WATER RESOURCES AND GROUND-WATER MODELING IN THE WHITE RIVER AND MEADOW VALLEY FLOW SYSTEMS

Clark, Lincoln, Nye and White Pine Counties, Nevada

by

Las Vegas Valley Water District

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Front cover picture insets from top left: Iverson Spring at Muddy Springs near Moapa (May 2001), discharge from MX-5 well after pump start-up (February 1998), spring flow below Pederson Spring at Muddy Springs near Moapa (May, 2001). Background picture of Coyote Spring Valley near MX-4 and MX-5 with pump rig in background.

1 INTRODUCTION

Urban development in southern Nevada is continuing and is now expanding to include the regions adjacent to Las Vegas Valley along the Interstate-15 corridor, including communities like Moapa Valley. In addition, numerous power-generating companies have expressed interest in building facilities in the same area.

Increased land development includes the need for additional water. In Coyote Spring Valley, just north of Las Vegas and the "I-15 Corridor," there are over 16,000 acre-feet of ground-water permits owned by the Southern Nevada Water Authority (SNWA), Nevada Power Company (NPC), and Coyote Spring Investment Inc (CSI). In addition to the existing ground-water permits there are 27,512 acre-feet of ground-water applications filed in 1989 by the Las Vegas Valley Water District (LVVWD). Also, there are over 100,000 acre-feet of ground-water applications more recently filed by CSI in 1997 and 1998, for a potential residential and golf course development in Coyote Spring Valley.

It is uncertain how many of the ground water applications in Coyote Spring Valley can be developed without impacting the down-gradient Muddy Springs in Upper Moapa Valley. The Muddy Springs are managed by the U.S. Fish and Wildlife Service (USFWS) and are the home of the Moapa dace (U.S. Fish and Wildlife Service, 1995), a protected species of fish listed as endangered under the Endangered Species Preservation Act of 1966 on March 11, 1967 (32 Federal Register 4001). Other aquatic species of concern that occur in the Muddy River ecosystem are three fish, two snails, and two insects. There are also springs in hydrologic basins near Coyote Spring Valley on lands managed by the U.S. Park Service (USPS) and Bureau of Land Management that are of concern to those agencies and the public who uses them.

Because there is need for development in the I-15 Corridor and Coyote Spring Valley and because impacts on nearby springs are unknown, LVVWD has carried out a detailed analysis in an attempt to understand the origin, movement, volume, and fate of ground-water in the general area. This report summarizes those findings. It is also a supporting document for the hearing scheduled before the Nevada State Engineer in July 2001 for water rights applications 54055 through 54059 (inclusive) held by LVVWD.

1.1 PURPOSE AND SCOPE

The purpose of this study is to further define the ground-water flow systems that are contributory to the Muddy Springs in Upper Moapa Valley and to determine if there is ground-water flow that bypasses the springs. The scope of the study is to estimate a water-resource budget for the White River Flow System, including the Meadow Valley Flow System component. This was done using additional precipitation data, the results of recent geologic investigations, geochemistry, and interpretive techniques that were not available to earlier investigators. Finally, a ground-water model was constructed to evaluate the hydrogeologic processes and to assess the future spring flow impacts of permitted and potential additional groundwater pumpage using various pumping simulations.

1.2 DEFINITION OF STUDY AREA OF THIS REPORT

The Muddy Springs and Muddy River represent a major discharge point in the White River and Meadow Valley Flow System that drains to the Colorado River. There are 27 hydrographic basins in eastern and southern Nevada that are part of the Colorado River Basin drainage (**Figure 1-1**). These basins form the White River and Meadow Valley Flow Systems; in this report, these basins are referred to collectively as the Colorado River Basin Province of Nevada. Much of the area is accessible by mule and rail. There are several other valleys in Nevada that are also tributaries to the Colorado River drainage, but are not within the study area.

The Muddy Springs and Muddy River, in part the focus of this study, are located in the eastern edge of Upper Moapa Valley (Eakin, 1964, Plate 1) and are the source of the Muddy River. There are 20-30 separate spring orifices that make up the Muddy Springs and these are located over an area of about three square miles (3 mi^2). Additionally there are undoubtedly diffuse seeps to the Muddy River and to the alluvial ground-water system within the Upper Moapa Valley that are undefined. The collective spring flow represents part of the discharge from the White River Flow system.

The study area includes all of the valleys that make up the White River Flow system as first defined by Eakin (1964) and we have included Hidden, Garnet, California Wash, Black Mountain Basin and Lower Moapa Valley. Also part of the study are all of the valleys that are tributary to, and including, Meadow Valley Wash as described by Rush and Eakin (1963), and Rush (1964). All valleys in the study area are listed in **Table 1-1** along with their appropriate references. The area modeled is much smaller and is shown on **Figure 1-1**. The detailed geologic interpretations are mostly confined to the area modeled.

Not all 27 basins are represented in the ground-water model constructed for this study, but their collective hydrologic resources are used. The net ground-water flow across the model boundary in both the alluvial aquifer system and the underlying, interconnected, regional carbonate aquifer system represents a valuable resource.

The study area encompasses about 7,734,000 acres (12,080 square miles) and covers significant parts of White Pine, Lincoln, and Clark Counties and a small part of Nye County. The highest points in the study area are Currant Mountain (11,513 feet) in the White Pine Range and Troy Peak (11,298 feet) in the Grant Range.

Most of the valleys within the study area have no surface outflow, yet all are tributaries to the Colorado River drainage through ground-water discharge. All of these valleys are in the classic Basin and Range physiographic region, as described by Fenneman (1931). The Basin and Range is a series of parallel to sub-parallel, north trending mountain ranges separated by elongated valley lowlands and are further classified by Heath (1984), as being in the Alluvial Basins Ground-Water Region. These basins are also part of the carbonate rock province of eastern-southern Nevada and western Utah as described by Plume and Carlton (1988). The carbonate rock province represents a regional aquifer system that underlies the entire area. The hydraulic

Table 4-3. Summary table of precipitation analysis.

Hydro-graphic No.	Valley Name	Area (ac.)	Total Precipitation (af.)	Precipitation greater than 8 inches (af.)
175	Long Valley	417,000	460,000 [d]	460,000 [d]
174	Jakes Valley	271,000	312,000 [d]	312,000 [d]
207	White River Valley	1,017,000	1,032,000 [d]	1,032,000 [d]
172	Garden Valley	318,000	320,000 [d]	320,000
171	Coal Valley	290,000	234,000 [b]	201,000 [b]
180	Cave Valley	230,000	258,000 [d]	258,000 [d]
208	Pahroc Valley	325,000	260,000 [b]	219,000 [b]
181	Dry Lake Valley	574,000	455,000 [b]	343,000 [b]
182	Delamar Valley	232,000	176,000 [b]	108,000 [b]
209	Pahranagat Valley	497,000	344,000 [b]	139,000 [b]
206	Kane Springs Valley	150,000	140,000 [c]	139,000 [c]
210	Coyote Springs Valley	392,000	224,000 [b]	72,000 [b]
219	Muddy River Springs Area	93,000	38,000 [b]	200 [b]
220	Lower Moapa Valley	176,000	101,000 [c]	12,000 [c]
217	Hidden Valley	52,000	28,000 [b]	5,000 [b]
216	Garnet Valley	102,000	45,000 [b]	5,000 [b]
218	California Wash	206,000	76,000 [b]	15 [b]
183	Lake Valley	354,000	437,000 [c]	437,000 [c]
202	Patterson Valley	267,000	275,000 [a]	275,000 [a]
201	Spring Valley	185,000	212,000 [a]	212,000 [a]
200	Eagle Valley	34,000	37,000 [a]	37,000 [a]
199	Rose Valley	8,000	7,000 [a]	7,000 [a]
198	Dry Valley	76,000	77,000 [a]	77,000 [a]
204	Panaca Valley	232,000	224,000 [a]	224,000 [a]
203	Clover Valley	220,000	205,000 [a]	205,000 [a]
205	Lower Meadow Valley Wash	606,000	523,000 [c]	437,000 [c]
215	Black Mountains Area	409,000	132,000 [b]	200 [b]
Total		**7,734,000**	**6,636,000**	**5,540,000**

[a] *Indicates precipitation was estimated using the "general" altitude-precipitation relationship.*
[b] *Indicates precipitation was estimated using the "dry" altitude-precipitation relationship.*
[c] *Indicates precipitation was estimated using the "wet" altitude-precipitation relationship.*
[d] *Indicates precipitation was estimated using the "WRV" altitude-precipitation relationship.*

4.2.5 Discussion of Precipitation Analysis Related to Previous Studies

The strong conservativeness of the earlier precipitation estimates can be demonstrated by plotting the gage averages (**Figure 4-7**) on the NDWR 1971 precipitation map. The precipitation gage data from Caliente (9.1 inches, altitude 4,400 feet) in Panaca Valley, Key Pittman Wildlife Refuge (7.9 inches, altitude 3950 feet) in Pahranagat Valley and Elgin (14.1 inches, altitude 3,300 feet) in Lower Meadow Valley Wash all suggest the altitude of eight inches of precipitation is about 4,000 rather than 6,000 feet of altitude and is probably lower in Lower Meadow Valley Wash. In addition, the altitude-precipitation relationship is not as steep as

Table 4-5. Comparison of this study to previous Maxey-Eakin (1949) natural recharge estimates.

Valley	Acres	Volume of Precipitation (afy)		Ground-water Recharge (afy)	
		Maxey-Eakin[1]	This Study	Maxey-Eakin	This Study
Long Valley	416,966	296,940	459,937	10,300	31,112
Jakes Valley	271,493	NR	312,462	13,000	24,194
White River Valley	1,016,871	NR	1,032,143	40,000	62,133
Garden Valley	318,055	137,080	320,039	10,000	19,153
Coal Valley	289,998	62,038	234,361	2,000	7,002
Cave Valley	229,755	206,495	258,445	14,000	19,595
Pahroc Valley	325,289	56,764	260,197	2,200	7,545
Dry Lake Valley	574,417	117,562	454,998	5,000	13,254
Delamar Valley	231,582	33,530	176,189	1,000	4,597
Pahranagat Valley	497,312	42,640	344,195	1,800	7,407
Kane Springs Valley	150,429	48,878	140,218	2,600	6,757
Coyote Spring Valley	391,621		224,278		4,000
Muddy River Springs Area	92,541	NR	38,380	Minor	237
Lower Moapa Valley	175,656	1,160	101,358	50	1,354
Hidden Valley	52,435	11,400	27,512	400	339
Garnet Valley	101,981	10,600	45,268	400	393
California Wash	205,550	2,000	75,608	100	311
Lake Valley	354,246	228,930	437,170	13,000	41,320
Patterson Valley	267,430	136,860	275,015	6,000	15,761
Spring Valley	184,945	176,600	212,364	10,000	16,151
Eagle Valley	34,458	197,810	36,927	8,000	2,349
Rose Valley	7,647		7,349		352
Dry Valley	76,339		77,388		4,237
Panaca Valley	220,435		204,587		9,041
Clover Valley	231,964		223,852		10,557
Lower Meadow Valley Wash	605,723		523,247		22,823
Black Mountains Area	408,919	132,254	132,254	100	438
Total	7,734,059	1,899,541	6,635,742	147,950	332,413

[1] *Only represents precipitation greater than 8 inches.*

In estimating the precipitation for this study, the standard assumption that precipitation less than 8 inches is "ineffective" had no impact on the estimation of natural recharge in valleys where the "general" and "WRV" local altitude-precipitation relationship was used. These are generally high northern valleys with minimal or no acreage below 5,000 feet. All of the local altitude-precipitation relationships predict, and the available gage suggests, that all of the acreage above 5,000 feet of altitude in the study area receive greater than 8 inches of precipitation. This assumption also had no effect on the only northern valley (Lake) where precipitation was estimated using the "wet" local altitude-precipitation relationship.

It was observed, however, (**Figure 4-9**) that, in valleys where the "wet" local altitude-precipitation equation was used to estimate precipitation the interval between 3,000 and 4,000 feet of elevation is about 7.6 inches. It was also noted that, in valleys where the "dry" local altitude-precipitation equation was used to estimate precipitation the interval between 4,000 and 5,000 feet of elevation is about 7.9 inches.

These transitional altitude intervals are a significant amount of acreage in the valleys in the central and southern parts of the study area. If the standard Maxey-Eakin assumptions are used, the precipitation in these intervals could either be considered "ineffective" (none of the precipitation in these areas becomes natural recharge), or partially effective (part of the precipitation could have been included in the recharge estimate). Another possibility exists however.

When Pohlmann and others (1998) analyzed the springs in the Lake Mead area, using stable and radio isotopes they concluded that the recharge sources of one-third of springs are "local" and low altitude. The area described in Pohlmann and others (1998) is the southernmost valley (Black Mountains Area) of this current study area **(Figure 4-1)**. Most of the area is at low altitude (< 3,000 feet) and the highest peak, Muddy Peak, is at an altitude of 5,363 feet. The use of the term "local" introduces the idea that precipitation below 8 inches may be "effective" although the recharge efficiency is very low (less than a percent). Eakin's (1966, p. 260-262) summary of the Maxey-Eakin method characterizes recharge in areas that receive less than 8 inches of precipitation as "negligible" rather than "none".

The Maxey-Eakin technique, as originally developed, is a step function designed for use with paper maps, planimeters, and adding machines. As long as the precipitation is reported by the same irregular intervals (8, 12, 15 and 20 inches of precipitation) of the traditional method no confusion exists as to the appropriate recharge efficiency coefficients. If an alternative precipitation map with either regular intervals (NDWR, 1971), other irregular intervals (some variations of the PRISM map), or in units other than feet and inches (meters, centimeters, millimeters) questions arise about the appropriate recharge efficiency coefficients to use near the break points. Because the Donovan and Katzer's (2000) mathematical approximation of the Maxey-Eakin efficiencies is a continuous function it can easily be used in conjunction with non-traditional precipitation maps and estimates.

Donovan and Katzer (2000) examined the potential use of the equation to estimate the natural recharge efficiency directly from the precipitation estimate of a given altitude interval ($r_e = 0.05 (P)^{2.75}$) for estimating the recharge efficiency coefficients for areas that receive less than 8 inches of precipitation. The increase in the Las Vegas Valley natural recharge estimate would have been about 5 percent.

Because of the large size of the transitional altitude areas in this current study, the same logic was applied. The increase in the natural recharge estimate in the whole area is about 3.5 percent from about 321,000 afy to 332,000 afy. As mentioned previously, modification of the assumption that precipitation of less than 8 inches is "ineffective" has no effect on the recharge estimate of the high altitude northern valleys and a minor increase (5 percent) in the Lower Meadow Valley natural recharge estimate. The largest percentage increases are in the 5 small valleys (including the Black Mountains Area) where recharge is estimated to be less than 500 afy and the one valley

Table 4-8. Water-use rates for valleys with significant ground-water discharge.

Valley	Land use[1] and area (ac.)	Water-Use Rates				
		Acre-feet/acre/year[2]			Volume (afy)	Total Volume (afy/valley)
		This study	USGS[3]	NRCS[4]	This study	This study
Long[5]	P/21,882	--	Variable	--	--	11,000
Jakes[5]	P/416	--	Variable	--	--	600
White River[6]	P/147,211	0.3	6/	--	44,736	
	A/14,736	2.0	--	2 - 4.5	29,472	
	W/1,975	3.0	--	--	5,925	79,560
Garden[7]	P/6,144	0.75	--	--	4,608	4,608
Cave[8]	P/9,272	0.3	--	--	2,781	
	A/1,021	2.0	--	2 – 4.5	2,042	4,823
Pahranagat[6]	P/1,431	0.45	6/	--	644	
	A/6,256	5.0	--	3.5 - 6	31,280	
	W/1,289	5.0	--	--	6,445	38,369
Upper Muddy	P/1,016	5.0	5.0	--	5,080	5,080
California Wash	P/1152	5.0		--	5,760	5,760
Lake	P/6,654	0.45	0.1 – 1.5	--	2,994	
	A/6,883	3.0	--	2.5 -5	20,649	23,643
Patterson	A/1,607	3.0	--	2.5 - 5	4,821	4,821
Spring	P/1,548	0.45	0.1 – 1.5	--	697	
	W/45	3.0	--	--	135	832
Eagle	A/549	2.0	3.0	2.5 - 5	1,098	1,098
Rose	A/350	2.0	3.0	2.5 - 5	700	700
Dry	P/153	0.45	0.1-0.2	--	69	
	A/2,039	2.0	3.0	2.5 - 5	4,078	
	W/58	4.0	--	--	232	4,379
Panaca	P/145	0.45	0.1-0.2	--	65	
	A/8,649	3.0	3.0	2.5 - 5	25,947	26,012
Clover	P/101	0.45	0.2-0.5	--	45	
	A/1,066	2.0	3.0	2 - 4	2,132	2,177
L. Meadow Valley Wash	P/3,854	5.0	0.1-3	--	19,270	
	A/1,576	5.0	5.0	3 - 7	7,880	27,294
Lower Moapa	P/5,301	5.0	--	5 - 7	26,505	26,505

[1] *Abbreviations: P, Phreatophytes; A, Agriculture; and W, open water.*
[2] *If no value is listed then no estimate was made or the estimate was not available.*
[3] *Values referenced are from appropriate USGS Reconnaissance and Bulletin Series.*
[4] *Consumptive use values according to the Natural Resource Conservation Service (NRCS, formally the Soil Conservation Service, 1981), taken from sites closest to indicated valley (rounded to nearest half foot) and represent the range for alfalfa and pasture.*
[5] *Nichols (2000, p. C42-43).*
[6] *Eakin (1966, Table 1) indicates that evapotranspiration is equal to regional spring discharge.*
[7] *Land use acreage includes several hundred acres of undifferentiated agriculture*

numerous springs in the mountain blocks and there is some agriculture of mostly meadow grass. We estimate the ET for this valley at 5,000 acre-feet/year.

4.5.1.4 Pahranagat Valley

This long and narrow valley floor has been converted from phreatophytes to agriculture. Under natural conditions the floor was probably covered by a dense growth of phreatophytes that, according to Eakin (1966, Table 1) consumed only the estimated regional spring discharge of 25,000 acre-feet/year. Our rationale for increasing this amount to 38,000 acre-feet/year is the same as discussed previously for White River Valley. Water levels were probably shallow and resulted in large marshy areas in the southern and northern parts of the valley. The now breached and dry Maynard Lake at the extreme south end of the valley probably indicates the abundance of water during natural conditions and a redistribution of ET under current conditions.

4.5.1.5 Upper Muddy Springs

The hydrographic area for the Muddy Springs has about 5,000 afy of natural ET. The distribution of ET upstream and downstream of the USGS gage (Muddy River near Moapa) is about 3,000 and 2,000 acre-feet/year respectively. The estimated ET (this study) upstream from the river gage agrees closely with Eakin's (1966, Table 1) original estimate of 2,300 acre-feet/year. Unlike ET estimates in other valleys current conditions for ET were not estimated. The reason for this is natural ET conditions were needed to determine if there were any impacts to total spring discharge. Within error of all hydrologic measurements by many investigators, the volume of spring discharge today appears to be equal to predevelopment conditions.

4.5.1.6 California Wash

Phreatophytic vegetation along the Muddy River corridor during predevelopment conditions was probably dominated by Mesquite and salt grass. The relatively flat flood plain where these phreatophytes grew has been converted to agriculture. We estimate the predevelopment ET was about 6,000 afy.

4.5.1.7 Lake Valley

Spring discharge along the west side of the valley undoubtedly accounted for much of the predevelopment ET. The larger springs are in the northwest part of the valley and under natural conditions there would have been an even larger marshy area than there is today. There is a large amount of agriculture land currently under production that is irrigated by ground-water pumpage and water levels are within a few 10s of feet of land surface throughout much of the valley. We believe that most, if not all, of this land was type converted from natural areas of phreatophytes, mostly the greasewood assemblage, to agriculture. ET for this valley is estimated at 24, 000 afy and is assumed to represent predevelopment conditions.

4.5.1.8 Patterson Valley

There are no remnants of natural ET left in this valley. The estimated ET today of about 5,000 afy is based on agriculture usage. Under natural conditions there was probably a much higher water table than currently exists and Patterson Wash would have had a significant amount of phreatophytes, mostly greasewood, particularly along its lower reach.

4.5.1.9 Panaca Valley

The predevelopment water table in this valley was undoubtedly very near land surface, and despite large scale agricultural development, large areas of standing water are common. Meadow Valley Wash is perennial today and even though there are significant still flows several thousand afy. So under natural conditions the flow was probably much larger. Additionally permeable carbonate rocks are at land surface and are in contact with less permeable volcanic rocks which tends to bring water closer to land surface. Phreatophytes and marsh land probably occupied much of the lands now under agriculture, and the predevelopment ET is estimated to be about 26,000 afy.

4.5.1.10 Remaining Valleys in the White River Flow System

Coal, Pahroc, Dry Lake, Delamar, Kane Springs, Coyote Spring, Hidden, and Garnet Valleys have only small amount of ET. The ET from Hidden and Garnet Valleys is virtually zero. The ET was estimated at a token 1,000 acre-feet/year for each of the other valleys to account for local spring discharge that is consumed including evaporation from bare soil. Most of the springs in these valleys are in the mountain blocks, some have been developed for stock watering. The hydrology of Black Mountain is dominated by surface flow in Las Vegas Wash and also the ET along the wash. These components are not part of this study

Estimates of ET and ground-water outflow are listed in **Table 4-9** and are compared to previous USGS estimates. In general the ET has been increased significantly in this study compared to previous estimates, although only minimally in some valleys. Ground-water outflow is also increased because the ground-water recharge is much higher than previously estimated.

4.5.2 Spring Flow in Model Area

Surface-water discharge in the model area occurs in Kane Springs Wash, Coyote Spring Valley, Lower Meadow Valley, California Wash, the Muddy Springs Area, and Black Mountains Area. The major springs in the model area are shown in **Figure 4-11**.

Several small springs discharge in Kane Springs Wash, Coyote Spring Valley, and California Wash at rates generally less than a few hundred acre-feet per year. The discharge from these springs is consumed locally through ET. In Kane Springs Valley the numerous small "local" springs are not part of the large regional carbonate aquifer system. These local springs are generally in volcanic rock and reflect local recharge and discharge. A single discharge point at the location of Kane Springs was used in the ground-water model to represent the diffuse local springs and associated ET in Kane Springs Valley. In Coyote Spring Valley several small springs exist in the mountain block, but a single discharge point at Coyote Spring, located on the valley floor in the northern end of the valley was utilized as the location of ET for the water budget and ground-water model in this study. California Wash has a couple of small local seeps south of the Muddy River that discharge very small volumes of water. These seeps were not considered significant in the overall water budget.

Table 4-9. Comparison of discharge estimated by previous USGS investigators and this study, in acre-feet/year. Numbers in *italics* are this study.

<table>
<tr><th>Valley</th><th colspan="3">Discharge</th><th colspan="2">Total Discharge</th></tr>
<tr><th></th><th>ET</th><th colspan="2">Ground-water Outflow</th><th colspan="2"></th></tr>
<tr><th colspan="6">WHITE RIVER FLOW SYSTEM</th></tr>
<tr><td>Long</td><td>2,200[a]/*11,000*</td><td colspan="2">8,000[a]/*12,000*</td><td colspan="2">10,200/*23,000*</td></tr>
<tr><td>Jakes</td><td>Minor/*600*</td><td colspan="2">17,000/*35,000*</td><td colspan="2">17,000/*36,000*</td></tr>
<tr><td>Cave</td><td><1,000/*5,000*</td><td colspan="2">14,000/*15,000*</td><td colspan="2">14,000/*20,000*</td></tr>
<tr><td>White River</td><td>37,000/*80,000*</td><td colspan="2">40,000/*32,000*</td><td colspan="2">77,000/*112,000*</td></tr>
<tr><td>Garden</td><td>2,000/*5,000*</td><td colspan="2">8,000/*14,000*</td><td colspan="2">10,000/*19,000*</td></tr>
<tr><td>Coal</td><td>Minor/*1,000*</td><td colspan="2">10,000/*20,000*</td><td colspan="2">10,000/*21,000*</td></tr>
<tr><td>Pahroc</td><td>Minor/*1,000*</td><td colspan="2">42,000/*59,000*</td><td colspan="2">42,000/*60,000*</td></tr>
<tr><td>Pahranagat</td><td>25,000/*38,000*</td><td colspan="2">35,000/*28,000*</td><td colspan="2">60,000/*66,000*</td></tr>
<tr><td>Dry Lake</td><td>Minor/*1,000*</td><td colspan="2">5,000/*12,000*</td><td colspan="2">5,000/*13,000*</td></tr>
<tr><td>Delamar</td><td>Minor/*1,000*</td><td colspan="2">6,000/*16,000*</td><td colspan="2">6,000/*17,000*</td></tr>
<tr><td>Kane Spring</td><td>Minor/*1,000*</td><td colspan="2">NR/*6,000*</td><td colspan="2">NR/*7,000*</td></tr>
<tr><td>Coyote Spring</td><td><1,000/*1,000*</td><td colspan="2">36,000/*53,000*</td><td colspan="2">36,000/*54,000*</td></tr>
<tr><td>Hidden</td><td>0/*0*</td><td>300/</td><td rowspan="2">*17,000*</td><td colspan="2" rowspan="2">600/*17,000*</td></tr>
<tr><td>Garnet</td><td>0/*0*</td><td>600/</td></tr>
<tr><td>California Wash</td><td>/*6,000*</td><td colspan="2">1/*41,000*</td><td colspan="2">/*47,000*</td></tr>
<tr><td>Black Mountains</td><td>1,200/*2,000*</td><td colspan="2">400/*0.3*</td><td colspan="2">1,600/*2,000*</td></tr>
<tr><td>Upper Moapa</td><td>2,300/*5,000*</td><td colspan="2">36,000/*32,000*[b]</td><td colspan="2">38,000/*37,000*</td></tr>
<tr><th colspan="6">MEADOW VALLEY FLOW SYSTEM</th></tr>
<tr><td>Lake</td><td>8,500/*24,000*</td><td colspan="2">3,000/*17,000*</td><td colspan="2">11,500/*41,000*</td></tr>
<tr><td>Patterson</td><td>80/*5,000*</td><td rowspan="8">*7,000*[c]</td><td>*28,000*</td><td rowspan="8">27,000[c]</td><td>*33,000*</td></tr>
<tr><td>Spring</td><td>1030/*1,000*</td><td>*15,000*</td><td>*16,000*</td></tr>
<tr><td>Eagle</td><td>290/*1,000*</td><td>*16,000*</td><td>*17,000*</td></tr>
<tr><td>Rose</td><td>10/*700*</td><td>*16,000*</td><td>*17,000*</td></tr>
<tr><td>Dry</td><td>10/*4,000*</td><td>*16,000*</td><td>*20,000*</td></tr>
<tr><td>Panaca</td><td>530/*26,000*</td><td>*27,000*</td><td>*53,000*</td></tr>
<tr><td>Clover</td><td>210/*2,000*</td><td>*9,000*</td><td>*11,000*</td></tr>
<tr><td>Meadow Valley Wash</td><td>20,000/*27,000*</td><td>*32,000*</td><td>*59,000*</td></tr>
<tr><td>Lower Moapa</td><td>25,000/*26,000*</td><td colspan="2">11,000[b]/*48,000*[b]</td><td colspan="2">36,000/*74,000*</td></tr>
</table>

a. Eakin (1961), Not Nichlos (2000).
b. Combination of ground and surface water.
c. Rush (1964) lumped all ET, added ET to estimated outflow and subtracted from ground-water recharge.

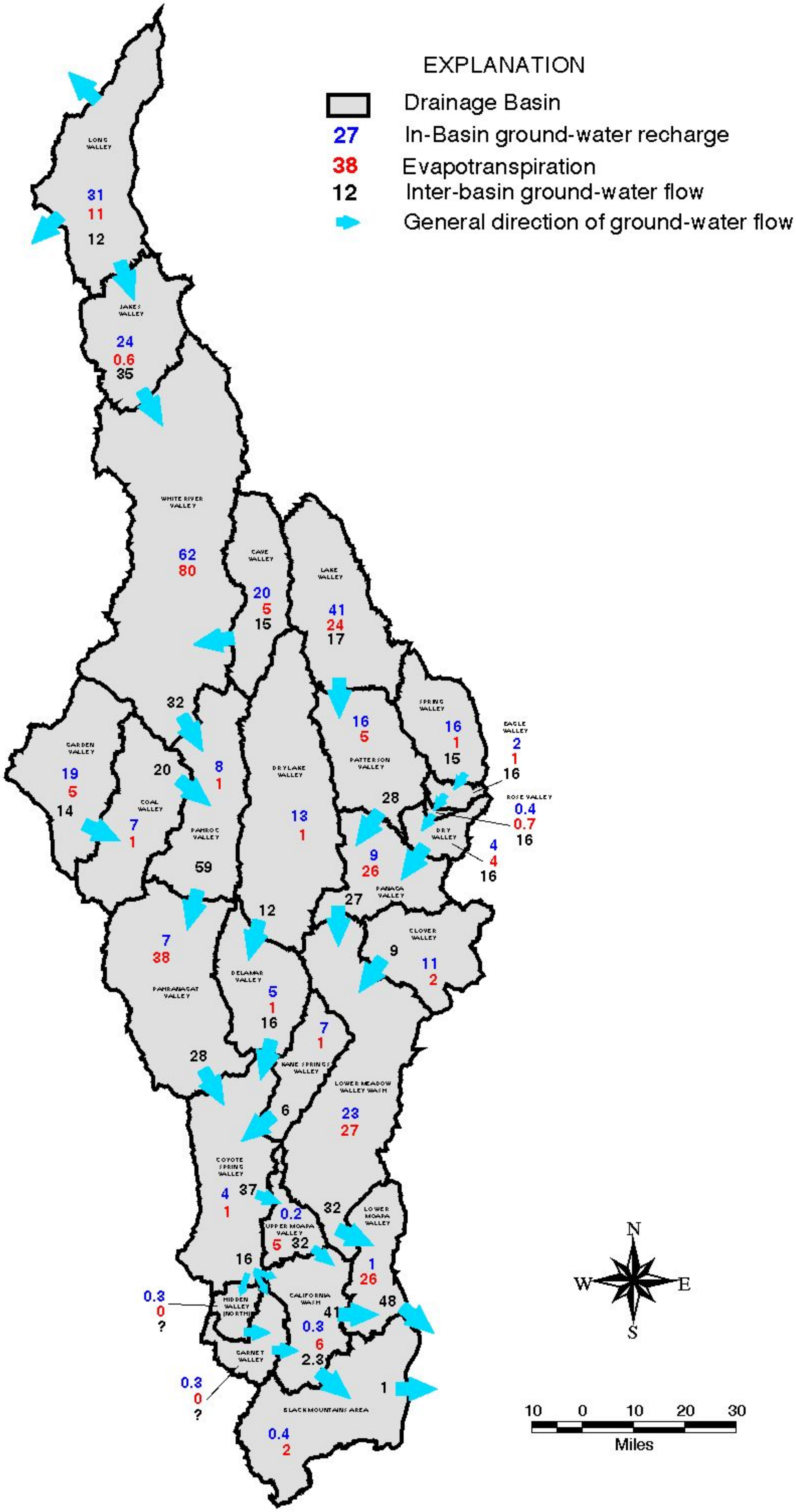

Figure 6-1. Generalized ground-water recharge, evapotranspiration, and inter-basin flow of the White River and Meadow Valley Flow Systems, units in thousands of acre-feet per year.

Table 6-1. Ground-water recharge, discharge, and inter-basin flow for selected Colorado River Basins in Nevada, in thousands of acre-feet/year (rounded).

Valley	Recharge from precipitation	Ground-water inflow	ET	Ground-water outflow	
				To	Volume
WHITE RIVER GROUND-WATER FLOW SYSTEM					
Long	31[a]	0	11	Jakes	12
Jakes	24	12	.6	WRV	35
Cave	20	0	5	WRV	15
WRV	62	50	80	Pahroc	32
Garden	19	0	5	Coal	14
Coal	7	14	1	Pahroc	20
Pahroc	8	52	1	Pahranagat	59
Pahranagat	7	59	38	Coyote	28
Dry Lake	13	0	1	Delamar	12
Delamar	5	12	1	Coyote	16
Kane	7	0	1	Coyote	6
Coyote	4	50	1	U. Muddy	37
				Hidden	16
				Garnet	
Hidden	0.3	16	0	California Wash	17
Garnet	0.3		0		
U. Moapa	0.2	37	5	California Wash	32
California Wash	0.3	49	6	L. Moapa	41
				Black Mtn.	2.3
Black Mountain	0.4	2.3	2	Carbonate outflow	1
Subtotals	200.5		158.6		
MEADOW VALLEY WASH GROUND-WATER FLOW SYSTEM					
Lake	41	0	24	Patterson	17
Patterson	16	17	5	Panaca	28
Spring	16	0	1	Eagle	15
Eagle	2	15	1	Rose	16
Rose	0.4	16	0.7	Dry	16
Dry	4	16	4	Panaca	16
Panaca	9	44	26	LMVW	27
Clover	11	0	2	LMVW	9
LMVW	23	36	27	L. Moapa	32
L. Moapa	1	73	26	Carbonate outflow	48
Subtotals	123		116.7		
Totals	**324**		**275**		

a. Only 23,000 acre-feet included in totals, remainder to non-White River flow system valleys (Nichols, 2000).