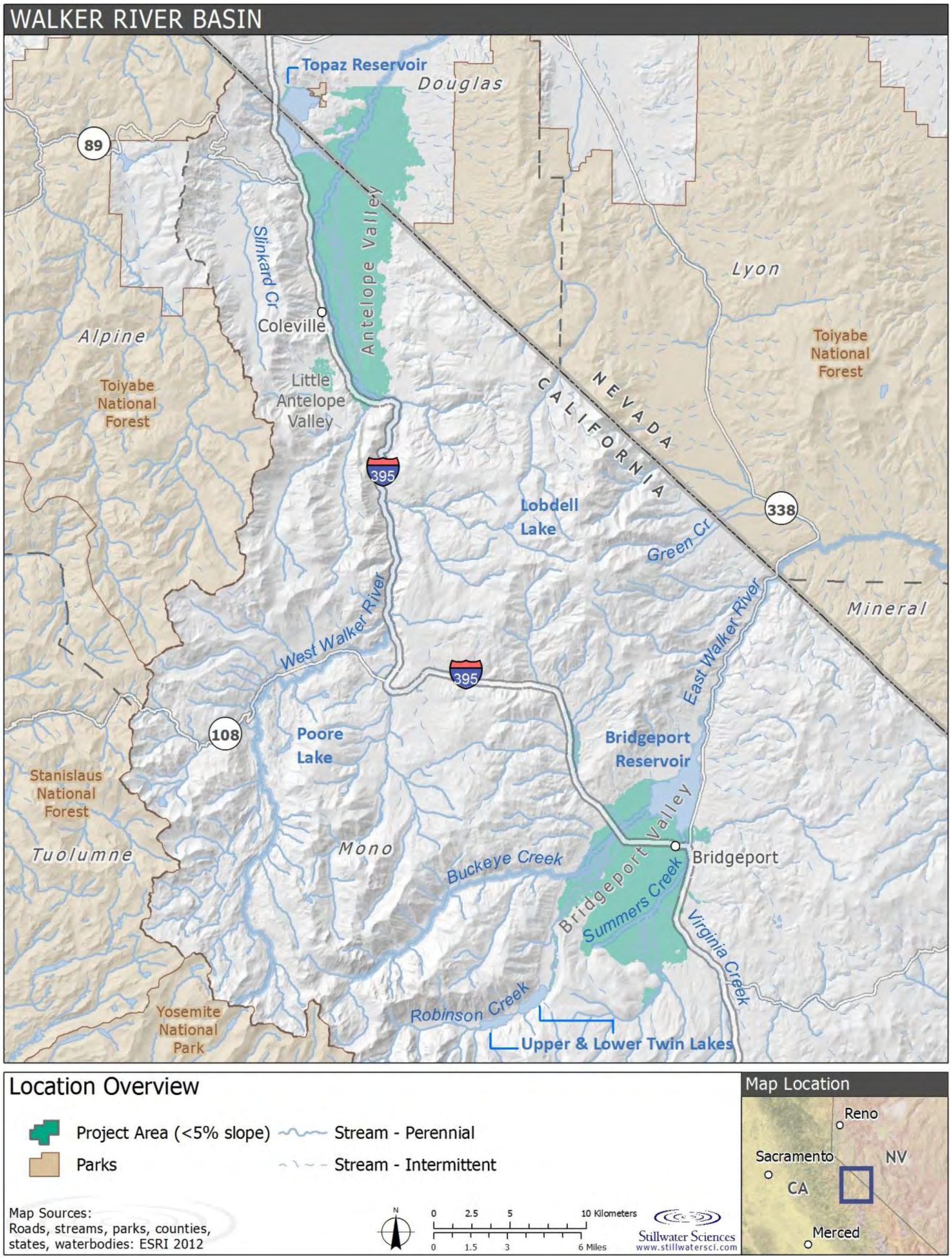

Figure 1-1. East and West Walker Rivers drain Bridgeport and Antelope Valleys, located on the eastern side of the Sierra Nevada.

1.2 Approach: Linkages between Water Use and Environmental Benefits

We use a conceptual linkages model to guide our steps in articulating potential environmental and agricultural impacts associated with changes in water transfers in the California East and West Walker Basins. The model, presented in Figure 1-2 below, includes three major paths of logic: one that links changes in diversions to consequent changes in in-stream flows and therefore potential effects on aquatic habitat and fisheries; one that links changes in diversions and irrigation to changes crop production; and a third that links changes in irrigation to changes in groundwater levels which then affect natural (including pastures) vegetation and therefore plant and wildlife habitat.

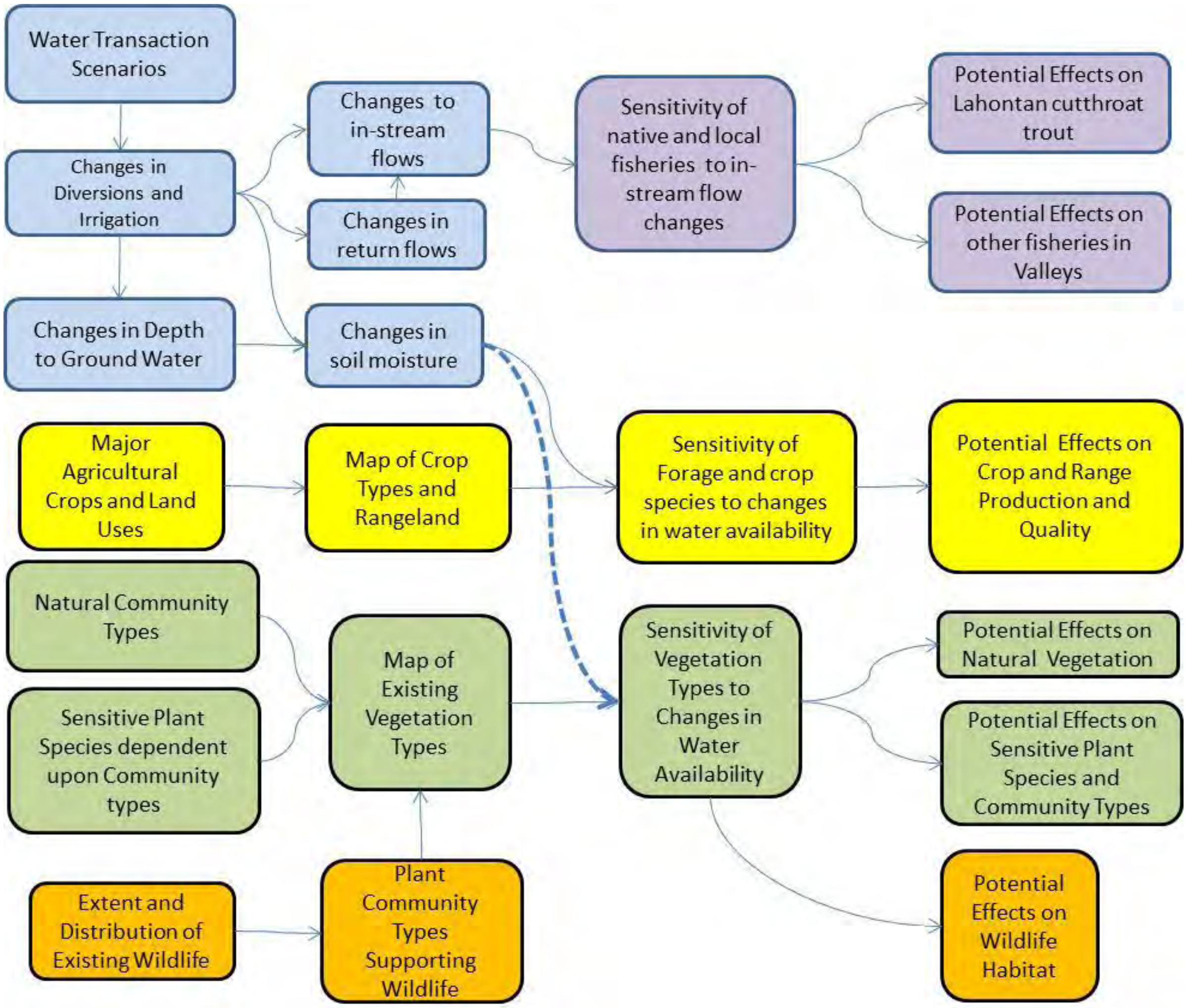

Figure 1-2. Conceptual model articulating linkages between water transfer scenarios and potential impacts to fisheries, crop production, sensitive plant species, natural vegetation, and wildlife habitat.

1.3 The Study Area and Hydrologic Response Units

We created Study Area boundaries for the area potentially affected by changes in water transfers in Antelope and Bridgeport valleys based on several assumptions: (1) all irrigated lands are subject to potential effects; (2) areas of low topographic relief in the irrigated valleys but outside of the designated irrigated areas can also be affected through associated changes in groundwater levels and return flows; and (3) the riparian corridor downstream of the upper-most diversion can be affected by altered in-stream flows. Where active irrigation was not applied, we delineated the edge of the valley floors where surface slopes fell below 5%, based on the assumption that areas with steeper slopes would have little or no interaction with the groundwater or irrigation return flows. For both valleys, the excluded steeper lope area includes only a very small percentage (<4%) of the valley floor land surface since most of the valley floors are actively irrigated through either flood or pivot irrigation. Thus, irrigated lands are the primary focus of the analysis and are captured in the hydrologic response units described below.

For the past 100 years, water flows into both Valleys has been controlled through a series of reservoirs, irrigation ditches (mostly unlined), flumes, weirs, river pumps, and water control gates. Upper watershed storage in the Green Lakes (Green, East, and West lakes), and Upper and Lower Twin Lakes above Bridgeport Valley, and in Poore and Lobdell Lakes and Black Reservoir for Antelope Valley is used to control and extend this run-off period through the growing season. Eleven different sets of water right decrees in the main valley, as well as a decree in Little Antelope valley, exist, each with different priority water rights, and use the Lower Antelope Valley water to irrigate designated potential acres of land in the valley (Table 1-1). Water flows through this valley are divided into ‗Hydrologic Response Units' (HRUs), according to the areas receiving irrigation flows from specific points of diversion and named based on the primary irrigation ditch used to transfer these waters to the irrigated fields (Figure 1-3). Although there are 27 different water decree rights in Bridgeport Valley, no information was available on applied irrigation volumes or distribution among irrigation ditches in Bridgeport Valley since this is not directly monitored by the Federal Water Master. Therefore the irrigated lands for Bridgeport Valley are presented as a single HRU with irrigated lands covering 17,926.8 acres (see Ecosystem Economics 2014). For this analysis, we use the HRU's as the primary unit for reporting potential or expected effects from, and responses to, changing the diversion and irrigation regime in the East and West Walker Valleys.

Table 1-1. Hydrologic Response Units in Antelope Valley.

Row Labels	Acres total	Percent of Irrigated Lands	Acres <5% slope	Acres > 5% slope
Alkali	206	1.4%	186.40	19.60
Big Slough	9839	65.9%	9,765.51	73.49
Carney	316	2.1%	301.91	14.09
Hardy	57	0.4%	50.06	6.94
Highline	259	1.7%	254.00	5.00
Little Antelope Valley	663	4.4%	187.98	475.02
Lone Company	272	1.8%	267.87	4.13
Main Canal	98	0.7%	96.05	1.95
Powell	181	1.2%	181.08	(0.08)
Rickey and Private	493	3.3%	493.01	(0.01)
Swauger	2271	15.2%	2,257.13	13.87
West Goodnough & Harney	266	1.8%	216.60	49.40
Grand Total	**14,921.00**	100.0%	**14,257.60**	**663.40**

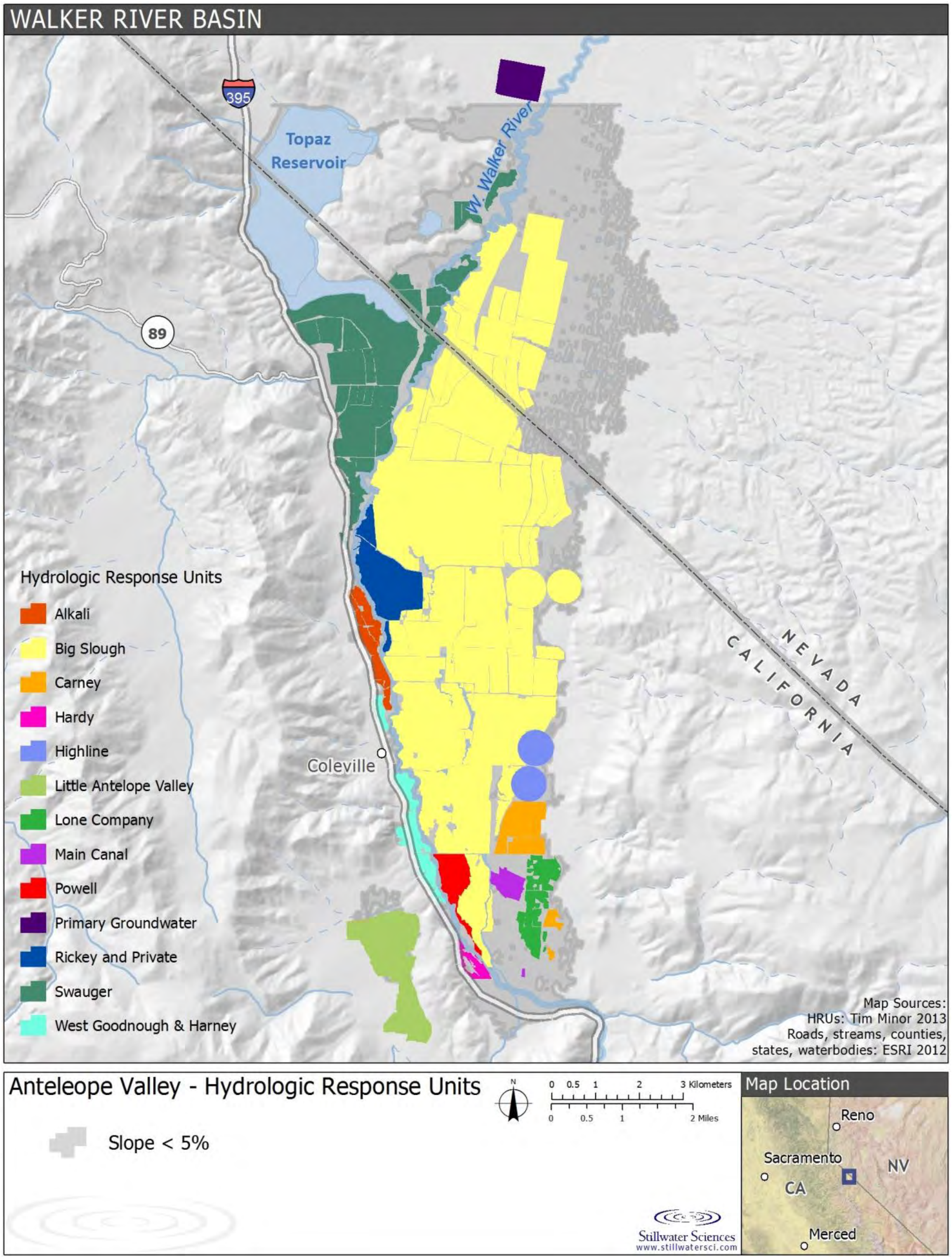

Figure 1-3. Hydrologic Response Units (HRUs) in Antelope Valley.

2 EXISTING SOILS, VEGETATION, AND WATER SOURCES

The soils in Antelope and Bridgeport valleys are briefly described, particularly as they affect plant-soil water availability. A large part of establishing necessary baseline information for this assessment includes describing and mapping existing vegetation in Antelope and Bridgeport valleys. Understanding the extent and distribution of this vegetation is critical for characterizing potential impacts of a water transfer program on existing terrestrial habitat and agricultural production. Finally, water sources are described, including potential spatial and temporal variability of near subsurface groundwater.

2.1 Existing Soils and Topography

Many different soil types occur in Antelope and Bridgeport valleys, most of which are composed of granitic and volcanic derived alluvium. Although textures range from clay to sand, the most common texture in both valleys is fine loam, and the second most common is sand, although some of the loams have high coarse content, and areas of clay soil exist near the reservoirs (Figures 2-1 and 2-2). Bridgeport valley soils are predominantly poorly to somewhat poorly drained, whereas soils in Antelope Valley are most often considered _well drained‘ (NRCS Soil Survey Staff 2014). For both Antelope and Bridgeport Valleys, surface slopes generally increase along the valley edges with more sloped areas along the southern valley borders (Figures 2-3 and 2-4). The extent and distribution of different soil textures and surface slope areas in Antelope and Bridgeport valleys is summarized in Table 2-1 and Table 2-2 below.

Table 2-1. Soil texture and surface slope classes in Antelope Valley, California.

Characteristic	Information source	Categories	Total acreage	Percent of total
Soil texture class	SSURGO dominant soil texture class	Sands	1,004	4
		Loams and Silt loams	16,234	69
		Clay and Fine Silt	3,345	14
		Unknown	2,809	12
		Total	**23,392**	**100**
Surface slope	30-m^2 DEM	0-3%	18,258	78
		3-5%	5,134	22
		Total	**23,392**	**100**

Table 2-2. Soil texture and surface slope classes in Bridgeport Valley, California.

Characteristic	Information source	Categories	Total acreage	Percent of total
Soil texture class	SSURGO dominant soil texture class	Sands	6,428	32
		Loams and Silt loams	11,648	58
		Clay and Fine Silt	50	<1
		Unknown	1,927	10
		Total	**20,053**	**100**
Surface slope	30-m^2 DEM	0-3%	18,255	91
		3-5%	1,799	9
		Total	**20,053**	**100**

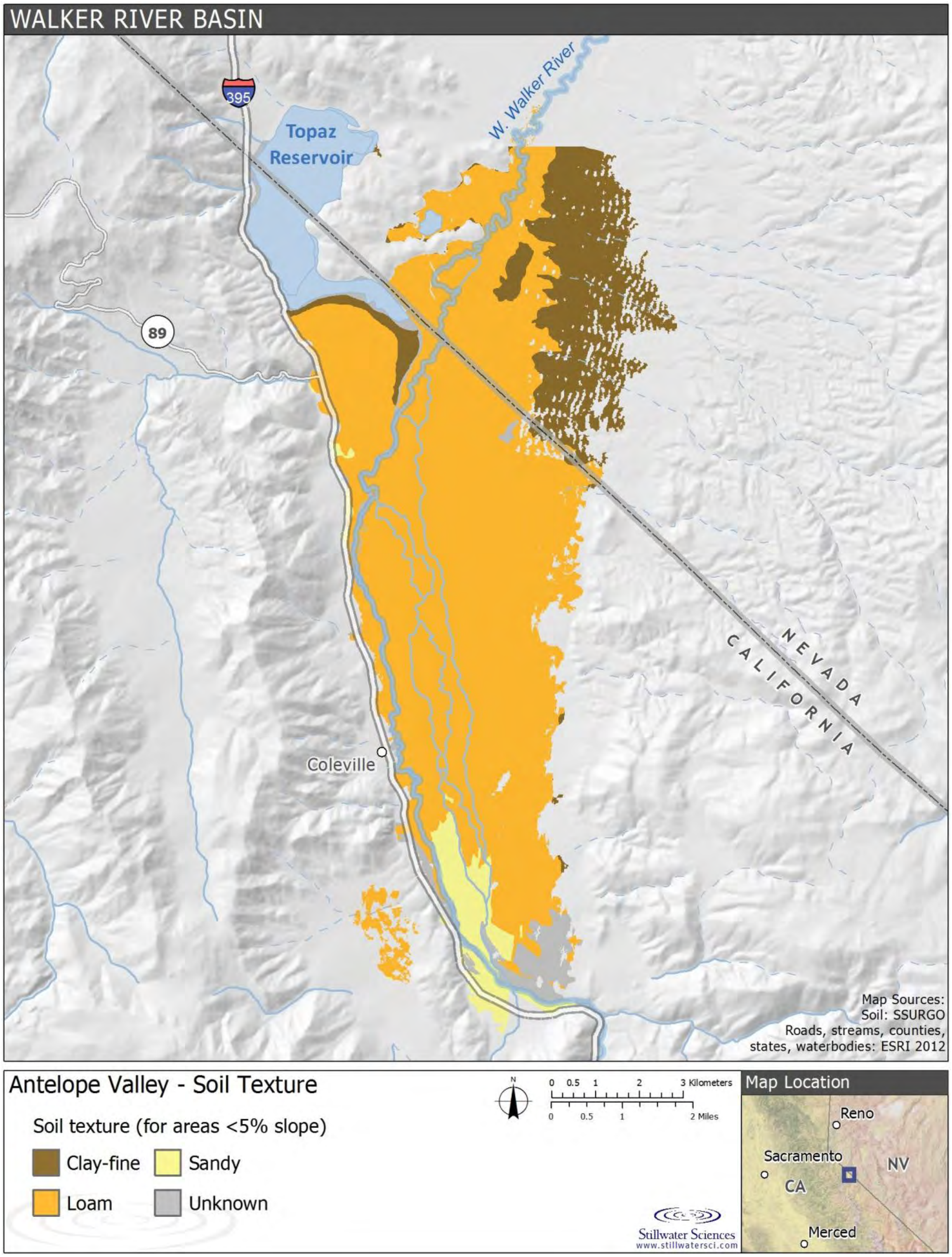

Figure 2-1. Surface soil textures in Antelope Valley.

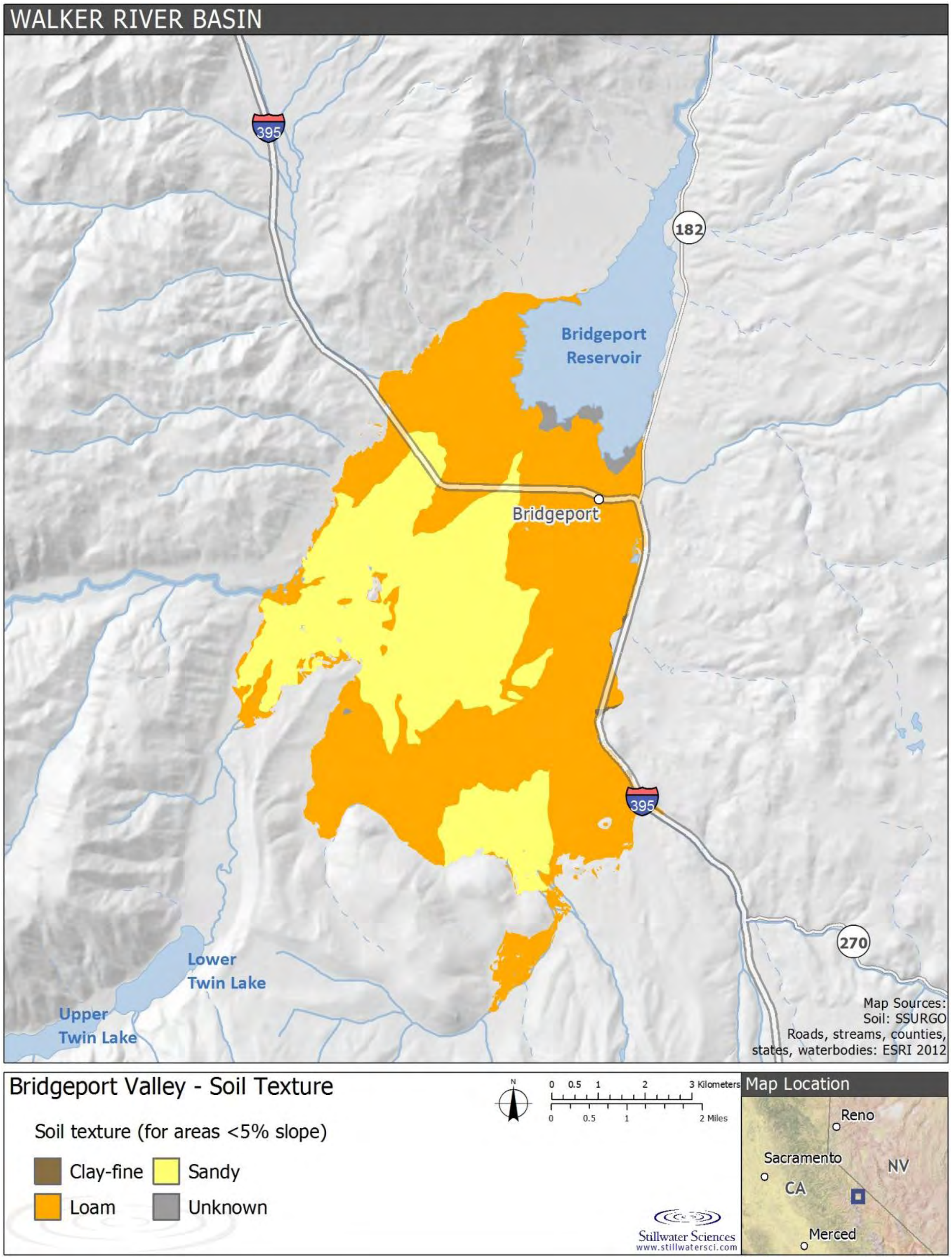

Figure 2-2. Surface soil textures in Bridgeport Valley.

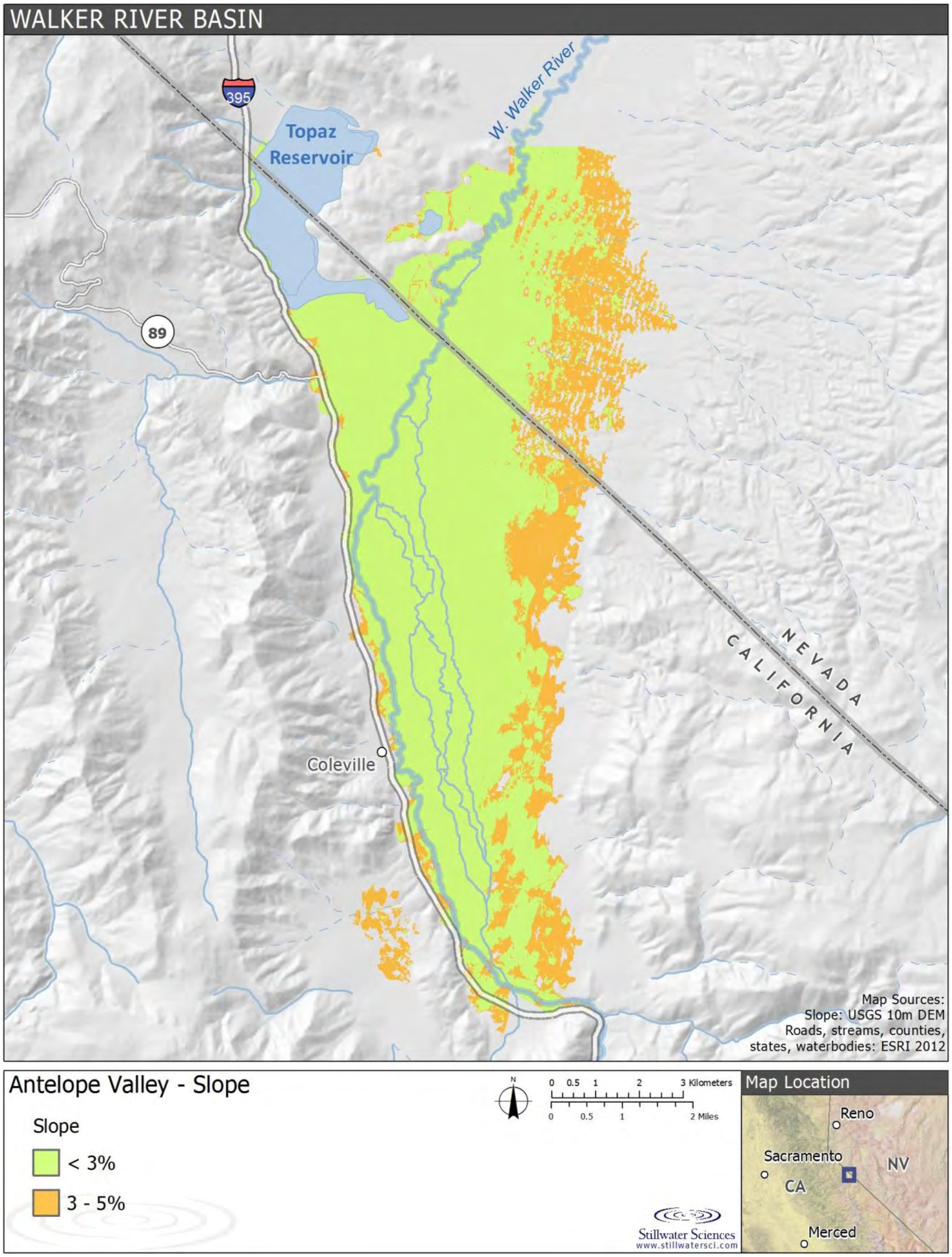

Figure 2-3. Surface slopes in Antelope Valley.

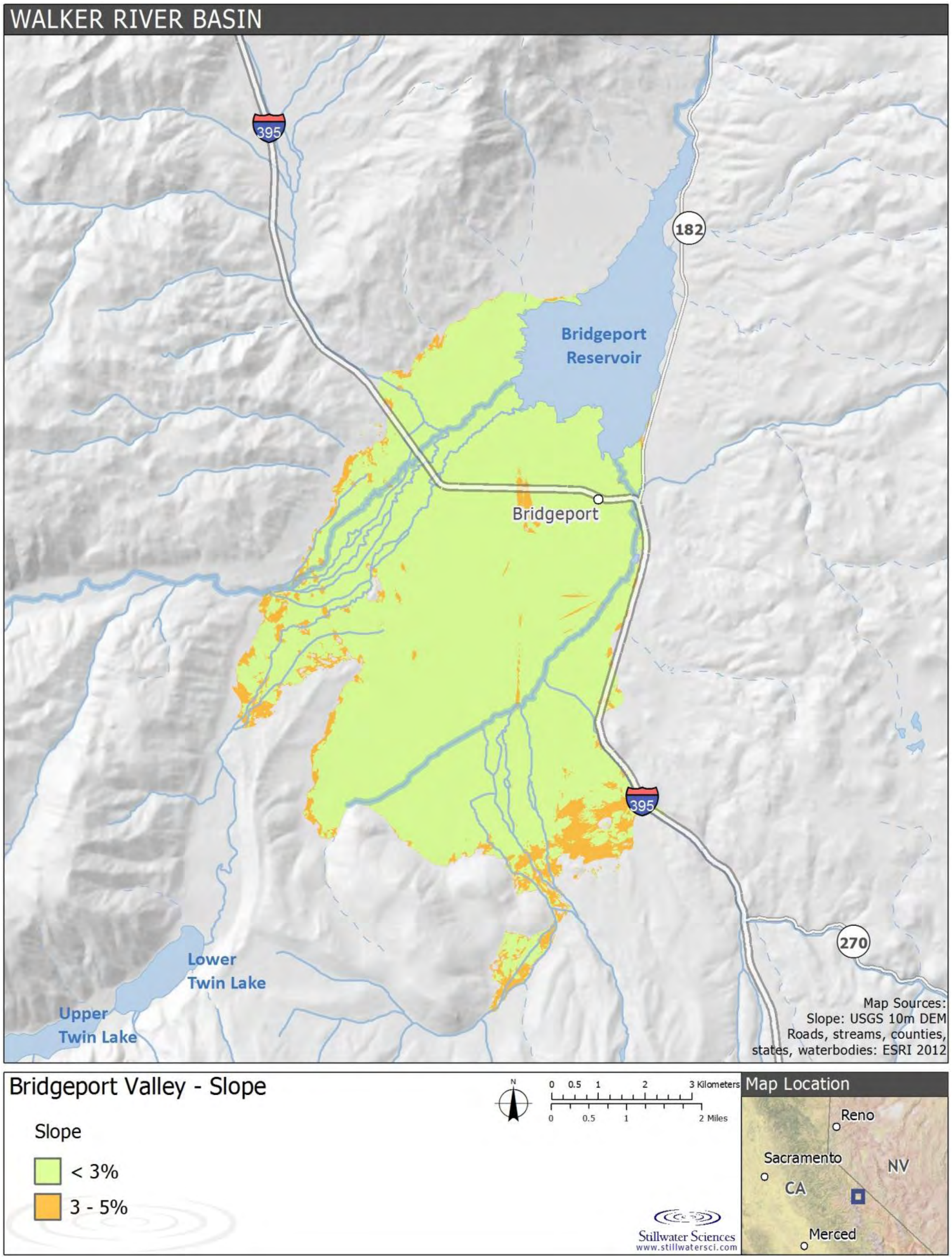

Figure 2-4. Surface slopes in Bridgeport Valley.

2.2 Vegetation in the Study Area

In order to assess likely impacts of a water transactions program on the agriculture, upland and riparian vegetation, and related sensitive animal and plant species, the following vegetation-related information was needed for the areas in Antelope and Bridgeport Valleys (under five percent slope):

- Key species composition for dominant vegetation types in, including riparian corridor, rangelands, other natural lands, and managed crop lands;
- A map of the location and approximate extent of each major vegetation type; and
- Potential vegetation type-specific responses to variations in water availability expected to occur with changes in irrigation.

The methods used to generate this information are described in the sections below, as are the vegetation types in the Study Area.

2.2.1 Existing information

A review of existing literature and spatial data provided general descriptions of vegetation types and their distributions in Walker and Bridgeport valleys (MCCDD 2007, Otis Bay 2009).). Otis Bay (2009) and Dilts et al. (2011) report on an historical analysis of vegetation in the Walker River watershed, and specifically the effects of irrigated agriculture on the distribution and extent of native riparian plant communities. Information from these reports was used to inform potential impacts of changes in irrigation on native riparian vegetation.

As part of an assessment of the most of the Walker River watershed (which included Nevada reaches, Walker lake, and Antelope Valley but not Bridgeport Valley), Otis Bay (2009) mapped seven riparian vegetation types in Antelope Valley: (1) Early Successional Riparian, (2) Emergent Marsh/Wetland, (3) High Density Riparian Shrub, (4) Low Density Riparian Shrub, (5) Mature Cottonwood with Riparian Shrub Understory, (6) Mature Cottonwood with Xeric Understory, and (7) Wet Meadow. The Otis Bay (2009) classification and map was used by this project for the riparian corridor of Antelope Valley. However, this covered only 165 acres of the Study Area in Antelope Valley.

Land cover in the rest of parts of Bridgeport Valley has been mapped by The Nature Conservancy (TNC) (provided to Stillwater by the MCRCD in 2013) and CALVEG (USDA Forest Service 2014). However, these maps do not differentiate among wet, moist, and dry meadows and grasslands in the non-row crop portions of Antelope and Bridgeport valleys, and, therefore, did not meet the needs of this study. As a result, a combination of field surveys, remote sensing, and heads-up digitizing were used to characterize and map non-row crop vegetation types outside the riparian corridor in Antelope Valley and all vegetation types in Bridgeport Valley. These methods are described below.

2.2.2 Field surveys

In August 2013, Stillwater Sciences staff visited both Antelope and Bridgeport valleys and recorded information on vegetation in publically accessible areas and in privately owned areas where the team had explicit access permission from land owners. During this three-day field visit, dominant plant species were recorded at 86 georeferenced and photographed points in both hillslope and meadow areas of Bridgeport and Antelope valleys. More detailed information was collected at 33 plots in flat areas (i.e., slopes under five percent), using a modified CNPS/DFG (2011) Rapid Assessment Protocol. At these plots, plant species composition and cover, percent bare ground and standing water, topographic position, grazing history, and moisture category were all recorded.

All recorded data were entered into a database, which then underwent an independent QA/QC check in September 2013. Where possible, data collection points were assigned a vegetation alliance, per the *Manual of California Vegetation* classification system (Sawyer et al. 2009). However, because vegetation at many of the meadow points did not conform to existing alliances, Canonical Correlation Analysis (CCA) of both physical conditions and plant species composition at the 33 plots was used to identify and assign coarser vegetation types to meadow areas.

2.2.3 Canonical Correlation Analysis (CCA)

CCA is a useful tool for systematically and objectively compiling multiple sets of information to classify areas into like and unlike groups. In CCA, data on site plant species cover and environmental characteristics are arrayed such that differences and similarities among sites are recognizable: sites with similar vegetation and environmental conditions are clustered and those that are very different are spread apart in two dimensional space (i.e., axes). PC-ORD (Version 4) was used to perform the CCA of the 33 plots, which included four environmental variables and 80 plant species. The CCA yielded eigenvalues for Axis 1 and 2 (out of three canonical axes) of 0.448 and 0.307, respectively, and the first two axes explained 11.8% of the total variance (6.4286) among plots (Table 2-3 below).

Table 2-3. CCA results for the 33 vegetation plots in the Study Area. Total variance ("inertia") in the species data: 6.4286.

Statistic	Axis 1	Axis 2	Axis 3
Eigenvalue	0.448	0.307	0.160
Variance in species data			
% of variance explained	7.0	4.8	2.5
Cumulative % explained	7.0	11.8	14.2
Pearson Correlation between species and environmental variables	0.893	0.852	0.602
Kendall (Rank) Correlation between species and environmental variables	0.769	0.602	0.481

Three distinct vegetation groups were identified by the CCA: (1) Wet Sedge, (2) Moist Grass, and (3) Dry Grass. As illustrated in Figure 2-5, axis 1 is most strongly correlated with surface moisture, and axis 2 is most strongly correlated to percent bare ground. There is some overlap among the Moist Grass and the Wet Sedge groups but generally the groups are well separated along these two axes. Results from the field surveys and CCA were then used to develop dominant species profiles for each of the distinct vegetation types, which all provide forage in the Bridgeport and Antelope Valleys.

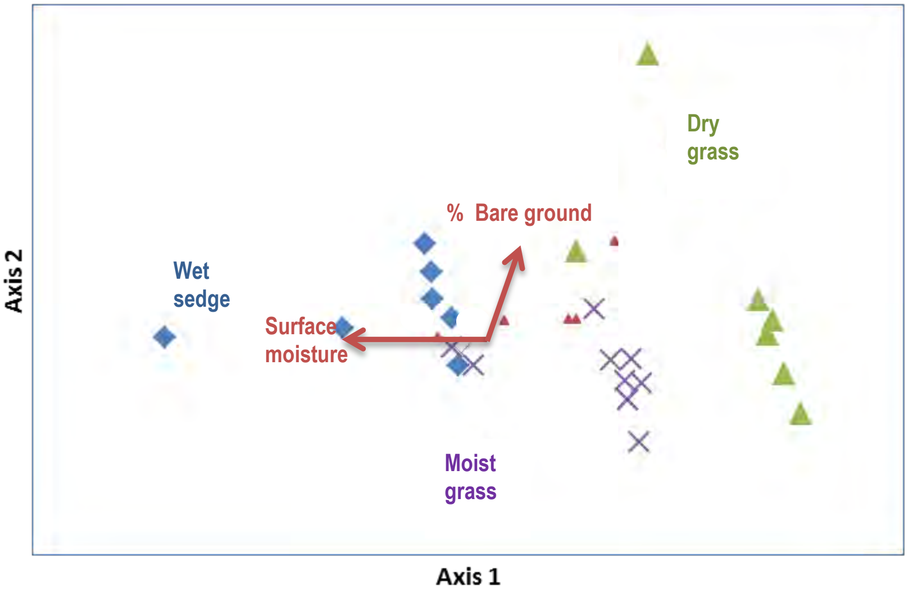

Figure 2-5. CCA biplot showing distribution of vegetation plots in Bridgeport and Antelope Valleys (blue diamonds, purple x's, and green pyramids) along surface moisture (axis 1) and percent bare ground (axis 2) axes.

2.2.4 Vegetation map

Using 2012 NAIP imagery reflectance data, vegetation cover in the non-riparian areas of Bridgeport and Antelope valleys was classified using the Normalized Difference Vegetation Index (NDVI)[1]. Species composition information from the 33 detailed field plots and 20 additional points was used to assign an appropriate vegetation type for each reflectance category.

To assess the accuracy of the NDVI classification, 46 10-m radius polygons were created in GIS and manually assigned one of five vegetation types based on the field surveys and photointerpretation of NAIP 2012 imagery: Barren, Sagebrush, Dry Grass, Moist Grass, or Wet Sedge. These polygons, which included an even distribution of the five vegetation types, were compared to 1-m^2 pixels of the NDVI-classification to assess the user's and producer's accuracy[2] of the final vegetation map (Tables 2-4a and 2-4b).

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[1] NDVI was developed in the early 1970's to distinguish living vegetation from senescent vegetation, soil, snow, and water as recorded by early LandSat multi-spectral scanners. It has been broadly applied in studies of ecology and vegetation science. The NDVI formula calculates the normalized difference in near infrared vs. visible red radiation that is absorbed by plants and other surfaces: (Near IR – Visible IR)/(Near IR + Visible IR). Negative values of NDVI (values approaching -1) correspond to water. Values close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow. Low, positive values (approximately 0.2 to 0.4) represent shrub and grassland, while high positive values (approaching 1) are indicative of forests.

[2] User's accuracy is the probability that an area labeled as a certain type on the map is really that type on the ground, while producer's accuracy is the probability that a certain land-cover type on the ground is classified as such in the map. The user and producer accuracy for any given class typically are not the same.

Table 2-4a. Vegetation map user's accuracy: Percent of area in each manually-classified 10-m radius polygon with matching NDVI-classification.

NDVI-classification	Manual-classification				
	Sagebrush/Barren	Dry Grass	Moist Grass	Wet Sedge	Total
Sagebrush/Barren	**94**	6	0	0	100
Dry Grass	74	**26**	0	0	100
Moist Grass	0	3	**75**	22	100
Wet Sedge	0	0	4	**96**	100

Table 2-4b. Vegetation map producer's accuracy: Percent of area in each NDVI-classified 1-m^2 pixel with matching manual-classification.

NDVI-classification	Manual-classification			
	Sagebrush/Barren	Dry Grass	Moist Grass	Wet sedge
Sagebrush/Barren	**15**	3	0	0
Dry Grass	85	**88**	0	0
Moist Grass	0	9	**95**	20
Wet Sedge	0	0	5	**80**
Total	100	100	100	**100**

The accuracy assessment demonstrated that many areas classified as Dry Grass using NDVI were manually classified as Sagebrush/Barren based on field observations and photointerpretation (85%; Table 2-4b) and many areas manually classified as Sagebrush/Barren were classified as Dry Grass based on the NDVI (74%; Table 2-4a). In both of these cases, Sagebrush was mistakenly classified as Barren and Dry Grass vegetation types by the NDVI. However, those areas manually classified as Sagebrush were correctly classified by NDVI 94% of the time. Since much of the inter-canopy area in the Sagebrush vegetation type supports Dry Grass, this discrepancy is likely more of a spatial-scale issue than an incorrect classification of the reflectance data. The reflectance data pixels are 1 m^2, while photointerpretation was performed on a scale 300 times larger (1 m^2 vs. 314 m^2) where variations at the 1 m^2 scale were integrated into a single vegetation type. Therefore, the NDVI Sagebrush/Barren classification should be interpreted as a minimum extent, of which much of the inter-shrub canopy area is represented by Dry Grass.

Moist Grass and Wet Sedge were well classified using NDVI: 75% to 80% accuracy was achieved in distinguishing Moist Grass from Wet Sedge. The NDVI analysis classified 22% of areas to Moist Grass that were manually classified as Wet Sedge (Table 2-4a) and the NDVI assigned Moist Grass to 20% of those areas that were manually classified as Wet Sedge (Table 2-4b). Thus, while some uncertainty remains between these two classes and mapped extents, the majority of both vegetation types was correctly classified and mapped by the NDVI.

The NDVI classification did not distinguish fairly large (e.g., 100 m^2 or greater), often isolated linear patches of coyote willow (*Salix exigua*), which were observed in several parts of Antelope and Bridgeport valleys and along some of the irrigation canals. To ensure this potentially important habitat was included in the vegetation map, the occurrence of Coyote Willow vegetation was hand digitized using NAIP 2012 imagery.

The Stillwater Sciences and Otis Bay (2009) maps were combined to create a final and comprehensive vegetation map for the Study Area. Figure 2-6 is the vegetation map for Antelope

Valley and Figure 2-7 is the vegetation map for Bridgeport Valley. Each of the vegetation types featured in these maps is described below.

2.2.5 Vegetation types

2.2.5.1 Wet Sedge

This vegetation type was classified by Stillwater Sciences using the NDVI, and occurs at seven of the field survey plots. All seven plots have wet surface soils or standing water and most have less than 5% bare ground. Dominant and common plant species include Nebraska sedge (*Carex nebrascensis*), other wet-site sedges (*C. aquatalis*, *C. simulatae*), and Baltic rush (*Juncus balticus*). Overall, graminoid species are diverse and cover an average of 90% of the plot. This type also includes several small areas (0.3 acres) along the Walker River riparian corridor that were classified by Otis Bay (2009) as Emergent Marsh and Wetlands. These areas occur in seasonally or semi permanently flooded oxbows or backwaters of an active channel, and are typically dominated by bulrush (*Schoenoplectus acutus*), cattail (*Typha spp.*), American speedwell (*Veronica americana*), and Baltic rush (*Juncus balticus*). There are 1,513 acres of Wet Sedge in Antelope Valley and 6,285 acres in Bridgeport Valley.

2.2.5.2 Moist Grass

This vegetation type was classified by Stillwater Sciences using the NDVI, and occurs at 12 of the field survey plots. Moist Grass occurs in areas where surface soils are moist or wet to the touch in late summer, but do not have standing water, and have very low percent cover of bare mineral soil. The Moist Grass vegetation type supports a diversity of graminoid and forb species, the most common of which are *Juncus balticus*, *Elymus triticoides*, *Agrostis exarata*, *Iris missouriensis*, *Phleum spp*. (*P. pretense* and *P. alpinum*), and some Nebraska sedge. Overall graminoid cover averages 73% in the 12 plots, and forb cover averages 19%. There are 4,347 acres of Moist Grass in Antelope Valley and 6,979 acres in Bridgeport Valley.

2.2.5.3 Dry Grass

This vegetation type was classified by Stillwater Sciences using the NDVI, and occurs at 11 of the field survey plots. Areas that fall into this vegetation type have surface soils that are dry to the touch in late summer, have modest to high (5 to 50%) percent cover of bare mineral soil, and support over 10% dry grass species and approximately 50% cover of all graminoid species. Typical plant species found in this type include *Bromus tectorum*, *Carex incurviformis*, *Elymus triticoides*, *Juncus balticus*, and *Iris missouriensis*. Approximately half of the Dry Grass plots also included over 10% cover of rabbit brush (*Ericameria nauseosa,* formerly *Chrysothamnus viscidiflorus*) or, less often, sagebrush (*Artemisia tridentata* or *A. cana*). There are 2,762 acres of Dry Grass in Antelope Valley and 3,127 acres in Bridgeport Valley.

2.2.5.4 Sagebrush-Rabbitbrush

This vegetation type was classified by Stillwater Sciences using the NDVI. Areas that fall into this vegetation type support some combination of sagebrush (*Artemisia tridentata*), rabbitbrush (*Ericameria nauseosa*), and Antelope bitterbrush (*Purshia tridentata*). Shrub cover exceeds 50% and the inter-shrub area is occupied by either bare ground or the Dry Grass vegetation type. The distinction between the Dry Grass and Sagebrush- Rabbitbrush vegetation types is not well validated by the manual, photointerpretation-based classification due, at least in part, to the fact that these two vegetation types co-occur in a large amount of the Study Area. There are 1,558 acres of Sagebrush-Rabbitbrush in Antelope Valley and 1,095 acres in Bridgeport Valley.

2.2.5.5 Barren

Barren areas were classified by Stillwater Sciences using the NDVI. Areas of bare mineral soil, excluding those areas along the riparian corridor mapped and classified as Early Successional Riparian (see below), are included in this type. Much of the area classified as Barren is actually part of the inter-shrub matrix in the Sagebrush-Rabbitbrush vegetation type. Developed areas are also included in this type, including the small towns of Coleville, Walker, and Bridgeport. There are 714 acres of Barren in Antelope Valley and 970 acres in Bridgeport Valley.

2.2.5.6 Early Successional Riparian

This vegetation type was classified by Otis Bay (2009). This vegetation type is mapped on mostly open depositional areas, such as point bars, along the channel margin, with sparse vegetation comprised of early successional woody species such as coyote willow (*Salix exigua*), sedges, grasses, and several forbs. There are seven acres of Early Successional Riparian in Antelope Valley (this type is included in the more general Riparian vegetation in Bridgeport Valley; see below).

2.2.5.7 Coyote Willow

This vegetation type was manually classified and mapped by Stillwater Sciences. Coyote Willow is typified by patches of coyote willow (*Salix exigua*), often mixed with Woods‘ rose (*Rosa woodsii*), along irrigation canals or ditches and in low spots of meadows or pastures with water close to or at the surface. Herbaceous vegetation, mostly graminoids, frequently occurs under the shrub canopy. There are 209 acres of Coyote Willow in Antelope Valley and 74 acres in Bridgeport Valley.

2.2.5.8 Mature Cottonwood

This vegetation type was classified by Otis Bay (2009). Fremont cottonwood (*Populus fremontii*) and black cottonwood (*Populus trichocarpa*) both occur in the Walker River watershed, sometimes mixed with red willow (*Salix laevigata*) in the overstory. Black cottonwood is more common in the upper reaches and Fremont cottonwood is more common in the main valleys. This type was divided into Mature Cottonwood with Riparian Understory and Mature Cottonwood with Xeric Understory by Otis Bay (2009). Riparian understory species include coyote willow, woods‘ rose, sagebrush, and dry land grasses. The xeric shrub understory is comprised of big sagebrush, saltbush (*Atripliex sp.*), and rabbitbrush, with dry land grasses and forbs (e.g., heliotrope [*Heliotropium curassavicum*], creeping wildrye [*Leymus triticoides*], and saltgrass [*Distichalis spicata*])) among the shrub patches. There are 17 acres of Mature Cottonwood in Antelope Valley (it is mapped as Riparian in Bridgeport Valley; see below).

2.2.5.9 Riparian

This vegetation type was classified by TNC and applies only to Bridgeport Valley since it is mapped by Otis Bay (2009) as Mature Cottonwood or Early Successional Riparian in Antelope Valley. In Bridgeport Valley, the Riparian vegetation type supports bare mineral soil and gravel, early successional herbaceous plants, and riparian shrubs and trees. There are 71 acres of Riparian in Bridgeport Valley.

2.2.5.10 Jeffrey Pine Forest

This vegetation type was classified by Otis Bay (2009). These are forested areas dominated by Jeffrey pine (*Pinus jeffreyi*) with curl-leaf mahogany (*Cerocarpus ledifolius*), juniper species (*Juniperus spp.*), sagebrush, and bitterbrush in the shrub understory. Jeffrey Pine Forest occurs in low-lying areas (less than 5% slope) in Antelope and Bridgeport valleys, but not within the HRUs themselves (therefore this vegetation type is not included in Table 2-5 below). There are three acres of Jeffrey Pine Forest in Antelope Valley and none in Bridgeport Valley.

2.2.5.11 Open Water

Open water was classified by Stillwater Sciences using the NDVI and includes areas of open water in river channels, wide or exposed irrigation canals, and ponded water. Neither Bridgeport nor Topaz reservoirs are included in the mapped areas.

2.2.6 Vegetation extent

Table 2-5 summarizes the types and extent of vegetation and agriculture mapped in the HRUs of Antelope and Bridgeport valleys. Because Barren is frequently part of the broader matrix of the Sagebrush-Rabbitbrush vegetation type (along with Dry Grass), these two types are combined in Table 2-5 as Barren/Sagebrush. The extent and relative distribution of the eight vegetation types mapped in the HRUs of Antelope and Bridgeport valleys are also displayed in Figures 2-6 and 2-7.

Table 2-5. Vegetation type, showing number of acres and percent area in Antelope and Bridgeport valley HRU lands under 5% slope.

Vegetation type	Antelope Valley		Bridgeport Valley	
	Acres	**Percent of Area**	**Acres**	**Percent of Area**
Alfalfa, Garlic	3,092	22	0	0
Barren/Sagebrush[2]	2,272	16	2,065	10
Coyote Willow	209	2	74	0.4
Dry Grass	2,762	19	3,127	16
Early Successional Riparian	7	0.1	NA	NA
Moist Grass	4,347	30	6,979	35
Wet Sedge	1,513	11	6,285	31
Mature Cottonwood	17	0.1	NA	NA
Riparian	NA	NA	71	0.4
Open water	38.6	0.3	1,452	7
Total	**14,257**	**100**	**20,053**	**100**

In Antelope Valley, Moist Grass covers the greatest area (30%), while irrigated fields of garlic and alfalfa cover a slightly smaller extent (22%; Table 2-5). Barren/Sagebrush is similar to the Dry Grass vegetation type and often the two types form a matrix that together occupies 35% of Antelope Valley. Wet Sedge occurs in pockets and larger areas distributed throughout the center of the Valley, and makes up over 11% of the area. Coyote Willow is mapped along many of the irrigation ditches and other low spots in Antelope Valley, but makes up less than 2% of the area. Similarly, Mature Cottonwood and Early Successional Riparian vegetation occupy very small portions of Antelope Valley (both 0.1%) and are clustered along the West Walker River channel.

Bridgeport Valley is larger than the irrigated HRU area in Antelope Valley, based on the extent of land in the HRUs with less than 5% slope (20,053 vs. 14,257 acres, respectively). Bridgeport Valley appears wetter, with three times the area of Wet Sedge and somewhat higher fraction of Moist Grass, but supports none of the alfalfa that covers over one-fifth of Antelope Valley (Table 2-5). Four large tributaries to the East Walker River run through Bridgeport Valley and are mapped as Riparian and Coyote Willow. Along with multiple irrigation ditches, these tributaries distribute surface water widely throughout Bridgeport Valley.

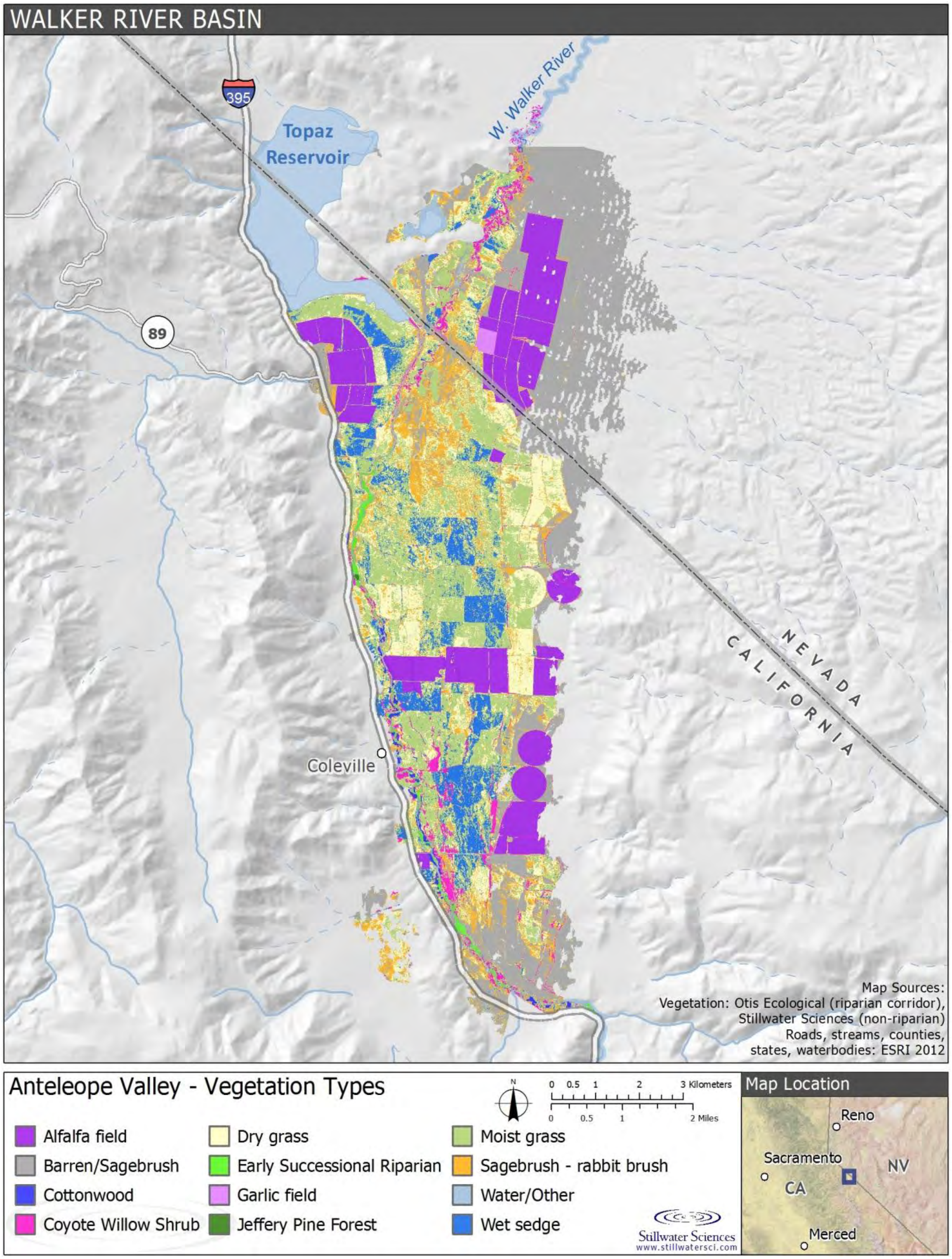

Figure 2-6. Vegetation map for Antelope Valley.

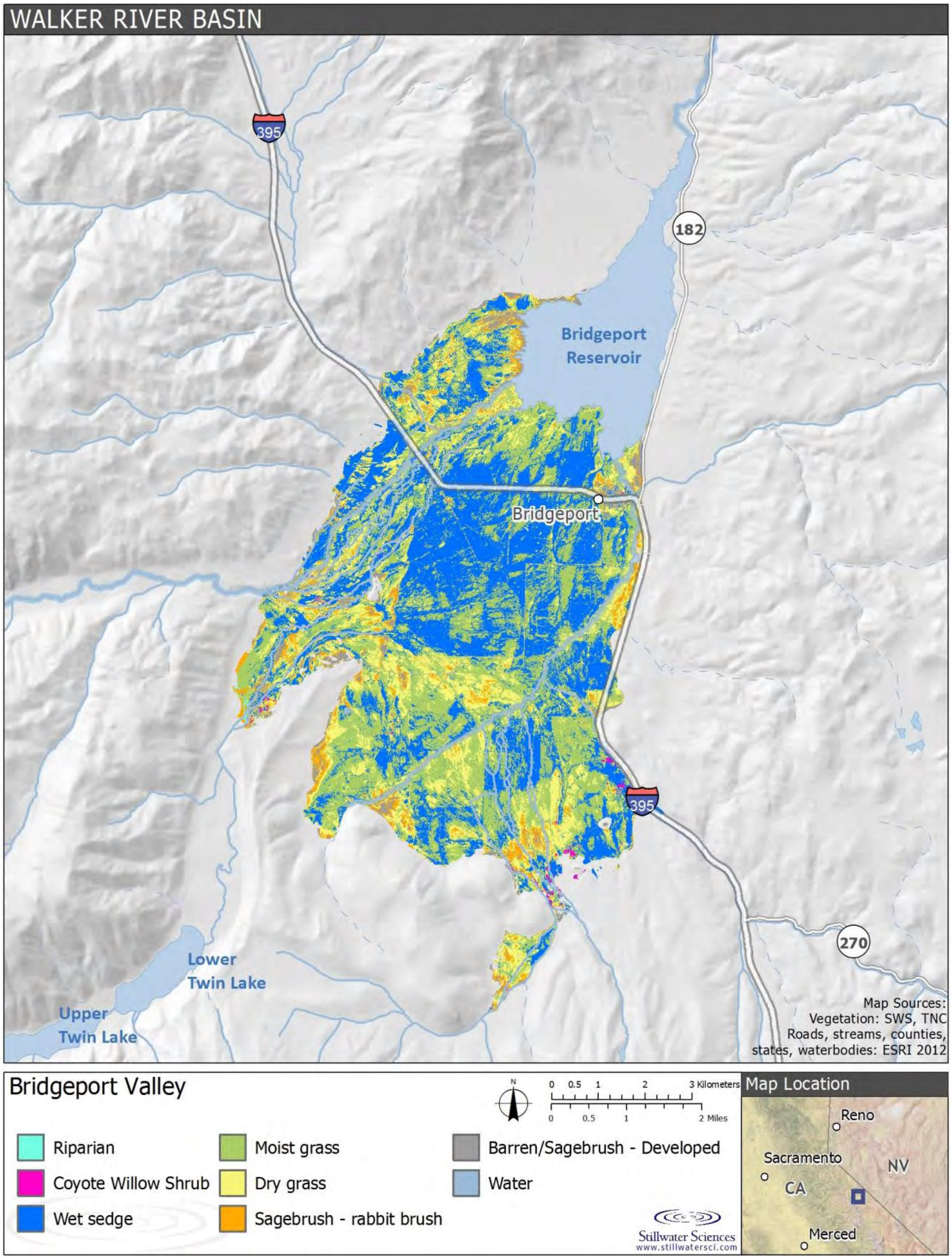

Figure 2-7. Vegetation map for Bridgeport Valley.

2.2.7 Existing sensitive plant species and plant communities

The special-status plant species and natural communities whose geographic distributions overlap with the Study Area were identified by reviewing and querying the following resources:

- The CDFW‘s California Natural Diversity Database (CNDDB; CDFG 2013), and
- The California Native Plant Society‘s (CNPS) online Inventory of Rare and Endangered Vascular Plants of California (CNPS 2012).

Altogether, 54 special-status plant species were found to potentially occur within the Study Area (Appendix Table A-1). Of these, six are considered seriously rare or threatened in California (list 1B.1 or 2B.1), five of which could occur in Moist Grass vegetation types, four in Wet Sedge, and three could occur in the Dry Grass-Sagebrush vegetation type matrix (Table 2-6 below). Sixteen species are considered moderately rare or threatened in California (list 1B.2 or 2B.2), fourteen of which could occur in the Dry Grass-Sagebrush vegetation type matrix, three in the Wet Sedge and Moist Grass, and three species could occur in all three graminoid vegetation types. Actual presence of these plant species within the Study Area is unknown; therefore only the potential to occur and be impacted by altered irrigation regimes can be assessed.

In addition, vegetation types mapped as Mature Cottonwoods with Riparian Shrub Understory and Riparian Cottonwood with Xeric Understory for Antelope Valley are both dominated by Fremont cottonwood, and fall under the *Populus fremontii* (Fremont cottonwood forest) Alliance which is on the CDFW Natural Communities list (http://www.dfg.ca.gov/biogeodata/vegcamp/natural_comm_background.asp). Natural communities of special concern are defined as those natural community types with a state ranking of S1 (critically imperiled), S2 (imperiled), or S3 (vulnerable). This alliance is ranked G4-S3, which translates to not imperiled at the global scale (G5 is _secure‘), but considered _vulnerable‘ at the state level (—a moderate risk of extinction or elimination due to a restricted range, relatively few populations, recent and widespread declines, or other factors” (NatureServe 2008, Evans 2011). This vegetation alliance is mapped on 75.4 acres within Antelope Valley (area under 5% slope) and 17 of those acres fall within the HRUs (Table 2-5). Different riparian vegetation types were not distinguished along the Bridgeport riparian corridors in existing information and are not mapped for this study. However, riparian corridors along the tributaries to the East Walker might have the potential to support cottonwoods; these areas are mapped on approximately 71 acres in the under 5% slope area of Bridgeport Valley (Table 2-5).

Table 2-6. Vascular and non-vascular plant species with California Rare Plant Rank (CRPR) rare and threatened status that could occur in the Study Area, and their associated mapped habitats. Species with the potential to occur in Wet Sedge, Moist Grass, or Dry Grass vegetation types are marked with a “✓“.

Scientific name	Common name	Status[1]: Federal/State/ CRPR	Likelihood of occurrence in assessment area	Wet sedge	Moist grass	Dry grass/RB-sage
Atriplex pusilla	smooth saltbush	–/–/2B.1	Potential habitat in sage and rabbit brush fields and in wet meadows, ponds	✓	✓	✓
Kobresia myosuroides	seep kobresia	–/–/2B.2	Potential habitat in upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓

Scientific name	Common name	Status[1]: Federal/State/ CRPR	Likelihood of occurrence in assessment area	Wet sedge	Moist grass	Dry grass/RB-sage
Mertensia oblongifolia var. *oblongifolia*	sagebrush bluebells	–/–/2B.2	Potential habitat in sage and rabbit brush fields, upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓
Polyctenium williamsiae	Williams' combleaf	–/–/1B.2	Potential habitat in sage, rabbit brush fields and in wet meadows, ponds	✓	✓	✓
Thelypodium integrifolium subsp. *complanatum*	foxtail thelypodium	–/–/2B.2	Potential habitat in sage and rabbit brush fields and in wet meadows, ponds	✓	✓	✓
Calochortus excavatus	Inyo County star-tulip	–/–/1B.1	Potential habitat in wet meadows	✓	✓	
Mimulus glabratus subsp. *utahensis*	Utah monkeyflower	–/–/2B.1	Potential habitat in wet meadows, ponds	✓	✓	
Ranunculus hydrocharoides	frog's-bit buttercup	–/–/2B.1	Potential habitat in wet meadows, ponds	✓	✓	
Sphaeromeria potentilloides var. *nitrophila*	alkali tansy-sage	–/–/2B.2	Potential habitat in wet meadows, ponds	✓	✓	
Sphenopholis obtusata	prairie wedge grass	–/–/2B.2	Potential habitat in wet meadows, ponds	✓	✓	
Botrychium paradoxum	paradox moonwort	–/–/2B.1	Potential habitat in wet meadows		✓	
Astragalus johannis-howellii	Long Valley milk-vetch	–/CR/1B.2	Potential habitat in sage and rabbit brush fields			✓
Astragalus monoensis	Mono milk-vetch	–/CR/1B.2	Potential habitat in sage and rabbit brush fields and upper valley dry meadows, forest edge			✓
Chaetadelpha wheeleri	Wheeler's dune-broom	–/–/2B.2	Potential habitat in sage and rabbit brush fields			✓
Cusickiella quadricostata	Bodie Hills cusickiella	–/–/1B.2	Potential habitat in sage and rabbit brush fields			✓
Lupinus duranii	Mono Lake lupine	–/–/1B.2	Potential habitat in sage and rabbit brush fields and upper valley dry meadows, forest edge			✓
Mentzelia torreyi	Torrey's blazing star	–/–/2B.2	Potential habitat in sage and rabbit brush fields			✓

Scientific name	Common name	Status[1]: Federal/State/ CRPR	Likelihood of occurrence in assessment area	Wet sedge	Moist grass	Dry grass/RB-sage
Phacelia monoensis	Mono County phacelia	–/–/1B.1	Potential habitat in sage and rabbit brush fields			✓
Polygala subspinosa	spiny milkwort	–/–/2B.2	Potential habitat in sage and rabbit brush fields. Documented within the assessment area.			✓
Tetradymia tetrameres	dune horsebrush	–/–/2B.2	Potential habitat in sage and rabbit brush fields			✓
Thelypodium milleflorum	many-flowered thelypodium	–/–/2B.2	Potential habitat in sage and rabbit brush fields			✓
Viola purpurea subsp. *aurea*	golden violet	–/–/2B.2	Potential habitat in sage and rabbit brush fields			✓

[1] **CRPR Status:**

– = None

Federal

FE = Endangered under the ESA
FT = Threatened under the ESA

State

CE = Endangered under the CESA
CR = Rare under the CNPPA

CRPR

1A = Plants presumed extirpated in California and either are or extinct elsewhere
1B = Plants rare, threatened, or endangered in California and elsewhere
2B = Plants rare, threatened, or endangered in California, but more common elsewhere
3 = Plants for which more information is need –a review list
4 = Plants of limited distribution – a watch list
0.1 = Seriously threatened in California
0.2 = Moderately threatened in California
0.3 = Not very threatened in California

2.3 Plant Water Sources

Water is made available to vegetation through surface inputs, such as direct precipitation, stream flood waters, or surface/aerial irrigation, and through subsurface water or groundwater accessed in the rooting zone. The depth of the rooting zone varies by plant species and soil site conditions, but rooting density and water uptake is greatest within the top meter of soil (Brady 1984). Direct precipitation in Antelope and Bridgeport valleys is very low, particularly during the growing season (May through August) when it averages less than 3 inches (Western Regional Climate Center at http://www.wrcc.dri.edu, as cited in MCCDD 2007 and Kattelmann 2012). Therefore, water available to irrigated and unirrigated lands outside of the riparian corridor comes from multiple sources during the growing season (generally mid-May through September):

- irrigation (flood and pivot),
- seepage from irrigation canals,
- irrigation return flow (which goes to sub-irrigation),
- near-surface groundwater (sub-irrigation),
- precipitation (very little in most years), and
- groundwater pumping (active wells in Antelope Valley; none in Bridgeport).

Seepage from irrigation canals and irrigation return flows is derived from irrigation diversions, and all three contribute to near-surface groundwater. Therefore, irrigation inputs likely affect depth (plant access) to near-surface groundwater in much of the Valley, which according to estimates described in Task 1 Report, could comprise from 14 to 33% of ET in Antelope Valley (Ecosystem Economics 2014). Water that is not diverted will presumably flow out of the valley, with relatively small amounts being lost to adjacent lands (it is unclear if and where losing reaches might exist).

Alterations in irrigation diversions will have several effects on water availability outside the riparian corridor. First, during periods when diversions are suspended, water in the irrigation canals themselves and adjacent soils will be greatly diminished, reducing water availability to plants directly adjacent to the canals during that time period. Second, lands usually irrigated during that time period will receive less water, and will depend on subsurface water alone rather than irrigation and subsurface water sources. Third, if diversions are altered for a full season or more, subsurface water inputs will be diminished in areas outside of the riparian corridor while vegetation draws on subsurface water will increase (due to reduced surface/irrigation water inputs) and could result in overall increase in the depth to the subsurface water. The rate, duration and drop in subsurface water levels will vary depending upon location in the valleys.

2.3.1 Potential groundwater response

The potential decline in subsurface water levels with reduced irrigation inputs could importantly affect vegetation response to water transaction scenarios assessed in this report. Therefore, we drew on available information to determine the potential degree of change in groundwater levels (sub-irrigation) with one to multiple-year transactions over a portion or all of Antelope Valley. Groundwater responses were only assessed for Antelope Valley because although groundwater information for Antelope Valley was scarce, it was non-existent for Bridgeport Valley. This assessment is general due to lack of available information on ground water processes in these valleys, and is therefore only meant to provide initial bounds on what is and is not likely to occur in Antelope Valley. To make this same, or a more refined, assessment for Bridgeport Valley, a more involved study with groundwater measurements would be required.

Information on depth to groundwater is available through a small network of groundwater wells in Antelope Valley (USGS http://waterdata.usgs.gov/nwis/gw). The Desert Research Institute (DRI) used depth values from these wells, along with a digital elevation model, to develop a generalized map of depths to groundwater for Antelope Valley under existing conditions. This work shows that depth to groundwater is generally greatest at the southern, more upstream end of the valley and least in the northern end, where the West Walker River flows out of the valleys.

In Antelope Valley, depths to groundwater are only recorded in the fall and early spring for most wells, and thus are not informative regarding changes in depth to groundwater over the growing season. One well, located on the western shoulder of Antelope Valley, has been monitored monthly from fall 2009 through the present. The area above this well is not irrigated, so variations reflect background, unirrigated conditions in which groundwater levels remain higher for a longer part of the season during wet years (2011) but drop off rapidly during dry water years (2012 – 2013) (Figure 2-8).

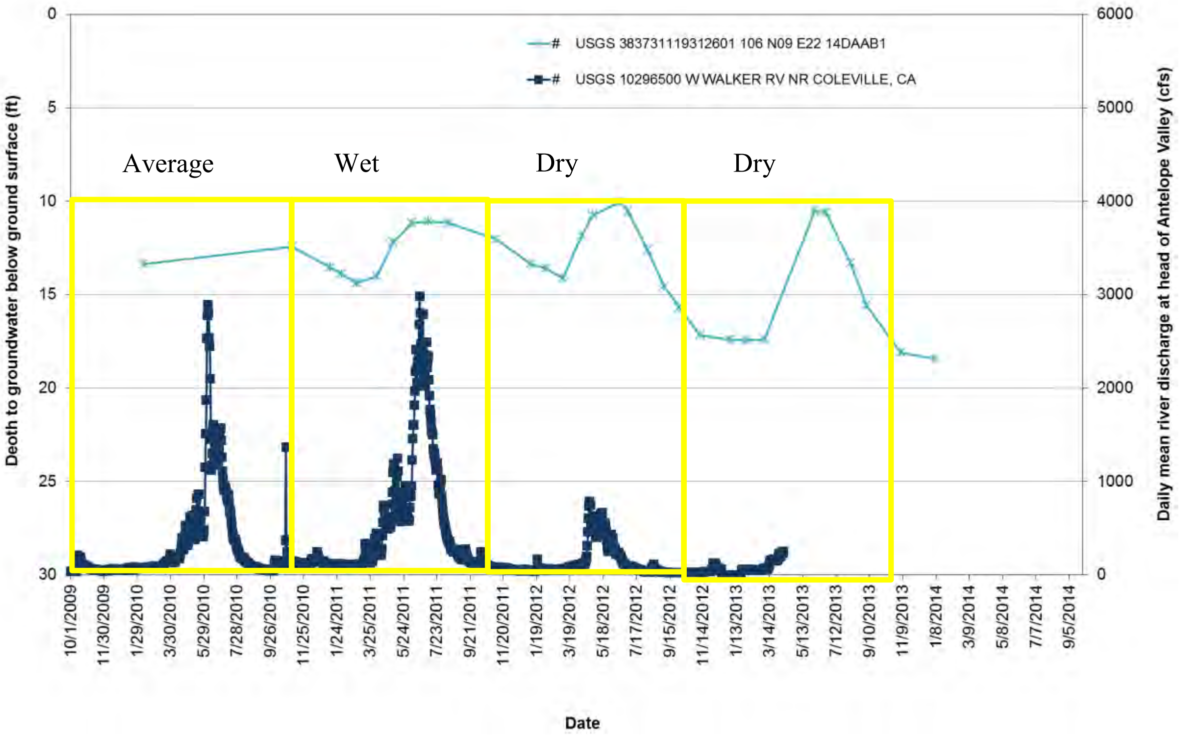

Figure 2-8. Stream flow (black line, cfs) from the Coleville stream gage and groundwater levels (blue line, ft below surface) measured at a well along the valley shoulder, south of the Slinkard Creek alluvial fan.

We used a whole valley water balance approach to assess the degree to which changes in depth to groundwater could occur with changes in irrigation diversions and stream flow. The area of interest for changes in depth to groundwater was defined as the area with low topographic relief (the flattest areas in the valley), using 5% slope as a somewhat arbitrary cut off. The assumption is that vegetation on lands with slopes of 5% or more are least affected by subsurface irrigation. The <5% slope area of Antelope Valley covers 24,722 acres (Figure 2-3).

A water balance equation includes water inputs, outputs, and changes in storage. For each of these variables, we acquired the best available information for Antelope Valley during water years 1985-2010. We limited these estimates to annual values because a monthly or finer time-scale water balance would require more site-specific and time-scale specific information than was available. Thus, whole-valley estimates of potential changes in depth to groundwater per year could be made based on reliable and well-documented sources, as listed below (Table 2-7). As an illustration of our methods, we have also included input and calculated values for the 2001 water year (an average water year). The final value is a rough estimate of average potential change in depth to groundwater for the entire <5% slope area of Antelope Valley and should not be interpreted as an estimate of change in depth to groundwater for any specific location.

Table 2-7. Information types, sources, and example values used to develop a valley-wide water balance for Antelope Valley of the West Walker River. The example year, 2001, is an 'average' water year.

Information Type	Information source	Example values for year 2001 (all in Acre-Feet)
Water Inputs		
Annual precipitation	PRISM data (http://www.prism.oregonstate.edu/)	14,894
Stream inflows less estimated total diversions	sum of mean daily flows for Oct 1 through Sept 30 as recorded at USGS gage # 10296500 West Walker River near Coleville, CA	84,571 (total =133,964)
Estimated total irrigation	Task 1 Report (Ecosystem Economics 2014)	49,393
Subsurface recharge	Carroll and Pohl 2013	11,724.00
Total Inputs		***160,582***
Water Outputs		
Evapotranspiration	DRI 2014 METRIC model (Minor 2009)	44,097
Stream outflow	Sum of mean daily flows for Oct 1 through Sept 30 at USGS gage # 10297500, located on West Walker below confluence with Topaz Canal	96,024
Evaporation (off Topaz)	Lopes and Allander 2009 p. 26.	8000
Total Outputs		***148,121***
Water Storage		
Change in Storage	Inputs – Outputs	12,461
Change in storage at Topaz Reservoir	Annual change in A-F storage as reported from USGS gage 10297000	(3,750)
Change in storage in Valley Groundwater	Total Change in Storage – Change in Storage at Topaz	16,211
Change in depth to groundwater, average for lands <5% slope	Change in GW storage/Total acres, e.g., for 2001: 16,211 acre-feet/24,722 acres	0.66 feet

* Annual values based on water year type, using values developed based on reflectance data for 2005, 2010, and 2002 as wet, average, and dry years, respectively.

Resulting estimates of valley-average changes in the subsurface groundwater level in Antelope Valley are presented in Figure 2-9. These calculations, based on water years 1985-2010, suggest that annual changes in depth to groundwater most frequently range between +2.5 to -1.5 feet, and average +/- 0.5 feet (Figure 2-9). These findings are similar to the more detailed assessment of contributions to ET by groundwater described in the Task 1 Report (Section 7.2), in which groundwater storage contributions to crop demand, growth, and ET are estimated to range from 1.08 AF/acre in a dry year to 0.53 AF/acre in a wet year. These numbers from the Task 1 Report only refer to changes in water balance during the growing season, as compared to the slightly larger range of values (+2.5 to -1.5 feet groundwater) presented above for the entire year, suggesting an average off-season recharge of approximately 1 foot/ yr. Based on these calculations, multiple consecutive years of increased reliance on near subsurface groundwater to meet crop water demands could reduce groundwater levels at a rate of 0.5 to 1 foot per year, on average, across Antelope Valley.

Change in depth to groundwater is expected to vary within the valley. Antelope Valley is tilted to the north- northwest, with the lowest point occurring where the West Walker River exits the valley east of Topaz Reservoir. Because of this, depth to groundwater is greater to the south-southeast and smaller to the north-northwest in Antelope Valley. Bridgeport Valley has a similar tilt orientation. Thus, groundwater levels in areas to the north-northwest of both valleys would be expected to drop more slowly if at all, compared to areas to the south-southeast.

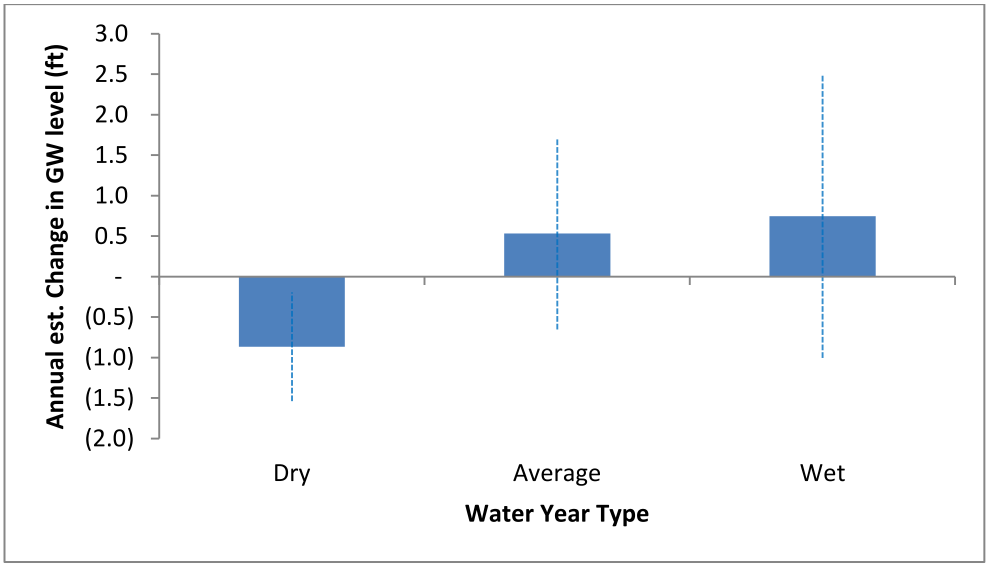

Figure 2-9. Estimated changes in depth to groundwater for Antelope Valley for wet, average and dry water year types occurring between 1985 and 2010 (feet, average and standard deviation)

3 VEGETATION—WATER LINKAGES

Overall, plant water availability is expected to vary within Antelope and Bridgeport Valleys based upon:

- Water-year type and associated groundwater consumption (wet, average, dry)
- Down vs. up-valley location (north vs. south valley tilt)
- Soil texture and water holding capacity (coarse and sands vs. loams vs. clays)
- Surface slope (>3% vs. <3%)

These four important controls on plant water availability were combined to direct focus on areas most likely vs. those least likely to experience drought effects under a reduced irrigation scenario. As described below, we combined spatially explicit information on soil water-holding capacity and drainage (surface slope) with plant species vulnerability to water stress in order to roll up, by HRU and vegetation type, potential effects of reduced irrigation. This information is then used to inform the water transaction effects on vegetation and wildlife habitat discussions in Section 6. Wildlife: Potential Effects of Water Transactions. Differences in water year type and down vs. up-valley location of the HRU are integrated into the assessment of each water transaction scenario.

3.1 Water Relations by Vegetation Type

Plant species vary in their ability to tolerate water stress. Differential species responses to water availability can result in changes in species competitive advantage over other species, shifts in dominant species cover, and over multiple seasons, changes in vegetation type (Corbin et al. 2012; Loheide and Gorelick 2007).

Graminoids, including annuals and perennials, respond to reductions in early spring (March – April) water availability by reduced above ground growth, with annuals being more affected during this time period than perennials (Harpole et al. 2012). Perennial grasses, such as *Elymus triticoides* and *Festuca idahoensis* and *F. californica*, have deeper rooting systems and can continue to grow through the summer, producing more above ground biomass with more summer water. Annuals on the other hand, go dormant by midsummer and therefore do not respond to increased water availability in mid to late summer. Very few annuals were observed during the late August 2013 field surveys, so increased productivity in the perennial dominated herbaceous layer with water during the early and mid to late summer is expected.

Native non-riparian shrubs, including *Artemisia tridentata*, *Purshia tridentata*, and *Ericameria nauseosa* are not strongly affected by limited periods of spring or summer drought (Evans et al. 2012; Harpole et al. 2012; Reever-Morghan et al. 2012).

Using information on characteristic and dominant species in each vegetation type, from both the summer 2013 survey observations and the USDA Plants database, we ranked each vegetation type by vulnerability to reduced water availability. Distributions of the key species observed during the August 2013 field visit are strongly correlated with CCA axis 1, which is most linked to observed surface soil moisture (Figure 3-1). Baltic rush, which occurs in all three graminoid vegetation types with fairly high cover and frequency, is located near the center of this graph, reflecting the species‘ wide distribution under a range of hydrologic conditions.

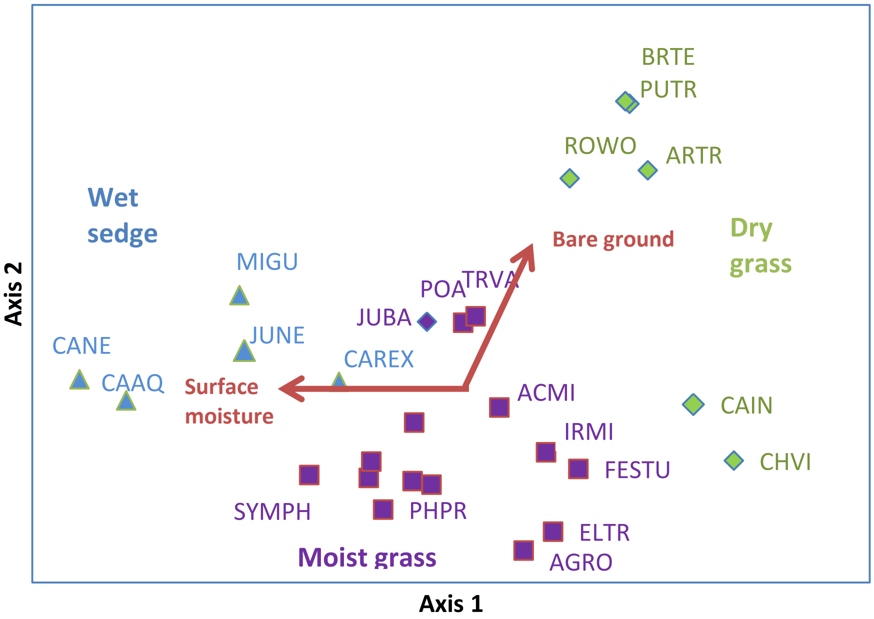

Figure 3-1. Most frequent plant species occurring with high cover in Antelope and Bridgeport valleys in August 2013 distributed along Canonical axes 1 and 2 as described in Section 2.2 Vegetation. Species codes by first two letters of genus and species epithet[3].

We also queried the USDA Plants Database for information on species-specific tolerances to drought and saturated soils (anaerobic conditions), as well as water use (Figure 3-2a-c and Table A-2 in Appendix A). As summarized in Figure 3-2a, the drought tolerant species are most common in the Dry Grass vegetation type and drought intolerant species are found in the Wet Sedge vegetation type. The majority of key species in the Moist Grass vegetation type are drought intolerant; however some are drought tolerant.

Based on this information, we assume that decreased growing season water availability to the point of ‗drought' would have the least effect on the Dry Grass vegetation type, and the greatest effect on the Wet Sedge vegetation type. The Riparian vegetation type would have a medium response to drought, e.g., growth might be reduced with some canopy die-back but most riparian species could withstand limited periods of drought conditions. The Moist Grass vegetation type is expected to have reduced growth and survival with some of the more drought tolerant species possibly increasing in cover with prolonged drought conditions.

Water use is reported as ‗high' for all the species representative of the Wet Sedge and Riparian vegetation types and for most of those in the Moist Grass vegetation types (Figure 3-2b). Thus,

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[3] Dry Grass species: ARTR = *Artemisia tridentata,* BRTE = *Bromus tectorum*, CAIN = *Carex incurva*, CHVI= *Chrysothamnus viscida*, PUTR = *Purshia tridentata*, ROWO = *Rosa woodsii;* Moist Grass Species: ACMI = *Achillea millefolium*, AGRO = *Agrostis spp*., ELTR = *Elymus triticoides*, FESTU = *Festuca spp*., IRME = *Iris missouriensis*, JUBA = *Juncus balticus*, PHPR = *Phleum pratense*, POA = *Poa spp*., SYMPH = *Symphyotrichum*, TRVA = *Trifolium variegatum*; and Wet Sedge Species: CAAQ = *Carex aquatalis*, CANE = *Carex nebrascensis*, CAREX = *Carex spp*., JUNE = *Juncus nevadensis*, MIGU = *Mimulus guttatus*.

reducing water availability to these types could reduce overall productivity. Water use is reported as low to moderate for the species common to the Dry Grass vegetation type; therefore productivity in these areas is not expected to be as affected by reduced water availability.

Although not shown here, we also queried the USDA plants database for the tolerance of key plant species to anaerobic conditions experienced with prolonged flooding (Appendix Table A-2). In the scenarios with increased river flows during the growing season, plants along the riparian corridor will be subjected to longer periods of flooding and high groundwater levels. Therefore, plants that are intolerant of such conditions but have moved into the riparian corridor over the past 100 years during which irrigation withdrawals have lowered summer stream flows, could be impacted. Similarly, water-loving species in these areas will gain some competitive advantage under wetter conditions. The primary riparian species, such as Fremont cottonwood and various willow specie are all tolerant of anaerobic conditions. Several of the understory species in the Mature cottonwood with xeric understory vegetation type are intolerant, including big sagebrush, rabbitbrush, and fourwing saltbush (*Atriplex canescens*). Thus, increased duration of flooding during the growing season could force a change in understory species composition for this riparian vegetation type. Other riparian vegetation types could experience increased growth and density of moisture loving species such as willow, sedge, and tules.

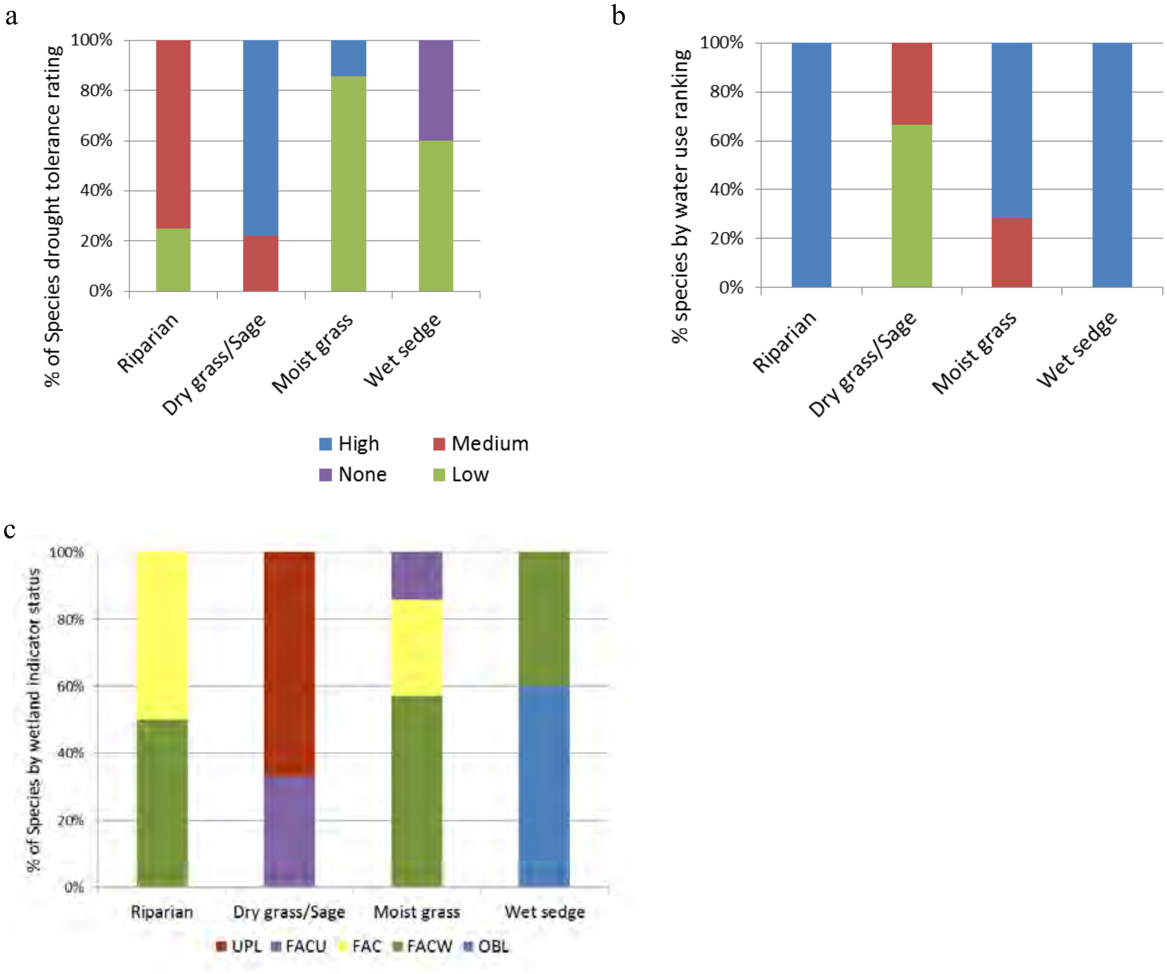

Figure 3-2. Drought (a) and water use (b) ratings, and wetland indicator status (c) for key plant species in vegetation types of Bridgeport and Antelope Valleys.

Based on the information presented in the above figures and detailed in Appendix Table A-2, we ranked the expected vulnerability of each vegetation type to reduced growing season water availability. These vulnerability rankings to drought are listed in Table 3-1.

Table 3-1. Vulnerability rankings by vegetation type, where 0 is not vulnerable, 1 is least, and 3 is most vulnerable to drought.

Vegetation type	Vulnerability
Barren	0
Coyote Willow	2
Dry Grass	1
Early Successional Riparian	1
Mature Cottonwood with Riparian Shrub Understory	2
Mature Cottonwood with Xeric Understory	2
Moist Grass	3
Sagebrush	1
Water-Asphalt-Rock	0
Wet Sedge	3

3.2 Water Stress and Vulnerability in the Study Area

Persistent reductions in groundwater inputs could affect water availability to the rooting zone and result in vegetation composition shifts that favor more drought-resistant species. We used available basin-wide information in order to assess the likelihood of changes in groundwater level with one to multiple years of suspended irrigation that are sufficient to impact plant species health and survival. We based this assessment on relative differences in the spatial distribution of depth to groundwater, soil water holding capacity, and plant vulnerability to drought.

As described in the Carroll and Pohll 2013 report, both Antelope and Bridgeport Valley groundwater basins tilt to the north, with groundwater draining from south to north. As illustrated in Figure 3-3a below, increases in depth to groundwater will be greater towards the upstream (left in the illustration) end of the basins. As suggested in the monthly variations in depth to groundwater depicted from the well on the western shoulder of Antelope Valley (Figure 2-8), groundwater levels under natural recharge could drop most rapidly in dry years after July 1.

Soil water holding capacity is greatest for fine textured soils and for soils with high amounts of organic matter; however water is held more tightly in heavy clay soils, so is less available for plant uptake than in coarser textured soils (Brady 1984). Loams and organic soils have the greatest capacity for holding onto plant available water. Surface slope also increases the rate at which surface and subsurface water drains from a specific location. Therefore, information on the distribution of soil texture classes (coarse sandy soils, loams, and fine silts and clays) were overlaid with information on surface slope (<3%, and 3-5%) within each Hydrologic Response Unit to identify areas that are expected to experience more vs. less water stress in response to changes in water input. Based on this information, low-lying lands within Antelope and Bridgeport valleys were assigned different rankings for potential water stress (high, moderate, low, none).

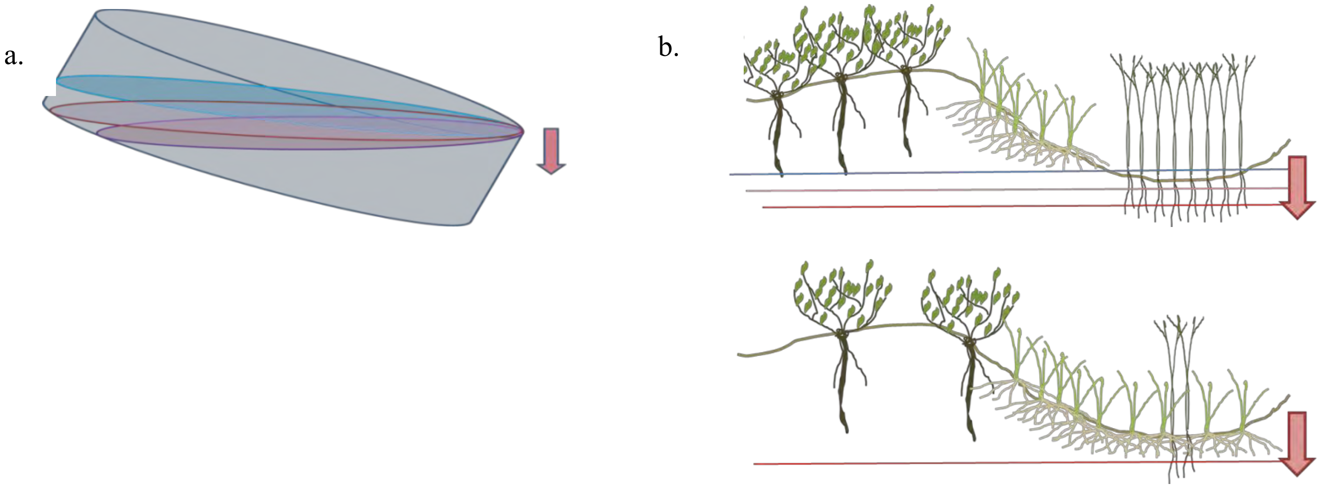

Figure 3-3. Diagram of a simplified tilted groundwater basin with water moving from left to right, (a) showing how groundwater lowering levels will be greater towards the upstream end of the basin (left in the illustration); and (b) diagram showing how persistent reductions in groundwater inputs could affect water availability to the rooting zone and result in shifts towards drier plant species composition.

Soils with coarser texture and on lands with higher slopes are expected to drain more rapidly than those with finer texture soil on flatter lands (Figure 3-3b). Based on this logic, we divided Antelope and Bridgeport valleys into areas based on the surface slope, and soil texture class using SURGGO soil data and a 30m digital elevation model (DEM). We overlaid soil texture and slope information to identify spatially explicit assessment of water stress (Table 3-2). We multiplied the vegetation vulnerability and location stress rankings per polygon (e.g., stress rank of 3 times vulnerability rank of 1 = effects rank of 3) to create an overall ranking of expected effects of drought on vegetation (Table 3-3). More specific impacts of reduced water availability per vegetation type are described with the scenarios in Section 4. Vegetation: Potential Effects of Water Transactions. We summarized this information for each HRU in order to identify HRUs with low to high expected effects on vegetation associated with altered irrigation schedules. The results from this spatial query are presented by HRU under Section 4.2 Scenario 1b. No Irrigation for Full Season: Part of Antelope Valley.

Table 3-2. Stress rankings by soil texture and slope, where 1 is least and 3 is most.

Slope/Soil	Sand	Loam	Clay-Fine	Unknown
<3 %	3	1	2	2
3-5 %	3	2	3	2

Table 3-3. Description of Effects Ranking for vegetation types associated with reduced water availability during the growing season based on species vulnerability and water stress related to soil water holding capacity and slope.

Rank name	Rank description
None	No effect on health or growth expected
Low	Little-to-no effect on vegetation expected
Minor	Some decrease in productivity expected
Moderate	Reduced productivity and possible changes in plant species distribution favoring drought tolerant over intolerant plants
Moderate-High	Pronounced reduction in productivity and percent cover shifts towards drought tolerant plant species
High	Large reductions in productivity and possible change in vegetation type over multiple seasons

4 VEGETATION: POTENTIAL EFFECTS OF WATER TRANSACTIONS

In the sections below, we assess the potential impacts of Transaction Scenarios 1-5 (described in section 1.1.1 Water transfer scenarios considered) on natural vegetation and special-status plant species, forage, and crop production.

4.1 Scenario 1a. No Irrigation for Full Season: Whole Valley

Under Scenario 1a, all of the currently irrigated areas are kept out of irrigation for one and possibly multiple growing seasons.

4.1.1 Effects on forage and alfalfa production

Effects on vegetation production are particularly important for pasture lands, planted alfalfa and garlic. In order to estimate likely effects of altering irrigation regimes on forage and crop production in Antelope and Bridgeport valleys, we gathered available published information on forage production rates for dry and moist grass vegetation types and for wet-sedge dominated plant communities under different hydrologic regimes. Similarly, we gathered information on dryland alfalfa cultivars and management to estimate changes in production. These are described in more detail below.

4.1.1.1 Alfalfa production

The impact of total non-irrigation on alfalfa in the Study Area depends on the specific cultivar grown. To our understanding, the current cultivars are not selected specifically to thrive under drought conditions. The current stands of alfalfa would not be expected to continue producing at economically viable levels.

If there was sufficient soil water available from late fall irrigation, winter moisture, and spring rains then the stand may regrow for a light first cutting. While we do not have soil moisture records for the area, anecdotal descriptions from landowners suggest that the soil profile is not normally saturated at the start of the growing season, and early irrigation is needed to ―fill” the soil. As such, we would expect very limited production from the existing alfalfa stands under dryland management. Since dryland cultivars in similar climates generally produce just over 1 ton / acre per season, production from the existing stands likely would be substantially less than that in the absence of irrigation (a rough estimate might be 0.5–0.75 tons/acre). There also may be the issue of weed encroachment within the stands during that first year, which could limit the value of hay produced. The existing stands would not be expected to regrow at a viable level during the second year of dryland management.

If landowners are interested in growing alfalfa hay under dryland conditions, it would be necessary to change to a cultivar developed specifically for dryland conditions. These cultivars go dormant when water-stressed, but then return to full yield potential for the next season. Dryland cultivars generally deliver only one cutting per season. Studies in comparable regions in Montana suggest that production rates of 1.00–1.60 tons may be expected, depending on the type of alfalfa, soils, and naturally available water (Cash and Wichman 2007). Dryland cultivar stands remain productive for 3-5 years.

Conclusions

Existing alfalfa stands would not maintain production at an economically viable level under dryland conditions, and conversion to alfalfa cultivars specific to dryland would be recommended. In this case, yields of 1–1.6 tons/ac/season would be expected.

4.1.1.2 Forage and grass-hay production

All of Bridgeport Valley is used as rangeland throughout the growing season and over half of Antelope Valley is rangeland. Therefore forage production is an important part of the local economy in both valleys. Forage is mapped as three graminoid dominated vegetation types in Antelope and Bridgeport valleys: Dry Grass, Moist Grass, and Wet Sedge. Important changes in forage production and quality could occur where reduced water availability results in effects that are rated as ‗high' or ‗moderately high' (see discussion in Section 3). Based on our mapping of Dry Grass, Moist Grass, and Wet Sedge vegetation types in Antelope and Bridgeport Valley, and our analysis of potential effects of reduced water availability on vegetation, approximately 10% and 36% of the forage lands in Antelope and Bridgeport valleys could be importantly affected; with prolonged suspended irrigation, these vegetation types could convert to the next driest graminoid vegetation type (Table 4-1).

Table 4-1. The extent of high, moderate and low negative effects of reduced water availability on forage lands in Antelope and Bridgeport valleys.

Vegetation type	Effect	Antelope Valley		Bridgeport Valley	
		Acres	Percent area	Acres	Percent area
Dry Grass	High	-	0	0	0
	Moderate	124	1	1,140	7
	Low or Minor	2,638	31	1,987	12
Moist Grass	High	658	8	3,099	19
	Moderate	3,689	43	3,880	24
	Low or Minor	0	0	0	0
Wet Sedge	High	145	2	2,803	17
	Moderate	1,369	16	3,483	21
	Low or Minor	0	0	0	0
Total		**8,622**	**100**	**16,391**	**100**

Suspended irrigation could have a high effect on Moist Grass and Wet Sedge areas in the areas with sandy soil in the central, west and southern parts of Bridgeport Valley (Figure 2-2); and along the southern and western edges of Antelope Valley (Figure 2-1). Many of the sandy soil areas in Antelope Valley are also on slightly steeper slopes, and in areas of the valley that drain to the north as the dry season progresses. Large areas with sandy soils in Bridgeport Valley occur in the central and lowest parts of the valley. In Bridgeport Valley, the observed high water table in many areas during the August 2013 visit and multiple channels running through the valley suggest that water availability could remain high throughout much of the central part of Bridgeport Valley. A study on groundwater depths and controls on groundwater fluctuations in the valley is needed since there is little-to-no information on this important half of the story on water availability in Bridgeport Valley. If the water table is minimally affected by lack of irrigation, then the extensive sandy soil areas in Bridgeport Valley will experience little impact to vegetation production rates. However, if lack of irrigation results in a seasonal drop in the groundwater table, vegetation could be impacted over large areas (Table 4-1). Changes are expected in areas along the south and western edges of Bridgeport Valley that have slopes over three percent. Differences in vegetation types were observed above and below irrigation ditches along sloped areas of the southeastern and western extents of Bridgeport Valley where sandy soils are prevalent.

Effects of reduced water availability could results in changes in the amount of forage produced per acre, as well as the quality of that forage. In the following paragraphs, we report on potential changes in forage quantity and quality with altered water availability.

The *quantity* of forage and grass-hay (from here on referred to simply as ‗forage') produced varies with dominant vegetation type. Figures for forage production rates for dry, moist and wet meadows in the Sierra Nevada, California emerge from a number of studies (see Appendix Table A-3 for details) and are presented in Figure 4-1.

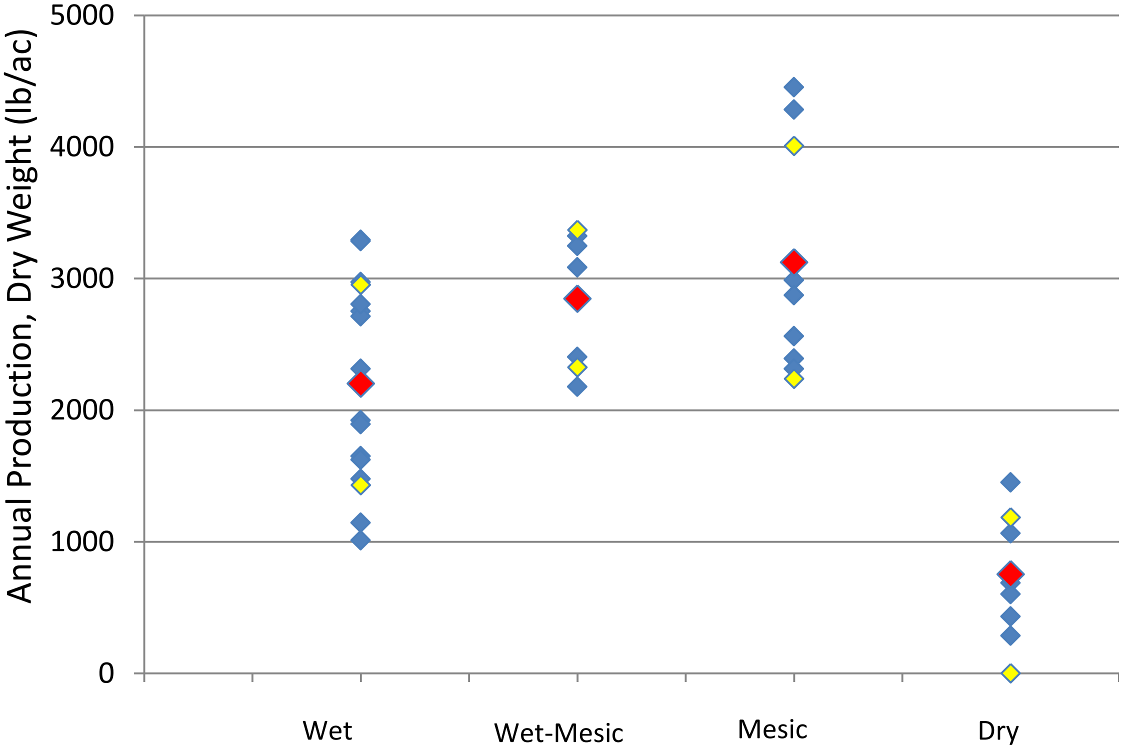

Figure 4-1. Annual Forage Production (dry weight, lb/ac) for wet, wet-mesic, mesic, and dry meadows in the Sierra Nevada, California (see Appendix Table A-3 for data list and sources). Average and standard deviations are shown in red and yellow.

The data from these studies suggest that vegetation in the Dry Grass type produce about one-quarter the biomass as vegetation in the Moist Grass vegetation type (750 vs. 3,000 lb/ac), and that vegetation in the Moist Grass type produce about one and third more forage than vegetation in the Wet Sedge vegetation type (2,200 vs. 3,000 lb/ac). There is large variability within these data, so it should be interpreted broadly. More precise estimates on altered production rates in Antelope and Bridgeport valleys could be based on local measurements made under irrigated and non-irrigated conditions. This analysis indicates that multiple years of reduced water availability could increase production where Wet Sedge converts to Moist Grass but decrease production where Moist Grass converts to Dry Grass.

Forage *quality* is another factor that can influence the on-site changes in livestock productivity that occurs with changes in meadow vegetation. A six-year study on forage changes associated with halting irrigation on large meadows in the Klamath Region (Wood River drainage in Oregon) is informative for the Walker Basin since these areas had also been irrigated using flood irrigation and natural sub-irrigation since the mid to late 19th Century (ORNCS 2010). Important and relevant findings for the Walker Basin are from intensive vegetation monitoring at six irrigated and six non-irrigated sites over a six year period (through year seven after halting irrigation in the non-irrigated sites) and indicate that, compared to the irrigated sites, the non-irrigated sites had:

- Lower overall forage production by approximately 20% (lb/acre), with greatest differences appearing in July through October
- Higher ratio of facultative vs. wetland obligate and wet-facultative vegetation
- Lower cover of Nebraska sedge and clover
- Higher grass cover (including timothy [*Phleum spp*.], Kentucky bluegrass [*Poa pratensis*], tufted hair grass [*Deschampsia cespitosa*], and one-spike oatgrass [*Danthonia unispicata*])
- Higher cover of Baltic rush
- Slightly higher percent cover of bare ground (from about 0 to 2 or 3% cover)

In the Walker Basin, Baltic rush and Missouri iris are prevalent in grazed areas and appear to increase in cover with grazing intensity. Although native, both of these plants are considered pest species in grazed lands because they tend to increase in cover once established but provide poor quality forage and are unpalatable to cattle. Baltic rush is grazed by cattle, but is not preferred and generally left for end of the season or bypassed altogether, thus leading to an increase in extent relative to preferred species (USDA JUBA 2014). Baltic rush is rhizomatous and tolerant of drought and flooding; it can therefore persist and even expand in cover while other species experience stress and mortality (USDA JUBA 2014). Missouri iris has a tuberous rhizome, which enables it to persist under brief periods of drought (it is ranked to have ‗low' tolerance to drought by the USDA) and to expand the population extent rapidly. Leaves of this plant are bitter and passed over by cattle, giving it a competitive advantage over other more palatable plant species (USDA IRMI 2014). The limited tolerance to drought and high water requirements of Missouri iris and Baltic rush suggests that these species would only persist and possibly expand in areas with wet to moist soil conditions but not in areas that become dry to very dry during the growing season. However, increased grazing pressure that comes with drought stress could increase the relative cover of these species.

The Wood River project also included a study on changes in forage nutritional quality with cessation of irrigation in grazing lands (ORNCS 2010). Using the same set of irrigated and non-irrigated pastures, the authors measured forage quality based on crude protein content (7% or greater is considered good) and content of digestible organic matter or DOM vs. crude protein (ratio of 4 to 8 is good, with 4 being optimal). Over six years of measurements indicate that compared to non-irrigated sites, forage from irrigated lands had higher crude protein in mid to late season, and the DOM: CP ratio was closer to the optimum from June through October (ORNCS 2010).

Results of work on meadows in the Sierra by Tate et al. (2011) take this analysis a step farther by estimating changes in cattle weight with altered forage quality. Tate et al. (2011) estimated decreased weight gain in cattle due to decreased meadow forage quality that occurred with a transition from wet to moist to dry meadow plant community types. The authors divided the season into early, mid and late seasons as 45-day increments from June through September. The authors then used existing literature and professional judgment to estimate changes in forage quality parameters during each season and applied these data to the Oklahoma State University‘s Cowculator (http://139.78.104.1/exten/cowculator/; accessed on 28 November 2011) to arrive at potential weight gain for ―stocker" cattle, with unrestricted grazing over a 45 day period (see Table 4-2). It is important to note that these numbers do not include changes in forage production rates, just quality. Thus, conversion from Moist Grass to Dry Grass type could lead to not only a 75% reduction in forage production rates, but also a 25% reduction in weight gain per ton of forage produced.

Table 4-2. Cattle weight gain by meadow condition (from Tate et al. 2011).

Meadow type	**Weight gain (lbs/day)**			**Average**
Seasons	**Early**	**Mid**	**Late**	
Dry	1.74	1.27	0.92	1.31
Moist	1.86	1.71	1.58	1.72
Wet	1.84	1.68	1.27	1.60

Conclusions

Suspended irrigation for one season, with ongoing grazing, is expected to favor pest weed species, including Baltic rush and Missouri iris. These species reduce forage quality and production and become increasingly difficult to remove or control as their populations increase. Seeding with preferred species, such as wild rye, alfalfa, or other grass species could counter these effects.

Overall, forage production is expected to decrease in both valleys. Assuming only the ‗high‘ ranked areas undergo type conversion (Table 4-1), approximately 650 acres of Moist Grass could convert to Dry Grass with associated large reduction in production rates. Assuming production rates are similar to the average rates reported for meadows for these vegetation types, this could translate into forage reduction of 730 tons of forage. Also, 145 acres of Wet Sedge could convert to Moist Grass with an associated 58 ton production increase, and netting an 87 ton decrease in overall forage production in Antelope Valley.

Effects on Bridgeport could be much greater if the natural ground water levels also drop (this important point cannot be adequately addressed with available information). Approximately 2,000 acres of Moist Grass could convert to lower productivity Dry Grass, resulting in roughly 2,250 ton drop in forage production, along with conversion of approximately 2,800 acres of Wet Sedge to Moist Grass and associated 1,120 ton increase in forage. The net result is roughly estimated to be 1,130 ton drop in forage production for Bridgeport Valley.

Estimates of effects on cattle weight gain include more uncertainty. Findings from Tate et al. 2011 indicate that early season grazing production would be minimally impacted but, as grazing continues into the late season, impacts to cattle weight grain increase dramatically. Changes in forage nutritional quality and associated effects on cattle weight gain per pound of forage produced would exacerbate the changes expected for each valley described above, but are likely within the range of uncertainty and so will not be converted to specific values here.

4.1.2 Effects on natural vegetation (including grazed lands)

4.1.2.1 Riparian corridor

The riparian corridor currently occupies a very limited area (185 acres in areas under 5% slope) in Antelope Valley and in Bridgeport Valley (~71 acres) due to the number of tributaries that flow through it. Returning the East and West Walker rivers to its natural hydrograph through suspension of all diversions would positively affect the riparian corridors in both valleys. River flows would be greater particularly during the spring snowmelt runoff period that extends roughly April through June, and during receding limb of the snowmelt runoff period in July and August, depending on the water year.

Increased in-stream early to late summer flows could impact the dry species-dominated understory of some of the cottonwood and red willow stands mapped along the West Walker River as Mature Cottonwood/ xeric understory (9.3 acres; Otis Bay 2009). Increasing the lateral extent and duration of spring flooding, and raising the subsurface water levels along the riparian corridor particularly in late July and August, will place stress on the xeric understory species intolerant of flooded, anaerobic conditions, such as sagebrush, rabbitbrush, bitterbrush, and the invasive weed, cheatgrass (*Bromus tectorum*).

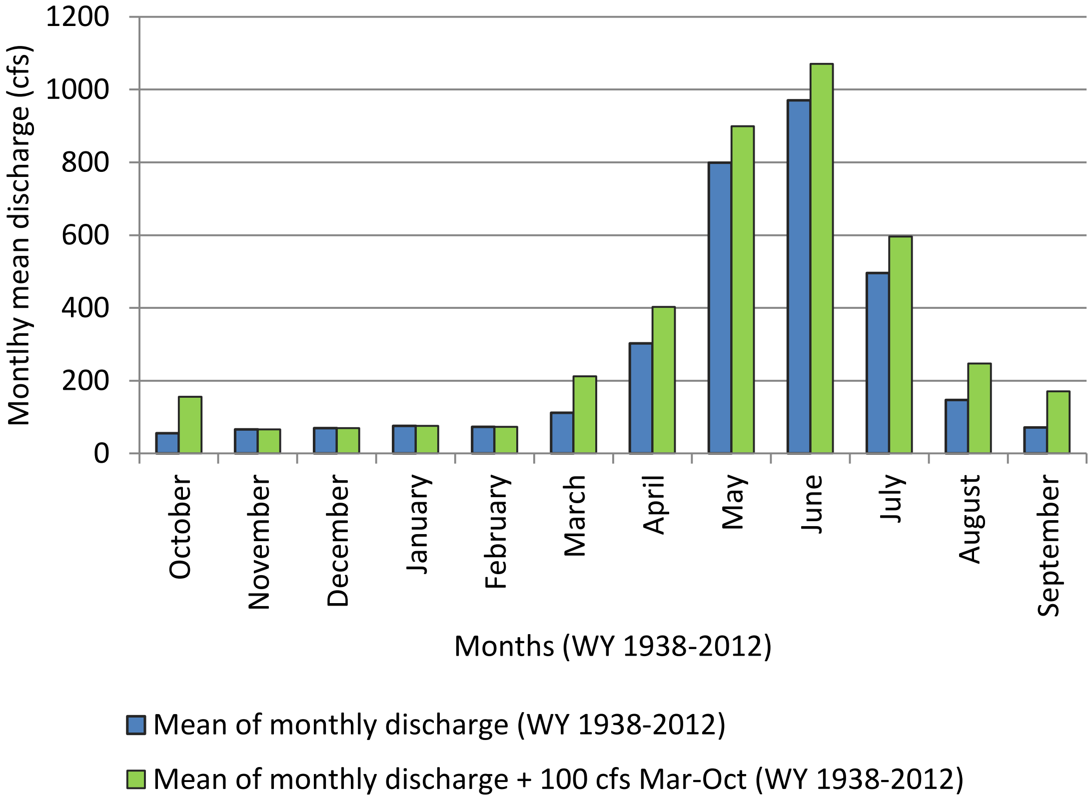

Figure 4-2. Estimated increase in mean monthly flows along the West Walker River during the irrigation season; increased in-stream flows are illustrated as equally distributed throughout the season (additional 100 cfs/month); although they are expected to be greater in the early rather than late season.

We base our analysis on the conservative assumption that the additional flows are evenly distributed across the growing season; in reality, the increase in flows will likely be skewed towards the early part of the season. With multiple years during which spring and late summer flows are significantly higher (e.g., over 50% higher than the current monthly average) than current conditions, these species could be replaced by a denser understory that includes more moisture loving (but shade tolerant) species, such as coyote willow, creeping wildrye, bluegrass species, as well as forb species. Percent cover of weedy species cover, such as bull thistle (*Cirsium vulgare*), Canada thistle (*Cirsium arvense*), and prickly lettuce (*Lactuca serriola*), among others, is also expected to increase with increased mid and late summer water availability. Areas currently mapped as Mature Cottonwood with Riparian Understory (7.6 acres; Otis Bay 2009) could also experience increased riparian shrub cover and density.

An increase in early spring flows during the cottonwood and willow seedling germination (May and June), as well as a more slowly receding hydrograph during July and August , could increase cottonwood and red willow recruitment survival and establishment (Rood et al. 2003, Shafroth et al. 1998, Stella et al. 2010). Increases in overall recruitment extent and density are also dependent upon management practices that might limit the lateral extent of flooding that can occur with increased spring flows, and the degree of mortality to any resulting cottonwood or willow seedlings due to mowing or trampling. Thus non-grazed or lightly grazed areas within the active floodplain, and particularly near or downstream of existing red willow or cottonwood stands, could experience increased recruitment and survival of cottonwood and red willow trees, which provide key structural elements (large overstory trees) to the riparian corridor. Since most of the cottonwoods and willows observed during the August 2013 visit were mature to senescent, this addition of new riparian overstory cohorts could have an important and long-lasting positive effect on the riparian corridors in both valleys.

More specific effects on the Bridgeport Valley riparian corridors are difficult to assess since these areas were not accessed during the 2013 field visit and have not been well mapped or described in other documents. Also, without more specific information on flows and the floodplain cross-sections in both valleys, it is not possible to estimate the extent of area potentially affected, other than to bound it to the extent of total riparian acres (185 and 71 acres mapped for Antelope and Bridgeport Valleys, respectively, excluding patches of Coyote Willow outside of the river corridors).

Conclusions

Return to the natural annual hydrograph through suspended irrigation withdrawals is expected to positively affect native riparian vegetation along the West Walker River and the four primary tributaries to the East Walker River that run through Bridgeport Valley. Density of understory willows and other native shrub and herbaceous species is expected to increase and overall recruitment of cottonwood and red willow is also expected to increase, bringing diversity to the age profile of the riparian forest stands found in both valleys. Large uncertainties in this assessment could be addressed through a more focused assessment of the existing riparian species composition and extent, the shape of the restored annual hydrograph, and the diversity in the physical structure of the riparian corridors in Study Area.

4.1.2.2 Natural lands outside riparian corridor

Suspended all-season irrigation outside the riparian corridor would result in some mid and late summer drought stress along south-central Antelope Valley where groundwater levels are deeper

(Carroll and Pohll 2013), along the eastern side of Antelope Valley where surface slopes are greater (Figure 2-3), and in the southern part of the valley where soil texture is coarser (Figure 2-1). Areas currently mapped as Moist Grass and Wet Sedge could experience some moderate effects, such as increased weed pressure and a decrease in overall production (Figure 4-3).

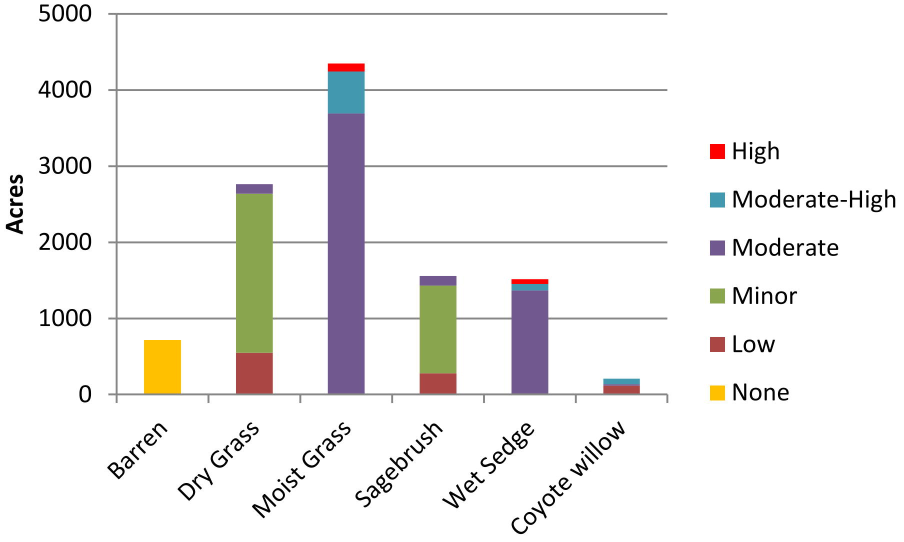

Figure 4-3. Natural vegetation types outside the riparian corridor in Antelope Valley, showing total acres and expected effects ranking due to reduced water availability.

In Bridgeport Valley, suspending irrigation could importantly effect vegetation in large areas with sandy soil in the central, west and southern parts of Bridgeport Valley (Figure 2-2), as discussed above in Section 4.1.1 Effects on forage and alfalfa production and summarized in Figure 4-4. However, lack of information regarding the response of the subsurface groundwater to suspended irrigation greatly increases the uncertainty in vegetation response.

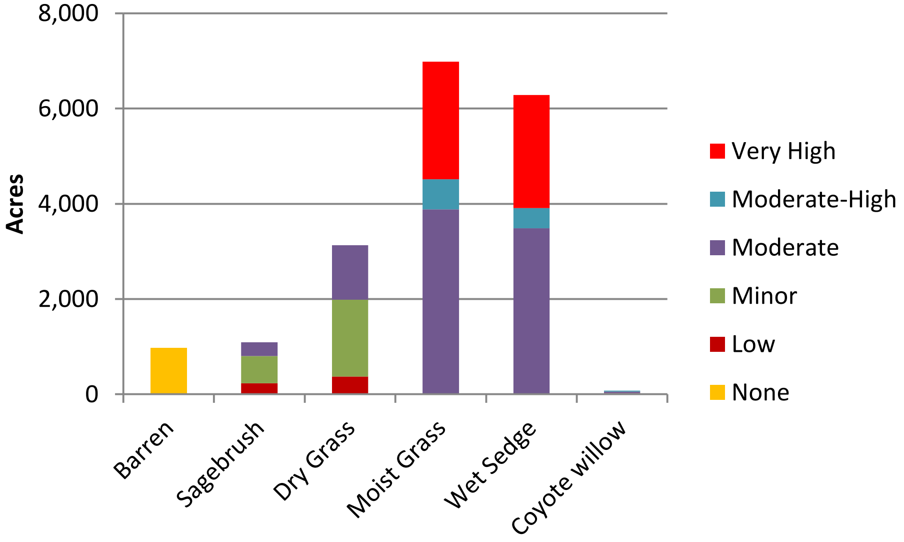

Figure 4-4. Natural vegetation types outside the riparian corridor in Bridgeport Valley, showing total acres and expected effects ranking due to reduced water availability.

Effects on forage production rates specific to Dry Grass, Moist Grass, and Wet Sedge vegetation types are discussed in the context of forage and beef production under section 4.1.1 Effects on forage and alfalfa production. These vegetation types are also discussed here, with an emphasis on vegetation composition and structure for habitat quality effects. Effects on Sagebrush and Coyote Willow are also described below.

Coyote Willow

Coyote willow, along with Woods‘ rose, occurs in wet to moist patches in Antelope Valley and along many of the unlined irrigation canals. Since coyote willow is moderately tolerant of drought conditions but is ranked as a ‗high‘ water user, it is expected to persevere through one to several continuous years of late summer drought and/or abbreviated growing season flows in irrigation canals. Growth, canopy cover and health of coyote willow is expected to deteriorate with ongoing dry late summer conditions however. Woods‘ rose is also moderately tolerant of drought and is rated as a medium water user. It is therefore expected that the Woods‘ rose, which was also frequently observed in the drier rabbit- and bitterbrush areas, would be less affected by one to several years of mid-summer drought conditions.

Over all of Antelope Valley, Coyote Willow is mapped on 209 acres, one-third (70 acres) of which are assessed to experience moderately-high drought effects with suspended irrigation. Over multiple years, this could result in transition of these areas to a drier vegetation type. In Bridgeport Valley, Coyote Willow is mapped on 74 acres, 16 of which are in areas where potential effects are ranked as moderately high. Thus, roughly one-third and one-fifth of the existing Coyote Willow habitat could be lost with multiple years without irrigation in Antelope and Bridgeport valleys. These losses could be compensated in both valleys by increases in Coyote Willow habitat along the riparian corridor.

Wet Sedge

This vegetation type occurs in areas where groundwater levels are within one to two feet of the surface all summer, or that have standing water. In some of these areas where ground and surface water levels are high (e.g., <1 ft below ground) in late summer due to sub-irrigation, changes in water availability is linked to groundwater levels in the valley, and changes in the overall balance would be required to limit water availability in these areas. Other areas supporting this vegetation type are adjacent to or part of surface irrigation ditches and therefore would be directly affected by suspended diversions. Those areas experiencing reduced saturated conditions in mid to late summer and over multiple years are expected to shift towards an increase in the species common to the moist grass vegetation type. Nebraska sedge and Sierra rush, which were observed in many of the wet sedge vegetation areas and can also co-occur with the moist grass vegetation type, could replace other water loving species (such as other sedge species, tules, and cattail). Nebraska sedge is a moderately attractive forage species (Tilley and Ogle. 2012); therefore with reduced water availability, this shift could increase the forage production in areas currently mapped as wet sedge vegetation type.

Overall of Antelope Valley, Wet Sedge is mapped on 1,513 acres, and about 10% (145 acres) of which are expected to experience moderately high to high effects without irrigation over one to multiple years and could undergo type conversion to Moist Grass. In Bridgeport Valley, effects on 2,800 acres of Wet Sedge (45% of the total area mapped as this vegetation type) are ranked as ‗high‘ or ‗moderately high‘ and could undergo type conversion to Moist Grass with prolonged lack of irrigation. Improved understanding of controls on ground water levels in the Basin are required in order to attach more certainty to this analysis for Bridgeport Valley in particular.

Moist Grass

This vegetation type provides the largest amount and highest quality forage for cattle and is an important food source for wildlife. Its most common species, as observed during August 2013, nearly all have low drought tolerance and medium to high water use. Thus, a reduction in mid to late-summer water availability (either through above ground irrigation or through root access to shallow groundwater) could result in a curtailed period of growth and reduced overall biomass. Over multiple years of mid to late-summer drought conditions and no other management actions, it is expected that species such as redtop (*Agrostis gigantea*), timothy (*Phleum pretense*), and marsh bluegrass (*Poa leptocoma*), might give way to more drought tolerant grasses such as creeping wildrye (*Elymus triticoides*), Canada bluegrass (*Poa compressa*), and squirrel tail (*Elymus elymoides*). Thus, replacement of a more drought tolerant grass species for the more moisture loving ones could result in little to no reduction in overall productivity or cover. However, reduced late season water availability combined with increased grazing pressure, could increase undesirable forage species, such as Missouri iris and Baltic rush in moister areas, and more drought tolerant invasives such as Scotch thistle (*Onopordum acanthium*) and perennial pepperweed (*Lepidium latifolium*) in other areas[4]. As demonstrated in the Oregon Wood River watershed, multiple years or permanent conversion to non-irrigated land could result in conversion from Moist Grass to Dry Grass vegetation type.

Dry Grass

All of the species that occur in this vegetation type are highly or for just two, moderately, drought tolerant. Most also are ranked as having low water use. Since this vegetation type is located in areas that are already experiencing dry surface soil conditions (per 2013 observations), it is not expected that they will experience large changes in late summer water availability with suspended irrigation. These areas are likely already outside of the irrigated and/or high groundwater areas. However, a shortening of the early spring moist period could affect a shift in the annual ground cover species away from the more mesic species such as Canada bluegrass (*Poa compressa*) towards drier sites species, such as squirreltail (*Elymus elymoides*) and cheatgrass (*Bromus tectorum*), and towards a lower overall productivity and higher percent of bare ground.

Moderate effects are expected for a small percentage (5% or 124 out of 2,762 acres) of the mapped Dry Grass vegetation type in Antelope Valley (none have a higher effect ranking). In Bridgeport Valley, 1,140 out of 3,127 acres mapped for Dry Grass are ranked to have moderate effects from non-irrigation. These areas could experience reduced productivity and increased percentage of bare ground with possible encroachment of Sagebrush- Rabbitbrush vegetation type with prolonged non-irrigation.

Sagebrush-Rabbitbrush

Species that dominate this vegetation type are adapted to drought and are not expected to respond quickly to reduced irrigation. With one or two years of non-irrigation, a reduction in grass and forb cover in between individual shrubs could occur, with minimal changes in shrub canopy

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[4] According to the species report by the California Invasive Plants Council, Scotch thistle often establishes in relatively rich soils but has a thick tap root that enables it to withstand periods of drought. According to the CAL IPC report on Scotch thistle, it, ―grows best on the slope between arid rangeland and wet meadows along streams. [And has been] observed to invade undisturbed sagebrush areas.” (citation - http://www.cal-ipc.org/paf/site/paf/393).

cover and productivity. With multiple sequential years of non-irrigation, overall brush cover could decrease more substantially, along with an extended decrease in dry grass and forb cover in between individual shrubs. Bare ground area would increase in the vegetation type.

The Sagebrush-Rabbitbrush vegetation type is mapped on a total of 1,558 acres in the Antelope Valley HRU area and approximately of these 125 acres have a ‗moderate' effect ranking (none have a higher effect ranking). Similarly, 295 out of 1,095 acres mapped as Sagebrush-Rabbitbrush are ranked to experience moderate effects with non-irrigation in Bridgeport Valley.

Conclusions

Overall, the extent of natural vegetation outside the riparian corridor affected could be greatest in Bridgeport Valley, depending upon how lack of irrigation affects subsurface groundwater levels during the growing season. The extent of area with expected high to moderately high impacts, in acres and as a percent of the total vegetation type mapped for each Valley, is summarized in Table 4-3 below. As emphasized above, there is great uncertainty regarding the degree of impact to the large areas currently mapped as Wet Sedge and Moist Grass in Bridgeport Valley that could be impacted under this scenario due to lack of information on natural vs. irrigated near surface groundwater response to suspended irrigation.

Table 4-3. Summary of the extent and percent of the mapped area for that vegetation type expected to have 'moderately high' to 'high' impacts were irrigation to be suspended for the full growing season in Antelope and Bridgeport valleys.

Vegetation type	Antelope Valley		Bridgeport Valley	
	Acres	Percent	Acres	Percent
Coyote Willow	70	33	16	20
Wet Sedge	145	10	2,800	45
Moist Grass	658	15	1,400	44
Dry Grass	0	0	0	0
Sagebrush-Rabbitbrush	0	0	0	0

4.2 Scenario 1b. No Irrigation for Full Season: Part of Antelope Valley

Under this scenario, some areas in Antelope Valley would suspend irrigation while others made no change in the irrigation schedule. Since Bridgeport is being treated as a single HRU, we discuss only Antelope Valley in this section.

Vegetation effects associated with this scenario are the same by vegetation type as described for Scenario 1a, but applied only to those participating HRUs. The differential effects of all-season suspended irrigation among HRUs are summarized in Table 4-4 and discussed by vegetation type below. In Table 4-4 we present a summary of the extent and potential impacts of limiting growing season water availability on vegetation in each HRU based on the combination of soils, slope, and existing vegetation.

Table 4-4. Potential effects* on vegetation types associated with reduced water availability by HRU in Antelope Valley.

Vegetation type	Expected drought effect	Alkali	Big Slough	Carney	Hardy	Highline	Little Antelope Valley	Lone Company	Main Canal	Powell	Rickey and Private	Swauger	West Goodnough & Harney	Grand total acres
Alfalfa field	High		58.0											58.0
	Moderate-high		478.3	82.0		118.9						11.2	19.3	709.7
	Moderate		1452.4	179.6		134.2						556.3	1.4	2323.9
	Total		1988.7	261.6		253.1						567.5	20.7	3091.7
Barren	None	1.2	492.3	20.7	16.8		12.9	28.7	29.1	26.4	1.8	83.2	1.4	714.5
	Total	1.2	492.3	20.7	16.8		12.9	28.7	29.1	26.4	1.8	83.2	1.4	714.5
Coyote Willow	Moderate-high		24.4		1.2				0.8	43.7		0.1		70.3
	Moderate	0.1	5.1	5.8	0.1	0.3	0.7	2.4	0.1	2.7	0.1	3.1	3.2	23.5
	Low	0.5	89.4	0.5		0.6	0.5	6.9	0.2		0.4	7.3	8.7	115.0
	Total	0.6	118.8	6.2	1.3	0.9	1.2	9.3	1.1	46.5	0.5	10.5	11.9	208.8
Dry Grass	Moderate		93.5		7.6		0.2	1.2	0.2	15.3		5.8		123.8
	Low	15.2	299.7	2.5	0.5		53.9	27.7	21.4	0.8	1.6	106.1	17.9	547.2
	Minor	29.2	1533.6	0.0			2.5	59.3	7.8	0.4	197.7	243.9	16.5	2090.9
	Total	44.4	1926.7	2.5	8.1		56.6	88.1	29.4	16.5	199.4	355.9	34.4	2761.9
Early Successional Riparian	None	0.0	1.6							3.0	0.6	0.8	1.2	7.1
	Total	0.0	1.6							3.0	0.6	0.8	1.2	7.1
Mature Cottonwood with Riparian Shrub Understory	Moderate	0.1	0.4								0.0	0.1	0.8	1.4
	Low	1.2	0.6								0.0	2.5	1.9	6.2
	Total	1.3	1.1								0.1	2.6	2.7	7.6

Vegetation type	**Expected drought effect**	**Alkali**	**Big Slough**	**Carney**	**Hardy**	**Highline**	**Little Antelope Valley**	**Lone Company**	**Main Canal**	**Powell**	**Rickey and Private**	**Swauger**	**West Goodnough & Harney**	**Grand total acres**
Mature Cottonwood with Xeric Understory	Moderate-high									1.8		0.2		2.0
	Moderate	1.3								1.6			1.3	4.3
	Low	0.4	0.6									0.7	1.3	3.1
	Total	1.8	0.6							3.4		0.9	2.7	9.3
Moist Grass	High		60.1		1.3		0.0	1.2	0.0	30.0		13.6		106.4
	Moderate-high	30.1	208.3	1.2	0.1		30.8	28.9	6.4	0.7	9.0	199.5	36.5	551.4
	Moderate	47.7	2778.9	0.0			2.0	46.6	2.5	2.1	210.8	560.2	38.4	3689.2
	Total	77.8	3047.3	1.2	1.4		32.8	76.6	9.0	32.9	219.8	773.3	74.9	4347.1
Sagebrush	Moderate		81.0		19.9		0.4	0.8	0.3	21.4		1.4		125.2
	Low	13.0	62.8	9.1	2.4		79.0	22.0	19.8	1.0	2.7	57.7	10.0	279.5
	Minor	12.9	941.4	0.1			3.5	39.4	6.6	0.0	47.7	91.4	9.8	1153.0
	Total	26.0	1085.3	9.2	22.3		82.9	62.2	26.7	22.4	50.4	150.5	19.8	1557.7
Water-asphalt-rock	None	0.1	5.1	0.0	0.0		0.1	0.0	0.1	0.1	0.3	32.6	0.2	38.6
	Total	0.1	5.1	0.0	0.0		0.1	0.0	0.1	0.1	0.3	32.6	0.2	38.6
Wet Sedge	High		21.0		0.1			0.0	0.0	26.7		14.5		62.4
	Moderate-high	11.9	7.5	0.4	0.0		1.1	1.6	0.7	0.6	0.2	19.2	39.3	82.4
	Moderate	21.4	1069.5				0.4	1.3	0.0	2.7	20.1	245.6	7.5	1368.5
	Total	33.2	1098.0	0.4	0.1		1.4	2.9	0.7	30.0	20.3	279.3	46.8	1513.2
Grand total acres	**Total**	**186.4**	**9765.5**	**301.9**	**50.1**	**254.0**	**188.0**	**267.9**	**96.1**	**181.1**	**493.0**	**2257.1**	**216.6**	**14257.6**

* Effects ranks are described in Table 3-3 and are summarized here: None: No effect on health or growth expected; Low: Little-to-no effect on vegetation expected; Minor: Some decrease in productivity expected; Moderate: Reduced productivity and possible changes in plant species distribution favoring drought tolerant over intolerant plants; Moderate-High: Pronounced reduction in productivity and percent cover shifts towards drought tolerant plant species; High: Large reductions in productivity and possible change in vegetation type over multiple seasons

4.2.1 Effects on forage and alfalfa production

Effects on the production volume and quality of forage and alfalfa are the same as discussed under Scenario 1a, but the distribution among HRUs varies. Forage and alfalfa production would be more affected by reduced irrigation for some of the HRUs than for others based on the distribution of surface soils, slope, and existing vegetation types, as described below.

4.2.1.1 Alfalfa production

Overall, most alfalfa is grown in the Big Slough HRU (1,989 acres). Swauger HRU includes over 560 acres in alfalfa, and Carney and Highline support alfalfa production on approximately 250 acres of land.

4.2.1.2 Forage production

With nearly 7,000 acres in some form of grassland, including Sagebrush, the Big Slough HRU has by far more forage land than any of the other HRUs in Antelope Valley (Figure 4-5), and most of this is expected to experience minor to moderate effects with suspended irrigation. This means that over multiple consecutive years of suspended irrigation, vegetation types could shift to a drier type (e.g., Moist Grass transitions to Dry Grass), and depending on grazing pressure, cover of pest species such as Baltic rush and Missouri iris could increase in Moist Grass areas. Swauger HRU and Rickey and Private HRU have the next greatest extent of lands supporting forage vegetation types, with similarly minor and modest levels of impact expected (Figure 4-5).

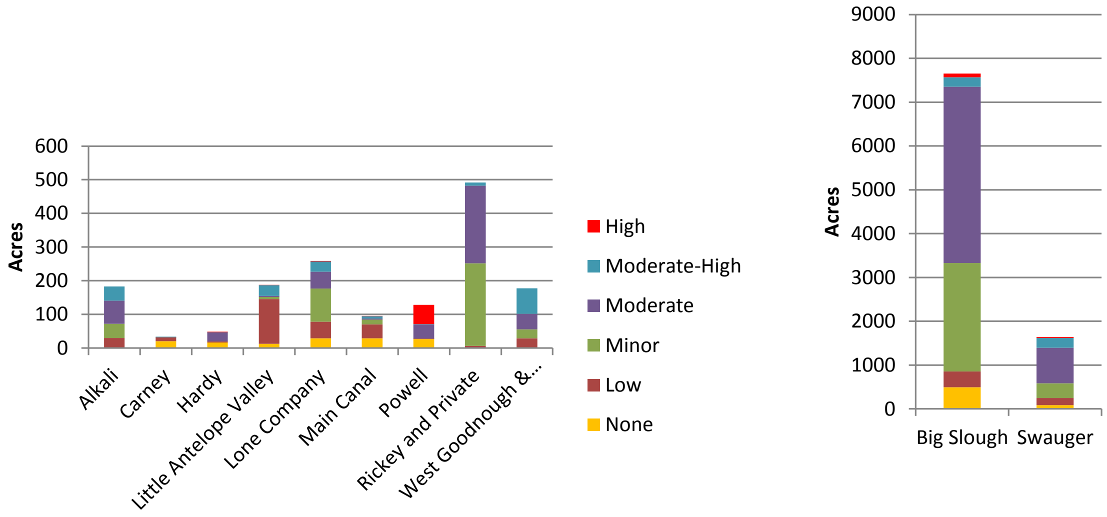

Figure 4-5. Vegetation types used for forage in Antelope by HRU, showing total acres and expected effects ranking due to reduced water availability. These include (Barren/Sagebrush, Dry Grass, Moist Grass, and Wet Sedge)

Effects of suspended irrigation on forage production also can be considered as the proportion of each HRU impacted, rather than as straight acres. West Goodenough & Harney, Swauger, Powell, and Alkali HRUs have the greatest proportion of wet to moist vegetation types that could be importantly affected by non-irrigation (Figure 4-6). Little Antelope Valley has a small amount of the area mapped as Moist Grass (33 acres), almost all of which is assessed at high risk of drought stress with suspended irrigation due to coarser soils and steeper slopes than in the main part of

Antelope Valley. Proportionally, Big Slough has the smallest percentage of forage areas ranked to have moderately high effects (Figure 4-6). Tables providing details on the distribution of vegetation types and the expected effects ranking per HRU are provided in Appendix A.

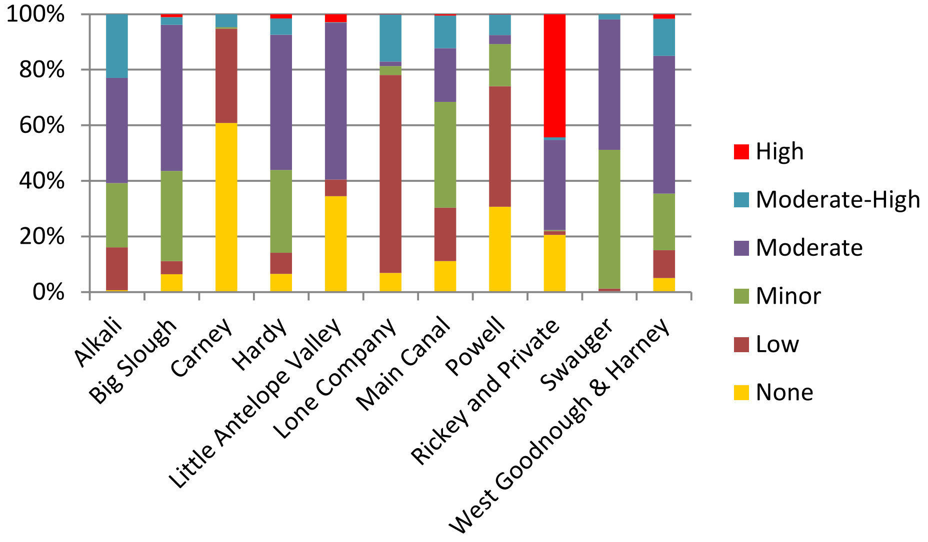

Figure 4-6. Vegetation types used for forage in Antelope by HRU, showing percent of HRU area with expected effects ranking due to reduced water availability. These include Barren/Sagebrush, Dry Grass, Moist Grass, and Wet Sedge.

4.2.1.3 Conclusions

Big Slough HRU would experience the greatest effects in alfalfa production, on an acreage basis, were irrigation suspended in this area. On an acreage basis, Big Slough, Swauger, and Rickey and Private HRUs would experience the greatest number of impacted acres in forage production under this scenario. West Goodenough & Harney, Swauger, Powell, and Alkali HRUs have the greatest proportion of their forage production areas that could be importantly affected under this irrigation scenario.

4.2.2 Effects on natural vegetation

4.2.2.1 Riparian corridor

Effects on vegetation in the riparian corridor depend on the timing and amount of water not diverted from the river. Reduced diversions, particularly during the early and late parts of the irrigation period, could result in a noticeable increase in the extent and density of riparian vegetation. As described under Scenario 1a, without more specific information on flows and the floodplain cross-section, it is not possible to estimate the extent of area potentially affected under this or other scenarios, or to determine a particular threshold level of reduced diversion (say, 25 cfs) that might provide important benefits to natural riparian vegetation.

4.2.2.2 Natural lands outside riparian corridor

Five vegetation types occur in the non-row crop fields and outside the riparian corridor: Barren ground /Sagebrush, Dry Grass/Sagebrush, Moist Grass, Wet Sedge, and Coyote Willow. These types are not evenly distributed among the HRUs. Since the greatest area for all types is in the largest HRUs, Big Slough and Swauger, more impacts to all vegetation types would occur if irrigation was suspended from one or both of these HRUs, rather than to one or several of the other smaller HRUs (Figure 4-7).

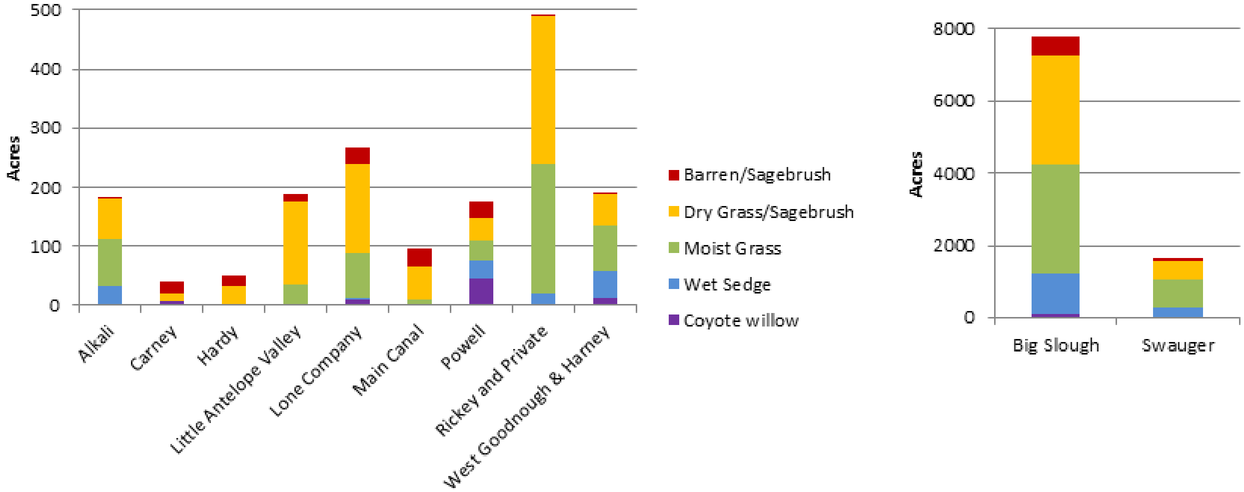

Figure 4-7. Areas in five natural vegetation types mapped outside the riparian corridor in Antelope Valley, organized by HRU.

Coyote Willow

Big Slough and Powell HRUs both have relatively large areas of Coyote Willow in areas ranked to have moderately high effects due to reduced water availability (24 and 44 acres, respectively).

Wet Sedge

Big Slough and Powell HRUs have the greatest area ranked to have high effects due to reduced water availability that are currently mapped as Wet Sedge (21 and 27 acres).

Moist Grass

Of the non-row crop area outside the riparian corridor in Antelope Valley, the Moist Grass type covers the greatest area (4,347 acres) and includes a small portion that is rated as likely to experience high to moderately high drought stress (658 acres, or 15%). Big Slough and Swauger HRUs have the greatest extent of the Moist Grass vegetation type (3,047 and 773 acre, respectively), and 268 (9%) and 213 (28%) of these are assessed to experience moderately high to high drought stress with suspended irrigation.

Dry Grass and Sagebrush

Although not considered highly vulnerable to a single season of reduced water availability, ceasing irrigation for multiple consecutive years could lead to increasing replacement of dry grasses with sagebrush or to bare ground. Ultimately, permanent conversion to Sagebrush or Barren/Sagebrush could occur. The greatest extent of Dry Grass vegetation type that would be impacted is in Big Slough HRU (nearly 2,000 acres); other HRUs with large extents of the Dry

Grass vegetation type are Swauger HRU (360 acres), Rickey and Private (200 acres), and Lone Company (88 acres). Carney and Hardy have the greatest percent area as Barren/Sagebrush that would be very resistant to effects of prolonged non-irrigation.

4.2.2.3 Conclusions

Of the HRU's in Antelope Valley, suspending irrigation would have the greatest impact on the overall production in Powell HRU since this area has the greatest proportion of area with high or moderately high negative effects rating (Table 4-4). Coyote Willow and Wet Sedge grow in a few areas located primarily in Big Slough and Powell HRU. Moist Grass with some likelihood of impact under this scenario occurs primarily in Big Slough and to a lesser amount in Swauger HRU. Moist Grass and Wet Sedge cover a small amount of land in Little Antelope Valley, but this comprises over half of arable land.

4.3 Scenario 2. Late Summer Reduction (after July 1)

Under this scenario, irrigation continues until July 1 but is shut off for the second half of the growing season.

4.3.1 Effects on forage and alfalfa

4.3.1.1 Alfalfa and garlic

This may be the best option for the most water savings with minimal impact on alfalfa production. It is often considered a best management strategy to eliminate irrigation late in the season to cause drought-induced dormancy (Shewmaker et al. 2013). More dormant varieties (as we believe are planted in the Study Area) will then develop toward increased persistence and more efficient water use. As discussed above, alfalfa has the highest water use efficiency early in the season, and the first cuttings are a larger proportional share of total production than later cuttings.

In some locations, especially those with sandy soil and high temperatures, prolonged drought over 12 weeks may damage the stand and not allow for recovery to full potential yield when water is made available again (Ottman et al. 1996). However, conditions where alfalfa is grown in Antelope Valley are generally favorable enough that this would be a reasonable option, assuming that the cultivars used are rated at least mildly dormant (Dormancy rating 1-4) (Putnam 2012).

Studies at various sites in the Klamath Basin demonstrated that lack of irrigation after the first cutting reduced seasonal yields by 0.60 – 2.20 tons/acre, and lack of irrigation after the second cutting reduced seasonal yields by 0.30 – 1.23 tons. The study sites produced 3 or 4 cuttings under normal irrigation (Orloff et al. 2005, Orloff et al. 2008).

While this report selected July 1 for cessation of irrigation for modeling purposes, for an actual transaction it might serve to adjust the exact date to accommodate a second cutting. Based on a conservative interpretation of conditions in Antelope Valley, if irrigation is suspended after the second cutting there may be a potential reduction in alfalfa around 0.8 tons/acre, or 14% of total annual yield. Under this approach a third cutting would still be expected, although greatly reduced. In sandy soils or hot conditions the third cutting may be reduced to the point where the cost of harvest outweighs the value of the alfalfa; although this is not expected to be a common occurrence.

Although this management approach is likely feasible with the existing alfalfa cultivars, when it is time to reseed landowners should consider cultivars with higher dormancy ratings. This will improve yield and longer-term permanence, as well as provide greater protection against damage from multiple dry years in succession.

4.3.1.2 Forage and grass hay

Forage production and quality could decline in areas supporting Moist Grass in the first year of altered irrigation since many of these species require wet to moist conditions to continue growing and providing high quality forage throughout the growing season (Ganskopp and Bohnert 2001). However, with multiple years of this irrigation regime, cover of mid-summer drought tolerant species, such as wheatgrass and wildrye, would be expected to increase, while that of less drought tolerant species, such as timothy and bentgrass (*Agrostis* spp), would diminish. This adjustment in species composition could reduce the impact of reduced late summer irrigation.

4.3.1.3 Conclusion

In summary, alfalfa production in other regions of California show reduced yields following mid-July suspension of irrigation that average 0.6 tons/acre and range from 0.1 to 0.8 tons/acre. Based on a conservative interpretation of this available information, potential reduction in alfalfa production with mid-July suspension of irrigation could be represented as ranging from 0, if other water sources are not constrained, to 0.8 tons/acre, which translates to roughly 0 to 14% of the total annual yield, depending on site-specific conditions. This would be a viable approach to water savings while maintaining alfalfa production, as it is practiced in many regions.

Forage production could be reduced for the first year or two but, given appropriate weed and grazing management, production could return to existing levels, or close to it, within several years of ongoing management.

4.3.2 Effects on natural vegetation

Effects on vegetation under this scenario would be generally less than those described under the first scenario for the full season since irrigation during the early part of the season supports the most important growth period for the dominant plant species.

However, late summer reduction in irrigation would have less effect on areas in the north, central part of Antelope and Bridgeport valleys, because the groundwater levels for both Valleys would be recharged with the early season irrigation and therefore support sub-irrigation during the late season in the northern low elevation areas. In particular, in Antelope Valley, the north-central areas of Big Slough, Swauger, and Rickey and Private would still benefit from sub-irrigation later in the growing season. HRUs to the south and along the sides of Antelope Valley, including West Goodenough & Harney, Alkali, Highline, Carney, and Lone Company, would probably have the least amount of supplemental sub-irrigation and therefore late summer reductions might have greater impacts to these HRUs.

Vegetation along the riparian corridor within the active floodplain would have a small benefit from increased flows in July, August and September such that, over multiple seasons, xeric understory and ground cover species might be replaced in some areas with a denser groundcover and shrub layer of moisture loving species such as sedges, forbs, and willow. With no changes in early season flows, recruitment of native cottonwood and willow trees is not expected to change.

4.3.2.1 Conclusions

Minor effects on natural vegetation would be expected with the post July 1 termination of irrigation practices since most species perform the greatest amount of growth and spread in June and early July. Areas in the southern part of Antelope Valley on sandy soils and slightly sloped surfaces could experience drier conditions than other areas; therefore production in these areas would be somewhat diminished in late summer.

4.4 Scenario 3. No Irrigation before June 1

Irrigation does not begin until June 1throughout the entire Valley.

4.4.1 Effects on forage and alfalfa

4.4.1.1 Alfalfa and garlic

While existing stands of alfalfa in the Study Area would likely survive without irrigation before June 1, they would have reduced production. It is important to note that early season is when alfalfa is most efficient in its water use. Alfalfa produces more for each unit of water in spring than during the rest of the season. Thus, delayed irrigation is likely not the most economically efficient approach to water savings on alfalfa fields.

There is little research that clearly shows the impact of delayed irrigation on alfalfa production in conditions similar to the Study Area. General practice is to make sure that there is no water stress on the plants as they come out of dormancy in the spring. As the first cutting is normally in June, it would be expected that the initial cutting would be significantly reduced. An educated estimate is that the first cutting production may be reduced to half of normal. If irrigation water is fully applied after the first cutting, however, the second and third cuttings would likely be at full yield potential.

One concern for this approach is during dry years, especially if there are multiple dry years in succession. If direct diversions are halted, and groundwater and storage water application onto acreage within the transaction are constrained, then there is the possibility that the stand would only get water for a short period of time: between June 1 and whenever diversions are halted, which often happens in July or August. While a stand may be able to survive one year of such treatment, production that year would be considerably lower than normal and a third cutting may not be advisable. Two or more dry years in succession would likely permanently reduce potential yields. If there are no constraints on groundwater and storage water application after June 1, then this is no longer a concern.

It is also important to note that delayed irrigation would not be possible in the year a new stand is being established. After emergence, seedlings require ample water for rapid growth. Early water stress will suppress seedling root growth, stem number and diameter, internode numbers and length, and leaf size (Efetha 2011). Additionally, alfalfa is a very poor competitor with weeds at the seedling stage (Armah-Agyeman et al. 2002).

4.4.1.2 Forage and grass hay

Delaying irrigation until June 1 is expected to affect forage production differently in Antelope vs. Bridgeport valleys due to temperatures differences in the early spring. In Antelope Valley, night time temperatures rarely go below freezing after mid-April; in Bridgeport Valley, night temperatures can dip below freezing throughout April and May. Thus, spring growth begins earlier in Antelope Valley; depending on the year, growth can begin in April and May. Therefore, delaying irrigation to June 1 could result in water-stressed conditions and reduced forage production during that time period for some areas of Antelope Valley. Since spring growth is expected to begin later in Bridgeport Valley, this timing is not expected to have a large impact on forage production there. Moreover, depending on the species and variety, perennial and annual grasses can respond rapidly to late season water availability (Ganskopp and Bohnert 2001).

4.4.1.3 Conclusions

This irrigation schedule is not recommended as the most efficient way to reach maximum production with water savings. We estimate that yield of first cutting would be at roughly half normal levels, but that the 2nd and 3rd cuttings could reach normal production levels, if they are irrigated with groundwater or storage water after direct diversions are curtailed. It may be difficult to accurately quantify water savings because they would vary by year, depending on existing soil moisture. Forage production is expected to diminish somewhat in Antelope Valley, but will vary depending upon fall precipitation and temperature. Forage production is not expected to be impacted in Bridgeport Valley under this scenario.

4.4.2 Effects on natural vegetation

4.4.2.1 Riparian corridor

An increase in early spring flows during the cottonwood and willow seed dispersal and germination period (May through June) could increase seedling germination across the floodplain. However, initiating withdrawals on June 1 would increase the rate of water level decline while seedlings are becoming established, resulting in reduced seedling survival rates (Stella et al. 2006). The net effect of increased seed germination across the floodplain and decreased seedling survival would probably be mixed, with patches of increased recruitment in floodplain areas with fine textured soils and/or local low elevations. Direct measures of flow with delayed withdrawal schedules during these months, along with topographic cross-sections of the floodplain areas could provide more precise information on how alteration of stream flow could affect riparian tree recruitment and survival in both Bridgeport and Antelope Valleys.

Conclusions

Some changes in cottonwood and willow tree recruitment would occur under this scenario with possible patches of new recruitment in low elevation areas that lie within the active floodplain.

4.4.2.2 Natural vegetation outside the riparian corridor

Effects on natural vegetation types in Bridgeport Valley would be negligible. Potential effects on natural vegetation types outside the riparian corridor in Antelope Valley are described below.

Coyote Willow

Growth, canopy cover and health of coyote willow would be slightly impacted where it occurs along irrigation canals and in low points of the southern half of Antelope Valley where groundwater levels are farther from the surface. Coyote Willow growing in areas actively grazed during early spring would experience the greatest impact since growth rates that otherwise mitigate browsing would be diminished.

Wet Sedge

The Wet Sedge vegetation type occurs in areas that naturally collect water, but saturation could vary in the southern areas of Antelope Valley without early season irrigation. The two dominant species in the Wet Sedge type, Nebraska sedge and water sedge, both establish and expand more effectively under variable moisture conditions than completely saturated ones (Tilley et al. 2011, Tilley et al. 2012). Thus, as a conservative estimate, reduced pre-June 1 irrigation is expected to have little-to-no effect on the Wet Sedge vegetation type in both Antelope and Bridgeport valleys.

Moist Grass

Most of the grasses observed in this vegetation type are perennial, and therefore new growth shoots and runners become quiescent under early drought conditions and can resume growth when water becomes available during mid-summer. Annual grasses are less favored by early drought since they continue to actively grow, mature, and senesce but at lower rates with less available water (Ganskopp and Bohnert 2001, Buxton and Marten 1989). Thus, while forage quality could remain the same, the overall volume per acre is expected to diminish. No measurements are available as a basis for estimating the actual amount of reduction in forage. Reduced spring moisture could impact forb species flowering and diversity (Bates et al. 1998).

Dry Grass and Sagebrush

Delayed spring moisture availability could have a short term effect on annual grass growth and production but species such as cheat grass and squirrel tail have been shown to recover production rapidly when water becomes available mid-season (Ganskopp and Bohnert 2001). Sagebrush floral shoot development was delayed in experimental plots with no spring precipitation, but also recovered lost production when water became available later in the season (Bates et al. 1998). In the same experiment, the authors report that forb flowering and diversity was diminished in sagebrush steppe vegetation types (Bates et al. 1998); similar responses could occur in the Dry Grass and Sagebrush/Barren vegetation types that would otherwise benefit from irrigation in Antelope Valley.

Conclusions

Since irrigation would commence close to the beginning of the growing season in Bridgeport Valley, no-to-minor changes in vegetation would be expected to occur there. In Antelope Valley, small but potentially noticeable changes could occur. These include some reduction in the health and density of Coyote Willow with one or several continuous years of this scenario, and similarly, a small reduction in overall density and diversity of vegetation in the Moist Grass vegetation type. Some changes in the diversity of forb species could occur in the Dry Grass and Sagebrush/ Barren vegetation types under this scenario.

4.5 Scenario 4. Reduced Irrigation Throughout

Irrigation is performed as if it were a dry water year throughout both Antelope and Bridgeport valleys. The intent behind this transaction approach is to approximate deficit irrigation where only the minimum water needed is applied. As this is very site-specific management, it was difficult to model for water savings and production impacts with the given information. Instead, the team looked at irrigating during a normal or wet year, using only as much water as was normally available in a dry year.

4.5.1 Effects on forage and alfalfa

4.5.1.1 Alfalfa and garlic

Alfalfa is a prime crop for true deficit irrigation due to its ability to withstand significant water stress. Landowners could practice true deficit irrigation, using soil moisture sensors to determine irrigation needs, and would likely create some water savings while maintaining alfalfa production near full yields. However, water savings would be very variable by site and year, and would be difficult to quantify. Savings would be based both on consumptive use and water left instream, and would likely need several years of monitoring to determine the appropriate amount of water to be protected instream.

Under the approach of using only the water available in a dry year to irrigate in a normal or wet year, alfalfa would likely produce yields similar to or slightly higher than yields with suspended late summer irrigation (Transaction 2). Sufficient irrigation would normally be available until July or August, and there would be minimal concern about weakening stand. As in late summer reduction, sandy soils and hot conditions may lead to a light third cutting in some years. When it is time to reseed landowners should consider cultivars with higher dormancy ratings to improve yield and longer-term permanence, as well as provide greater protection against damage from multiple dry years in succession.

Conclusion

Using the ―irrigate as if a dry year in a normal year" approach would be similar to Scenario 2 in terms of alfalfa response. True deficit irrigation would likely result in higher yields, but it would be difficult to quantify water savings. Effect on forage production would be similar to those described for late summer cessation of irrigation practices described for Scenario 2, with likely minor reductions in the one to two years, followed by some recovery with proper weed and grazing management.

4.5.2 Effects on natural vegetation

Responses of natural vegetation types to dry-year irrigation would be similar to those described for Scenario 2, late summer reduction, and therefore are not repeated here.

4.6 Scenario 5. End of Season Storage Water Release

Storage water releases would occur after the end of the growing season, and therefore would not affect vegetation.

4.7 Special-Status Plant Species and Community Types

Areas mapped as ‗high' potential effects for Wet Sedge, Moist Grass, and Dry Grass could also impact special-status plant species, as listed in Table 2-6. Bridgeport Valley has the greatest extent of areas ranked to have potentially high effects associated with Scenario 1, particularly in the Wet Sedge and Moist Grass vegetation types. In contrast, no areas mapped as supporting Dry Grass or Sagebrush-Rabbitbrush are expected to experience moderately high or high impacts even under the most extreme scenario (Scenario 1). Thus the list of potentially impacted special-status plant species is provided in Table 4-5 below. As described for each of the scenarios and graminoid vegetation types above, no impacts to the Dry Grass or Sagebrush-Rabbitbrush types are expected. However, the potential habitat area for eleven rare or threatened special-status species dependent upon Wet Sedge and/or Moist Grass vegetation types that could be impacted by suspended irrigation over the full season, or delayed irrigation to June 1, is large (Table 4-5). Therefore, rare plant surveys should be performed in order to document any occurrences and develop avoidance and/or mitigation plans prior to implementing a water transactions program in Antelope or Bridgeport valleys.

Potential impacts to Fremont Cottonwood alliance (Rarity ranking G4 S3.2) are described under ‗Effects on Natural Vegetation' for each of the five transaction scenarios in the sections above.

Table 4-5. Vascular and non-vascular plant species with CRPR rare and threatened status that could occur in the Study Area currently supporting vegetation types with moderately high to high potential effects rankings for any one of the transaction scenarios, and their associated mapped habitats are listed. The number of acres of mapped suitable habitat that could be impacted under Scenario 1a is also listed for Antelope and Bridgeport valleys.

Scientific name	Common name	Status[1]: Federal/State/ CRPR	Likelihood of occurrence in assessment area	Wet sedge	Moist grass	Dry grass/RB-sage	Antelope (acres)	Bridgeport (acres)
Atriplex pusilla	smooth saltbush	–/–/2B.1	Potential habitat in sage and rabbit brush fields and in wet meadows, ponds	✓	✓	✓	803	4,200
Kobresia myosuroides	seep kobresia	–/–/2B.2	Potential habitat in upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓	803	4,200
Mertensia oblongifolia var. *oblongifolia*	sagebrush bluebells	–/–/2B.2	Potential habitat in sage and rabbit brush fields, upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓	803	4,200
Polyctenium williamsiae	Williams' combleaf	–/–/1B.2	Potential habitat in sage, rabbit brush fields and in wet meadows, ponds	✓	✓	✓	803	4,200
Thelypodium integrifolium subsp. *Complanatum*	foxtail thelypodium	–/–/2B.2	Potential habitat in sage and rabbit brush fields and in wet meadows, ponds	✓	✓	✓	803	4,200
Calochortus excavatus	Inyo County star-tulip	–/–/1B.1	Potential habitat in wet meadows	✓	✓			
Mimulus glabratus subsp. *Utahensis*	Utah monkeyflower	–/–/2B.1	Potential habitat in wet meadows, ponds	✓	✓			
Ranunculus hydrocharoides	frog's-bit buttercup	–/–/2B.1	Potential habitat in wet meadows, ponds	✓	✓			

Scientific name	**Common name**	**Status^1: Federal/State/ CRPR**	**Likelihood of occurrence in assessment area**	**Wet sedge**	**Moist grass**	**Dry grass/RB-sage**	**Antelope (acres)**	**Bridgeport (acres)**
Sphaeromeria potentilloides var. *nitrophila*	alkali tansy-sage	–/–/2B.2	Potential habitat in wet meadows, ponds	✓	✓			
Sphenopholis obtusata	prairie wedge grass	–/–/2B.2	Potential habitat in wet meadows, ponds	✓	✓			
Botrychium paradoxum	paradox moonwort	–/–/2B.1	Potential habitat in wet meadows		✓			

5 EXISTING WILDLIFE AND HABITAT NEEDS

There are various common and special-status wildlife species that occur or could occur in the Walker River Basin. The following species were included in this document because of their special-status designation and/or high public interest value, as well as their potential to be affected by water diversions. All of these species are known to currently exist in the general vicinity of the Study Area boundaries (as described in Section 1.3); however this is not an exhaustive list of all species that are linked to habitats and ecological processes within Antelope and Bridgeport valleys.

5.1 Greater Sage-grouse

Greater sage-grouse (*Centrocercus urophasianus*) is designated as a candidate species for listing under the federal Endangered Species Act (ESA), and is a California Department of Fish and Wildlife (CDFW) Species of Special Concern. In California, this uncommon species ranges from the Oregon border to northern Inyo County, along the east side of the Cascade Range and east side of the Sierra Nevada (Zeiner et al. 1990a). In late winter and early spring, males from several square miles gather at traditional leks—assembly areas where courtship behaviors are displayed (Zeiner et al. 1990a). Sage-grouse exhibit both resident behavior (remaining within 10 km [16 mi] of leks year-round) and migratory behavior (moving greater than 10 km [16 mi] from breeding leks to summer or winter habitats) in California (Connelly et al. 2000, Hall et al. 2008).

Year-round, greater sage-grouse require vast and relatively continuous expanses of sagebrush (*Artemisia* spp.) for food and cover. Greater sage-grouse have specific habitat requirements for nesting, brood rearing, and wintering (Schroeder et al. 1999). Leks are at sites in or adjacent to potential nesting habitat, on open patches of bare ground surrounded by sagebrush where visibility among males is unobstructed (Connelly et al. 2000). Leks are often on broad ridge tops, grassy swales, disturbed sites (e.g., burns), and dry lake beds (Schroeder et al. 1999). Nests are placed in the shade of relatively thick vegetative cover, often dominated by big sagebrush and including herbaceous cover and residual grass from the previous growing season that aid visual screening (Schroeder et al. 1999, Hall et al. 2008). Habitats with diverse vegetation likely provide the best nesting environments by aiding nest concealment (Schroeder et al. 1999). Brood-rearing areas are in a broad mosaic of habitats, including open stands of sagebrush, wet meadows, irrigated farmland, and other irrigated areas adjacent to sagebrush habitats; these areas are rich in forbs and insects (Schroeder et al. 1999, Connelly et al. 2000, Connelly et al. 2004). Summer foraging habitats may include areas used for agriculture such as hay fields, edges of bean and potato fields, as well as more typical sagebrush uplands and moist drainages (Braun et al. 2005). Greater sage-grouse is often found near water (Zeiner et al. 1990a); however, proximity to water—or vegetation associated with water—may be important in some areas and not in others (Schroeder et al. 1999). In some areas, meadows provide summer habitat for sage-grouse because they provide an abundance of succulent forbs; these areas are especially important during drier summers (Klebenow 1985).

The California side of the Walker River Basin is at the western edge of the greater sage-grouse‘s distribution, and includes the range of the Bi-State Distinct Population Segment (DPS) for two Population Management Units (PMUs): the Pine Nut PMU and the Desert Creek/Fales PMU. The Pine Nut PMU overlaps the portion of the Study Area around Topaz Lake; however there are no documented greater sage-grouse from radio-telemetry studies in this area (Bi-State Technical Advisory Committee 2012). The Desert Creek/Fales PMU overlaps the remaining portion of the

Walker Basin south of Topaz Lake; radio-telemetry data shows fairly robust greater sage-grouse populations in this PMU (Bi-State Technical Advisory Committee 2012). There is one documented sighting of greater sage grouse in the Study Area; this is a recent (2014) eBird sighting of nine greater sage grouse (6 males and 3 females) east of I-395 near the intersection with State Route 182. There are many documented telemetry locations in the area between Antelope Valley and Bridgeport Valley (Bi-State Technical Advisory Committee 2012), numerous sightings by birders in the area between Bridgeport Reservoir and Mono Lake (eBird 2013), and a known population in the Fales area, north of Bridgeport Valley along Highway 395 (Hall et al. 2008). While sage-grouse are known to historically occupy sagebrush scrub habitat in the Slinkard Valley Wildlife Area (Little Antelope Valley), no sage-grouse have been observed there since 1987 (Taylor 2011). No studies on what factors limit the greater sage-grouse population in this area were located for this effort; therefore it is unknown whether or not the extent of sagebrush habitat, or some other aspect of their natural history, is limiting their population.

5.2 Yellow Warbler

Yellow warbler (*Dendroica petechial*), a CDFW Species of Special Concern, is a summer resident that breeds throughout much of California, except the Central Valley, southern Californian deserts, and high Sierra Nevada (Zeiner et al. 1990a; Heath 1998, 2008). The largest concentrations of breeding pairs occur in northeastern California, in Modoc National Forest and Shasta County, as well as in the Cascade Range and Sierra Nevada (Heath 2008). The preferred habitat of yellow warbler includes open canopy or deciduous riparian vegetation, often along streams or wet meadows (Heath 2008). This species frequently nests in small willows and alders (*Alnus* spp), and is also associated with cottonwoods, Oregon ash (*Fraxinus latifolia*), and other riparian shrubs and trees, depending upon the geographic region (Zeiner et al. 1990a, Heath 2008). This species also occasionally nests in montane chaparral in open coniferous forests (Heath 2008). Breeding occurs from mid-April through early August, with peak activity in June (Zeiner et al. 1990a). Yellow warblers nest 1–5 m (2–16 ft) above ground, at the bases of branches (branch forks) in small deciduous trees and shrubs, often in willow thickets (Zeiner et al. 1990a, Lowther et al. 1999). Birds forage for insects within the shrub and tree canopy, occasionally feeding on the wing or eating fruit (Zeiner et al. 1990a, Lowther et al. 1999).

There are numerous documented observations of yellow warbler throughout the West Walker River Basin, particularly along the east fork of the Walker River downstream of Bridgeport Reservoir (eBird 2013). Yellow warbler may nest in deciduous riparian vegetation along streams or wet meadows in the West Walker River Basin.

5.3 Mt. Lyell Salamander

Mt. Lyell salamander (*Hydromantes platycephalus*), a CDFW Species of Special Concern, is endemic to California. This species ranges along the crest of the Sierra Nevada Mountains from Sierra Buttes, Sierra County, south to the Franklin Pass area, Tulare County, from 4,000 to 12,000 feet elevation (Stebbins 2003). Habitat is primarily rocky, granite exposures with seeping water, including granite talus, caves, granite boulders, rock fissures, rocky stream edges, cliff faces, and seepages (Stebbins 2003, Nafis 2013). During periods of activity, this species finds cover under flat granite rocks (Zeiner et al. 1988). During winter, retreat habitat is likely within deep rock fissures or under slabs of exfoliating granite (Zeiner et al. 1988).

Mt. Lyell salamander may occur in the westernmost extent of the Walker River watershed above Twin Lakes in the Sierra Nevada near Sonora Pass (BLM et al. 2001, Sharpe et al. 2008, Kattelmann 2012). Since this species' distribution does not currently overlap with the area potentially affected by changes in water transfers in Antelope and Bridgeport valleys, this species will not be discussed further.

5.4 Yosemite Toad

Yosemite toad (*Anaxyrus canorus*), a federal candidate for listing under the ESA and a CDFW Species of Special Concern, is endemic to California. This species is found in the high Sierra, historically from the vicinity of Ebbetts Pass, Alpine County, to south of Kaiser Pass, Fresno County from 6,400 to 11,300 feet in elevation (Jennings and Hayes 1994). Yosemite toad occurs in high montane and subalpine vegetation in relatively open wet meadows surrounded by forests of lodgepole pine (*Pinus contorta*) or whitebark pines (*Pinus albicaulis*) (Jennings and Hayes 1994). Suitable breeding sites are generally in shallow, warm waters found at the edges of wet meadows and ponds, slow moving streams, grassy areas adjacent to lakes, sloughs, and backwaters. These breeding sites are often dominated by short emergent sedges (*Carex* spp.) or rushes (*Juncus* spp.) (Jennings and Hayes 1994). During inactive periods, these toads seek shelter inside abandoned rodent burrows, or in clumps of grasses, sedges, or willows (Zeiner et al. 1988, Stebbins 2003). While they spend most of their time on land, this species is usually found not more than a hundred meters from permanent water (Nafis 2013). Yosemite toad has experienced declines or disappeared from more than 50% of the sites from which it has been documented (Jennings and Hayes 1994).

Yosemite toad may occur in montane meadows near the upper west fork of the Walker River, or the upper east fork of the Walker River in the vicinity of Twin Lakes Reservoir. The large expansive area of wet meadow upstream of Bridgeport Reservoir may provide physically suitable Yosemite toad breeding habitat. However, the likelihood of Yosemite toads occurring in this area is low, since this area is outside of the species' current known distribution (BerkeleyMapper 2013), and is at the lower limit of the species' elevational range. Since this species' distribution does not currently overlap with the area potentially affected by changes in water transfers in Antelope and Bridgeport valleys, this species will not be discussed further.

5.5 Sierra Nevada Yellow-legged Frog

Sierra Nevada [formerly ―mountain"] yellow-legged frog (*Rana sierrae* [formerly *muscosa*]), a highly aquatic frog, is a proposed for listing as endangered under the federal Endangered Species Act, and is state-listed as threatened under CESA. This species ranges from Plumas County, south through the Sierra Nevada, to Inyo County. It is associated with lakes, ponds, and streams in montane riparian, lodgepole pine, subalpine conifer, and wet meadow habitats. Sierra Nevada yellow-legged frogs seem to prefer open, sloping banks of meadow streams, riverbanks, isolated pools, and lake borders with vegetation that is continuous to the water's edge. Tadpoles do not turn into frogs in their first year and may need 3 or 4 overwintering years before metamorphosis (Matthews and Preisler 2010). At high elevations, the species is typically limited to deeper lakes and ponds that do not freeze completely to the bottom, as required for larvae to overwinter, and preferably without predators such as trout (AmphibiaWeb 2013). It appears to be absent from the smallest creeks, probably because these have insufficient depth for adequate refuge and overwintering (Jennings and Hayes 1994). Streams may be important as dispersal corridors (AmphibiaWeb 2013).

Most of the West Walker River Basin is outside of the current known range of Sierra Nevada yellow-legged frog, with the exception of the Twin Lakes area (BerkeleyMapper 2013). The nearest documented occurrence of Sierra Nevada yellow-legged frogs to the West Walker River Basin was at Wolf Creek Lake in 1993 (Wong 1993, as cited in the West Walker River Basin Watershed Assessment), which is approximately 3 miles west of the Mono County border, 8 miles southwest of Topaz Lake, and outside of the Walker River Basin. It is unlikely that Sierra Nevada yellow-legged frogs will be affected by future water management activities in the Walker River Basin. Since this species' distribution does not currently overlap with the area potentially affected by changes in water transfers in Antelope and Bridgeport valleys, this species will not be discussed further.

5.6 Pygmy Rabbit

Pygmy rabbit (*Brachylagus idahoensis*), a CDFW Species of Special Concern, is extremely dependent on sagebrush for both food and shelter throughout the year. This species is uncommon and local in Great Basin habitats of Modoc, Lassen, and Mono counties (Zeiner et al. 1990b. Pygmy rabbits typically occur in dense, tall sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus, Ericameria* spp.), and bitterbrush (*Purshia tridentata*), in deep, friable soils, with good grass and forb cover for summer forage (Bolster 1998). Big sagebrush is highly preferred for feeding, providing up to 99% of the pygmy rabbit's diet in winter (Zeiner et al. 1990b). From mid-summer to fall, a variety of grasses and forbs provides up to 40% of the species' diet (Zeiner et al. 1990b). This species excavates its own burrow, which is unique among rabbits in western North America. The removal of sagebrush to improve rangelands for livestock grazing has made many areas unsuitable for pygmy rabbits (Bolster 1998).

It is likely that pygmy rabbit occurs in the West Walker River Basin. The Study Area is within the range of the species and suitable sagebrush habitat is present.

5.7 Western White-tailed Jackrabbit

Western white-tailed jackrabbit (*Lepus townsendii townsendii*), a CDFW Species of Special Concern, is an uncommon to rare year-round resident of the crest and upper eastern slope of the Sierra Nevada, primarily from the Oregon border south to Tulare and Inyo counties (Zeiner et al. 1990b). Western white-tailed jackrabbit inhabits a variety of habitats, including sagebrush, perennial grasslands, alpine dwarf-shrub, wet meadows, and early successional stages of a variety of conifer habitats (Bolster 1998). This species prefers open or sparsely wooded areas with young or stunted conifers or scattered shrubs, which are used for protective cover during the day (Bolster 1998).

There are historical records for western white-tailed jackrabbit in the West Walker River Basin near the town of Bridgeport, south of the Bridgeport reservoir (CDFW 2013).

5.8 Sierra Nevada Mountain Beaver

Sierra Nevada mountain beaver (*Aplodontia rufa californica*), a CDFW Species of Special Concern, is thought to be the most primitive living rodent. Its populations are local and uncommon in the Sierra Nevada mountains (Zeiner et al. 1990b). This species is typically found in humid and moist, densely vegetated, deciduous riparian corridors in high elevation, and steep, montane riparian-deciduous habitats (Beier 1989, Zeiner et al. 1990b). Populations are often separated by distance and topography (Beier 1989). Sierra Nevada mountain beaver is associated with a dense growth of small deciduous trees and shrubs, wet soil (and/or nearby a water source), and an abundance of herbaceous understory growth (forbs, ferns, berry vines, etc.) (Williams 1986).

Presence of Sierra Nevada mountain beaver in the Walker River Basin is unknown. Habitat may be present in riparian areas along some of the higher-elevation drainages with project diversions; however, it is likely that these areas do not provide sufficient humidity and moisture to support mountain beaver. Since this species' does not likely occur in the project-affected area, this species will not be discussed further.

5.9 American Badger

American badger (*Taxidea taxus*) is a CDFW Species of Special Concern. In California, badgers are uncommon, permanent residents throughout the state except in the humid coastal forests of Del Norte County and the northwest portion of Humboldt County (Harris and Ogan 1997, CDFG 1986). Suitable habitat for badgers is characterized by shrubland, open grasslands, fields, and alpine meadows with friable soils (Zeiner et al. 1990b, Harris and Ogan 1997). A powerful digger, badgers dig burrows in friable soils for cover and frequently use old burrows excavated by other species (Harris and Ogan 1997).

American badger may occur in dry upland habitats of the East and West Walker Basins.

5.10 Mule Deer

Mule deer (*Odocoileus hemionus*) is not federally or state-listed and has no special protections under federal or state law. However, as a big game species, they are a relatively high-profile species and considered valuable as a recreational (e.g., wildlife viewing and hunting) and economic resource for the state. Mule deer are a common to abundant yearlong resident or elevational migrant in California, with a widespread distribution throughout most of the state except for deserts and intensively farmed areas without cover (Zeiner et al. 1990b).

Mule deer habitat requirements include access to water sources, an abundance of herbaceous forage, and cover (e.g., vegetation and/or topography) (NRCS 2005, Cox et al. 2009). They occur in early- to intermediate-successional stages of most forest, woodland, and brush habitats, preferring a mosaic of various-aged vegetation that provides woody cover, meadow and shrubby openings, and free water (Zeiner et al. 1990b). Primarily browsers, the majority of the mule deer's diet is comprised of forbs (herbaceous plants), and leaves and twigs of woody shrubs. Shrubs occur mostly in early succession habitats (those recently disturbed), meaning disturbance is a key element for maintaining high quality deer foraging habitat (Cox et al. 2009). Deer require a reliable source of drinking water, since they need about 2.8 liters (3 quarts) of water per day per 45 kg (100 lbs) of body weight (Zeiner et al. 1990b).

Little Antelope Valley Wildlife Area, often referred to as Slinkard Valley Wildlife Area and managed by CDFW, is home to the West Walker mule deer herd in winter. The Slinkard Valley Wildlife Area Browse Enhancement and Protection Project was undertaken in 2009 by CDFW, BLM, and the California Deer Association to ―(1) protect remaining mixed stands of antelope bitterbrush (*Purshia tridentata*) and big sagebrush (*Artemisia tridentata*) from loss to wildfire by eliminating continuous brush and pinyon pine (*Pinus monophylla*) fuel conditions; and (2) increase browse production by reducing pinyon pine competition and encroachment" (Taylor

2011). Without frequent ground fires to clear out overgrown vegetation, land managers cut back large brush cover and pinyon pine to prevent conversion to pine forest.

6 WILDLIFE: POTENTIAL EFFECTS OF WATER TRANSACTIONS

Water transactions could affect wildlife by changing the density and distribution of vegetation habitats. In Table 6-1, we provide a summary of habitat associated with sensitive wildlife species known or expected to occur in the Study Area. We use this table in combination with the vegetation effects Table 4-3, presented in Section 4. Vegetation - Potential Effects of Water Transactions, in order to assess potential wildlife impacts associated with each of the five water transaction scenarios. Section 1.2 provided a conceptual model linking how changes in diversions may result in changes in groundwater levels, subsequently affecting vegetation and wildlife habitats (Figure 1-2).

Pygmy rabbit, western white-tailed jackrabbit, and American badger are all species well-adapted to living in dry environments with scarce available water. Therefore, no impacts on these species under the various water transaction scenarios are anticipated. The following analyses focus on effects of various water transaction scenarios on greater sage grouse, yellow warbler, and mule deer.

Table 6-1. Sensitive wildlife species in Antelope and Bridgeport valleys and their associated vegetation/habitat types present in the Study Area (* = required habitat).

Common name (*Scientific name*)	**Status[1]: Federal /State**	**Vegetation types in the Study Area**							
		Wet sedge	**Moist grass**	**Dry grass**	**Sagebrush-rabbit brush**	**Barren**	**Early successional riparian**	**Coyote willow**	**Mature cottonwood**
Greater sage-grouse (*Centrocercus urophasianus*)	FC/SSC	✓	✓	✓	✓*	✓*			
Yellow warbler (*Dendroica petechial*)	–/SSC						✓	✓	✓
Pygmy rabbit (*Brachylagus idahoensis*)	–/SSC				✓*				
Western white-tailed jackrabbit (*Lepus townsendii townsendii*)	–/SSC	✓	✓	✓	✓				
American badger (*Taxidea taxus*)	–/SSC			✓	✓				
Mule deer (*Odocoileus hemionus*)	–/–	✓	✓	✓	✓		✓	✓	✓

[1] Status: FC = federal candidate species; FPE = federally proposed as endangered; ST = state threatened; SSC = state species of special concern

[2] Habitat associations may include one or more of the following: breeding, wintering, migrating, and/or foraging habitat.

6.1 Scenario 1. No Irrigation for Full Season

6.1.1 Greater sage-grouse

While greater sage grouse require vast and relatively continuous expanses of sagebrush for food and cover, they are also known to be associated with irrigated areas adjacent to sagebrush habitats. Proximity to water—or vegetation associated with water—may be important to sage grouse in some areas and not in others (Schroeder et al. 1999); accordingly, water availability and sage grouse habitat are not inextricably connected. Water transaction scenarios that result in the replacement of wet sedge or moist grass habitats with sagebrush could increase the extent, availability, and quality of sagebrush habitat required for greater sage grouse; late autumn, winter, and early spring are the seasons when sage grouse are most dependent on sagebrush for both food and cover. Greater sage grouse are also known to use irrigated areas adjacent to sagebrush habitats, since meadows can provide an abundance of succulent forbs for foraging during summer. These areas are especially important during drier summers. In addition to food, herbaceous vegetation also provides cover during the nesting and early brood-rearing seasons. Therefore, a water transaction scenario that suspends all water delivery to irrigated areas or wet meadows may reduce the availability and/or quality of nesting, brood-rearing, and summer foraging habitats. However any potential effects are highly dependent on the current distribution of greater sage-grouse use in the Study Area, which has not yet been determined.

6.1.1.1 Conclusions

There would likely be an increase in the extent and availability sagebrush habitat for sage-grouse, with a possible simultaneous impact on adjacent wet areas used for rearing/cover and summer foraging. It is difficult to ascertain whether the increase in amount and extent of sagebrush would offset the loss of moist, irrigated habitats within the valley floors. Clearly, extensive amounts of sagebrush habitat are available in the surrounding uplands adjacent to the valley edges. Since Sagebrush-Rabbitbrush habitat is currently mapped on less than 20% of the valley bottoms in both Bridgeport and Antelope Valleys, and the Graminoid vegetation types take up most of the remaining area, an increase in Sagebrush-Rabbitbrush habitat would likely increase the amount of area where a combination of both habitat types are available. One could hypothesize that an increase in the amount of area supporting a combination of moist grass and sagebrush could positively affect the greater sage-grouse. However all of this is predicated on the assumption that there is a population of greater sage-grouse that use areas in Bridgeport or Antelope valleys. Studies to determine the distribution and habitat use of greater sage-grouse in the Study Area would be a first step in identifying where potential changes in vegetation might affect the greater sage-grouse. Once determined, a closer examination of how water transactions might affect vegetation in those areas, and if those changes would affect the greater sage-grouse, would be needed.

6.1.2 Yellow warbler

Returning the East and West Walker rivers to their natural hydrograph through suspension of all diversions would positively affect the riparian corridors in both valleys (Section 4.1.2), and increase the amount of available nesting habitat for yellow warbler. The riparian corridor currently occupies a very limited area in Antelope Valley and somewhat more extensive area in Bridgeport Valley (Section 4.1.2). Increased in-stream early to late summer flows could increase the lateral extent and duration of spring flooding, and increase the amount of potential yellow warbler nesting habitat, including willows, alders, cottonwoods, and other riparian shrubs and trees. Conversely, there may be a negative effect on yellow warbler associated with a reduction of coyote willow in non-riparian areas. Coyote willow currently occurs in Antelope Valley in low wet patches in meadows or pastures where water is close to or at the surface, and along many of the unlined irrigation canals or ditches. Roughly one-third and one-fifth of the existing coyote willow habitat could be lost without irrigation over multiple years in Antelope and Bridgeport valleys. These losses could be compensated in both valleys by increases in coyote willow habitat along the riparian corridor (Section 4.1.2).

6.1.2.1 Conclusions

Thus, effects of Scenario 1 transactions on yellow warbler is again mixed, since some increase in habitat could occur along the river corridors, but with a potential loss of habitat in patches and along irrigation ditches in other parts of both valleys.

6.1.3 Mule deer

Mule deer are extremely reliant on water. However, future water transaction scenarios in the Walker River Basin should not change water availability for this species since the West Walker herd is present in the Study Area winter, and changes in water availability from current conditions under various water transaction scenarios would be during March through October. Water transaction scenarios could, however, affect the distribution of forage vegetation if there are long-term landcover type changes. No impacts to foraging habitat are anticipated for the mule deer herd that specifically uses Slinkard Valley in winter, since this area is situated above the flow diversion and no subsequent changes to vegetation would occur.

A few important mule deer forage plants occur in the Study Area, including (but are not limited to) bitterbrush, rabbitbrush, Woods‘ rose, sagebrush, willow, bluegrass, squirreltail, and fescue (Cox et al. 2009). This diet includes a mix of plants adapted to both wet and dry conditions.

6.1.3.1 Conclusions

Therefore, while shifts in the extent and distribution of wet vs. dry-adapted species could occur in the Study Area in response to Scenario 1, this is not expected to affect the mule deer because of their diverse diet. In addition, little-to-no effects are expected on sagebrush-rabbitbrush communities, which include shrubs that are part of the mule deer‘s diet in this region.

6.2 Scenario 1b. No Irrigation for Full Season: Part of Antelope Valley

6.2.1 Greater sage-grouse

Big Slough and Powell HRUs have the greatest area ranked to experience high effects on (i.e., reduction of) Moist Grass and Wet Sedge due to reduced water availability, and ceasing irrigation for multiple consecutive years could lead to increased replacement of dry grasses with sagebrush or with bare ground in these or other HRUs. Overall, the replacement of dry grasses with sagebrush or to bare ground could result in improved habitat quality for greater sage-grouse. Areas currently with a high proportion of Barren/Sagebrush vegetation types (e.g., Carney and Hardy ESUs) would be very resistant to effects of prolonged non-irrigation. Subsequently, any potential effects on greater sage-grouse would be less prominent in these areas. As with Scenario 1a (Section 6.1.1), while there would likely be an overall improvement in the extent and availability of required sagebrush habitat for sage-grouse, there could be a possible simultaneous impact on adjacent wet areas used for rearing/cover and summer foraging. It is problematic to ascertain whether the increase in amount and extent of sagebrush would offset the loss of moist, irrigated habitats, without information regarding distribution and habitat use of the Study Area by greater sage-grouse.

6.2.2 Yellow warbler

Effects on yellow warbler habitat in the riparian corridor depend on the timing and amount of water not diverted from the river. Reduced diversions, particularly during the early and late parts of the irrigation period, could have a noticeable positive effect on the extent and structure of riparian vegetation (section 4.2.2). Big Slough and Powell HRUs both have relatively large areas of coyote willow ranked to have moderately high effects due to reduced water availability; therefore suspended irrigation in these HRUs result in negative effects on yellow warbler habitat associated with non-riparian areas. However, this would be balanced with a potential increased extent of yellow warbler habitat along the river corridor in Antelope Valley.

6.2.3 Mule deer

As with Scenario 1a, little effect is expected on mule deer that may use these areas in winter, since their diet is diverse and changes are not expected to reduce the variety of existing vegetation types used for forage.

6.3 Scenario 2. Late Summer Reduction (after July 1)

Overall, late summer reduction in flows is expected to have minor effects on most natural vegetation types and therefore minor or no effects on dependent wildlife species. Specifically, minor effects to greater sage-grouse habitat are expected with the post July 1 termination of irrigation practices. With no changes in early season flows, recruitment of native cottonwood and willow trees is not expected to change, and therefore potential yellow warbler habitat is expected to remain the same. Minor effects to natural vegetation, and therefore to winter herd mule deer forage habitat, are expected with ending irrigation on July 1.

6.4 Scenario 3. No Irrigation before June 1

Responses of natural vegetation types (and therefore habitat for special-status species of concern) to delayed irrigation would be minor, since Sagebrush- Rabbitbrush habitat would experience negligible effects and Greater Sage-grouse and mule deer are not expected to respond strongly to minor fluctuations in the extent of different graminoid vegetation types. Yellow warbler habitat could increase along the river corridors with increased early season flows expected to support native riparian vegetation.

6.5 Scenario 4. Reduced Irrigation Throughout

Responses of natural vegetation types (and therefore habitat for special-status species of concern) to dry-year irrigation would be similar to those described for Scenario 3, late summer reduction.

6.6 Scenario 5. End of Season Storage Water Release

Storage water releases would occur after the end of the growing season (whole Valley), and would therefore not affect vegetation.

7 FISHERIES

The Walker River basin in California currently supports both native and non-native (i.e., introduced) fish species. The native fish species include trout (specifically Lahontan cutthroat trout, [LCT]) and whitefish (Salmonidae), along with non-game fish species such as sucker (Catastomidae), minnows (Cyprinidae), and sculpin (Cottidae). Introduced fish species primarily include non-native trout (brook, brown, and rainbow), which are planted in various lakes, reservoirs, and stream reaches to provide improved recreational fishing opportunities. Other non-native fish species such as bass and hybrid trout have been introduced into reservoirs in the basin (MCCDD 2007); however are not reported to be distributed within stream reaches subject to the effects of water diversions, and will not be discussed here.

In this document we focus on fish species in stream reaches likely to be affected by water diversions. Below we provide a brief description of the life history, distribution, and habitat requirements of native and non-native fish species potentially affected by irrigation diversions, and summarize potential factors which may limit production of fish populations in affected reaches.

7.1 Fish Life-history Timing

The life-history timing of fish species documented in the Walker River can generally be divided into two groups; (1) fish that spawn in the spring and summer, including rainbow trout and many native non-game species (e.g., Tahoe sucker, Lahontan redside, mountain sucker, Piute sculpin), and (2) fish that spawn in the fall including browntrout, brook trout, and mountain whitefish.

Fish that spawn in the spring and summer (including most native endemic fish species) are generally adapted to take advantage of the snowmelt runoff period, roughly April–July (Figure 7-1). Conditions during this period can offer relatively abundant spawning and rearing habitat and food resources. During the runoff peak, conditions can be unstable with frequently changing flows and habitat conditions. During the receding limb of the snowmelt runoff period, water velocities are on a decreasing trend, and habitat conditions are generally suitable for rearing and growth of early life stages, as well as juveniles and adults.

Fall-spawning fish such as brown trout have fry that emerge during late-winter and early-spring, prior to the peak runoff period. As a result, fry may be susceptible to displacement by high flows occurring during the snowmelt runoff period. However, the tradeoff to their relatively early hatching (and emergence), can give them a longer opportunity to rear and grow compared with spring-spawning fish, and can provide a competitive advantage over other fish of the same age class. This is particularly true for fish that establish hierarchies and actively defend territories; for example, trout species compete with one another for territory.

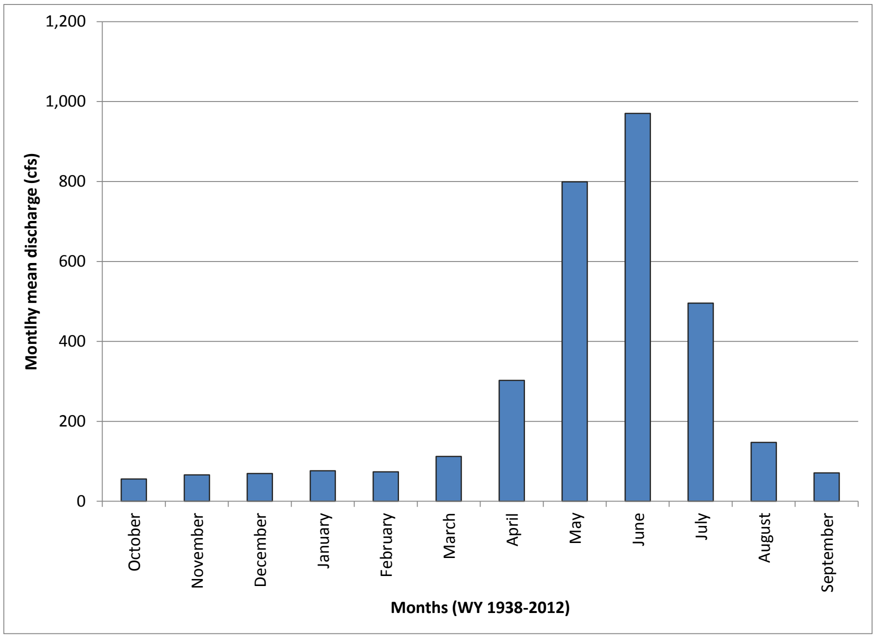

Figure 7-1. Mean monthly flow for the West Walker River (1938–2012) (USGS gage 10296000 W. Walker River near Coleville).

7.2 Native Fish Species

Native fish resources in the Walker River basin include the Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*), mountain whitefish (*Prosopium williamsoni*), mountain sucker (*Catostomus platyrhynchus*), Tahoe sucker (*Catostomus tahoensis*), Piute sculpin (*Cottus beldingii*), Lahontan tui chub (*Siphateles bicolor*), Lahontan redside (*Richardsonius egregious*), and speckled dace (*Rhinichthys osculus*) (MCCDD 2007).

The species descriptions that follow are summarized predominantly from Moyle (2002) which provides a comprehensive summary of these species. Supplementary information used in species descriptions are cited where appropriate. Information on fish species distribution and habitat condition within specific stream reaches in the Walker River basin, however, is limited.

7.2.1 Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*)

Lahontan cutthroat trout are native to the Lahontan basin of northeast California and western Nevada which extends from the Avlord and Coyote Lake basins in the north, to the Humboldt River basin in the east, and to the Carson and Walker river basins in the south. Lahontan cutthroat trout populations currently occupy less than three percent of their historic range, and are listed as threatened under the Endangered Species Act (Federal Register Vol. 40, p. 29864).

Historically, Lahontan cutthroat trout (LCT) were likely the dominant species in the Walker River basin with distribution extending from small headwater streams in the Sierra Nevada to the California-Nevada border and downstream to Walker Lake (USFWS 2009, Kattelmann 2012). Other native fish species were likely occurred throughout most of the LCTs distribution. Currently, the range of LCT in the Walker River has been reduced by over 90%. In the West Walker, LCT are currently restricted to a number of isolated populations in small tributaries draining the east slope of the Sierra Nevada including Slinkard, Mill, Silver, and Wolf creeks (USFWS 2009). In the East Walker, LCT are currently restricted to two small tributary basins draining the eastern Sierra Nevada, Murphy and By-Day creeks (USFWS 2009).

Lahontan cutthroat trout are found in a wide variety of habitats including large desert lakes with high alkalinity (e.g., Pyramid, Walker), relatively warm Nevada desert streams which may exceed 27°C for short periods of time, and alpine lakes and streams with relatively cool water temperatures year-round. Historically, stream-dwelling LCT in California were most often found in cool streams that rarely exceeded 23°C. LCT generally mature in their second to fourth year. Spawning behavior and timing is similar to rainbow trout and occurs during April–July. Eggs hatch in about six to eight weeks, depending on temperature, and emerge about 2 weeks after hatching. Similar to other trout, early fry tend to use shallow margin habitat with low water velocities. As they grow, stream-dwelling LCT tend to utilize deeper habitats and associate with cover.

7.2.2 Mountain whitefish (*Prosopium williamsoni*)

Mountain whitefish are in the family Salmonidae, the same family that contains the salmon, trout and char. Mountain whitefish are distributed throughout western North America, although their distribution within California is limited to a few Lahontan basins draining the eastern Sierra Nevada including the Walker River. They are commonly found in streams with large pools (>1 m depth) and clear cold water, with summer water temperatures of 11–21°C. Populations in California are generally found at elevations of approximately 4,600–7,500 ft, which is within the range of both Antelope and Bridgeport valleys. Mountain whitefish mature at age 2–4 and spawn in the fall (October–early December). Eggs typically take about 6–10 weeks to hatch (or longer) depending on water temperature. After hatching, the young fish are carried downstream into calm habitats such as alcoves and backwaters. As fish grow larger they typically use progressively deeper and faster habitats.

7.2.3 Mountain sucker (*Catostomus platyrhynchus*)

Mountain sucker are native to, and distributed throughout, western North America, although their native distribution within California is limited to Lahontan basin streams draining the eastern Sierra Nevada including the Walker River. Mountain sucker have been recorded at elevations up to approximately 9,000 ft and water temperatures to 28°C. They are characteristically found in relatively shallow streams (< 2ft) of moderate size (3–15 m width). In Lahontan basin streams, their abundance has been found to be positively correlated with pools and negatively correlated with riffles. Male mountain sucker mature in their second or third year, and females in their third or fourth year. Spawning occurs in summer (June–early August) at temperatures of 11–19°C, and young fish use low-velocity areas along stream margins to forage and grow when rearing.

7.2.4 Tahoe sucker (*Catostomus tahoensis*)

Tahoe sucker are native to Lahontan basin streams draining the eastern Sierra Nevada including the Walker River. Tahoe sucker are found in a wide variety of habitats including lakes, reservoirs, and streams. They are frequently found in streams with summer temperatures below 16°C, although they are relatively temperature tolerant and are found in streams exceeding 25°C in summer. Tahoe sucker generally spawn in March–May, and as late as August, when temperatures reach 11–14°C. Spawning success appears to be highest when sustained high flows occur during spawning, and is presumably related to the prevalence of flooded vegetation. Tahoe sucker populations can be limited by egg predation from Lahontan redside and other species.

7.2.5 Piute sculpin (*Cottus beldingii*),

Piute sculpin are widely distributed in the lower Columbia and Snake river basins in Oregon, Washington, Idaho, and Wyoming, and they are the only sculpin native to the Lohantan basin. Piute sculpin tend to prefer clear cold streams with cobble and gravel bed substrate. They have been found in streams with summer water temperatures to 25°C, although are found mostly in streams with temperatures less than 20°C. Piute sculpin typically mature at 2–3 years, and spawn in May–June, depending on water temperature. Juvenile sculpin are benthic feeders, and rear on the streambed and in the interstices of streambed substrate.

7.2.6 Lahontan tui chub (*Siphateles bicolor*)

Lahontan tui chub are considered abundant and widely distributed in habitats of the eastern Sierra Nevada. In the Walker basin (CA) they are likely most abundant in lakes and reservoirs (e.g., Topaz Lake and Bridgeport reservoir), with densities likely decreasing in an upstream direction as gradient, water velocity, and elevation increases, and stream size decreases. Tui Chub are found in waters with a wide range of conditions including total dissolved solids, pH, and dissolved oxygen, and water temperature. They are considered relatively temperature-tolerant, and are typically found in habitat where summer water temperature is greater than 20°C. Tui chub are relatively long-lived, with individuals reaching over 20 years old in some populations (e.g., Eagle Lake, CA). Tui chub typically spawn in shallow water during the spring (April–July). Eggs hatch within 3–6 days and larvae are mainly planktonic. Interestingly, juvenile and adult tui chub in the Lahontan basin display two forms, a benthic form found in streams and lakes which feed on the bottom in shallow water, and a planktiverous form found in lakes and feeds in open water on plankton.

7.2.7 Lahontan redside (*Richardsonius egregious*)

Lahontan redside are native to the old Lahontan basin and present in streams draining the northeastern Sierra Nevada including the Susan, Truckee, Carson, and Walker basins. Lahontan redside are likely distributed throughout most of the reservoir, valley, and upper stream reaches of the Walker basin in California. Lahontan redside become sexually mature at 3–4 years of age. Spawning generally takes place during late-July when water temperature is 13–24°C, although can occur anytime between late-May and August. Fry rear in calm, shallow water. During winter, when water temperatures are <10°C, Lahontan redside retreat to the interstices of streambed substrate where they are relatively inactive. Their abundance can be negatively affected by high winter flows and predation by brown trout.

7.2.8 Lahontan speckled dace (*Rhinichthys osculus*)

Lahontan speckled dace are distributed throughout the northeastern Sierra Nevada. In the Walker River basin, speckled dace are widely distributed in lakes, streams, and reservoirs. They inhabit a wide range of habitat including intermittent streams, small spring and brooks, large rivers, and lakes. They particularly thrive in small streams. Speckled dace are relatively temperature tolerant, with some populations commonly surviving summer water temperatures of 25–30°C. Speckled dace can spawn throughout the summer, with most spawning occurring in June and July. Eggs generally take about a week to hatch and another week before fry emerge from bed substrate. After fry emerge they tend to use warm shallow water habitats for rearing. Speckled dace are common forage for brown trout which can reduce population abundance or restrict their range.

7.3 Non-native Fish Species (Introduced Trout)

Non-native trout have been introduced to streams lakes and reservoirs in the Walker River basin, and continue to be stocked in some locations to improve recreational fishing opportunities (Milliorn et al., 2004, as cited in MCCDD 2007; EWRTC 2008). Due to the wealth of information on the life history, regional distribution, and habitat requirements of these trout species, we did not attempt to provide a comprehensive summary here; rather we provide a summary consistent with those for the native fish species (above) and relevant to the assessment. Information on the distribution of non-native trout within specific stream reaches in the Walker River in California is limited.

7.3.1 Rainbow trout (*Onchorhynchus mykiss*)

Non-native rainbow trout are widely distributed in the Walker River basin and considered a prized sport fish. Rainbow trout densities in stream reaches are likely highest in the larger streams and valley reaches, with decreasing in abundance moving upstream. Rainbow trout generally prefer habitats with cool, clear water. Optimal temperatures for growth are around 15–18°C, and water temperature above 20–22° generally become stressful. Rainbow trout typically spawn in the spring by burying eggs in stream gravels. Eggs typically take about 3–4 weeks to hatch and emerge as fry 2–3 weeks later, although times vary depending on water temperature. Fry prefer shallow water with low water velocity, and use deeper and faster water as they grow.

7.3.2 Brown trout (*Salmo trutta*)

Brown trout are native to Europe and have been introduced throughout North America. They are widely distributed in the Walker River basin, with their distribution generally overlapping with rainbow trout. Brown trout generally have similar habitat and temperature requirements as rainbow trout, although brown and rainbow trout life history timing differ in that brown trout spawn in the fall. The difference in spawning time affects the relative timing of the early life stages of these species, such that juvenile brown trout during their first summer are typically larger than rainbow trout at any given time, which can give brown trout a competitive advantage over rainbow trout. Adult brown trout tend to be more of a nocturnal predator compared with rainbow trout, and largely piscivorous at larger sizes.

7.3.3 Brook trout (*Salvelinus frontinalis*)

Brook trout are native to the northern half of the eastern Unites States and eastern Canada and have been introduced throughout much of the United States and Canada. In the Walker River basin, brook trout are widely distributed in lakes and streams, and tend to dominate in the smaller headwater streams. Brook trout generally have similar habitat and temperature requirements as rainbow and brown trout, and like brown trout, typically spawn in the fall with the timing dependent on water temperature. Brook trout can be highly territorial and aggressive, and have been identified as a factor in the decline and limited remaining distribution of LCT (USFWS 2009).

7.4 Limiting Factors

Potential factors currently limiting the production of native and non-native fish populations in the East Walker and West Walker rivers have been attributed to ice formation in winter, high flow in spring and early summer, high water temperature in summer and fall, low stream flow due to drought and irrigation diversions, entrainment into diversions, and habitat alteration due to land management (e.g., cattle grazing) (USFWS 1995, USFWS 2009, MCCDD 2007). Species interactions, including competition for food and space, as well as direct predation on fish and/or eggs, also potentially limit native and non-native fish populations (USFWS 2009, MCCDD 2007).

Ice and snow are potentially affect the distribution and abundance of fish resources in some stream reaches. Ice formation on the bed (anchor ice), in the water column (frazzle ice), and along the banks can strongly influence winter survival. In addition, snow and ice along channel banks may concentrate high flow and exacerbate bed scour (MCCDD 2007). Since this assessment focuses on the effects of potential changes to diversions on habitat availability, and the diversion season extends from March to October, factors potentially limiting fish populations in winter are not a focus of this report.

Water temperature has been identified as a potential factor limiting fish habitat quantity and quality in affected reaches, and relative differences in water temperature related to potential changes of diversion flows is considered. Other water quality parameters, such as the effects of nutrients and dissolved oxygen levels, are not considered.

7.4.1 Lahontan cutthroat trout

The decline of LCT in the West Walker basin has been attributed to changes in streamflow, channel conditions, and overfishing (Knapp 1996, as cited in USFWS 2009), as well as hybridization and competition with introduced trout (Gerstubg 1988, as cited in USFWS 2009). Population and habitat fragmentation is currently a primary concern with regard to the vulnerability of the existing LCT populations.

7.4.2 Native fish

Other native fish species are likely limited by winter ice conditions, seasonal high flows, entrainment into diversions, and interspecific interactions with other fish, particularly non-native trout. High summer water temperatures could affect mountain whitefish, but is likely not a major source of stress or mortality for other native fish species due to their relatively high temperature tolerance, although other water quality elements may influence survival.

7.4.3 Non-native trout

Under existing conditions, non-native brown and rainbow trout populations in the Walker basin (CA) are likely limited by winter ice conditions (physical and bioenergetics), high flows (displacement), entrainment into diversions, habitat quantity and quality during summer and fall, and water quality/temperature late summer. The extent to which specific factors affect population abundance would likely depend on seasonal climactic and hydrologic conditions. During wet water years, high flow conditions likely have a strong influence on survival, whereas during warm and dry water years, summer habitat conditions may be more limiting to survival. During particularly cold winters, ice conditions may be have a particularly strong influence on survival; although this factor would not be affected by diversions.

Physical habitat conditions such as complex pool and backwater habitats can also affect survival, particularly during periods of low and high flow. Riparian conditions can provide shade and moderate temperatures, as well as provide channel complexity.

In addition to the physical factors described above, adult rainbow and brown trout may struggle bioenergetically to maintain their condition from year to year. In particular, spawning can be extremely energetically demanding, and surviving through spawning to the next growing season may limit adult brown and/or rainbow trout populations. Brown trout spawn in the fall, and winter is often a poor time for improving condition. Therefore, it may be difficult for adult brown trout to maintain their condition through winter until food resources and water temperatures increase in the spring. Rainbow trout spawn in the spring, and their condition going into spawning may determine whether they are able to survive spawning. As a result, adult rainbow trout condition going into winter is critical to their survival, and highlights the importance of the spring–fall growing season.

8 FISHERIES: POTENTIAL EFFECTS OF WATER TRANSACTIONS

8.1 Approach

To assess the potential effects of different water transaction scenarios on fish resources in the Walker River basin, we consider flow magnitude and timing in relation to the life history timing of fish expected to be present within affected reaches. The general approach is to evaluate changes between current flow conditions and potential future conditions expected under an alternative flow/diversion scenario as they relate to the fish species of interest, during times when habitat conditions are potentially limiting. Stream reaches likely to show substantial changes in aquatic habitat conditions as a result of water transactions are the focus of the assessment. Since the irrigation/diversion season extends from March 1 to October 31 in the Antelope Valley, and March 1 to September 15 in the Bridgeport Valley, we focus this assessment on potential impacts during these periods.

Fish species documented or likely to be present in the Bridgeport and/or Antelope valley reaches, and subject to effects of diversions, include non-native brown and rainbow trout, as well as mountain whitefish, Tahoe sucker, speckled dace, Lahontan redside, mountain sucker, and Piute sculpin (Milliorn et al., 2004, as cited in MCCDD 2007). These comprise the focal fish species for the assessment of valley reaches. Lahontan cutthroat trout is the focal species for the assessment of Lost Canyon and Mill creeks.

Fish habitat conditions are qualitatively assessed based on the relative quantity and quality of habitat available during key life stages of the focal fish species. Only substantial shifts in estimated habitat quantity and/or quality are considered during the assessment due to uncertainties resulting from data limitations. Note that potential benefits to fish populations resulting from possible water transactions scenarios focus on relative changes to flows and habitat conditions rather than specific habitat or water quality (e.g., temperature and nutrients) conditions. For the purposes of this assessment, we discuss trout (native and non-native) separately from the other native fish species (sucker, minnow, and sculpin), due to the economic importance of trout for recreation, and the similar habitat requirements among trout species (however we note where differences in life history are important).

Note that available data to support the assessment of the potential effects of water transactions on fish resources in the Walker River basin are sparse. The approach described above, and assessment presented below, is based primarily on (rough) flow estimates, general regional climactic conditions, general life history and habitat requirements of focal fish species from studies mostly done elsewhere, and professional judgment. The information that would be required to make strong informed conclusions about water transactions on fish populations would include: fish sampling (species abundance, size, and age distribution), flow management (diversion timing and volume), streamflow (in-channel and accretion flow), aquatic habitat conditions (habitat frequency, cover, and complexity), flow-habitat relationships for focal fish species and life stages, entrainment (season and flow), and water quality (temperature and nutrients). This data would form the basis of a more comprehensive assessment of the factors controlling fish populations, and could lead to additional information needs such as food availability and bioenergetics modeling to understand key linkages between fish habitat and population abundance.

8.2 West Walker (Antelope Valley)

Based on available information of fish distributions and diversion locations in the West Walker River, we focus this assessment on reaches that extend through Antelope Valley from the Main Canal diversion downstream to Lake Topaz. Focal species for Antelope Valley include rainbow and brown trout and several native fish species. Native LCT distribution does not extend downstream into the Mainstem Walker River in Antelope Valley, and non-native brook trout are likely in greater abundance in the smaller tributary streams upstream of the valley. Since brook trout have a fall-spawning life history similar to brown trout, the effects of water transactions on habitat quantity and quality for these two species can be considered the same.

In the West Walker basin, the primary points of diversion are located near the upstream end of Antelope Valley near the town of Walker (Figure 8-1). Combined, the upper-valley diversions (Main Canal downstream to West Goodnough) account for approximately 75% of the allocated rate of diversion (Ecosystem Economics 2014). From Walker downstream to the town of Coleville (about 4 miles), two diversion ditches (Harney and Alkali) account for approximately 5% of the allocated rate of diversion. The Swauger/Rickey diversion, located about 1 mile downstream of Coleville, and about half way down Antelope Valley between Walker and Lake Topaz (referred to here as the valley reach), accounts for about 15% of the allocated rate of diversion.

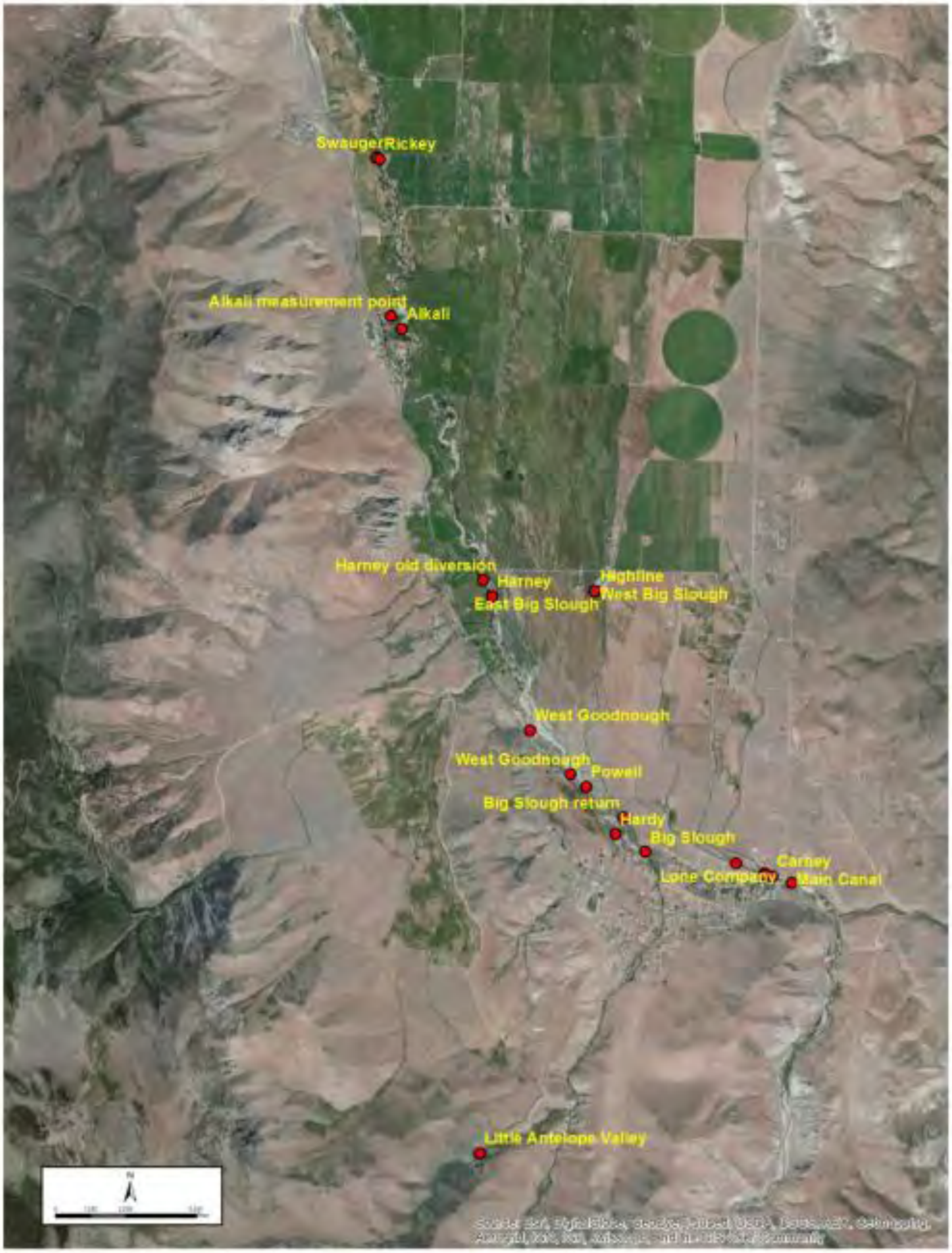

Figure 8-1. Points of diversion in upper Antelope Valley and Lost Canyon Creek (Little Antelope Valley).

To understand the potential effect of water transactions on fish habitat and populations in the West Walker River through Antelope Valley, we developed flow estimates based on USGS gage data (Coleville gage), and the allocated rates of diversion based on the water use analysis

(Ecosystem Economics 2014), using daily mean values during the diversion season (March 1–October 31). To assess the potential range of conditions expected under different hydrologic conditions, we consider a range of representative water year types (i.e., dry, mid, and wet), using 2002, 2010, and 2005 to represent dry, mid, and wet water year types, respectively. These years were selected to be consistent with the vegetation impact assessment described in Section 4, as well as other assessments in the Walker basin (e.g., Boyle et al. 2009, Ecosystem Economics 2014). We use the combined allocated rate of diversion from Main Canal to Swauger/Ricky, which represents the majority of diverted flow in the Antelope Valley downstream to the Topaz diversion (Figure 8-1).

In some cases, this approach results in the allocated rate of diversion exceeding flow measured at the Coleville gage (Figure 8-2). This typically occurs early and late in the season, and not during the April–August period. It was most pronounced during March in all study years (2002 [dry], 2005 [wet], and 2010 [mid]), September and October 2005 (wet), and September 2010 (mid). During these periods, we do not infer conditions relative to flow at the Coleman gage. During much of the irrigation season (April–August), this approach may provide a reasonable flow estimate immediately below the Swauger/Ricky diversion, although it clearly over estimates the rate of diversion between the Colevlle gage and the Swauger/Ricky diversion. Despite issues with the accuracy of estimated flow values, the results are useful for identifying periods when diversions are most likely to affect habitat quantity and quality for focus fish species.

Irrigation returns supply accretion flow to the West Walker River throughout the Antelope Valley reach, resulting in incremental changes to flow and habitat. However, available information is not sufficient to accurately determine spatial differences in accretion within the valley reach. Without this information, it was not possible to discern meaningful spatial differences in habitat quantity and quality along the valley reach; therefore we focus this assessment on the valley reach as a whole.

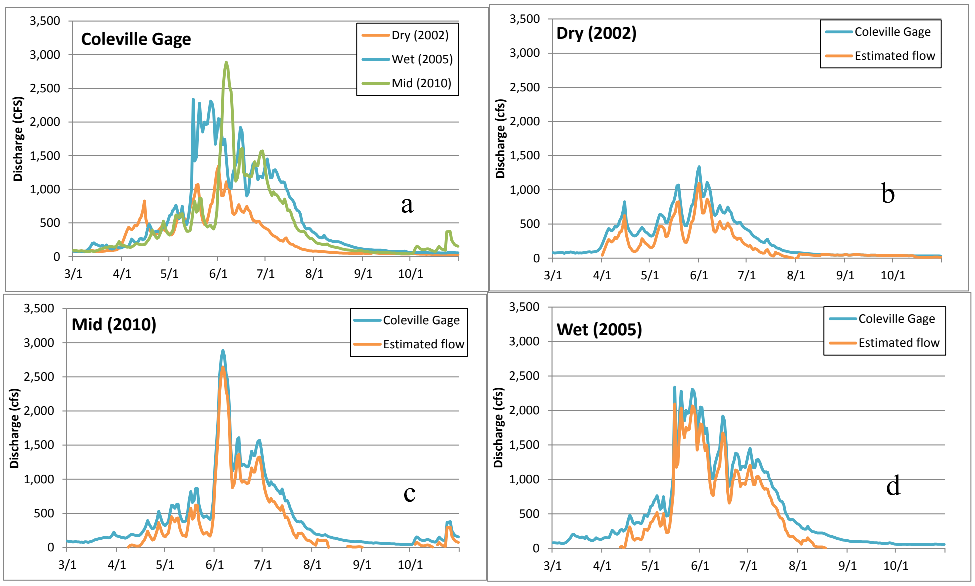

Figure 8-2. Daily average flow hydrograph for the irrigation diversion season (March-October) for the Coleville gage (USGS gage10296500) during representative dry (2001), mid (2010), and wet (2005) water year types (a); estimated flow in the West Walker River for the irrigation season based on the allocated rate of diversion from Main Canal to Swauger/Ricky in representative dry (b), wet (c), and mid (d) water years.

Based on the estimated flow in the West Walker downstream of major diversions compared with flow at the Coleville gage, the effects of diversions on habitat availability are likely to be most pronounced during periods when flow at the Coleville gage is low (e.g. March–April and July–October). During the snowmelt runoff period, when flows are relatively high (May–June), the effects of diversions on habitat quantity and quality are expected to be relatively small. Early in the season (March–April), water temperatures are expected to be cool, and within a range considered suitable for all native and non-native fish species present. July and August are likely critical months since decreasing flows and associated higher water temperatures could substantially effect habitat availability. Although water temperature will likely have cooled from summer highs, habitat availability could continue to limit fish population carrying capacity and abundance through September and October.

8.2.1 Scenario 1a. No Irrigation for Full Season: Whole Valley

In this scenario, all areas are kept out of irrigation for the entire growing season.

In general, unregulated flow conditions (i.e., Scenario 1a) would be expected to benefit both native and non-native fish species. Based on the timing and magnitude of diversions and the resulting estimated flow in the West Walker River through the Antelope Valley, benefits to non-native trout and native fish species are expected to be greatest in the summer during the receding limb of the annual hydrograph when water temperatures are expected to be highest (July–August), and in the fall when flow is relatively low and habitat quantity is expected to be correspondingly low (September–October). Available data offers little information on the extent to which diversions might affect habitat quantity and quality early in the irrigation season (March).

8.2.1.1 Trout

Non-native brown and rainbow trout would likely benefit under Scenario 1. Increased base flows during the receding limb of the annual hydrograph (July–August) could increase food production and growth during this period, and improve the general condition of trout going into fall and winter. During August–September (depending on water year), increased base flow would be expected to increase the quantity of available habitat. Under this scenario, the period when water temperatures are favorable for trout growth could also extend later in the year. For example, flows in the 100–500 cfs range could be extended by a few days to a month, depending on flow and water year. Since brown trout spawn in the fall, an extended growing period could improve their condition for spawning. Notably, in dry water years (e.g., 2002), when conditions are likely to be most limiting, diversions might be suspended due to low flow, diminishing the contrast between conditions under this scenario and under existing water management (assuming that in-stream flows are equally affected with late-summer suspended diversions). For example, the water use analysis indicates that diversions would have been suspended from approximately August 18 through October 14, 2002 (Ecosystem Economics 2014).

Entrainment into diversions would presumably be eliminated under Scenario 1. Young fry with relatively poor swimming ability would be particularly vulnerable to entrainment. Therefore, based on their life history timing, rainbow trout fry could possibly benefit a bit more from Scenario 1 compared with brown trout, although all species and age classes could be susceptible to entrainment.

8.2.1.2 Native fish

Native fish in Antelope Valley would likely benefit under Scenario 1, primarily during the summer and fall when increased base flows would likely increase the quantity and quality of habitat available for rearing and growth. Entrainment into diversions would presumably be eliminated, and young age classes with relatively poor swimming ability would potentially benefit more compared with older age classes. In general, warm water temperatures are not expected to limit production of native fish due to their relatively high temperature tolerance, with the possible exception of mountain whitefish.

8.2.1.3 Conclusion

Of the scenarios evaluated and described below, Scenario 1a would be expected to provide the greatest benefit to native and non-native fish species by eliminating the effects of reduced flow in the West Walker River on fish habitat quantity and quality, and eliminating the possibility of entrainment. The greatest benefits to fish are expected during summer and fall (July–October). Potential benefits during the early irrigation season (March–June) are uncertain.

8.2.2 Scenario 1b. No Irrigation for Full Season: Part of Antelope Valley

In this scenario, particular areas in Antelope Valley are kept out of irrigation for the entire growing season.

Scenario 1b would likely provide benefits to native and non-native fish in Antelope Valley in-line with those described in Scenario 1a above. However, the relative degree of any potential benefit would presumably be correlated with the volume and location of the diversion (i.e., larger diversion volumes would have a larger effect on habitat quantity (area) and quality, and diversions further upstream would affect a greater linear distance of habitat). Flow-habitat relationships for native and non-native fish species have not been developed for the West Walker in Antelope Valley (or Bridgeport Valley), and therefore, the potential effect of specific water transactions on fish habitat quantity and quality (in general, or for specific subreaches) is not well understood; specifically, the extent to which small volumes of water may provide incremental benefits to habitat quantity and quality is not known. As a result, potential effects from implementing Scenario 1b include a high degree of uncertainty regarding potential incremental benefits that may result from specific water transactions.

To understand the potential for incremental increases in flow to affect habitat quantity and quality would require information on habitat conditions in the West Walker River through Antelope Valley including: flow-habitat relationships for target fish species and life stages, water quality monitoring data, flow management (diversion timing and volume), and streamflow (in-channel and accretion flow.

8.2.2.1 Conclusion

Scenario 1b would likely provide benefits to native and non-native fish species in Antelope Valley, with the relative level of benefit likely dependent on the volume and location of diversion(s) included. Similar to Scenario 1a, the greatest benefits to fish would be expected during summer and fall (July–October), and the potential benefits during the early irrigation season (March–June) are uncertain.

8.2.3 Scenario 2a. Late Summer Reduction (after July 1): Whole Valley

Irrigation continues through July 1 but is shut off for the second half of the growing season.

Scenario 2a would likely provide benefits to native and non-native fish in Antelope Valley in-line with those described for Scenario 1a. Scenario 2a would affect habitat conditions during those periods most likely to benefit native and non-native fish species; in the summer during the receding limb of the annual hydrograph when water temperatures are expected to be highest (July–August), and in the fall when flow is relatively low and habitat quantity is also likely near its lowest level (September–October). Entrainment potential at diversions in Antelope Valley in relation to flow and fish species life history timing patterns is unknown.

8.2.3.1 Conclusion

Scenario 2a would likely provide the majority of the benefits to native and non-native fish described in Scenario 1a, while maintaining irrigation diversions through the first half of the season. The extent to which entrainment potential may be reduced under Scenario 2a is uncertain.

8.2.4 Scenario 2b. Late Summer Reduction (after July 1): Part of Antelope Valley

Irrigation continues through July 1 but is shut off for the second half of the growing season in only part of the valley.

Scenario 2b would likely provide benefits to native and non-native fish in-line with those described for Scenario 2a, with the relative level of benefit likely dependent on the volume and location of diversion(s) included. Available information is insufficient to assess potential incremental benefits to habitat quantity and quality that may result from specific water transactions. As a result, potential effects from implementing Scenario 2b include a high degree of uncertainty. Entrainment potential at diversions in Antelope Valley in relation to flow and fish species life history timing patterns is unknown.

8.2.4.1 Conclusion

Scenario 2b would likely provide benefits to native and non-native fish, with the relative level of benefit likely dependent on the volume and location of diversion(s) included. Irrigation diversions through the first half of the season would be maintained. The extent to which entrainment potential may be reduced under Scenario 2b is uncertain.

8.2.5 Scenario 3. No Irrigation before June 1

Irrigation is shut off for the first half of the growing season in either all or part of Antelope Valley.

Scenario 3 is not likely to provide substantial benefits to native or non-native fish species in Antelope Valley, whether this is implemented across the entire or part of the valley. As stated above, potential benefits to non-native trout and native fish species would be expected to be greatest in the summer when water temperatures are highest, and in the fall when flow is relatively low. Scenario 3 would not affect habitat conditions for fish resources during these critical periods.

There is currently little information on the extent to which diversions may affect habitat quantity and quality early in the irrigation season based on available data, particularly in March. Based on the allocated rate of diversion during our test years (2002, 2005, 2010), flows appear to be over allocated during most, if not all, days in March (all days in March were over allocated during test years). Therefore, diversions in March are generally less than the allocated rate of diversion, and likely to be substantially less than the available flow at the Coleville gage. Stream gage data (Coleville gage) indicates that flows generally remain relatively low through March and therefore, habitat limitations resulting from diversions would be possible during this time, depending on the diversion volume. However, stream gage data (Coleville gage) also indicate that flows during September–October are generally substantially lower than in March, and therefore, habitat near the end of the irrigation season (September–October) is likely more limiting than it would be in March. In addition, water temperatures (and bioenergetic requirements) are also generally higher late in the season compared with March.

It is possible that early-season flow increases could improve conditions for non-native rainbow trout and other native species that spawn in the spring, by improving their condition prior to spawning, and thus increasing post-spawn survival. Eliminating diversions during March–June would eliminate entrainment during this period. Presumably, early fry would be most susceptible to entrainment due to their poor swimming ability, although entrainment patterns in Antelope Valley are unknown.

8.2.5.1 Conclusion

Scenario 3 is not likely to provide substantial benefits to native or non-native fish species in Antelope Valley because the effects would occur during periods when habitat conditions are not likely limiting to fish populations. The potential effects of Scenario 3 on fish entrainment and condition during March–June is uncertain.

8.2.6 Scenario 4. Reduced Irrigation Throughout

Under this scenario, irrigation proceeds every year using dry year water allocations. Scenario 4a assumes this occurs across the whole valley while Scenario 4b assumes it occurs in a subset of the valley.

Scenario 4a is likely to provide benefits to native and non-native fish species, however the relative difference between Scenarios 1 and 4 is unknown, and would depend on available flow and the allocated rate of diversion for each priority water right set by the Federal Water Master on a daily basis. Daily allocated rates of diversion set by the Federal Water Master do not follow a simple approach or formula; therefore, flow for the Walker River under Scenario 4 could not be estimated. Presumably, there would be no difference between Scenarios 1a and 4a, and 1b and 4b, during dry water years. During mid and wet water years, there could potentially be substantial benefits. Based on the average proportion of the allocated rate of diversion (Main Canal-Swauger/Ricky) to flow at Coleville gage to during the irrigation season in test years (33% [dry], 47% [mid], and 39% [wet]), the greatest benefits would potentially occur during mid-water years, which, comprise approximately 50 percent of years.

Scenario 4b would likely provide benefits to native and non-native fish in mid and wet years, with the relative level of benefit likely dependent on the volume and location of diversion(s) included.

8.2.6.1 Conclusion

Scenario 4 would likely provide benefits to native and non-native fish in mid and wet years. The extent to which entrainment potential may be reduced under Scenario 4 is uncertain.

8.2.7 Scenario 5. End of Season Storage Water Release

Storage water releases occur after the end of the irrigation period (whole Valley).

As stated above, potential benefits to non-native trout and native fish species in the Antelope Valley would likely be greatest in the summer when water temperatures are expected to be high, and in the late-summer and fall when flow is relatively low and habitat availability likely most limiting. Scenario 5 would not affect habitat conditions for fish resources during the critical summer and fall periods. Therefore other scenarios (Scenarios 1, 2, and 3) have the greatest potential to improve conditions for fish populations in the Antelope Valley.

The extent to which a release of stored water at the end of the irrigation season would improve conditions for native and non-native fish populations is uncertain. The magnitude and duration of such a release would likely be important to the overall benefit to fish populations. Scenario 5 would presumably increase flows above those present under natural (unregulated) conditions for some period of time, depending on available storage volume. Flow in the West Walker at the Coleville gage are typically relatively low at the end of the irrigation season, and average about 70 cfs in November (Figure 7-1), although conditions vary by water year type. Average monthly flow in November during test years were 45 cfs in 2002 (dry), 74 cfs in 2005 (wet), and 57 cfs in 2010 (mid).

Based on flow conditions at the Coleville gage during test years, late-season flow increases can occur naturally. During 2010, approximately three relatively small flow events occurred during October, with daily average flow at the Coleville gage ranging up to about 375 cfs, presumably from storm precipitation (Figure 8-2). Naturally, such low duration flow events likely bring with them a flush of cool water, and potentially a spike in terrestrial and aquatic food items. In addition, an increase in flow would presumably increase habitat quantity.

Short-duration flow increases from upstream storage of less than a week would likely have a similar effect to a natural freshet by increasing food and habitat availability during the release period. Such an event is not likely to have a great benefit to fish populations due to the relatively short duration, although the extent to which increased food availability could transfer to improved condition prior to spawning could have a benefit to fall spawning fish, particularly in drier years with stressful late-summer and fall conditions.

Long-duration releases of a week to about a month, would likely show a greater benefit compared with a short-duration release, although the effects are uncertain, and likely dependent on the duration of release, water temperature (related to bioenergetics), and when the release occurs in relation to spawning (specifically for fall-spawning species such as brown trout and mountain whitefish).

8.2.7.1 Conclusions

Fall releases could have a positive impact on fish species occupying reaches below the point of release. The degree of positive effect would be greater for fall-spawning species (e.g. brown trout and mountain whitefish), and would largely depend on the duration and volume of the release.

8.3 East Walker (Bridgeport Valley)

In the East Walker basin, streams enter Bridgeport Valley from many directions, and diverge into distributary channels and irrigation ditches which are largely ungauged. Points of diversion within Bridgeport Valley are not well documented, thus making an assessment of water transactions effects on fish resources extremely difficult. In addition, there is no available information on rates of diversion in Bridgeport Valley, thus introducing additional uncertainty regarding when, and to what extent, irrigation diversions (and water transactions) are likely to affect fish habitat conditions.

Due to this lack of information, we did not attempt to evaluate the potential effects of water transactions on fish resources in the East Walker River basin for specific streams or reaches. Rather we relied largely on the assessment for the West Walker River in Antelope Valley because we believe the potential effects that could be expected as a result of water transactions in Bridgeport Valley would be similar. We attempt to describe where differences between Antelope and Bridgeport Valleys are known or likely, and to summarize how these differences might influence conclusions regarding the effect of water transactions on fish resources. Similarities and differences relevant to this assessment are described below.

The irrigation season in the Bridgeport Valley extends from March 1 to September 15 and, therefore, is slightly shorter than in Antelope Valley. The shorter irrigation season likely corresponds to a shorter growing season in the Bridgeport Valley. The elevation of Bridgeport Valley is approximately 6,500 ft, which is about 1,500 ft higher than Antelope Valley. This elevation difference generally translates to cooler expected temperatures rear-round in Bridgeport

Valley streams. It may also indicate harsher conditions in winter related to snow, ice, and freezing.

The annual hydrograph in the Bridgeport Valley is generally similar to that of Antelope Valley, with low flows persisting from about November through February, flows slowly increasing during March–April as snowmelt begins, relatively high flows resulting from snowmelt runoff during May–July, and flows receding during August–October (Figure 8-3). Overall, differences in flow magnitude between Bridgeport and Antelope valleys are uncertain because the many streams which supply water to Bridgeport Valley are not gaged. A notable difference in fish habitat characteristics between Bridgeport and Antelope valleys is that Bridgeport Valley has four (or more) major natural channels running through the valley whereas Antelope Valley only has one, the West Walker River. As a result, stream channel dimensions in Bridgeport Valley are smaller, and fish habitat characteristics (e.g., pool depth, extent of undercut bank) may differ substantially between the two valleys. Such differences in channel size and flow capacity have a strong influence on sediment transport capacity and bed substrate characteristics, as well as overall channel morphology, which can all influence fish habitat conditions.

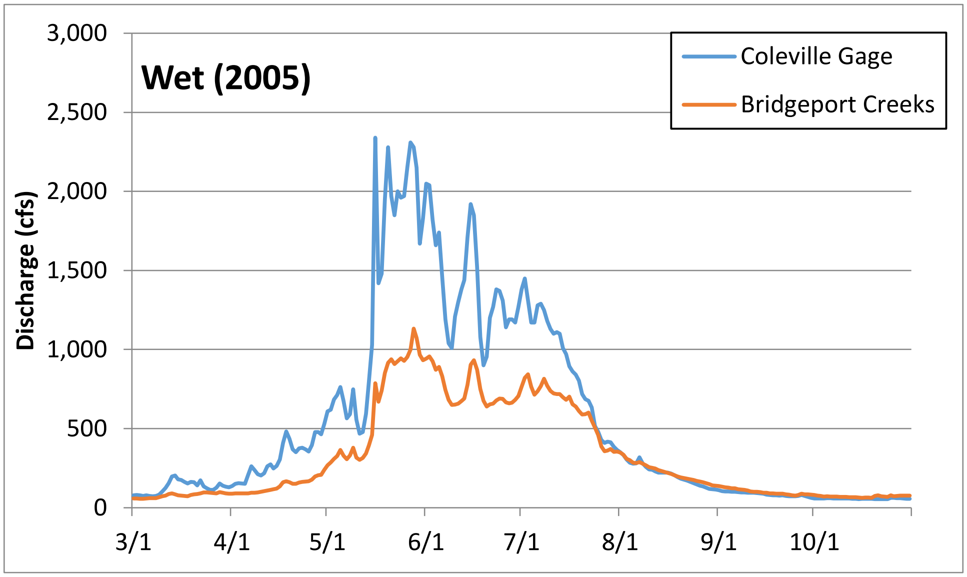

Figure 8-3. Daily average flow hydrograph for March-October at the Coleville gage (USGS gage 10296500) in Antelope Valley, and for four of the main tributaries to Bridgeport Valley (combined) during a representative wet (2005) water year.

Fish resources in Bridgeport Valley were generally considered to be similar to those addressed for the Antelope Valley above, although it is possible that the presence or relative abundance of certain species might be quite different. Based on the hydrology of streams in the Bridgeport Valley, its elevation, and regional climate, we expect the potential benefits to non-native trout and native fish species from water transactions would be greatest in the summer when water temperatures are high, and in the fall when flow is relatively low. The elevation of Bridgeport valley likely influences water temperatures such that there may be a shorter period of time when water temperatures are not favorable for fish growth (particularly salmonids) during the irrigation season, compared with Antelope Valley. Based on available information, the potential effects of water transactions on fish resources in the Bridgeport Valley would likely be similar, in general, to those outlined above for the West Walker River in Antelope Valley.

There is insufficient information on conditions in Bridgeport Valley to draw different conclusions than those described for Antelope Valley regarding the potential effects of water transactions on fish resources. Therefore, we do not include scenario-specific descriptions. Additional information similar to that described in Section 8.1.1 above for Antelope Valley, would be needed to develop strong conclusions regarding the effects of various water transaction scenarios on fish resources in the Bridgeport Valley.

8.3.1 Twin Lakes

Twin Lakes provide upper watershed storage for the Bridgeport Valley, and it is possible that water storage here, and other upstream storage reservoirs, could be managed differently if sale incentives for stored water were to change. Twin Lakes also provides a popular recreational fishery, having established resorts and campgrounds near the lakes and along Robinson Creek. Humwell Dam was built on Robinson Creek in 1888 to increase the size and water storage capacity of Lower Twin Lake for stock watering and irrigation in Bridgeport Valley, about 10 miles downstream (Case Study Report #48, no date.). Water storage capacity on Upper Twin Lake has also been increased. Based on available information, upper and lower Twin Lakes would likely maintain mean and maximum depths sufficient to provide suitable water temperatures during the irrigation season for resident trout survival, during years when maximum drawdown is reached (Table 8-1). The long term effect of annual maximum drawdown on existing fish populations in Twin Lakes and Robinson Creek are uncertain.

Table 8-1. Hydrographic Data, Twin Lakes, Mono County (Table recreated from: (CDFG no date, *A progress report of the Twin Lakes kokanee salmon and catchable trout fishery*)

	Lower Twin Lake	Upper Twin Lake
Elevation at spill level	7,076 feet	7,096 feet
Area at spill level	375 acres	265 acres
Mean depth at spill level	50 feet	50 feet
Mean depth at maximum drawdown	47 feet	36 feet
Maximum .depth	149 feet	112 feet
Volume at spill level	18,800 acre-feet	12,455 acre-feet
Estimated average discharge	33.0 cfs	28.0 cfs

Historic information indicates that flows in Robinson Creek downstream of Twin Lakes may reach zero in dry years, however, flow greater than zero is generally maintained to support the recreational fishery and associated businesses (Case Study Report #48, no date). The extent to which stored water sale incentives would change management of flow into Robinson Creek is uncertain; however, it appears that flow could reach zero, which could result in impacts to fish populations in Robinson Creek downstream of Twin Lakes.

8.3.2 Conclusions

The potential effects of water transactions on fish resources in the Bridgeport Valley would likely be similar to those outlined above for the West Walker River in Antelope Valley. However, very little information is available on aquatic habitat and stream hydrology in Bridgeport Valley, and a survey of channels and site conditions, along with flow information would be needed in order to develop a more refined assessment of potential water transaction impacts to fisheries for this area.

The effects of changes to stored water sale incentives on management of reservoir storage and stream flow release on fish resources in Twin Lakes and Robinson Creek is uncertain. Available information suggests that flow in Robinson Creek could be reduced to zero, particularly in dry water years.

8.4 Mill Creek

A diversion on Lost Canyon Creek (Little Antelope Valley) above its confluence with Mill Creek, provides irrigation supply to Little Antelope Valley, and affects flows in Mill Creek from the confluence with Lost Canyon Creek downstream to the West Walker River near the town of Walker, a distance of approximately 1.8 miles (Figure 8-1). Currently, LCT distribution in Mill Creek extends downstream to just above the confluence with Lost Canyon Creek (USFWS 2009, Figure A1.16); the historic distribution of LCT did not extend into Lost Canyon Creek (USFWS 2009, Figure A1.16). Daily average flows in Lost Canyon and/or Mill Creek were not available, and other information regarding fish habitat quantity and quality, and diversion management were also unavailable. However, entrainment of LCT is not expected since distribution of LCT does not extend into Lost Canyon Creek.

The annual hydrograph in Mill Creek is likely similar to that of the West Walker River, with relatively high flows during the snowmelt runoff period, receding flows during summer, and low flow for the remainder of the year. The irrigation season in Little Antelope Valley is the same as in Antelope Valley and extends from March 1 to October 31. Based on available data, the relative contribution of flow in Lost Canyon Creek to Mill Creek is unknown, and the extent to which flow in Lost Canyon Creek is perennial is uncertain, particularly in dry years.

Fish habitat conditions in Mill Creek are likely quite different from those in the West Walker River through Antelope Valley (and the East Walker in Bridgeport Valley). Mill Creek has a relatively small contributing drainage area compared with the West Walker River at the Coleville gage, and channel size (width) is expected to be much smaller. As a result, riparian vegetation may have a relatively strong influence on habitat complexity, cover, and stream shading. In addition, channel gradient is steep compared with the West Walker River, with differences in channel bed morphology (e.g., step-pool, cascade), and bed substrate coarseness (cobble/boulder).

Despite differences in habitat characteristics between Mill Creek and the West Walker River in Antelope Valley, we expect that potential benefits to LCT from water transactions would be focused during similar periods: in the summer during the receding limb of the annual hydrograph when water temperatures are expected to be highest (July–August), and in the fall when flow is relatively low and habitat quantity is also likely near its lowest level (September–October). However, since LCT are not currently distributed in the affected reach of Mill Creek (downstream of Lost Canyon Creek) the threshold for improving conditions to a point where habitat conditions allow LCT populations to redistribute and persist, is unknown and highly speculative.

8.4.1 Conclusions

Overall, there was insufficient information on conditions in Mill and Lost Canyon creeks to support a detailed assessment of potential effects of water transactions on LCT populations.

Therefore, we do not include scenario-specific descriptions for Mill Creek. Additional information similar to that described in Section 8.1.1 above for Antelope Valley, would be needed to develop strong conclusions regarding the effects of various water transaction scenarios on fish resources in the Mill Creek.

9 SUMMARY

Of the five scenarios considered, Scenario 1, in which all irrigation is suspended, could have the greatest positive effect on the local fisheries, wildlife, and riparian plant communities. This scenario could have a large impact on alfalfa production and could only be feasible with conversion to more dryland varieties of alfalfa. Impacts to rangeland production could be large, particularly in Bridgeport Valley; however information on surface and groundwater conditions in Bridgeport Valley is needed in order to estimate these effects with any certainty. Impacts to rangeland production in Antelope Valley could be important, particularly in the southern extent of the valley and along the more well-drained valley edges. Scenario 1 could affect greater sage-grouse habitat; however more information is needed on the distribution and habitat preferences of the local populations. Native riparian cottonwood and willow forests along the riparian corridors could be positively affected by a return to the natural hydrograph which could occur with Scenario 1, as would the native fish species in the valley reaches.

Scenario 2, in which diversions continue through July 1, could have the least effect on forage and alfalfa production, while providing limited benefits to aquatic and wildlife species and negligible effects on native riparian plant communities and other natural vegetation types in the Study Area. By holding off irrigation until June 1, benefits are provided to native riparian willows and cottonwoods and the associated yellow warbler, and to native and non-native fish populations. Impacts on forage production and other natural vegetation types could be minor; however, alfalfa production in Antelope Valley could be importantly reduced if these areas were included in the program. Implementing reduced irrigation levels throughout the irrigation season is expected to have effects similar to those in which irrigation stops as of July 1. Finally, release of storage water after the end of the irrigation season (e.g. in October in Bridgeport or November in Antelope Valley) would have no effect on vegetation but could have a very minor positive effect on aquatic species.

Our ability to clearly and accurately assess potential positive or negative effects associated with a water transaction program in the California Walker River watershed is greatly constrained by gaps in existing information. The greatest information gaps relate to Bridgeport Valley, where stream flows and groundwater conditions are not well quantified. However, the vegetation map created through this effort, and the framework for assessing linkages between water availability and plant, wildlife and aquatic species represent important steps towards better understanding how changes in water management in the East and West Walker Rivers in California could be made with the least impact to agricultural production.

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Appendices

Appendix A

Background Tables for Vegetation Effects Analysis

Table A-1. Special-status plant species documented in the Project region.

Scientific name	Common name	Status[1]: Federal/State/ CRPR	Suitable habitat type	Likelihood of occurrence in assessment area	Wet sedge	Moist grass	Dry Grass/ RB-Sage	Salix exigua	Rip decid
Vascular plants									
Allium atrorubens var. *atrorubens*	Great Basin onion	–/–/2B.3	Rocky or sandy soils in Great Basin scrub and pinyon and juniper woodland.	Potential habitat in sage and rabbit brush fields			✓		
Astragalus johannis-howellii	Long Valley milk-vetch	–/CR/1B.2	Sandy loam soils in Great Basin scrub.	Potential habitat in sage and rabbit brush fields			✓		
Astragalus monoensis	Mono milk-vetch	–/CR/1B.2	Pumice, gravelly or sandy soils in Great Basin scrub and upper montane coniferous forest.	Potential habitat in sage and rabbit brush fields and upper valley dry meadows, forest edge			✓		
Atriplex pusilla	smooth saltbush	–/–/2B.1	Alkali soils in Great Basin scrub and hot springs in meadows and seeps.	Potential habitat in sage and rabbit brush fields and in wet meadows, ponds	✓	✓	✓		
Boechera bodiensis	Bodie Hills rockcress	–/–/1B.3	Alpine boulder and rock fields, Great Basin scrub, pinyon and juniper woodland, and subalpine coniferous forest.	Potential habitat in sage and rabbit brush fields and upper valley dry meadows, forest edge and upper valley dry meadows, forest edge			✓		
Boechera cobrensis	Masonic rockcress	–/–/2B.3	Sandy soils in Great Basin scrub and pinyon and juniper woodland.	Potential habitat in sage and rabbit brush fields			✓		
Boechera tularensis	Tulare rockcress	–/–/1B.3	Rocky slopes in subalpine coniferous forest and upper montane coniferous forest.	Potential habitat in upper valley dry meadows, forest edge			✓		

Scientific name	**Common name**	**Status[1]: Federal/State/ CRPR**	**Suitable habitat type**	**Likelihood of occurrence in assessment area**	**Wet sedge**	**Moist grass**	**Dry Grass/ RB-Sage**	**Salix exigua**	**Rip decid**
Bolandra californica	Sierra bolandra	–/–/4.3	Mesic, rocky soils in lower montane coniferous forest and upper montane coniferous forest.	Potential habitat in upper valley dry meadows, forest edge and in wet meadows		✓	✓		
Botrychium ascendens	upswept moonwort	–/–/2B.3	Mesic soils in lower montane coniferous forest and meadows and seeps.	Potential habitat in upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓		
Botrychium lunaria	common moonwort	–/–/2B.3	Meadows and seeps, subalpine coniferous forest, and upper montane coniferous forest.	Potential habitat in upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓		
Botrychium paradoxum	paradox moonwort	–/–/2B.1	Limestone and marble in alpine boulder and rock fields and moist soils in upper montane coniferous forest.	Potential habitat in wet meadows		✓			
Calochortus excavatus	Inyo County star-tulip	–/–/1B.1	Alkaline, mesic soils in chenopod scrub and meadows and seeps.	Potential habitat in wet meadows	✓	✓			
Carex occidentalis	western sedge	–/–/2B.3	Lower montane coniferous forest and meadows and seeps.	Potential habitat in upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓		
Carex petasata	Liddon's sedge	–/–/2B.3	Broadleafed upland forest, lower montane coniferous forest, meadows and seeps, and pinyon and juniper woodland.	Potential habitat in upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓		

Scientific name	Common name	Status[1]: Federal/State/ CRPR	Suitable habitat type	Likelihood of occurrence in assessment area	Wet sedge	Moist grass	Dry Grass/ RB-Sage	Salix exigua	Rip decid
Carex vallicola	western valley sedge	–/–/2B.3	Mesic soils in Great Basin scrub and meadows and seeps.	Potential habitat in sage and rabbit brush fields and in wet meadows, ponds	✓	✓	✓		
Chaetadelpha wheeleri	Wheeler's dune-broom	–/–/2B.2	Sandy soils in desert dunes, Great Basin scrub, and Mojavean desert scrub.	Potential habitat in sage and rabbit brush fields			✓		
Cryptantha glomeriflora	clustered-flower cryptantha	–/–/4.3	Granitic or volcanic, sandy soils in Great Basin scrub, meadows and seeps, subalpine coniferous forest, and upper montane coniferous forest.	Potential habitat in sage and rabbit brush fields, upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓		
Cryptantha scoparia	gray cryptantha	–/–/4.3	Chenopod scrub, Great Basin scrub, and pinyon and juniper woodland.	Potential habitat in sage and rabbit brush fields			✓		
Cusickiella quadricostata	Bodie Hills cusickiella	–/–/1B.2	Clay or rocky soils in Great Basin scrub and pinyon and juniper woodland.	Potential habitat in sage and rabbit brush fields. Documented within the assessment area (Bridgeport).			✓		
Dicentra nevadensis	Tulare County bleeding heart	–/–/4.3	Alpine boulder and rock fields and gravelly or sandy soils in openings in subalpine coniferous forest.	Potential habitat in upper valley dry meadows, forest edge Close to out of range			✓		
Eremothera boothii subsp. *alyssoides*	Pine Creek evening-primrose	–/–/4.3	Sandy, gravelly soils in Great Basin scrub.	Potential habitat in sage and rabbit brush fields			✓		

Scientific name	Common name	Status[1]: Federal/State/ CRPR	Suitable habitat type	Likelihood of occurrence in assessment area	Wet sedge	Moist grass	Dry Grass/ RB-Sage	Salix exigua	Rip decid
Erigeron miser	starved daisy	–/–/1B.3	Rocky soils in upper montane coniferous forest.	Potential habitat in upper valley dry meadows, forest edge			✓		
Eriogonum nutans var. *nutans*	Dugway wild buckwheat	–/–/2B.3	Sandy or gravelly soils in chenopod scrub and Great Basin scrub.	Potential habitat in sage and rabbit brush fields			✓		
Glyceria grandis	American manna grass	–/–/2B.3	Streambanks and lake margins in bogs and fens, meadows and seeps, and marshes and swamps.	Potential habitat in wet meadows, ponds and riparian. Documented within the assessment area (Walker and Bridgeport).	✓	✓		✓	✓
Hymenopappus filifolius var. *nanus*	little cutleaf	–/–/2B.3	Carbonate soils in pinyon and juniper woodland and subalpine coniferous forest.	Potential habitat in upper valley dry meadows, forest edge			✓		
Ivesia unguiculata	Yosemite ivesia	–/–/4.2	Meadows and seeps, subalpine coniferous forest, and upper montane coniferous forest.	Potential habitat in upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓		
Kobresia myosuroides	seep kobresia	–/–/2B.2	Mesic soils in alpine boulder and rock fields, carbonate soils in meadows and seeps, and subalpine coniferous forest.	Potential habitat in upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓		

Scientific name	**Common name**	**Status[1]: Federal/State/ CRPR**	**Suitable habitat type**	**Likelihood of occurrence in assessment area**	**Wet sedge**	**Moist grass**	**Dry Grass/ RB-Sage**	**Salix exigua**	**Rip decid**
Lupinus duranii	Mono Lake lupine	–/–/1B.2	Volcanic pumice, gravelly soils in Great Basin scrub, subalpine coniferous forest, and upper montane coniferous forest.	Potential habitat in sage and rabbit brush fields and upper valley dry meadows, forest edge			✓		
Lupinus pusillus var. *intermontanus*	intermontane lupine	–/–/2B.3	Sandy soils in Great Basin scrub.	Potential habitat in sage and rabbit brush fields			✓		
Mentzelia monoensis	Mono Craters blazing star	–/–/4.3	Pumice, gravelly, disturbed areas in Great Basin scrub and upper montane coniferous forest.	Potential habitat in sage and rabbit brush fields and upper valley dry meadows, forest edge			✓		
Mentzelia torreyi	Torrey's blazing star	–/–/2B.2	Sandy or rocky, alkaline, usually volcanic soils in Great Basin scrub, Mojavean desert scrub, and pinyon and juniper woodland.	Potential habitat in sage and rabbit brush fields. Documented within the assessment area (Bridgeport).			✓		
Mertensia oblongifolia var. *oblongifolia*	sagebrush bluebells	–/–/2B.2	Usually mesic soils in Great Basin scrub, lower montane coniferous forest, meadows and seeps, and subalpine coniferous forest.	Potential habitat in sage and rabbit brush fields, upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓		
Mimulus glabratus subsp. *utahensis*	Utah monkeyflower	–/–/2B.1	Meadows and seeps and pinyon and juniper woodland.	Potential habitat in wet meadows, ponds	✓	✓			

Scientific name	**Common name**	**Status[1]: Federal/State/ CRPR**	**Suitable habitat type**	**Likelihood of occurrence in assessment area**	**Wet sedge**	**Moist grass**	**Dry Grass/ RB-Sage**	**Salix exigua**	**Rip decid**
Phacelia monoensis	Mono County phacelia	–/–/1B.1	Clay, and often roadsides of Great Basin scrub and pinyon and juniper woodland.	Potential habitat in sage and rabbit brush fields			✓		
Polemonium chartaceum	Mason's sky pilot	–/–/1B.3	Rocky, serpentinite, granitic, or volcanic soils in alpine boulder and rock fields and subalpine coniferous forest.	Potential habitat in upper valley dry meadows, forest edge			✓		
Polyctenium williamsiae	Williams' combleaf	–/–/1B.2	Sandy, volcanic soils along lake margins of Great Basin scrub, marshes and swamps, pinyon and juniper woodland, playas, and vernal pools.	Potential habitat in sage, rabbit brush fields and in wet meadows, ponds	✓	✓	✓		
Polygala subspinosa	spiny milkwort	–/–/2B.2	Gravelly, rocky soils in Great Basin scrub and pinyon and juniper woodland.	Potential habitat in sage and rabbit brush fields. Documented within the assessment area (Walker).			✓		
Polystichum kruckebergii	Kruckeberg's sword fern	–/–/4.3	Rocky soils in subalpine coniferous forest and upper montane coniferous forest.	Potential habitat in upper valley dry meadows, forest edge			✓		
Ranunculus hydrocharoides	frog's-bit buttercup	–/–/2B.1	Freshwater marshes and swamps.	Potential habitat in wet meadows, ponds	✓	✓			

Scientific name	Common name	Status[1]: Federal/State/ CRPR	Suitable habitat type	Likelihood of occurrence in assessment area	Wet sedge	Moist grass	Dry Grass/ RB-Sage	Salix exigua	Rip decid
Sidalcea multifida	cut-leaf checkerbloom	–/–/2B.3	Great Basin scrub, lower montane coniferous forest, meadows and seeps, and pinyon and juniper woodland.	Potential habitat in sage and rabbit brush fields and upper valley dry meadows, forest edge			✓		
Sphaeromeria potentilloides var. *nitrophila*	alkali tansy-sage	–/–/2B.2	Usually alkaline soils in meadows and seeps and playas.	Potential habitat in wet meadows, ponds	✓	✓			
Sphenopholis obtusata	prairie wedge grass	–/–/2B.2	Mesic soils in cismontane woodland and meadows and seeps.	Potential habitat in wet meadows, ponds	✓	✓			
Tetradymia tetrameres	dune horsebrush	–/–/2B.2	Sandy soils in Great Basin scrub.	Potential habitat in sage and rabbit brush fields			✓		
Thelypodium integrifolium subsp. *complanatum*	foxtail thelypodium	–/–/2B.2	Alkaline or subalkaline, mesic soils in Great Basin scrub and meadows and seeps.	Potential habitat in sage and rabbit brush fields and in wet meadows, ponds	✓	✓	✓		
Thelypodium milleflorum	many-flowered thelypodium	–/–/2B.2	Chenopod scrub and sandy soils in Great Basin scrub.	Potential habitat in sage and rabbit brush fields			✓		
Trifolium dedeckerae	DeDecker's clover	–/–/1B.3	Granitic, rocky soils in lower montane coniferous forest, pinyon and juniper woodland, subalpine coniferous forest, and upper montane coniferous forest.	Potential habitat in upper valley dry meadows, forest edge			✓		

Scientific name	Common name	Status[1]: Federal/State/CRPR	Suitable habitat type	Likelihood of occurrence in assessment area	Wet sedge	Moist grass	Dry Grass/ RB-Sage	Salix exigua	Rip decid
Triglochin palustris	marsh arrow-grass	–/–/2B.3	Mesic soils in meadows and seeps, freshwater marshes and swamps, and subalpine coniferous forest.	Potential habitat in upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓		
Viola purpurea subsp. *aurea*	golden violet	–/–/2B.2	Sandy soils in Great Basin scrub and pinyon and juniper woodland.	Potential habitat in sage and rabbit brush fields. Documented within the assessment area (Bridgeport).			✓		
Non-vascular									
Helodium blandowii	Blandow's bog moss	–/–/2B.3	Damp soils in meadows and seeps and subalpine coniferous forest.	Potential habitat in upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓		
Meesia triquetra	three-ranked hump moss	–/–/4.2	Soil in bogs and fens, meadows and seeps, subalpine coniferous forest, and mesic soils in upper montane coniferous forest.	Potential habitat in upper valley dry meadows, forest edge and in wet meadows, ponds	✓	✓	✓		
Orthotrichum shevockii	Shevock's bristle moss	–/–/1B.3	Granitic and rocky soils in Joshua tree "woodland" and pinyon and juniper woodland.	Potential habitat in upper valley dry meadows, forest edge. Documented within the assessment area (Walker).			✓		

Scientific name	Common name	Status[1]: Federal/State/ CRPR	Suitable habitat type	Likelihood of occurrence in assessment area	Wet sedge	Moist grass	Dry Grass/ RB-Sage	Salix exigua	Rip decid
Orthotrichum spjutii	Spjut's bristle moss	–/–/1B.3	Granitic and rocky soils in lower montane coniferous forest, pinyon and juniper woodland, subalpine coniferous forest, and upper montane coniferous forest.	Potential habitat in upper valley dry meadows, forest edge			✓		

[1] Status:

–	=	None
Federal		
FE	=	Endangered under the ESA
FT	=	Threatened under the ESA
State		
CE	=	Endangered under the CESA
CR	=	Rare under the CNPPA
CRPR		
1A	=	Plants presumed extirpated in California and either are or extinct elsewhere
1B	=	Plants rare, threatened, or endangered in California and elsewhere
2B	=	Plants rare, threatened, or endangered in California, but more common elsewhere
3	=	Plants for which more information is need –a review list
4	=	Plants of limited distribution – a watch list
0.1	=	Seriously threatened in California
0.2	=	Moderately threatened in California
0.3	=	Not very threatened in California

Quad‘s included in the Walker CNDDB and CNPS queries:
Carter‘s Station, Heenan Lake, Topaz Lake, Long Dry Canyon, Wolf Creek, Coleville, Risue Canyon, Desert Creek Peak, Disaster Peak, Lost Cannon Peak, Chris Flat, Mt. Patterson, Sweetwater Creek, Sonora Pass, Pickel Meadow, Fales Hot Springs, Mt. Jackson, Bridgeport, Dome Hill, Tower Peak, Buckeye Ridge, Twin Lakes, Big Alkali, Bodie, Dunderberg Peak, Lundy, Negit Island

CNPS queries:
Coleville (505D) 3811955, Lost Cannon Peak (489A) 3811945, Disaster Peak (489B) 3811946, Long Dry Canyon (504B) 3811964, Risue Canyon (504C) 3811954, Chris Flat (488B) 3811944, Topaz Lake (505A) 3811965, Heenan Lake (505B) 3811966, Wolf Creek (505C) 3811956

Chris Flat (488B) 3811944, Risue Canyon (504C) 3811954, Desert Creek Peak (504D) 3811953, Lost Cannon Peak (489A) 3811945, Pickel Meadow (489D)3811935, Coleville (505D) 3811955, Mount Patterson (488A) 3811943, Fales Hot Springs (488C) 3811934, Mount Jackson (488D) 3811933

Mount Patterson (488A) 3811943, Risue Canyon (504C) 3811954, Desert Creek Peak (504D) 3811953, Sweetwater Creek (487B) 3811942, Bridgeport (487C)3811932, Chris Flat (488B) 3811944, Fales Hot Springs (488C) 3811934, Mount Jackson (488D) 3811933

Big Alkali (470B) 3811922, Bridgeport (487C) 3811932, Dome Hill (487D) 3811931, Twin Lakes (471A) 3811923, Dunderberg Peak (471D) 3811913, Mount Jackson (488D) 3811933, Bodie (470A) 3811921, Lundy (470C) 3811912, Negit Island (470D) 3811911

Fales Hot Springs (488C) 3811934, Twin Lakes (471A) 3811923, Buckeye Ridge (471B) 3811924, Pickel Meadow (489D) 3811935, Lost Cannon Peak (489A)3811945, Tower Peak (472A) 3811925, Mount Jackson (488D) 3811933, Mount Patterson (488A) 3811943, Chris Flat (488B) 3811944

Sonora Pass, Carter‘s Station: no occurrences in old or new CNPS

Table A-2. Drought tolerance, anaerobic tolerance, and water use efficiency for plant species commonly found in Antelope and Bridgeport valleys.

Key species in vegetation type	Scientific name	Common name	Drought tolerance	Anearobic tolerance	Water use
Riparian	*Populus fremontia*	Fremont cottonwood	Medium	Medium	High
	Populus trichocarpa	black cottonwood	Low	Medium	High
	Salix exigua	coyote willow	Medium	High	High
	Salix laevigata	red willow	Medium	High	High
Wet sedge	*Carex nebrascensis*	Nebraska sedge	None	High	High
	Juncus nevadensis	Sierra rush	Low	High	High
	Mimulus guttatus	seep monkey flower	None	Medium	High
	Carex aquatilis	water sedge	Low	High	High
	Juncus balticus (J. mexicanus data)	baltic rush	Low	High	High
Moist grass	*Agrostis exarata*	spike bentgrass	Low	Medium	Medium
	Agrostis gigantea	redtop (a bentgrass)	Low	Medium	Medium
	Leymus triticoides	creeping wildrye	High	High	Medium
	Festuca spp. (Festuca idahoensis)	fescue	Low	Low	Medium
	Iris missouriensis	western blue flay	Low	High	High
	Phleum pratense	timothy	Low	Low	Medium
	Poa leptocoma	marsh bluegrass	Low	High	High

Key species in vegetation type	**Scientific name**	**Common name**	**Drought tolerance**	**Anearobic tolerance**	**Water use**
Dry grass/Sage	*Poa compressa*	Canada bluegrass	Medium	None	Medium
	Artemisia cana	silver sagebrush	High	None	Low
	Artemisia tridentata	big sagebrush	High	None	Medium
	Bromus tectorum	cheat grass	High	Low	Low
	Ericameria nauseosa	rubber rabbit brush	High	None	Low
	Chrysothamnus viscidiflorus	stickyleaf rabbit brush	High	None	Low
	Elymus elymoides	Squirrel tail or bottlebrush	High	None	Low
	Purshia tridentata	bitterbrush	High	Low	Low
	Rosa woodsii	Woods' rose	Medium	None	Medium
Invasive Weed	*Bromus tectorum*	Cheat grass			
	Iris missouriensis	Missouri iris or Blue flag			
	Lactuca serriola	Prickly lettuce			
	Cirsium arvense	Canada thistle			
	Carderia draba	Hoary cress			
	Lepidium latifolium	Perrenial pepperweed			
	Cirsium vulgare	Bull thistle			

Table A-3. Information sources used to develop production rate estimates for meadow vegetation types associated with different hydrologic regimes.

Citation	Vegetation type class	Hydrologic regime	Production total dry lb/acre	Project location
McIlroy 2008	*Carex* (*utriculata*, *vesicaria*) Herbaceous Alliance (1)	wet	3293	Stanislaus National Forest
McIlroy 2008	*Carex* (*utriculata*, *vesicaria*) Herbaceous Alliance (1)	wet	3283	Stanislaus National Forest
Allen-Diaz 1991	*Carex angustata*/*Poa pratensis* (4)	wet	2750.91	Sagehen Creek Basin, northern Sierra Nevada
Ratcliff 1985	Few-flowered Spikerush Vegetation Series (2); Few flowered spikerush/Primrose monkey flower Plant Association (3)	wet	1145	Sierra Nevada
McIlroy 2008	*Eleocharis macrostachya* Herbaceous Alliance (1)	wet	2712	Sierra National Forest
McIlroy 2008	*Eleocharis macrostachya* Herbaceous Alliance (1)	wet	2314	Sierra National Forest
Allen-Diaz 1991	*Carex angustata* (4)	wet	2953.41	Sagehen Creek Basin, northern Sierra Nevada
Ratliff 1985	*Carex nebrascensis* Herbaceous Alliance (1)	wet	2805	Sierra Nevada
McIlroy 2008	Few-flowered Spikerush Vegetation Series (2); Few flowered spikerush/Primrose monkey flower Plant Association (3)	wet	1922	Sierra National Forest
McIlroy 2008	*Eleocharis macrostachya* Herbaceous Alliance (1)	wet	1893	Sierra National Forest
Ratcliff 1985	*Carex* (*utriculata*, *vesicaria*) Herbaceous Alliance (1)	wet	1650	Sierra Nevada
McIlroy 2008	Few-flowered Spikerush Vegetation Series (2); Few flowered spikerush/Primrose monkey flower Plant Association (3)	wet	1625	Sierra National Forest
McIlroy 2008	Few-flowered Spikerush Vegetation Series (2); Few flowered spikerush/Primrose monkey flower Plant Association (3)	wet	1477	Sierra National Forest
Ratliff 1985	Slender Spikerush Vegetation Series (2);	wet	1010	Sierra Nevada
Cole et al. 2004	*Deschampsia caespitosa* Herbaceous Alliance (1)	wet-mesic	3323	Harden Lake
Cole et al. 2004	*Deschampsia caespitosa* Herbaceous Alliance (1)	wet-mesic	3248	Harden Lake
Ratliff 1985	*Deschampsia caespitosa* Herbaceous Alliance (1)	wet-mesic	2405	Sierra Nevada

Citation	Vegetation type class	Hydrologic regime	Production total dry lb/acre	Project location
Allen-Diaz 1991	*Poa pratensis* Semi-Natural Herbaceous Stands (1)	wet-mesic	3085.16	Sagehen Creek Basin, northern Sierra Nevada
McIlroy 2008	*Carex jonesii* Herbaceous Alliance (1)	wet-mesic	2177	Sierra National Forest, Stanislaus National Forest
McIlroy 2008	*Veratrum californicum* Herbaceous Alliance (1)	mesic	4453	Sierra National Forest, Stanislaus National Forest
McIlroy 2008	*Veratrum californicum* Herbaceous Alliance (1)	mesic	4283	Stanislaus National Forest
McIlroy 2008	*Veratrum californicum* Herbaceous Alliance (1)	mesic	2987	Stanislaus National Forest
McIlroy 2008	*Carex nebrascensis* Herbaceous Alliance (1)	mesic	2873	Sierra National Forest, Stanislaus National Forest
Cole et al. 2004	*Calamagrostis breweri* Vegetative Series(2), Shorthair sedge - Shorthair reedgrass Plant Association (3)	mesic	2391	Tuolumne Meadows
McIlroy 2008	*Carex microptera* Provisional Herbaceous Alliance (1)	mesic	2315	Sierra National Forest, Stanislaus National Forest
Allen-Diaz 1991	*Deschampsia caespitosa* Herbaceous Alliance (1)	mesic	2563	Sagehen Creek Basin, northern Sierra Nevada
Cole et al. 2004	*Calamagrostis breweri* Vegetative Series (2), Shorthair sedge - Shorthair reedgrass Plant Association (3)	xeric	1450	Tuolumne Meadows
Ratliff 1985	*Calamagrostis breweri* Vegetative Series (2), Shorthair sedge - Shorthair reedgrass Plant Association (3)	xeric	1065	Sierra Nevada
Van Dyke and Darragh 2006	*Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance (1)	xeric	432	South central Montana
Cole et al. 2004	*Carex filifolia* Herbaceous Alliance (1)	xeric	687	Gaylor Lakes basin (Yosemite/Sierra Nevada)
Cole et al. 2004	*Carex filifolia* Herbaceous Alliance (1)	xeric	602	Gaylor Lakes basin (Yosemite/Sierra Nevada)
Ratliff 1985	*Carex filifolia* Herbaceous Alliance (1)	xeric	285	Sierra Nevada

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