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Update to the Ground-Water Withdrawals Database for the Death Valley Regional Ground-Water Flow System, Nevada and California, 1913–2003

Data Series 340

U.S. Department of the Interior
U.S. Geological Survey

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By Michael T. Moreo and Leigh Justet

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Conversion Factors and Datums

Conversion Factors

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
	Area	
acre	0.4047	hectare (ha)
acre	43,560	square foot (ft^2)
acre	4,047	square meter (m^2)
	Volume	
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.325851	million gallons (Mgal)
million gallons (Mgal)	3,785	cubic meters (m^3)
million gallons (Mgal)	3,785	million liters (Mliters)
	Volumetric Rate	
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
million gallons per year (Mgal/yr)	3,785	cubic meter per year (m^3/yr)

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Altitude, as used in this report, refers to distance above the vertical datum.

Update to the Ground-Water Withdrawals Database for the Death Valley Regional Ground-Water Flow System, Nevada and California, 1913–2003

By Michael T. Moreo and Leigh Justet

Abstract

Ground-water withdrawal estimates from 1913 through 2003 for the Death Valley regional ground-water flow system are compiled in an electronic database to support a regional, three-dimensional, transient ground-water flow model. This database updates a previously published database that compiled estimates of ground-water withdrawals for 1913–1998. The same methodology is used to construct each database. Primary differences between the 2 databases are an additional 5 years of ground-water withdrawal data, well locations in the updated database are restricted to Death Valley regional ground-water flow system model boundary, and application rates are from 0 to 1.5 feet per year lower than original estimates. The lower application rates result from revised estimates of crop consumptive use, which are based on updated estimates of potential evapotranspiration. In 2003, about 55,700 acre-feet of ground water was pumped in the DVRFS, of which 69 percent was used for irrigation, 13 percent for domestic, and 18 percent for public supply, commercial, and mining activities.

Introduction

The U.S. Geological Survey (USGS), in cooperation with the Department of Energy, developed a transient ground-water flow model of the Death Valley region of southern Nevada and southeastern California to evaluate the effects of Nevada Test Site (NTS) activities on the regional ground-water flow system (Belcher and others, 2004; fig. 1). A database of spatially and temporally distributed ground-water withdrawals was developed to provide input datasets for modeling this large and complex ground-water flow system (San Juan and others, 2004). The previously published database documented the history of ground-water withdrawals in the Death Valley regional ground-water flow system (DVRFS) by user and water-use category from 1913 to 1998 (Moreo and others, 2003). Refining the ground-water flow model required extending the database through 2003 and improving water-use estimates.

Purpose and Scope

This report documents updates to the original ground-water withdrawals database for the DVRFS ground-water flow model. Annual ground-water withdrawal estimates from 1913 to 2003 for each identified withdrawal location are compiled in an electronic database that is included in this report. Three revisions were made to the database. First, the updated database extends annual ground-water withdrawal estimates from 1998 through 2003 by using the same methodology described by Moreo and others (2003). Second, the updated database includes only data for withdrawal locations within the DVRFS model boundary as defined by Belcher and others (2004). Third, the ground-water withdrawal for irrigation was recomputed using improved estimates of crop consumptive use.

Methods for Database Update

Similar to the previously constructed database, this database integrates datasets obtained from multiple sources: (1) well-log and water-rights databases and pumpage inventories from the Nevada Division of Water Resources (NDWR), (2) data obtained directly from water users, (3) remotely sensed Thematic Mapper (TM) imagery, and (4) estimates of potential evapotranspiration (PET). Together, these datasets are used to develop reasonable estimates of annual ground-water withdrawal from known and approximate well locations (Moreo and others, 2003).

Subsequent to the completion of the previous database, a newer more accurate PET dataset was developed by Flint and Flint (2007) for use in their Basin Characterization Model (BCM). The Flint and Flint (2007) PET dataset was computed using the Priestley-Taylor equation, and compares well to measured rates from 204 weather sites operated by the California Irrigation Management Information System (CIMIS; http://wwwcimis.water.ca.gov) and 26 weather sites operated in Arizona by the Arizona Meteorological Network (AZMET; http://ag.arizona.edu/azmet/). The CIMIS and

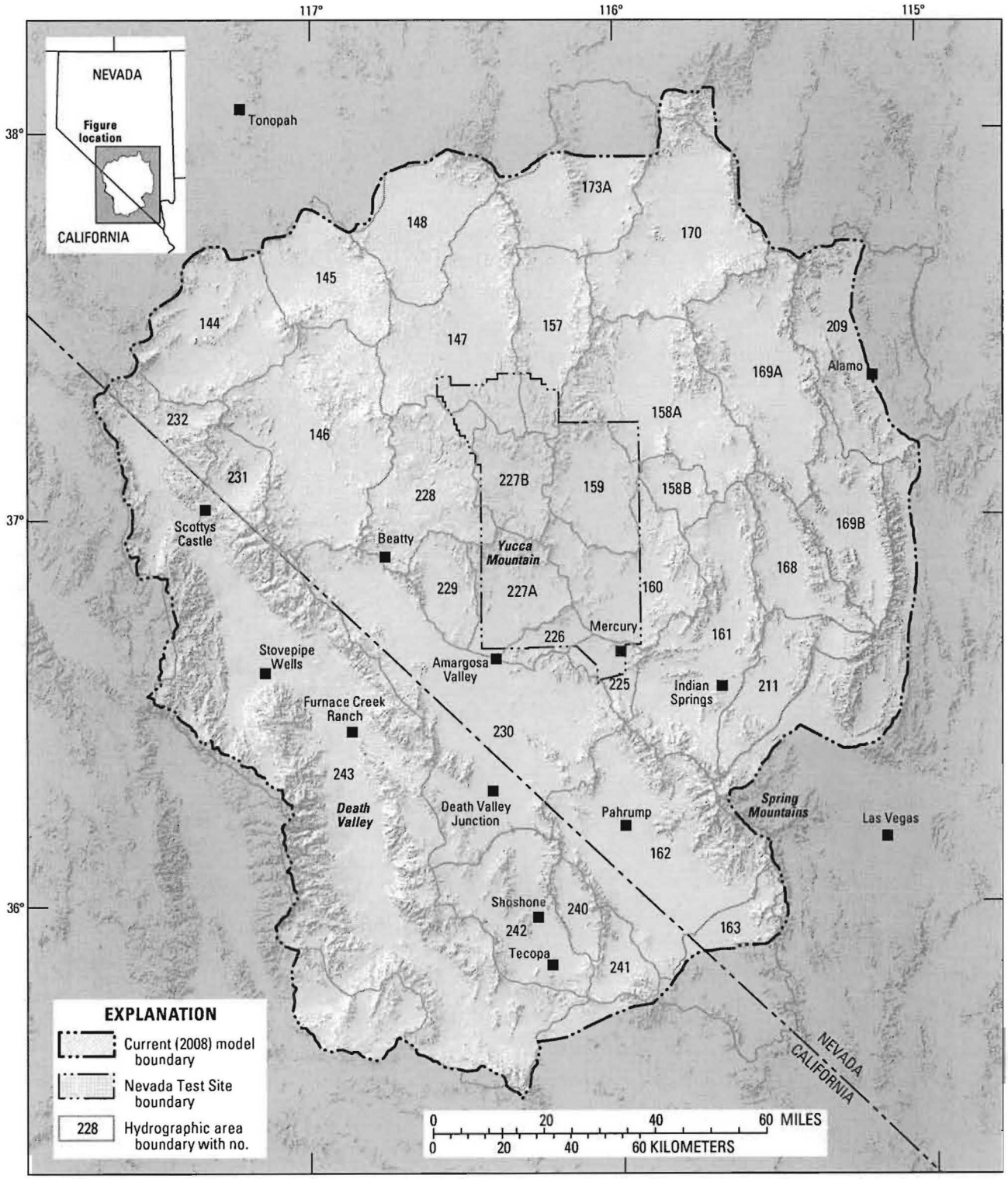

Figure 1. Boundaries of Death Valley regional ground-water flow system model, Nevada Test Site, and hydrographic areas, Nevada and California.

AZMET networks use the standardized Penman-Monteith reference *ET* equation (ET_o) to calculate PET (Allen and others, 2005). Crop consumptive use, referred to here as crop evapotranspiration (ET_c), is the product of ET_o and a crop coefficient (K_c) (U.S. Department of Agriculture, 1993):

$$ET_c = ET_o * K_c \ . \tag{1}$$

where

ET_c is annual crop evapotranspiration, in feet per year;

ET_o is reference evapotranspiration, in feet per year, and

K_c is the crop coefficient, dimensionless.

PET computed by Flint and Flint (2007) is considered a reasonable surrogate for ET_o. A network similar to CIMIS does not exist to estimate ET_o in Nevada, thus PET computed by Flint and Flint (2007) is the best available substitute. The advantages of using ET_o for the present study are: (1) ET_o is thought to be more accurate for estimating water use by irrigated agriculture than the previously applied PET estimates (Shevnell, 1996), and is gaining acceptance as the benchmark equation used by the agricultural community (Allen and others, 2005), and (2) K_c values developed by CIMIS are transferable (Allen and others, 2005), and as a result can be used to estimate ET_c in Nevada.

High-water-use crops (primarily alfalfa) accounted for about 95 percent of irrigated acreage from 1999 to 2003. ET_c for high-water-use crops was computed as the product of ET_o and the average growing season K_c value of 1 developed by CIMIS for alfalfa. The difference between revised and original ET_c estimates for high-water-use crops ranged from -0.9 to +0.3 ft/yr (table 1).

The rate at which water is applied by an irrigation system to a crop during a growing season is referred to as the application rate (*AR*). *AR* estimates for high-water-use crops based on the revised ET_c rates were from 0 to 1.5 ft/yr lower than original estimates (table 1). *AR* estimates for high-water-use crops in the original and updated databases were based on the following equation (Moreo and others, 2003):

$$AR = ET_c \ / \ Eff, \tag{2}$$

where

AR is application rate, in feet per year; and

Eff is irrigation efficiency, dimensionless.

Irrigation efficiency (*Eff*) is the ratio of water beneficially used by a crop to ground water pumped during an irrigation season. Values of *Eff* were unchanged from those used by Moreo and others (2003); therefore, lower application rate estimates for high-water-use crops in Pahrump Valley and Amargosa Desert were based on lower ET_c estimates. The method used to estimate *AR* for low-water-use crops was unchanged from the original database (Moreo and others, 2003).

The range in *AR* uncertainty for high-water-use crops in this database (table 1) is narrower to reflect a more reasonable minimum and maximum for model simulations than the range in the previous database (table 1). The uncertainty range in the original database assumed extreme irrigation system efficiencies during the shortest and longest possible growing season (Moreo and others, 2003). The revised *AR* uncertainty range was based on interviews with local farmers in Pahrump Valley and Amargosa Desert, and on limited metered or measured withdrawals reported in NDWR pumpage inventories from 1959 to 2003.

Table 1. Estimated application rates for high-water-use crops by hydrographic area from the original database and revised application rates developed for the updated database, Death Valley regional ground-water flow system, Nevada and California.

[**Application rate**: Calculated using equation 2 in text. Most likely application rate determined using crop coefficient = 1.0 and irrigation efficiency = 0.75 (except HA 162 = 0.65). **Original database**: Potential ET estimated from Shevenell (1996). **Updated database**: Potential ET estimated from Flint and Flint (2007). **Abbreviations**: ET, evapotranspiration; ft/yr, foot per year]

Hydrographic area		Original database (Moreo and others, 2003)					Updated database (This report)				
		ET (ft/yr)		Application rate (ft/yr)			ET (ft/yr)		Application rate (ft/yr)		
Number	Name	Potential	Crop	Minimum	Likely	Maximum	Potential	Crop	Minimum	Likely	Maximum
162	Pahrump Valley	6.4	5.9	5	9	14	5.0	5.0	5	7.5	10
170	Penoyer Valley	3.8	3.5	3	5	7	3.8	3.8	4	5	6
230	Amargosa Desert	6.4	5.9	5	8	12	5.1	5.1	5	7	9

Discussion of Database Update

The major differences within the DVRFS model boundary between the previous and updated databases are that (1) estimated *AR* for high-water-use crops were based on new estimates of crop consumptive use and (2) the updated database extends ground-water withdrawal estimates through 2003. The updated database still shows the same overall spatial and temporal trends. In the three hydrographic areas with significant irrigation, the "likely" *AR* estimates for high-water-use crops are 1.5 ft/yr lower in Pahrump Valley, identical in Sand Spring Valley (known locally as Penoyer Valley), and 1 ft/yr lower in the Amargosa Desert (table 1). An overall decrease in the irrigation water use estimate results from adjusting the application rate. Estimates between the previous and updated databases decreased by 0 to 7 percent before 1978, and by 8 to 13 percent from 1979 to 1998. For example, the irrigation water use in 1998 decreased by about 13 percent from the previous estimate (60,500 acre-ft) to the updated estimate (52,800 acre-ft). Prior to 1979 estimates more heavily relied on literature values rather than on the crop coefficient method and thus were not influenced as significantly by the current evaluation (Moreo and others, 2003).

In the extended time frame of the updated database, the total ground-water withdrawal decreased from a maximum of about 69,800 acre-ft in 1998 to 62,900 acre-ft in 1999 to 55,500 acre-ft in 2000; from 2001 to 2003, the total ground-water withdrawal remained relatively constant. In 2003, about 55,700 acre-ft of ground water was pumped in the DVRFS, of which 69 percent was used for irrigation, 13 percent for domestic, and 18 percent for public supply, commercial, and mining activities (fig. 2).

Between 1998 and 2003 total ground-water withdrawal from Pahrump Valley decreased by 10,000 acre-ft, irrigation use decreased by 12,000, and public supply and domestic water use increased by about 2,000 acre-ft (fig. 3). This decrease in total water use was attributed primarily to agricultural fields removed from production in Pahrump Valley where irrigated acreage decreased from about 3,100 acres in 1998 to 2,400 acres in 1999 to 1,600 acres in 2000. By 2003, 1,700 acres had been converted from agriculture to residential land use. The maximum ground-water withdrawal in Pahrump Valley occurred during 1968 when 8,100 acres of cotton and alfalfa were irrigated with 46,000 acre-ft.

Total ground-water withdrawal from Amargosa Desert decreased from 1998 (21,100 acre-ft) to 2001 (14,100 acre-ft), and then increased through 2003 (17,600 acre-ft). Total ground-water withdrawal averaged 16,800 acre-ft from 1994 through 2003 and ranged from 14,100 to 21,100 acre-ft. The annual variation in total ground-water withdrawal is attributed primarily to crop and irrigation cycles (fig. 3). Alfalfa fields typically are fallowed 2 years during a 7-year period. Other fields are irrigated once every 5 years to demonstrate beneficial use and maintain water rights.

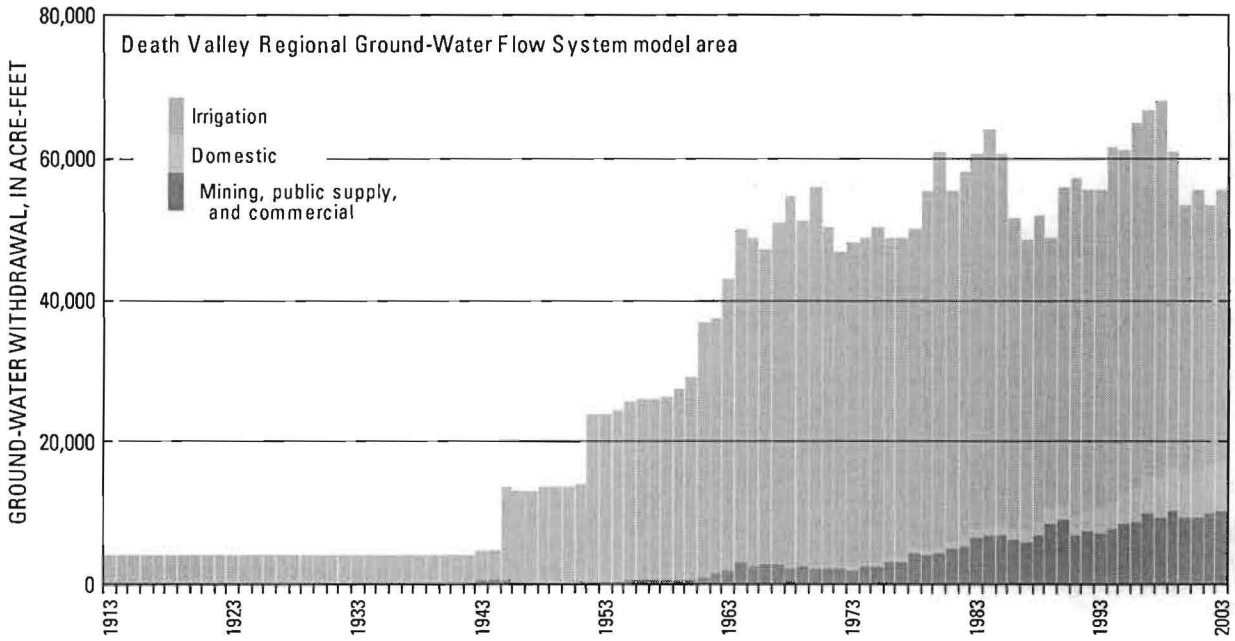

Figure 2. Total ground-water withdrawals by water-use class in the Death Valley regional ground-water flow system model area, Nevada and California, 1913–2003.

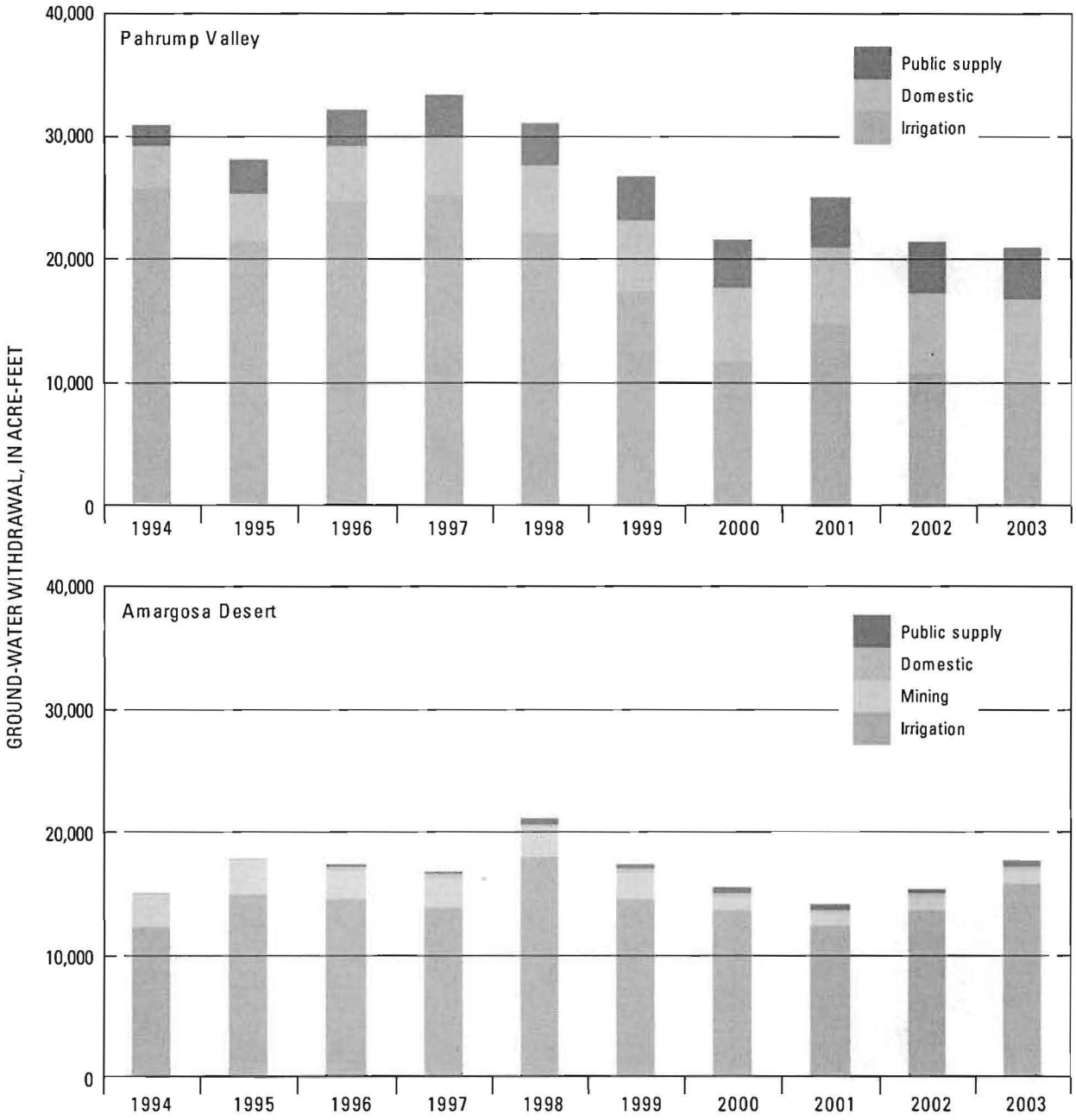

Figure 3. Ground-water withdrawals for significant water-use classes for selected hydrographic areas and Nevada Test Site, Death Valley regional ground-water flow system, Nevada and California, 1994–2003.

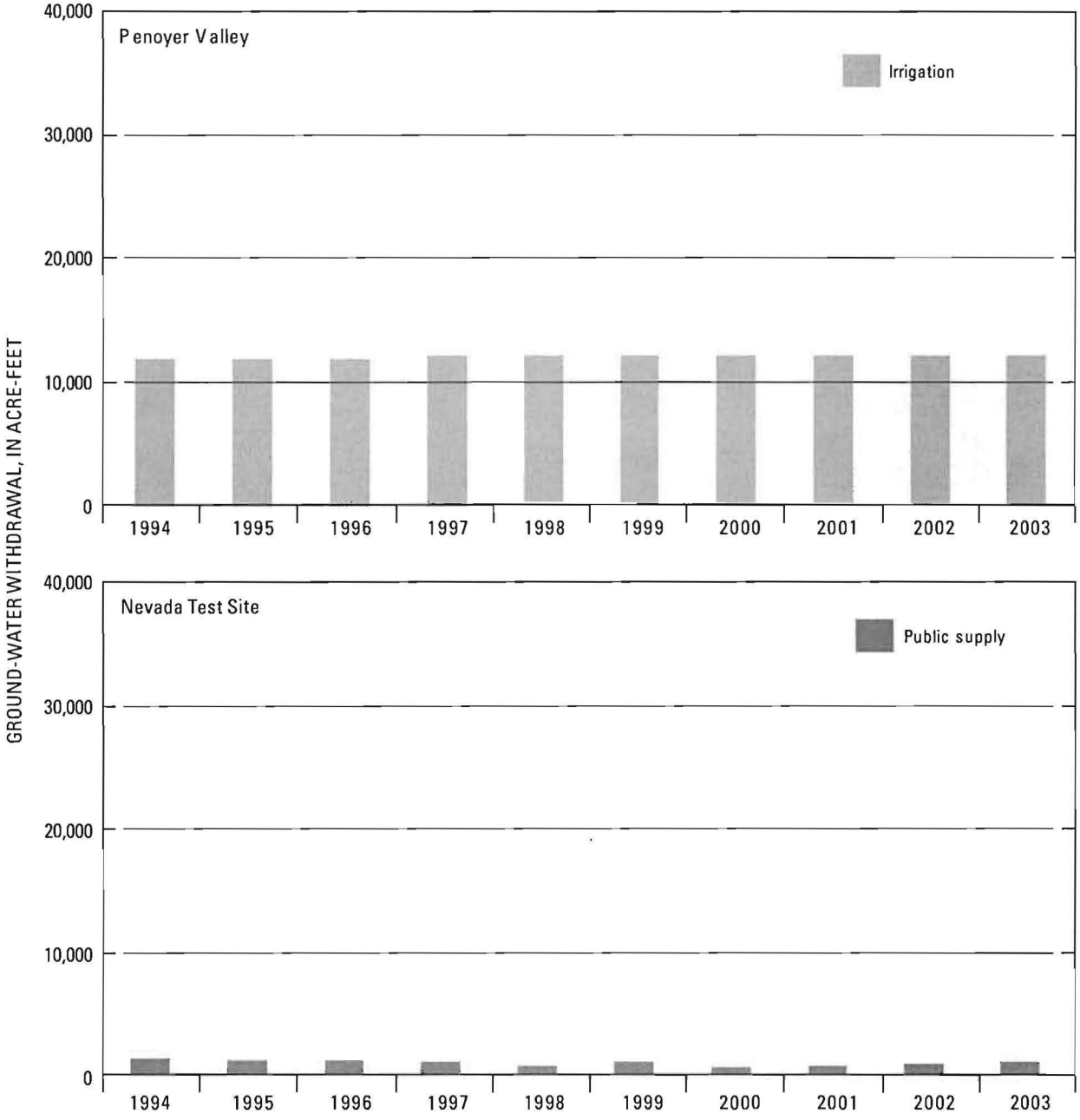

Figure 3.—Continued

In 2003, 12 percent of reported irrigated acreage for Amargosa Desert was metered, including two of the larger fields, 125 and 112 acres. Application rates for these two fields were about 5 and 6 ft, respectively. These rates were on the low end of 5 to 9 ft/yr range estimated for the Amargosa Desert (table 1). It is unclear whether these application rates are representative of application rates in other fields that are not metered.

Ground-water withdrawals for nonirrigation use in Amargosa Desert ranged from 11 to 16 percent of total ground-water withdrawals between 1998 and 2003. Ground-water use for mining decreased from 2,400 acre-ft (11 percent of total water use) in 1998 to 1,200 acre-ft (7 percent of total water use) in 2003 because of the closure of the Bullfrog Mine owned by Barrick Gold Corporation. Domestic and public supply water use from 1998 to 2003 was less than 5 percent of the total water use.

Other significant areas of ground-water withdrawal are Penoyer Valley and NTS (fig. 3). Irrigation is the only major water use in Penoyer Valley, and did not change from 1998 to 2003 (about 12,600 acre-ft). Ground-water withdrawals supporting NTS activities ranged from about 670 acre-ft to 1,040 acre-ft between 1998 and 2003.

Acknowledgments

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Appendix A. Ground-Water Withdrawal Data for the Death Valley Regional Ground-Water Flow System, 1913–2003

The database distributed with this report is in Microsoft® Access 2000 format. Table names are prefixed with "tbl_" and queries with "qry_". Table, query, and column headings are described in table A1. The location of withdrawal points used for public supply have been omitted and replaced with "99999" pursuant to directives issued by the Department of Homeland Security.

Table A1. Description of Microsoft® Access database for ground-water withdrawal data, Death Valley regional ground-water flow system, Nevada and California, 1913–2003.

[**Table/query/column headings:** Table names preceded by tbl_; query names preceded by qry_]

Table/Query/Column Headings	
Tables	**Description**
tbl_application rates	Rates applied to irrigation and domestic uses
tbl_raw_data	Raw annual data
tbl_spatial	Location and depths of withdrawal points
tbl_withdrawals	Withdrawals summed by withdrawal point and year
Queries	**Description**
qry_domestic_withdrawals_ha	Domestic withdrawals summed by hydrographic area and year
qry_domesic_withdrawals_withdrawal point	Domestic withdrawals summed by withdrawal point and year
qry_irrigation_withdrawals_ha	Irrigation withdrawals and irrigated acres summed by hydrographic area and year
qry_irrigation_withdrawals_record	Irrigation withdrawals summed by record
qry_irrigation_withdrawals_withdrawal point	Irrigation withdrawals and irrigated acres summed by withdrawal point and year
qry_other_withdrawals_ha	All withdrawals other than irrigation and domestic summed by hydrographic area and year
qry_other_withdrawals_record	All withdrawals other than irrigation and domestic summed by record
qry_other_withdrawals_withdrawal point	All withdrawals other than irrigation and domestic summed by withdrawal point and year
Column	**Description**
acres_irrigated	Number of acres irrigated
altitude	Withdrawal point altitude, in feet above mean sea level
application_rate_best	Best estimate application rate (foot per year)
application_rate_max	Maximum estimated application rate (foot per year)
application_rate_min	Minimum estimated application rate (foot per year)
bottom_completion	Lower end of interval in which ground water is withdrawn, in feet below land surface
bottom_max_completion	Maximum lower end of interval in which ground water is withdrawn, in feet below land surface
crop_type	L=low water-use crops; H=high water-use crops; M=undifferentiated crop types; X= not applicable
east_utm	Easting of withdrawal point, in meters
error_coefficient	-4=no use extrapolated; -3=no use interpolated; -2,-1, 0=no use reported or interpreted; 1,2=withdrawal reported or interpreted; 3=withdrawal interpolated; 4=withdrawal extrapolated; 5=withdrawal metered
ha	Hydrographic area designator
ha_plss_id	Hydrographic area, township, range, section
latitude	Latitude of withdrawal point, in decimal degrees
longitude	Longitude of withdrawal point, in decimal degrees
north_utm	Northing of withdrawal point, in meters
remarks	Point of withdrawal description
top_completion	Upper end of interval in which ground water is withdrawn, in feet below land surface
top_min_completion	Minimum upper end of interval in which ground water is withdrawn, in feet below land surface
withdrawal_best	Best withdrawal estimate, in acre-feet

Table A1. Description of Microsoft® Access database for ground-water withdrawal data, Death Valley regional ground-water flow system, Nevada and California, 1913–2003.—Continued

[**Table/query/column headings:** Table names preceded by tbl_; query names preceded by qry_]

Table/Query/Column Headings	
Column	**Description**
withdrawal_coefficient	Irrigation use = number of acres irrigated, domestic use = number of wells, all other water uses = amount of withdrawal, in acre-feet per year
withdrawal_max	Maximum withdrawal estimate, in acre-feet
withdrawal_min	Minimum withdrawal estimate, in acre-feet
withdrawal_point	Point of withdrawal designator
withdrawal_point_accuracy	Accuracy of latitude/longitude placement of withdrawal point, in feet
wtr_use	Water use; C=commercial; H=domestic; I=irrigation; K=mining; N=industrial; P=public supply; R=recreation; S=stock; W=wildlife; Z=other
year	Calendar year of withdrawal

For more information contact:
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