U.S. Department of the Interior
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Ground-Water Use, Locations of Production Wells, and Areas Irrigated Using Ground Water in 1998, Middle Humboldt River Basin, North-Central Nevada

Water-Resources Investigations Report 03–4227

Prepared in cooperation with the
NEVADA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

(Back of Cover)

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By Russell W. Plume

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Carson City, Nevada
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U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
acre	4,047	square meter
acre-foot (acre-ft)	0.001233	cubic hectometer
acre-foot per day (acre-ft/d)	0.001233	cubic hectometer per day
foot (ft)	0.3048	meter
gallons per minute (gal/min)	$6.309X10^{-5}$	cubic meter per second
inch (in.)	25.4	millimeter
kilowatthour (kWh)	3,600,000	joule
kilowatthour per day (kWh/d)	3,600,000	joule per day
kilowatthour per acre-foot (kWh/acre-ft)	2,919	joule per cubic meter
mile (mi)	1.609	kilometer
square miles (mi^2)	2.59	square kilometer
watthour (Wh)	3,600	joule

Temperature: Degrees Celsius (^oC) can be converted to degrees Fahrenheit (^oF) by using the formula $^oF = [1.8(^oC)]+32$. Degrees Fahrenheit can be converted to degrees Celsius by using the formula $^oC = 0.556(^oF-32)$.

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929, formerly called "Sea-Level Datum of 1929"), which is derived from a general adjustment of the first-order leveling networks of the United States and Canada.

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By Russell W. Plume

Abstract

In 1998, ground water was being pumped from about 420 production wells in the middle Humboldt River Basin for a variety of uses. Principal uses were for agriculture, industry, mining, municipal, and power plant purposes. This report presents a compilation of the number and types of production wells, areas irrigated by ground water, and ground-water use in 14 hydrographic areas of the middle Humboldt River Basin in 1998.

Annual pumping records for production wells usually are reported to the Nevada Division of Water Resources. However, operators of irrigation wells are not consistently required to report annual pumpage. Daily power-consumption and pump-discharge rates measured at 20 wells during the 1998 irrigation season and total power use at each well were used to estimate the amount of water, in feet of depth, applied to 20 alfalfa fields. These fields include about 10 percent of the total area, 36,700 acres, irrigated with ground water in the middle Humboldt River Basin. In 1998 an average of 2.0 feet of water was applied to 14 fields irrigated using center-pivot sprinkler systems, and an average of 2.6 feet of water was applied to 6 fields irrigated using wheel-line sprinkler systems. A similar approach was used to estimate the amount of water pumped at three wells using pumps powered by diesel engines. The two fields served by these three wells received 3.9 feet of water by flood irrigation during the 1998 irrigation season.

The amount of water applied to the fields irrigated by center-pivot and wheel-line irrigation systems during the 1998 irrigation season was less than what would have been applied during a typical irrigation season because late winter and spring precipitation exceeded long-term monthly averages by as much as four times. As a result, the health of crops was affected by over-saturated soils, and most irrigation wells were only used sporadically in the first part of the irrigation season. Power consumption at 19 of the 20 wells in the 1994-97 irrigation seasons was 110 to 235 percent of the power consumption in the 1998 irrigation season. If the amount of water applied to fields during the 1998 irrigation season were adjusted to account for these differences in power consumption, the average amount of water applied to a field during a typical season using center-pivot and wheel-line sprinkler systems would be 3.1 feet and 3.7 feet, respectively.

Total ground water pumped in the middle Humboldt River Basin during 1998 was about 298,000 acre-feet. This pumpage was distributed as follows: 78 percent for mining, 19 percent for irrigation, and 3 percent for industrial, municipal, and power plants combined. Mining pumpage is by far the largest source of ground-water use because several large gold mines have extended below local ground-water levels and the area around each mine must be dewatered in order to maintain a dry and workable mine. Total mining pumpage in 1998 was 233,000 acre-feet, of this total, 23,600 acre-feet was for consumptive use and 209,000 acre-feet was for dewatering eight mines. Excess water from the mines being dewatered was distributed as follows: 74,500 acre-feet was returned to aquifers by infiltration; 33,100 acre-feet was used for irrigation and for consumptive use at two mines and a power plant; 96,700 acre-feet was released to the Humboldt River or one of its tributaries; and 5,260 acre-feet was lost to evaporation.

Introduction

Background

The Humboldt River Basin covers an area of nearly 17,000 mi^2 in Nevada, and it is the only major river basin that is entirely in the State (fig. 1). Streamflow of the Humboldt River and its tributaries and ground water are used by diverse, and sometimes competitive interests. Streamflow historically has been used for agricultural purposes—mainly irrigation of crops and meadows and watering stock. However, wetlands along the river and its tributaries provide wildlife habitat, and infiltration of streamflow is a source of recharge to shallow aquifers underlying the river floodplain. Prior to 1980, most ground-water pumped in the Humboldt River Basin was used for municipal and domestic use, irrigation of crops, watering stock, and for use at a few mines. During the last 20 years, pumping in the basin has increased as a result of the expansion of irrigated areas, the development of two power plants, a general increase in population, and development of large gold mines (fig. 1).

Agencies of Federal, State, and local government and other groups are concerned about the long-term viability of the water resources of the Humboldt River Basin because of the increased demand for ground water and the need to dewater some of the gold mines. In response to this concern, the U.S. Geological Survey, in cooperation with the Nevada Department of Conservation and Natural Resources, initiated the Humboldt River Basin Assessment. The objectives of the assessment are to (1) provide scientific appraisals of the ground-water and surface-water resources of each hydrographic area in the Humboldt River Basin, (2) determine the contribution of each hydrographic area to the quantity and timing of flow in the Humboldt River, and (3) determine the effects of all major water uses in the basin.

So far, assessment activities have focused on the middle Humboldt River Basin, which consists of 14 hydrographic areas[1] that cover 7,480 mi^2 (fig. 1 and table 1). The 14 areas are tributary to the reach of the Humboldt River that extends from the mouth of Pine Creek on the east to Preble on the west (plate 1). The principal tributaries to this reach of the river are Pine Creek, Rock Creek, and the Reese River. Within the middle Humboldt River Basin there are 16 mines of varying size (15 gold mines and a barite mine), eight of which were being dewatered in 1998, several areas of differing size where ground water is used for irrigating crops, several municipalities that rely on ground water, and the Valmy Power Plant and Beowawe Geothermal Power Plant.

Purpose and Scope

The purpose of this report is to document the results of a study on ground-water use in the middle Humboldt River Basin during 1998 (fig. 1). The study objectives were to (1) identify areas where ground water is used for irrigation, (2) identify the principal crop type in each area, (3) determine irrigation application rates for each crop type, (4) use these rates to determine total pumpage for irrigation in each hydrographic area, and (5) develop a compilation of all production wells and associated ground-water pumpage in the middle Humboldt River Basin.

For purposes of this report, production wells are defined as those wells used for generating electricity, municipal use, mining including dewatering, industrial purposes other than mining, and agricultural. Production wells typically are pumped at rates ranging from hundreds to thousands of gallons per minute. Domestic wells and stock wells were not inventoried as part of this study because they typically are pumped at rates of only a few tens of gallons per minute or less. Total pumpage from domestic and stock wells had less potential to affect ground water than pumpage from production wells.

Approach

The approach used for this study was to first complete inventories of all production wells and of lands being irrigated with ground water in 1998 in the middle Humboldt River Basin. Locations of production wells were obtained from Nevada Division of Water Resources (NDWR) records and from well owners. Locations of irrigated lands and irrigation wells were determined from field inventories completed as part of this study. Most operators of production wells routinely report annual volumes of ground-water pumpage to the NDWR. This agency is the source for all pumpage information listed in this report, except for irrigation pumpage.

[1]Formal hydrographic areas in Nevada were delineated systematically by the U.S. Geological Survey and Nevada Division of Water Resources in the late 1960's for scientific and administrative purposes (Cardinalli and others, 1968; Rush, 1968). The official hydrographic-area names, numbers, and geographic boundaries continue to be used in Geological Survey scientific reports and Division of Water Resources administrative activities.

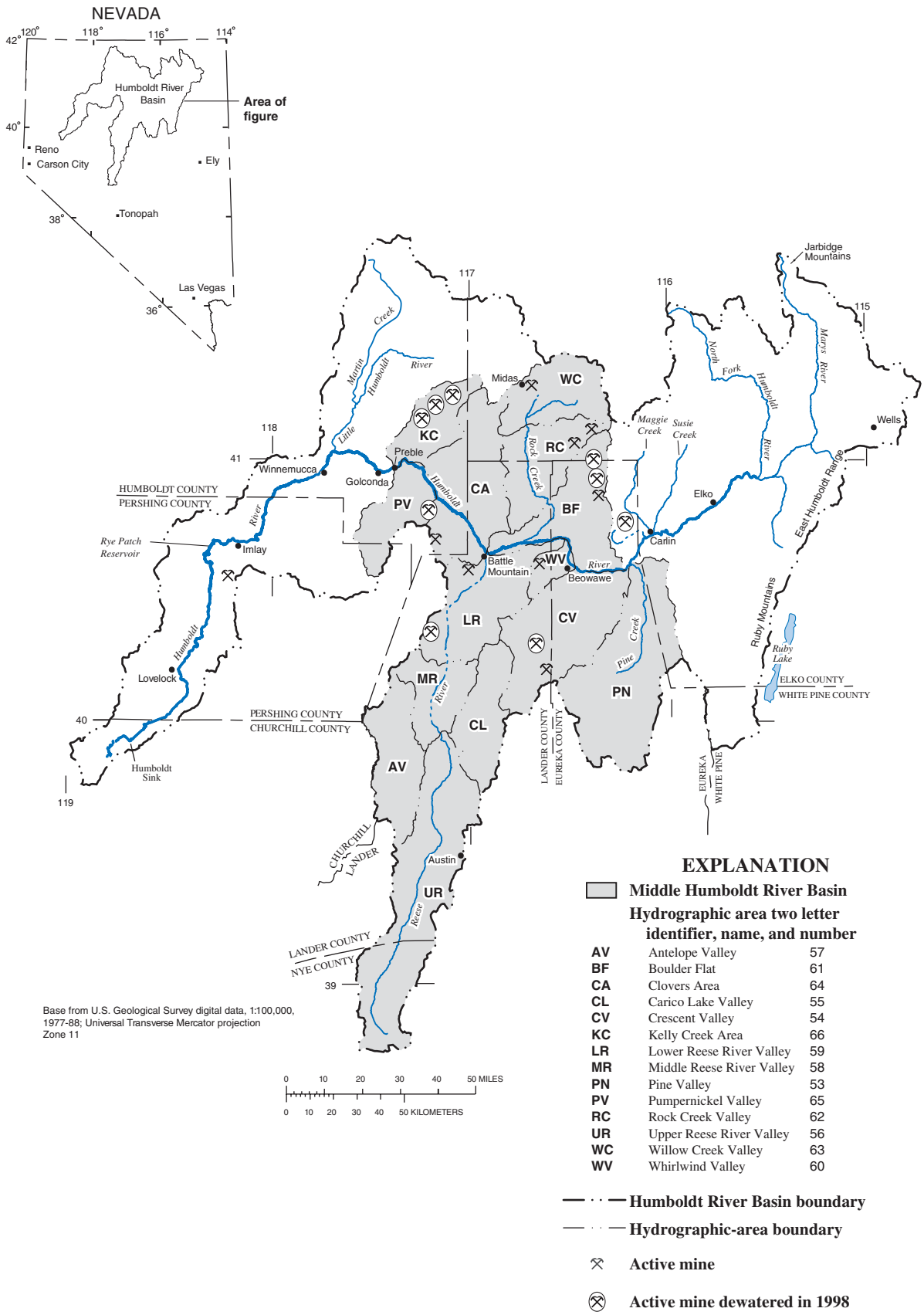

Figure 1. Hydrographic areas in the middle Humboldt River Basin, north-central Nevada.

Table 1. Hydrographic areas in the Middle Humboldt River Basin, north-central Nevada (see fig. 1 for locations).

Hydrographic area [1]				
Identifier	**Name**	**Number**	**Area [2] (square miles)**	**Area[2] (acres)**
AV	Antelope Valley	57	450	288,000
BF	Boulder Flat	61	540	346,000
CA	Clovers Area	64	720	461,000
CL	Carico Lake Valley	55	380	243,000
CV	Crescent Valley	54	750	480,000
KC	Kelly Creek Area	66	300	192,000
LR	Lower Reese River Valley	59	600	384,000
MR	Middle Reese River Valley	58	320	205,000
PN	Pine Valley	53	1,010	646,000
PV	Pumpernickel Valley	65	310	198,000
RC	Rock Creek Valley	62	450	288,000
UR	Upper Reese River Valley	56	1,140	730,000
WC	Willow Creek Valley	63	410	262,000
WV	Whirlwind Valley	60	100	64,000
	Totals		**7,480**	**4,790,000**

[1] Formal hydrographic areas in Nevada were delineated systematically by the U.S. Geological Survey and Nevada Division of Water Resources in the late 1960's (Cardinalli and others, 1968, and Rush, 1968). These areas have been the basic units for assembling hydrologic data and for regulating water use in the State since 1968. The official hydrographic area names, numbers, and geographic boundaries continue to be used in Geological Survey scientific reports and Division of Water Resources administrative activities.

[2] Areas, in square miles, from Berger (2000, p. 4). Areas in acres and totals rounded to three significant figures.

Owners of most irrigation wells are not required to report annual pumpage to the State of Nevada. Thus, an additional task was to estimate the amount of ground water pumped for irrigation in each hydrographic area in 1998. Total ground water pumped at selected wells during the 1998 irrigation season was estimated from (1) measurements of the amount of power used to pump one acre-ft of ground water, and (2) total power used at each of the wells during the irrigation season. The application rates at the fields served by these wells, in feet of water, were then used to estimate total ground water pumped for irrigation in each hydrographic area during the 1998 irrigation season. These totals are based on average application rates and on the inventories of irrigated acreage.

Acknowledgments

The successful completion of this report depended, in large part, on the assistance, cooperation, and contributions of many people. Private landowners and managers or owners of large ranches in the middle Humboldt River Basin granted the author access to their lands and wells. Personnel at the Betze, Genesis, Cortez, Pipeline, Lone Tree, McCoy, Twin Creeks, Getchell, Pinson, Copper Canyon, and Marigold Mines provided locations of production and dewatering wells at the mines. Support for the Humboldt River Basin Assessment was provided by Barrick Goldstrike Mines, Newmont Mining Corporation, Getchell Gold Company, and Glamis Gold Limited.

Irrigation Pumpage

1998 Irrigation Season

Total amounts of ground water, in feet of water, applied during the 1998 irrigation season, was estimated for 20 fields consisting of 3,850 acres of alfalfa and minor amounts of oats (table 2). This area represents about 10 percent of the total area of 36,700 acres irrigated by ground water in the middle Humboldt River Basin. The 20 fields are served by 20 irrigation wells from which total volumes of ground water pumped during the 1998 irrigation season were estimated using daily power-consumption and pump-discharge rates and total power used during the season. Both rates were measured one or more times during the irrigation season. The rates were used to compute a ratio that is the estimated amount of power required to pump one acre-ft of ground water. Instantaneous pump discharge was measured with an acoustic flowmeter and converted to an estimated daily pumpage rate, in acre-feet per day. Power consumption, in kilowatt-hours per day, was estimated by making an instantaneous measurement of the rate at which the disk on the electrical meter was revolving. The equation for converting this rate to an estimated daily power consumption rate, P, is

$$P = (86.4 \times Kh \times T_f \times rev)/t, \quad (1)$$

where Kh is the electrical meter constant in watt-hours per disk revolution (this value is shown on the meter face);

T_f is the transformer factor, a dimensionless ratio provided by the local power company;

rev is the number of revolutions the electrical meter disk turns in time (t), in seconds; and

86.4 is a conversion factor that yields a value of P in kilowatt-hours per day.

This equation is a variation of one used by Hurr and Litke (1989, p. 13). Values for daily pump-discharge, power-consumption rates, and for the amount of power needed to pump an acre-foot of water are listed in table 2.

The total volume of ground water, in acre-feet, pumped at each irrigation well during the 1998 irrigation season was computed as the total power used during the year divided by the average power-use to pumpage ratio for the year (table 2). Finally, the amount of water, in feet of depth, applied to each field, was computed as total volume of ground water pumped during the 1998 irrigation season divided by total area of the field, in acres.

The most common irrigation method using ground water in the middle Humboldt River Basin is the center-pivot sprinkler system, which consists of sprinklers attached to a supply pipe that is mounted on wheels. The entire system revolves in a circle of about 1/4-mile radius from a center pivot. The area irrigated by a center-pivot system is about 126 acres, but the area of individual fields can range from 120 to 130 acres. Total ground water, in feet, applied during the 1998 irrigation season by the 14 center-pivot sprinkler systems listed in table 2 ranged from 1.7 to 2.2 ft. The average, weighted by irrigated area, was 2.0 ft.

Wheel-line sprinkler systems are gradually being replaced in the middle Humboldt River Basin by the more efficient center-pivot sprinkler systems. Even though wheel-line sprinkler systems are not as common as center-pivot systems, they are still widely used. A wheel-line sprinkler system also consists of sprinklers attached to a supply pipe that is mounted on wheels; however, this type of system does not revolve around a center-pivot. Instead, a series of several wheel lines advance in a straight line from one side of a field to the other side. Total ground water, in feet, applied during the 1998 irrigation season by the six wheel-line sprinkler systems listed in table 2 ranged from 2.1 to 3.1 ft. The average, weighted by irrigated area, was 2.6 ft.

Flood irrigation is used extensively in the middle Humboldt River Basin where streamflow is diverted from the Humboldt River or one of its tributaries. However, there are two reasons why this irrigation method is not commonly used in areas where irrigation water must be pumped. First, more water must be applied to a flood-irrigated field than to a field of equal size irrigated by a center-pivot or wheel-line sprinkler system. One rancher stated that flood irrigation requires at least twice the amount of water needed for a center-pivot sprinkler system. Second, flood irrigation is more labor intensive and requires more care than the center-pivot or wheel-line irrigation systems.

In Pumpernickel Valley, three wells are used to flood irrigate two 320-acre fields (plate 1). The pump for each of these wells is driven by a diesel engine equipped with a meter that records hours of operation. These meters were read before and after the 1998 irrigation season. The total volume of water pumped at each of the wells during the season is computed as the daily pumpage, in acre-feet per day, multiplied by the number of days the diesel engine was in operation (table 3). The amount of water, in feet, applied to the two fields during the irrigation season was computed by dividing total pumpage from the three wells by the area of the two fields. The total amount of water applied to these fields was 3.9 ft during the 1998 irrigation season (table 3).

Table 2. Power consumption, pump discharge, and estimated 1998 irrigation season pumpage for selected irrigation wells in the Middle Humboldt River Basin, north-central Nevada

Well number (see plate 1)	USGS site identification number[1]	Irrigated area (acres)	Electrical meter				Daily power use[5] (kw-hr/d)	Daily pumpage[6] (acre-feet per day)	Power use to pumpage ratio[7] (kw-hr/acre-ft)	1998 irrigation season		
			Date[2]	Time[2] (seconds)	Kh[3]	T_f[4]				Power use[8] (kw-hr)	Pumpage[9] (acre-feet)	Water used[10] (feet)
Center-Pivot Sprinkler Systems												
8	400607117092801	249	5/5/98	30.6	1.8	96	2,440	6.67	366	-	-	-
		249	7/13/98	29.6	1.8	96	2,522	6.98	361	-	-	-
			1998 Irrigation Season			**-**	**-**	**-**	**[11]364**	**192,288**	**528**	**2.1**
12	400509117103201	251	5/5/98	29.0	1.8	96	2,574	7.33	351	-	-	-
		251	7/13/98	29.2	1.8	96	2,556	7.20	355	-	-	-
			1998 Irrigation Season			**-**	**-**	**-**	**[11]353**	**183,744**	**521**	**2.1**
13	400514117112401	248	5/5/98	27.0	1.8	96	2,765	5.78	478			
		248	7/13/98	29.0	1.8	96	2,574	5.24	491			
			1998 Irrigation Season			**-**	**-**	**-**	**[11]484**	**202,368**	**418**	**1.7**
14	400501117113701	121	7/20/98	34.6	1.8	96	2,158	5.29	[12]408	103,680	254	2.1
15	400445117113701	123	7/20/98	32.5	1.8	96	2,297	6.00	[12]383	102,240	267	2.2
16	400410117140101	254	5/6/98	24.6	1.8	96	3,035	7.56	401	-	-	-
		254	7/13/98	25.0	1.8	96	2,986	8.04	371	-	-	-
			1998 Irrigation Season			**-**	**-**	**-**	**[11]386**	**197,376**	**511**	**2.0**
17	400317117131001	257	5/6/98	22.0	1.8	96	3,393	8.67	391	-	-	-
		257	7/13/98	22.0	1.8	96	3,393	8.58	395	-	-	-
			1998 Irrigation Season			**-**	**-**	**-**	**[11]393**	**179,328**	**456**	**1.8**
18	400316117123401	256	5/6/98	19.2	1.8	96	3,888	8.49	458	-	-	-
		256	7/13/98	20.0	1.8	96	3,732	8.44	442	-	-	-
			1998 Irrigation Season			**-**	**-**	**-**	**[11]450**	**249,312**	**554**	**2.2**

Summary--14 center-pivot sprinkler systems, supplied by 8 wells, were used to irrigate 1,760 acres of alfalfa during the 1998 irrigation season. Total pumpage from the 8 wells was 3,510 acre-feet. Total water applied to the 14 fields, in feet of depth, ranged from 1.7 to 2.2 feet, and the average, weighted by irrigated area, was 2.0 feet.

Table 2. Power consumption, pump discharge, and estimated 1998 irrigation season pumpage for selected irrigation wells in the middle Humboldt River Basin, north-central Nevada--Continued

Well number (see plate 1)	USGS site identification number[1]	Irrigated area (acres)	Electrical meter				Daily power use[5] (kw-hr/d)	Daily pumpage[6] (acre-feet per day)	Power use to pumpage ratio[7] (kw-hr/acre-ft)	1998 irrigation season		
			Date[2]	Time[2] (seconds)	Kh[3]	T_f[4]				Power use[8] (kw-hr)	Pumpage[9] (acre-feet)	Water used[10] (feet)
Wheel-Line Sprinkler Systems												
1	410621117134301	(13)	5/1/98	18.6	1.8	96	4,013	6.13	655	-	-	-
		(13)	7/10/98	19.0	1.8	96	3,929	6.22	632	-	-	-
			1998 irrigation season						**[11]644**	**267,744**	**416**	**-**
2	410606117134901		7/10/98	27.0	1.8	96	2,765	3.91	[12]707	14,784	21	-
3	410542117135001	(13)	5/1/98	15.0	0.9	192	4,977	5.56	895	-	-	-
			7/10/98	14.5	0.9	192	5,148	5.56	926	-	-	-
			1998 irrigation season						**[11]910**	**361,536**	**397**	**-**
	Totals for Field	**316**									[14]**834**	**2.6**
7	400615117082501	270	5/4/98	12.0	0.9	96	3,110	7.78	400	-	-	-
		270	7/13/98	12.2	0.9	96	3,059	7.60	402	-	-	-
			1998 irrigation season						**[11]401**	**277,440**	**692**	**2.6**
9	400539117092101	(15)	5/4/98	37.4	1.8	96	1,996	6.40	312	-	-	-
			7/13/98	38.2	1.8	96	1,954	5.87	333	-	-	-
			9/11/98	39.6	1.8	96	1,885	6.13	308	-	-	-
			1998 irrigation season						**[11]318**	**159,456**	**501**	**-**
10	400513117093801	(15)	5/4/98	23.5	1.8	48	1,588	3.09	514	-	-	-
			9/1198	24.0	1.8	48	1,555	2.93	531	-	-	-
			1998 irrigation season						**[11]522**	**133,392**	**256**	**-**
11	400519117095601	(15)	5/4/98	18.8	1.8	96	3,971	10.4	382	-	-	-
			7/13/98	19.2	1.8	96	3,888	9.47	411	-	-	-
			9/11/98	20.8	1.8	96	3,589	9.47	379	-	-	-
			1998 irrigation season						**[11]391**	**353,376**	**904**	**-**
	Totals for Field	**653**									[16]**1,661**	**2.5**

Table 2. Power consumption, pump discharge, and estimated 1998 irrigation season pumpage for selected irrigation wells in the middle Humboldt River Basin, north-central Nevada--Continued

Well number (see plate 1)	USGS site identification number[1]	Irrigated area (acres)	Electrical meter				Daily power use[5] (kw-hr/d)	Daily pumpage[6] (acre-feet per day)	Power use to pumpage ratio[7] (kw-hr/acre-ft)	1998 irrigation season		
			Date[2]	Time[2] (seconds)	Kh[3]	T_f[4]				Power use[8] (kw-hr)	Pumpage[9] (acre-feet)	Water used[10] (feet)
Wheel-Line Sprinkler Systems												
19	400418117114201	(17)	5/6/98	16.0	1.8	96	4,666	9.07	514	-	-	-
			7/13/98	16.0	1.8	96	4,666	8.44	553	-	-	-
			1998 irrigation season						**[11]534**	**351,360**	**658**	**-**
20	400339117112401	(17)	5/6/98	27.4	1.8	96	2,724	2.84	959	-	-	-
			7/15/98	32.0	1.8	96	2,333	2.89	807	-	-	-
			1998 irrigation season						**[11]883**	**164,352**	**186**	**-**
21	400327117112701	(17)	5/6/98	24.2	1.8	192	6,169	12.3	502	-	-	-
			7/15/98	25.4	1.8	192	5,878	11.3	520	-	-	-
			1998 irrigation season						**[11]511**	**361,344**	**707**	**-**
	Totals for Field	**554**								-	**[18]1,551**	**2.8**
22	400249117151301	156	6/4/98	31.2	1.8	96	2,393	5.60	427	-	-	-
		156	7/14/98	32.3	1.8	96	2,311	5.91	391	-	-	-
			1998 irrigation season						**[11]409**	**198,240**	**485**	**3.1**
23	400158117151601	145	7/14/98	35.8	1.8	96	2,085	4.09	[12]510	156,192	306	2.1

Summary--6 wheel-line sprinkler systems, supplied by 12 wells, were used to irrigate a total of 2,090 acres (1,930 acres of alfalfa and 160 acres of oats) during the 1998 irrigation season. Total pumpage from the 12 wells was 5,530 acre-feet. Total water applied to the 6 fields, in feet of depth, ranged from 2.1 to 3.1 feet, and the average, weighted by irrigated area, was 2.6 feet.

[1] USGS site identification numbers shown in this table are based on grid system of latitude and longitude. Each number consists of 15 digits. First six digits denote degrees, minutes, and seconds of latitude; next seven digits denote degrees, minutes, and seconds of longitude; and last two digits (assigned sequentially) identify sites within 1-second grid. For example, site identification number for well number 8 is 400607117092801. This number refers to 40° 6′ 7″ latitude and 117° 9′ 28″ longitude, and it is first site recorded in that 1-second grid. This 15-digit number is retained as permanent identifier even if more precise latitude and longitude are determined later.

[2] On indicated date, disk on electrical meter was turning at measured rate of five revolutions in indicated time, in seconds.

[3] Meter constant imprinted on a metal tag attached to the face of electrical meter. This constant indicates the number of watt-hours of electricity being consumed for every revolution of the meter disk.

[4] Dimensionless number called the transformer factor that usually must be obtained from local power company. Number is used in calculation of energy consumption rate when electrical supply lines for pump motor do not pass directly through electrical meter. See Hurr and Litke (1989, p. 10-13 and fig. 5) for additional information.

[5] Power consumption rate, in kilowatt-hours per day (kw-hr/d) is computed from the following equation: P = (86.4 x Kh x Tf x rev) / time, where Kh is meter constant in watt-hours per meter disk revolution, Tf is transformer factor, a dimensionless ratio, rev is the number of meter revolutions (in this table, 5 revolutions) measured in time, in seconds, and 86.4 is a constant that yields a value of P, in kilowatt-hours per day.

[6] Daily pump discharge, in acre-feet per day (acre-ft/d), estimated by measuring the instantaneous pump discharge with an acoustical flow meter.

[7] Ratio is determined by dividing daily power use by daily pumpage. Ratio, in kilowatt-hours per acre-foot (kw-hr/acre-ft), is an estimate of amount of electrical power needed to pump one acre-foot of water on indicated date.

[8] Amount of electrical power, in kilowatt-hours (kw-hr), consumed by pump motor at well during 1998 irrigation season. Data obtained from Sierra Pacific Power Company with permission of well owner.

[9] Estimated total ground water, in acre-feet, pumped during 1998 irrigation season. Computed by dividing total power used during 1998 irrigation season by average ratio of power use to pumpage.

[10] Estimated amount of water, in feet of depth, used to irrigate field(s) supplied by this/these well(s) during 1998 irrigation season. Computed by dividing total pumpage, in acre-feet, by total irrigated area, in acres.

[11] Average of ratios determined during 1998 irrigation season.

[12] Assumed to represent average ratio for 1998 irrigation season because site was visited only once during season.

[13] Wells 1, 2 and 3 are used together to irrigate a single 316-acre field.

[14] Total pumpage from wells 1, 2, and 3 during 1998 irrigation season.

[15] Wells 9, 10,and 11 are used together to irrigate a single 653-acre field.

[16] Total pumpage from wells 9, 10, and 11 during 1998 irrigation season.

[17] Wells 19, 20, and 21 are used together to irrigate a single 554-acre field.

[18] Total pumpage from wells 19, 20, and 21 during 1998 irrigation season.

Table 3. Pump discharge and estimated 1998 irrigation season pumpage for three wells serving two flood-irrigated fields in Pumpernickel Valley, Nevada.

Well number	USGS site identification number [1]	Irrigated area (acres)	Date	Daily pumpage [2] (acre-feet per day)	1998 irrigation season		
					Time of pumping [3] (days)	Pumpage [4] (acre-feet)	Water use [5] (feet)
4	404613117274101	(6)	7/11/98	7.1	81.3	577	-
5	404614117270901	(6)	7/12/98	12.0	85.7	1,030	-
6	404546117274101	(6)	5/2/98	7.87	20.2	159	-
		(6)	7/11/98	11.1	63.3	703	-
Totals for 1998 irrigation season		**640**	**-**	**-**	**-**	**2,470**	**3.9**

[1] USGS site identification numbers shown in this table are based on grid system of latitude and longitude. Each number consists of 15 digits. First six digits denote degrees, minutes, and seconds of latitude; next seven digits denote degrees, minutes, and seconds of longitude; and last two digits (assigned sequentially) identify sites within 1-second grid. For example, site identification number for well 4 is 404613117274101. This number refers to 40° 46′ 13″ latitude and 117° 27′ 41″ longitude, and it is the first site recorded in that 1-second grid. This 15-digit number is retained as a permanent identifier even if more precise latitude and longitude are determined later.

[2] Estimated daily pump discharge, in acre-feet per day, measured on the pump discharge pipe with an acoustical flow meter.

[3] Pumps are driven by diesel engines. Time of pumping determined from hour meter on each engine.

[4] Computed by multiplying daily pumpage by time of pumping.

[5] Computed by dividing total pumpage by irrigated area.

[6] Wells 4, 5, and 6 are used together to irrigate two 320-acre fields of alfalfa.

Comparison of 1998 Irrigation Season with 1994-97 Seasons

A typical irrigation season in the middle Humboldt River Basin usually begins in early April and ends in early September with the final cutting of alfalfa. The typical season not only includes years of average or near average precipitation, but also includes years of below average precipitation. The 1998 irrigation season was not a typical irrigation season because winter and spring precipitation were well above average in the middle Humboldt River Basin. Precipitation at Battle Mountain was about twice the monthly average from January through April and in June, and was more than four times the monthly average in May (fig. 2). Consequently, soil moisture was well above normal by early April when pumping of ground water should have begun. Most center-pivot and wheel-line sprinkler systems were idle, or only used sporadically, in April, May, and early June because soils were so saturated that the growth and health of the alfalfa crops were being affected. Thus, the amounts of ground water applied to the 20 different fields listed in table 2 do not represent the amount of ground water that would have been used in a typical year.

Power-consumption records for the four irrigation seasons preceding 1998 were compared with 1998 records and used to adjust 1998 water use (table 2) to an estimated use for the 1994-97 irrigation seasons, all of which were typical years. Table 4 lists comparisons of power consumption during each of the 1994-97 irrigation seasons with 1998 power consumption for 19 of the 20 irrigation systems listed in table 2. Power-consumption records for 1994-97 for well 8 were not available. The factors for each year were determined by dividing power use for a specific sprinkler system by power use in 1998. The factors indicate that power use in 1998 was consistently exceeded by power use in the 1994-97 irrigation seasons at all of the irrigation systems listed in table 4.

Water used at each of the irrigation systems during a typical irrigation season was estimated by multiplying the amount of water used by the system in 1998 by the average factor for the 1994-97 seasons (table 4). Ground water applied to fields during the 1998 irrigation season ranged from 1.7 to 2.2 ft using the center-pivot sprinkler systems and ranged from 2.1 to 3.1 ft using the wheel-line sprinkler systems. Estimated amounts of ground water applied to the same fields during the previous four irrigation seasons ranged from 2.4 to 4.8 ft and 3.2 to 4.2 ft for center-pivot and wheel-line sprinkler systems, respectively. The area-weighted averages for a typical season are 3.1 ft for the center-pivot systems and 3.7 ft for the wheel-line systems.

Ground-Water Use in 1998

Locations of production wells and areas irrigated with ground water in each hydrographic area in the middle Humboldt River Basin are shown on plate 1. Types and numbers of production wells, irrigated acreage, and water use for each hydrographic area are listed in table 5.

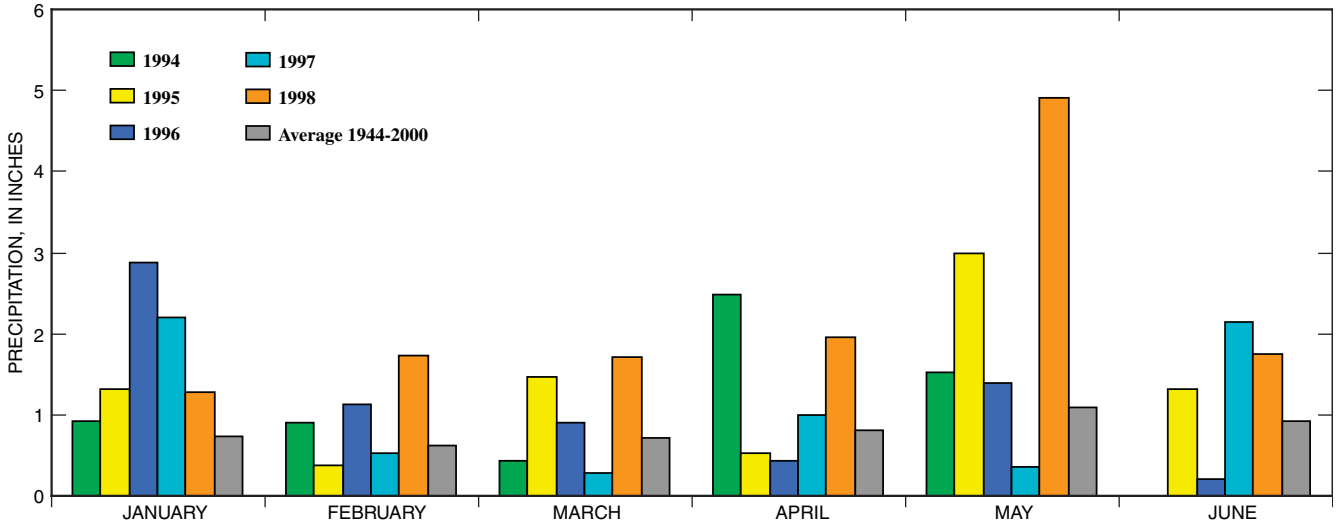

Figure 2. Total monthly precipitation January through June, 1994-98, Battle Mountain, Nevada.

Table 4. Comparison of power consumption during the 1994-97 irrigation seasons with power consumption during the 1998 season at selected irrigation wells and estimated water use during an average irrigation season in the middle Humboldt River Basin, north-central Nevada.

Well numbers (see plate 1)	Irrigated Area (acres)	Ratio of 1994-97 power consumption to 1998 power consumption[1]					Water use (feet of depth)	
		1994	1995	1996	1997	Average[2]	1998 (see table 2)	Average irrigation season[3]
Center-Pivot Sprinkler Systems								
12	251	-	1.29	1.60	1.35	1.41	2.1	3.0
13	248	-	-	1.48	1.32	1.40	1.7	2.4
14	121	2.26	2.14	2.22	2.23	2.21	2.1	4.6
15	123	2.25	2.02	2.11	2.35	2.18	2.2	4.8
16	254	-	1.33	1.76	1.38	1.49	2.0	3.0
17	257	-	-	-	1.49	1.49	1.8	2.7
18	256	1.64	1.28	1.35	1.19	1.36	2.2	3.0
Total Area	**1,510**					**Weighted Average**	**2.0**[4]	**3.1**[4]
Wheel-Line Sprinkler Systems								
1, 2, and 3	316	-	-	1.10	1.33	1.22	2.6	3.2
7	270	-	-	-	1.34	1.34	2.6	3.5
9, 10, and 11	653	-	-	-	1.39	1.39	2.5	3.5
19, 20, and 21	554	1.56	1.38	1.51	1.52	1.49	2.8	4.2
22	156	-	-	-	1.25	1.25	3.1	3.9
23	145	-	-	-	1.63	1.63	2.1	3.4
Total Area	**2,100**					**Weighted Average**	**2.6**[4]	**3.7**[4]

[1] Power consumption data at selected wells for 1994-97 irrigation seasons obtained from Sierra Pacific Power Company with well owner's permission. Ratios computed by dividing power consumption for indicated year by 1998 power consumption. Dash indicates power consumption data not available for that year.

[2] Average power consumption for 1994-97 irrigation seasons. When only one value was available for 1994-97 period, that value was used as average.

[3] Amount of water, in feet of depth, used in an average irrigation season. Computed by multiplying average ratio by amount of water, in feet of depth, applied in 1998.

[4] This is a weighted average where the weighting is by irrigated area.

Total ground-water pumpage from 420 production wells in the middle Humboldt River Basin in 1998 was about 298,000 acre-ft (table 5). This pumpage was distributed as follows—78 percent for mining, 19 percent for irrigation, and 3 percent for power plant, industrial, and municipal needs combined (fig. 3A).

The largest single source of ground-water pumpage in the middle Humboldt River Basin is mining. Total ground water pumped at 16 gold mines in 1998 was 233,000 acre-ft (tables 5 and 6) and exceeded the total of all other ground-water pumpage by about four times (fig. 3A). Consumptive use for mining purposes was 23,600 acre-ft, and the excess of 209,000 acre-ft was pumped for the dewatering of eight gold mines. Dewatering totals in 1998 at the eight mines ranged from 90 acre-ft at the Pinson Mine to 95,400 acre-ft at the Betze Mine (table 6).

Managing this excess water can be difficult, especially when the volumes of water are large. The NDWR policy requires the excess water be returned to the aquifer in the same basin from which it was pumped either by infiltration or reinjection. However, these methods do not always work because the properties of soils and shallow alluvium may not be suitable for infiltration, and the unsaturated zone may not have the capacity to store the large volumes of ground water that must be pumped. Therefore, a second alternative for managing excess water is to substitute it for ground

water being pumped for another purpose in another part of the basin. If neither infiltration nor substitution of use is feasible, the third alternative is to release excess water to the Humboldt River or one of its tributaries.

Table 6 and figure 3B show how water from the eight mines being dewatered was distributed in 1998 according to the alternatives discussed above. A total of about 74,500 acre-ft (36 percent) of excess ground water was returned to aquifers by infiltration at Boulder Flat (Betze and Genesis Mines), Crescent Valley (Pipeline Mine), Lower Reese River Valley (McCoy Mine), and the Kelly Creek Area (Getchell, Pinson, and Twin Creeks Mines). A total of about 33,100 acre-ft (16 percent) of excess water was being substituted for other uses. Of this total, 28,100 acre-ft of excess water from the Betze Mine was for irrigation use in Boulder Flat, and 5,020 acre-ft from the Lone Tree Mine was for consumptive use at the Marigold Mine, and the Valmy Power Plant in the Clovers Area, and the Trenton Canyon Mine located outside the study area. A total of 96,700 acre-ft (46 percent) of excess water was released to the Humboldt River or one of its tributaries from the Betze, Lone Tree, and Twin Creeks Mines. However, releases from the Betze Mine ended in February 1999. Finally, a total of about 5,260 acre-ft (2 percent) of excess water was lost to evaporation.

An estimated 57,800 acre-ft of ground water was pumped during 1998 for irrigation purposes (table 5). This pumpage is widely scattered in the middle Humboldt River Basin, and except for Rock Creek and Willow Creek Valleys, each hydrographic area has some area irrigated by ground water (plate 1). Irrigation pumpage is concentrated in relatively large areas in Antelope and Middle Reese River Valleys and to a lesser extent in Upper and Lower Reese River Valleys, the Clovers Area, and the Kelly Creek Area. The largest irrigated area by far is in Boulder Flat where center-pivot sprinkler systems are used to irrigate about 10,100 acres of alfalfa and pasture. However, all of the water used for irrigating these fields comes from wells used to dewater the Betze Mine about 10 miles to the north.

Municipal wells serve the towns of Austin, Battle Mountain, Crescent Valley, and Beowawe. They also serve groups of residences at a Nevada Department of Transportation maintenance station on the eastern side

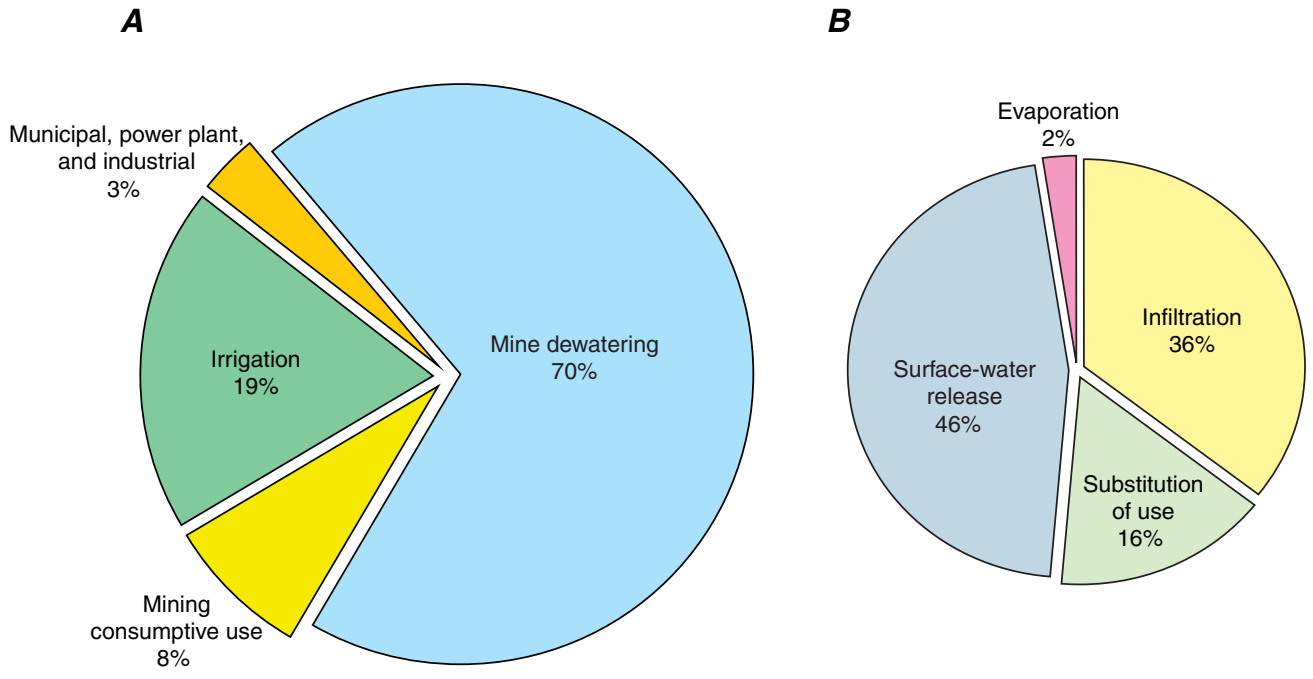

Figure 3. Distribution of (A) Total ground-water pumpage, and (B) Total mine dewatering pumpage, 1998, middle Humboldt River Basin, north-central Nevada. Total pumpage was 298,000 acre-feet and total mine dewatering pumpage was 209,000 acre-feet

Table 5. Area irrigated with ground water, types and numbers of actively used production wells, and total ground-water use in 1998 in hydrographic areas of the Middle Humboldt River Basin, north-central Nevada

Hydrographic area	Irrigated area (acres)	Production wells										Total pumpage (acre feet)
		Irrigation		Power plant		Mining		Industrial		Municipal		
		Number	Pumpage[1] (acre feet)	Number	Pumpage (acre feet)	Number	Pumpage (acre feet)	Number	Pumpage (acre feet)	Number	Pumpage (acre feet)	
Pine Valley	600	4	[2]1,330	0	0	0	0	1	[3]254	0	0	1,580
Crescent Valley	380	2	[4]896	0	0	42	[5]35,100	0	0	4	[6]173	36,200
Carico Lake Valley	300	3	[7]585	0	0	0	0	0	0	0	0	585
Upper Reese River Valley	2,310	17	[8]5,110	0	0	0	0	0	0	7	[9]130	5,240
Antelope Valley	4,780	29	[10]12,200	0	0	0	0	0	0	0	0	12,200
Middle Reese River Valley	7,490	42	[11]16,900	0	0	0	0	0	0	0	0	16,900
Lower Reese River Valley	3,650	19	[12]9,000	0	0	19	[13]28,600	0	0	6	0	35,800
Whirlwind Valley	36	1	[15]47	[16]3	[16]6,670	3	[17]71	0	0	0	0	6,790
Boulder Flat	10,100	1	[18]390	0	0	87	[19]102,000	1	261	2	[20]-	103,000
Rock Creek Valley	0	0	0	0	0	1	[21]196	0	0	0	0	196
Willow Creek Valley	0	0	0	0	0	4	[22]79	0	0	2	[23]-	79
Clovers Area	1,910	17	[24]3,970	21	[25]1,480	3	[26]419	0	0	3	[14]1,070	6,940
Pumpernickel Valley	860	4	[27]2,880	0	0	9	[28]51,400	0	0	0	0	54,300
Kelly Creek Area	1,360	11	[29]3,490	0	0	51	[30]14,900	0	0	0	0	18,400
Totals	**36,700**	**150**	**57,800**	**24**	**8,150**	**219**	**233,000**	**2**	**515**	**24**	**1,370**	**298,000**

[1] Computed as area, in acres, of center-pivot irrigation systems times 2 feet plus area, in acres, of wheel-line irrigation systems times 2.6 feet plus area, in acres, of flood-irrigation systems times 3.9 feet.

[2] Value based on 378 acres irrigated by center pivots and 221 acres irrigated by wheel lines.

[3] Water pumped as a by-product of oil production (Davis, 1999, p. 48). This water was returned to the local aquifer by way of injection wells.

[4] Value based on 123 acres irrigated by center pivots and 250 acres irrigated by wheel lines.

[5] Of this total, 2,420 acre-feet was for consumptive use at Cortez and Pipeline Mines and 32,700 acre-feet was for dewatering Pipeline Mine.

[6] Water supply for town of Crescent Valley and Beowawe School.

[7] Value based on 300 acres irrigated by flood. Ground water is used to supplement streamflow runoff for an estimated one-half of the irrigation season.

[8] Value based on 1,890 acres irrigated by center pivots, 230 acres irrigated by wheel lines, and 187 acres irrigated by flood

[9] Water supply for town of Austin.

[10] Value based on 2,770 acres irrigated by center pivots, 900 acres irrigated by wheel lines, and 1,110 acres irrigated by flood.

[11] Value based on 4,280 acres irrigated by center pivots and 3,210 acres irrigated by wheel lines.

[12] Value based on 880 acres irrigated by center pivots, 1,610 acres irrigated by wheel lines, and 1,160 acres irrigated by flood of which 760 acres is irrigated by surface water for one-half of the season.

[13] Of this total, 1,640 acre-feet was for consumptive use at the Copper Canyon and McCoy Mines and 25,200 acre-feet for dewatering the McCoy Mine. Of the dewatering total, 88 acre-feet was evaporated from infiltration ponds and 25,100 acre-feet was returned to local aquifers by infiltration.

[14] Water supply for town of Battle Mountain.

[15] Value based on 36 acres of wheel lines. Ground water is used about one-half of the season to supplement streamflow diversions from the Humboldt River.

[16] Value is total withdrawal from geothermal wells at Beowawe Geothermal Power Plant. Of this total, 5,650 acre-feet is re-injected after passing through cooling tower and 1,020 acre-feet lost as evaporation.

[17] Ground water pumped for consumptive use at Mule Canyon Mine.

[18] Pumpage for 150 acres irrigated by wheel line in southern Boulder Flat. However, part of the water pumped from Betze Mine is used for irrigation in central Boulder Flat. See next footnote.

[19] Of this total, 6,340 acre-feet was for consumptive use at the Betze, Genesis, Dee, and Carlin Mines and 95,700 acre-feet was for mine dewatering mostly at the Betze Mine. Of the dewatering total, 13,800 acre-feet was returned to local aquifers by infiltration, 28,100 acre-feet was used for irrigation on 10,100 acres at 73 center-pivot sprinkler systems, 5,170 evaporated from infiltration ponds, and 48,600 acre-feet was discharged to the Humboldt River. Discharges to Humboldt River ceased early in 1999.

[20] Municipal wells serving small groups of residents at Dunphy and at Nevada Department of Transportation Maintenance station in eastern Boulder Flat. Pumpage volumes not reported.

[21] Permitted consumptive use at Rossi Mine. Pumpage not reported.

[22] Consumptive use at Midas Joint Venture Gold Mine.

[23] Water supply for town of Midas. Pumpage not reported.

[24] Value based on 1,510 acres of center pivots, 261 acres of wheel lines, and 138 acres of flood that supplements surface-water diversion for one half the season.

[25] Ground water pumped for cooling purposes at Valmy Power Plant. An additional 4,760 acre-feet was delivered from the Lone Tree Mine.

[26] Consumptive use pumpage at Marigold Mine. Does not include 220 acre-ft delivered from Lone Tree Mine. See footnote 28.

[27] Value based on 250 acres of center pivots and 610 acres of flood.

[28] Of this total, 2,470 acre-feet was for consumptive use and 48,900 acre-ft was for mine dewatering. Of the dewatering total, 176 acre-ft used at Marigold Mine (220 acre-ft according to Marigold reports), 66 acre-ft used at Trenton Canyon Mine outside study area, 4,740 acre-ft used at Valmy Power Plant, 21 acre-ft used for watering stock, and 44,000 acre-ft released to Humboldt River by way of the Iron Point Relief Canal.

[29] Value based on 1,270 acres of wheel lines, and 95 acres of flood that supplements streamflow diversions for one-half of each season.

[30] Of this total, 7,960 acre-feet was for consumptive use and 6,970 acre-feet was for mine dewatering at the Twin Creeks, Getchell, and Pinson Mines. Of the dewatering total, 2,880 acre-feet was returned to aquifers as infiltration, and 4,090 acre-ft released to Kelly Creek.

Table 6. Ground-water pumpage for mining purposes in 1998, Middle Humboldt River Basin, north-central Nevada.

[All values in acre-feet, rounded to three significant figures if more than 100 acre-feet and two significant figures if less.]

Mine name	Total mining pumpage	Consumptive use	Excess water[1]	Distribution of excess water			
				Infiltration	Substitution of use	Release to Humboldt River or tributary	Evaporation
Betze	101,000	5,610	95,400	13,500	[1]28,100	[2]48,600	5,170
Carlin	94	94	-	-	-	-	-
Copper Canyon	1,790	1,790	-	-	-	-	-
Cortez	407	407	-	-	-	-	-
Dee	427	427	-	-	-	-	-
Genesis	490	205	285	285	-	-	-
Getchell	4,360	1,610	2,750	2,750			-
Lone Tree	51,400	2,470	48,900	-	[3]5,020	[4]44,000	-
Marigold	419	[5]639	-	-	-	-	-
McCoy	26,800	1,630	25,200	25,100			88
Midas Joint Venture	79	79	-	-	-	-	-
Mule Canyon	71	71	-	-	-	-	-
Pinson	1,120	1,030	90	90	-	-	-
Pipeline	34,700	2,010	32,700	32,700	-	-	-
Rossi[6]	[6]196	196					-
Twin Creeks	9,450	5,320	4,130	40		[7]4,090	
Totals	**233,000**	**23,600**	**209,000**	**74,500**	**33,100**	**96,700**	**5,260**

[1] Used to irrigate 10,100 acres by center pivot in Boulder Flat.

[2] Released to Humboldt River near Dunphy. No releases since February 1999.

[3] Water delivered to Valmy Power Plant and Marigold and Trenton Canyon Mines.

[4] Water released to Iron Point Relief Canal.

[5] Total includes 220 acre-ft of water delivered from Lone Tree Mine.

[6] The Rossi Mine is a small barite mine. The total pumpage shown was not reported. Instead, the value is the permitted pumpage.

[7] Released to Kelly Creek, a tributary of Humboldt River. All of this water infiltrates the stream channel before reaching the Humboldt River.

of Boulder Flat, at Dunphy in southern Boulder Flat, and at Valmy in the western part of the Clovers Area. Total municipal use was 1,370 acre-ft in 1998 (table 5).

Ground water is used in the Clovers Area and in Whirlwind Valley for generation of electricity. In 1998, 1,480 acre-ft of ground water was pumped at 21 wells in the Clovers Area for cooling purposes at the Valmy Power Plant (table 5). However, since 1998 these cooling water needs have been met mostly with excess water from the nearby Lone Tree Mine. Three geothermal wells at the Beowawe Geothermal Power Plant in Whirlwind Valley produce steam that is used to generate electricity. The total water withdrawn in 1998 was 6,670 acre-ft, of which 85 percent was returned to the geothermal reservoir by re-injection, and the balance was lost to evaporation.

Ground-water pumpage for industrial purposes is not common in the middle Humboldt River Basin. The only industrial pumpage that could be confirmed from State of Nevada records was 254 acre-ft of water pumped as a by-product of oil production in Pine Valley and 261 acre-ft pumped at a chemical plant in western Boulder Flat (table 5).

Summary

Ground water is pumped in the middle Humboldt River Basin for a variety of uses, the principal of which are agricultural, industrial, mining, municipal, and power plant purposes. Ground water also is pumped at a number of domestic and stock wells, but these two uses are relatively small when compared with the principal uses. The purpose of this report is to develop a compilation of all production wells and areas irrigated by ground water, and to quantify 1998 ground-water use in each of the 14 hydrographic areas of the middle Humboldt River Basin.

Annual pumping records for production wells generally are reported to the Nevada Division of Water Resources. However, operators of irrigation wells are not consistently required to report annual pumpage. In order to make reasonable estimates of pumpage for irrigation use, daily power-consumption and pump-discharge rates were measured at 20 wells used to irrigate 3,850 acres of alfalfa and minor amounts of oats by center-pivot and wheel-line sprinkler systems. This area represents about 10 percent of the total area of 36,700 acres irrigated by ground water in the middle Humboldt River Basin. The two rates were used to compute a ratio that would estimate the amount of power required to pump one acre-foot of water at each of the wells. The estimated total volume of ground water pumped at each well during the irrigation season was determined by dividing total power use at the well during the season by the ratio. A similar approach was used to estimate total water pumped at three wells using pumps powered by diesel engines to flood-irrigate two fields. Finally, the total amount of water, in feet, applied to the irrigated fields was estimated by dividing area, in acres, irrigated by total amount of water, in acre-feet, that was pumped.

The amount of water applied to the fields irrigated by center-pivot and wheel-line sprinkler systems in 1998 ranged from 1.7 to 2.2 ft and 2.1 to 3.1 ft, respectively. The averages were 2.0 and 2.6 ft, respectively. The amount of water, in feet of depth, applied to the flood-irrigated fields was 3.9 ft, about twice the amount of that used by a center-pivot sprinkler system.

The amounts of water applied to these fields during the 1998 irrigation season were less than what would have been applied during a typical irrigation season. Late winter and spring precipitation in 1998 exceeded long-term monthly averages for January through June by almost two to four times. As a result, most irrigation wells were used only sporadically in the first part of the 1998 irrigation season.

Comparison of 1998 power-consumption records with those for 1994-97 shows that 1998 power consumption was consistently exceeded during the previous four years by 110 to 235 percent. If the amounts of water applied to fields during the 1998 irrigation season are adjusted to account for this, the average amount of water applied to a field using center-pivot and wheel-line sprinkler systems during a typical year would be 3.1 ft and 3.7 ft, respectively.

Total ground water pumped in the middle Humboldt River Basin during 1998 was about 298,000 acre-ft, and was distributed as follows: 78 percent for mining (including 70 percent for dewatering), 19 percent for irrigation, and 3 percent for industrial, municipal, and power plants combined. Mining pumpage was by far the largest because several gold mines have extended below local ground-water levels and the area around each mine must be dewatered in order to maintain a dry and workable mine. Excess water from the eight mines was distributed as follows: (1) A total of about 74,500 acre-ft of excess ground water was returned to aquifers by infiltration at Boulder Flat, Crescent Valley, Lower Reese River Valley, and the Kelly Creek Area; (2) A total of 33,100 acre-ft was being substituted for irrigation use in Boulder Flat and for consumptive use at a mine and a power plant in the Clovers Area and at a mine outside the study area; (3) A total of 96,700 acre-ft was released to the Humboldt River or one of its tributaries from three mines; and (4) A total of 5,260 acre-ft was lost to evaporation.

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