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Estimated Colorado Golf Course Irrigation Water Use, 2005

Open-File Report 2008–1267

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

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By Tamara Ivahnenko

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

U.S. Department of the Interior
KEN SALAZAR, Secretary

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
section (640 acres or 1 square mile)	259.0	square hectometer (hm^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
million gallons (Mgal)	3,785	cubic meter (m^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
	Flow rate	
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Estimated Colorado Golf Course Irrigation Water Use, 2005

By Tamara Ivahnenko

Abstract

Golf course irrigation water-use data were collected as part of the U.S. Geological Survey National Water Use Program's 2005 compilation to provide baseline information, as no golf course irrigation water-use data (separate from crop irrigation) have been reported in previous compilations. A Web-based survey, designed by the U.S. Geological Survey, in cooperation with the Rocky Mountain Golf Course Superintendents Association (RMGCSA), was electronically distributed by the association to the 237 members in Colorado. Forty-three percent of the members returned the survey, and additional source water information was collected by telephone for all but 20 of the 245 association member and non-member Colorado golf courses.

For golf courses where no data were collected at all, an average "per hole" coefficient, based on returned surveys from that same county, were applied. In counties where no data were collected at all, a State average "per hole" value of 13.2 acre-feet was used as the coefficient. In 2005, Colorado had 243 turf golf courses (there are 2 sand courses in the State) that had an estimated 2.27 acre-feet per irrigated course acre, and 65 percent of the source water for these courses was surface water. Ground water, potable water (public supply), and reclaimed wastewater, either partially or wholly, were source waters for the remaining courses. Fifty-three of the 64 counties in Colorado have at least one golf course, with the greatest number of courses in Jefferson (23 courses), Arapahoe (22 courses), and El Paso Counties (20 courses). In 2005, an estimated 5,647.8 acre-feet in Jefferson County, 5,402 acre-feet in Arapahoe County, and 4,473.3 acre-feet in El Paso County were used to irrigate the turf grass.

Introduction

Golf has been formally played in Colorado since 1895, when the City of Denver opened the first 18-hole course in the State at Overland Park (originally the Denver Country Club) (National Golf Foundation, 2006; Goodstein, 2007). Since then, 244 more courses have been added, with 8 more scheduled to open between 2006 and 2008. Little or no golf course irrigation data have been collected from these courses as part of the U.S. Geological Survey's (USGS) National Water Use Program's compilations since the inception of the compilations in 1950. As part of the 2005 Colorado water-use compilation, the USGS, in cooperation with the Rocky Mountain Golf Course Superintendents Association (RMGCSA), distributed a Web-based water-use survey to the association's 237 Colorado members. This report summarizes the results, at the State and county levels, of the 2005 survey as well as the estimated water usage for the courses where no survey was returned.

Purpose and Scope

The purpose of this report is to provide a summary of golf course irrigation data to the RMGCSA. The data were collected as part of the USGS 2005 National Water Use Program compilation to provide baseline information, as no golf course irrigation water-use information (separate from crop irrigation) has been reported in previous compilations. Only 2005 survey results and estimated State and county-level irrigation golf course data from the 245 courses in Colorado are discussed, with no water-use information on any single course presented (except in counties that contain a single golf course).

Acknowledgments

The author would like to thank Joe McCleary, past President of the RMGCSA, for his cooperation and assistance in designing the Web-based irrigation water-use survey, and distributing the survey URL to the RMGCSA members. The author also thanks all the association members who completed the survey either online or by telephone and who provided valuable information on Colorado golf course irrigation and maintenance.

Methods

A Web-based survey, designed by the USGS in cooperation with the RMGCSA, was electronically distributed to all the RMGCSA members in Colorado. This survey (Appendix) queried the members for basic golf course information (location, contact information, irrigated acres), identification of source water type (ground water, surface water, purchased potable water [treated public-supply] or reclaimed water) and total amount of water withdrawn from each source type in 2005.

Of the 237 golf courses with superintendents as members of the RMGCSA, 101 (43 percent) surveys were returned (both electronically and by telephone). At least one golf course survey was returned from nearly every county in which a golf course is located (the exceptions are Chaffee, Elbert, Montezuma, Ouray, Prowers, Teller, Saguache, and Sedgwick Counties). Golf course information (date established, number of holes, contact information) was obtained from the 2006 Golf Course Directory (National Golf Foundation, 2006). Springfield Golf Course (Baca County) and Hugo Golf Course (Lincoln County) are not included in the statistics, as these are sand courses (no turf) and use little or no water for irrigation. During the telephone surveys, source water types for other courses in the same county were queried, especially if the course survey had not been completed. Source water information (necessary information for estimating irrigation water use) was collected for all but 20 golf courses. County information, either from returned surveys or telephone calls, was used to infer water source types for those 20 courses.

To estimate the amount of water used for irrigation in 2005 for the 142 golf courses, with no survey information, a "per hole" value was used. Because information was lacking on total irrigated acres for any course that did not return a survey, this method offered a baseline from which to start water-use estimates. These "per hole" values were calculated on the basis of returned survey information and were applied by county to other courses in the same county, thereby ensuring estimated values based on similar environmental factors, although not necessarily similar irrigation practices. In counties where no surveys were returned, a State average "per hole" value of 13.2 acre-feet (acre-ft) was used as the coefficient.

Estimated Golf Course Irrigation Water Use, 2005

In 2005, Colorado had 243 turf golf courses and an estimated 2.27 acre-ft per irrigated course acre. Approximately 24,800 acres in Colorado were irrigated course turf. Surface water, ground water, potable (public supply) water, and reclaimed wastewater are the four source water types in Colorado. In 13.5 percent of courses statewide, irrigation water was obtained from a mixture of these sources. Surface water is the predominant source, and provides either partially or wholly, 66 percent of irrigation water. Ground water provided 15 percent, while reclaimed wastewater and potable public supply provided 11 and 8 percent of the irrigation water, respectively.

Fifty-three of the 64 counties in Colorado have at least one golf course (table 1), with the greatest number of courses in Jefferson (23 courses), Arapahoe (22 courses), and El Paso Counties (20 courses). Total irrigation water use by county reflects the number of courses in that county, as illustrated in figure 1. In 2005, an estimated 5,647.8 acre-ft in Jefferson County, 5,402 acre-ft in Arapahoe County and 4,473.3 acre-ft in El Paso County were used to irrigate the turf grass. However, there are a few outlying data points based on the number of courses per county (fig. 2, table 1). Summit County, which has five courses, had an estimated 544 acre-ft of irrigation water use, a use value closer to the counties that have two to three courses. Boulder County, however, had 11 courses in 2005 and used an estimated 1,946.7 acre-ft, a use closer to counties having 6 to 8 courses. Fremont County had an estimated water use of 1,098.6 acre-ft, a use about 2 to 3 times higher than other counties with two courses. The variation in water use in counties may be due to environmental (precipitation, soil types, temperature) and anthropogenic (irrigation and xeriscape practices, turf species, number of acres irrigated) factors.

Table 1. Number of golf courses, by source water type, by Colorado county, 2005.

[SW, surface water; GW, ground water; PPW, purchased potable water; RWW, reclaimed wastewater; Number of golf courses by source water type does not add to total number of courses due to multiple source water types used by some golf courses in that county; Baca and Lincoln Counties each have a sand course not included in statistics, as little irrigation takes place on these courses]

County	Number of golf courses by source water type				Total number of courses
	SW	GW	PPW	RWW	
Adams	4	2	0	4	9
Alamosa	1	0	1	0	1
Arapahoe	7	13	5	6	22
Archuleta	1	0	0	0	1
Baca	0	0	0	0	1
Bent	1	0	0	0	1
Boulder	10	0	1	1	11
Broomfield	2	0	1	1	4
Chaffee	2	0	1	0	2
Cheyenne	0	1	0	0	1
Custer	1	0	0	0	1
Delta	2	0	0	0	2
Denver	5	3	5	3	9
Douglas	1	9	2	5	15
Eagle	15	0	0	0	15
Elbert	1	0	0	0	1
El Paso	8	7	3	7	20
Fremont	2	0	0	0	2
Garfield	8	0	0	0	8
Grand	4	0	0	0	4
Gunnison	2	0	0	0	2
Huerfano	2	0	0	0	2
Jefferson	21	2	2	2	23
Kiowa	0	1	0	0	1
Kit Carson	0	2	0	1	3
Lake	0	1	0	0	1
La Plata	3	2	0	1	4
Larimer	13	1	0	0	14
Las Animas	0	0	1	0	1

Table 1. Number of golf courses, by source water type, by Colorado county, 2005.—Continued

[SW, surface water; GW, ground water; PPW, purchased potable water; RWW, reclaimed wastewater; Number of golf courses by source water type does not add to total number of courses due to multiple source water types used by some golf courses in that county; Baca and Lincoln Counties each have a sand course not included in statistics, as little irrigation takes place on these courses]

County	Number of golf courses by source water type				Total number of courses
	SW	GW	PPW	RWW	
Lincoln	0	1	0	0	2
Logan	0	2	0	0	2
Mesa	6	0	0	0	6
Moffat	1	0	0	0	1
Montezuma	1	0	0	0	1
Montrose	4	0	2	0	4
Morgan	0	2	0	0	2
Otero	1	1	1	0	3
Ouray	1	0	0	0	1
Phillips	1	1	0	0	2
Pitkin	3	0	0	0	3
Prowers	0	0	1	0	1
Pueblo	2	0	2	1	5
Rio Blanco	2	0	0	0	2
Rio Grande	1	0	1	0	2
Routt	4	1	1	0	4
Saguache	0	1	0	0	1
San Miguel	1	0	0	0	1
Sedgwick	0	1	0	0	1
Summit	5	1	0	0	5
Teller	1	0	0	0	1
Washington	0	1	0	0	1
Weld	7	0	2	1	10
Yuma	0	1	2	0	3
Total	157	57	34	33	245

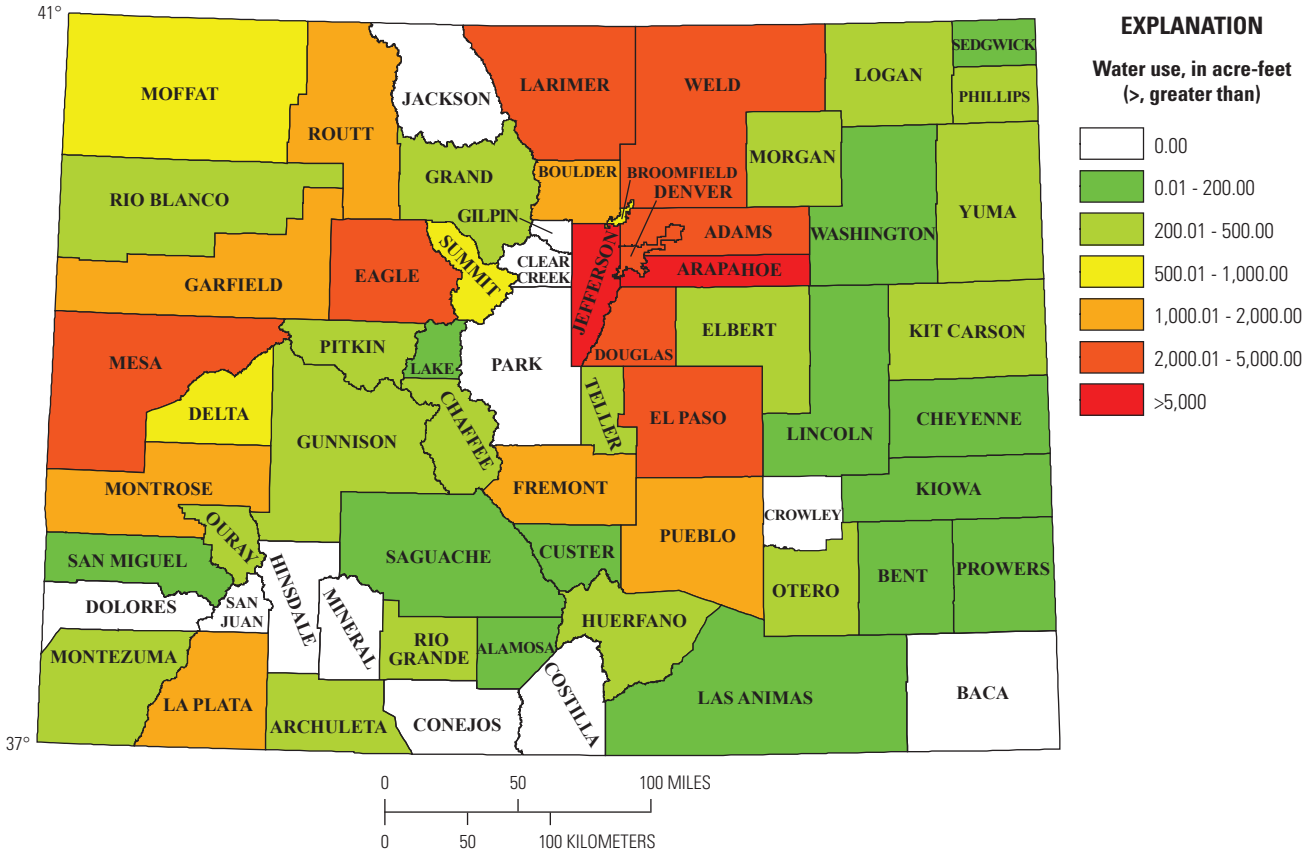

Figure 1. Total golf course irrigation water use, by Colorado county, 2005.

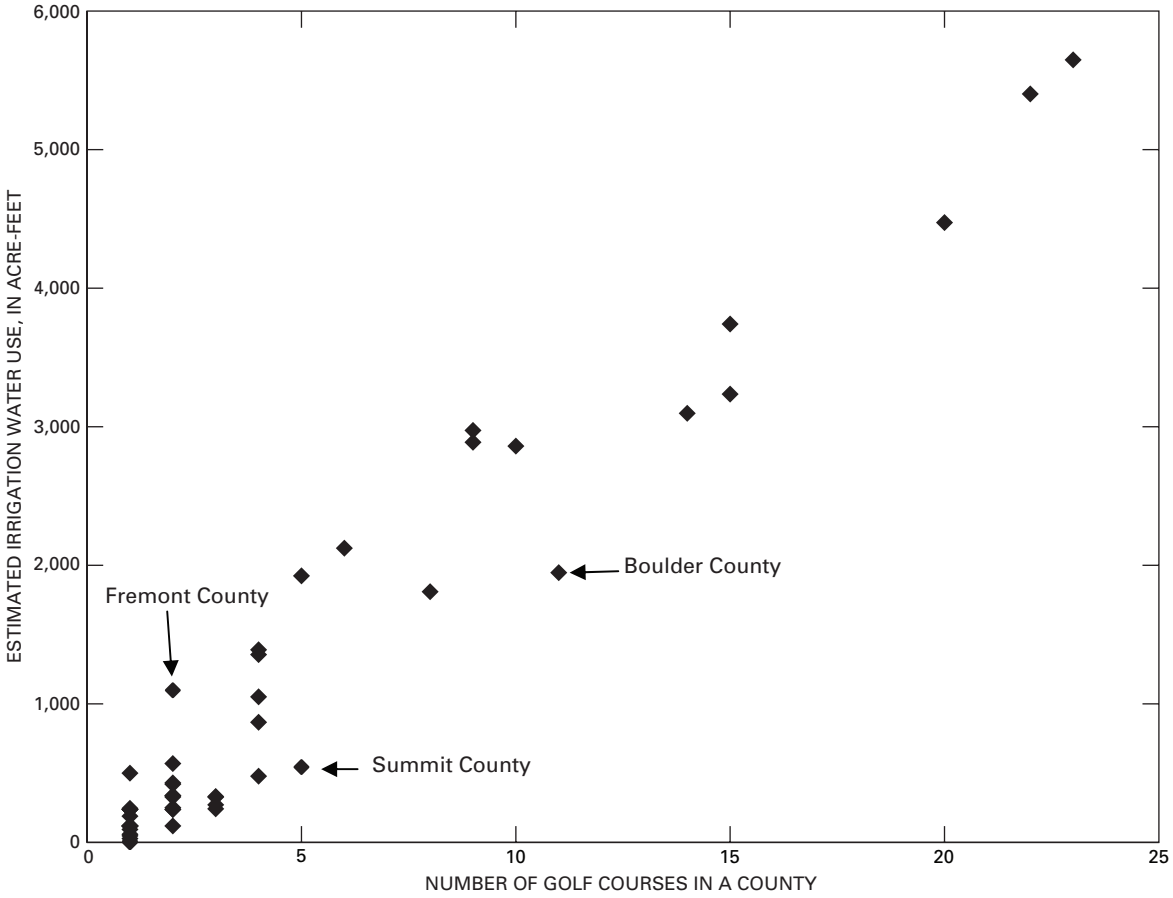

Figure 2. Estimated golf course irrigation water use in 2005 and number of golf courses per county, in Colorado.

In total, 39 counties use surface water as an irrigation source, and the use of surface water for golf course irrigation was greatest in Jefferson, Eagle, Larimer, Weld, and Mesa Counties (table 2 and fig. 3). Nineteen of those 39 counties report surface water as the sole source water type for golf course irrigation (table 2). Ground-water resources are used for irrigation in 23 counties, with the greatest uses in Arapahoe, Douglas, and El Paso Counties (table 2, fig. 4). The Arapahoe aquifer (a part of the Denver Basin aquifer system) is the most frequently tapped aquifer as determined from the returned surveys (unpublished data on file at U.S. Geological Survey, Pueblo Colorado office). Eight counties (Cheyenne, Kiowa, Lake, Lincoln, Logan, Morgan, Sedgwick, and Washington) have ground water as the only source water type for golf course irrigation. Potable (public supply) water use is greatest in Douglas, Pueblo, and Arapahoe Counties, respectively (table 2, fig. 5); but of all of the 18 counties that use potable water for irrigation, only Prowers and Las Animas Counties use this water type as the sole source (table 1). Finally, golf courses in 12 of the 53 counties provided estimated use of reclaimed water, and the greatest reported uses were in El Paso, Arapahoe, Denver, Adams and Douglas Counties (table 2, fig. 6). In all 12 counties, reclaimed water use for irrigation is not a sole source water type, but is used as a supplement to one of the other three source water types (table 1).

Table 2. Estimated golf course irrigation water use, by source water type, and irrigated acres by Colorado county, 2005.

[SW, surface water; GW, ground water; PPW, purchased potable water; RWW, reclaimed wastewater]

County	Total estimated irrigation water use by source type (acre-feet)				Total estimated irrigation water use (acre-feet)	Estimated irrigated acres
	SW	GW	PPW	RWW		
Adams	1,336.2	834.7	0	803.0	2974	1,024
Alamosa	90.8	0	98.3	0	189.1	75
Arapahoe	1,864.0	1,880.6	480.6	1,176.8	5,402	2,240
Archuleta	246.3	0	0	0	246.3	150
Bent	119.2	0	0	0	119.2	48
Boulder	1,730.1	0	92.7	123.9	1,946.7	1,365
Broomfield	268.6	0	273.3	325.2	867.1	314
Chaffee	214.5	0	24.2	0	238.3	97
Cheyenne	0	119.2	0	0	119.2	48
Custer	9.2	0	0	0	9.2	60
Delta	569.6	0	0	0	569.6	205
Denver	1,292.4	330.5	448.5	816.4	2,887.8	1,182
Douglas	145.2	1526.2	1045.3	519.0	3,235.7	1,589
Eagle	3,741.8	0	0	0	3,741.8	1,675
Elbert	238.3	0	0	0	238.3	97
El Paso	1,570.6	1,037.3	338.6	1,526.8	4,473.3	2,814
Fremont	1,098.6	0	0	0	1,098.6	240
Garfield	1,809.4	0	0	0	1,809.4	630
Grand	478.0	0	0	0	478.0	425
Gunnison	336.4	0	0	0	336.4	185
Huerfano	327.4	0	0	0	327.4	120
Jefferson	4,651.3	406.9	239.5	350.1	5,647.8	2,533
Kiowa	0	119.2	0	0	119.2	48
Kit Carson	0	238.3	0	3.9	242.3	30
Lake	0	28.3	0	0	28.3	23
La Plata	466.8	466.8	0	116.7	1,050.4	385
Larimer	2,961.3	134.6	0	0	3,096.6	1,466
Las Animas	0	0	47.5	0	47.5	34
Lincoln	0	119.2	0	0	119.2	48
Logan	0	430	0	0	430	110
Mesa	2,123.3	0	0	0	2,123.3	888

Table 2. Estimated golf course irrigation water use, by source water type, and irrigated acres by Colorado county, 2005.—Continued

[SW, surface water; GW, ground water; PPW, purchased potable water; RWW, reclaimed wastewater]

County	Total estimated irrigation water use by source type (acre-feet)				Total estimated irrigation water use (acre-feet)	Estimated irrigated acres
	SW	GW	PPW	RWW		
Moffat	500.2	0	0	0	500.2	165
Montezuma	238.3	0	0	0	238.3	97
Montrose	1,384.9	0	4.9	0	1,389.8	350
Morgan	0	420.5	0	0	420.5	185
Otero	109	98.1	119.8	0	326.9	98
Ouray	238.3	0	0	0	238.3	97
Phillips	119.2	119.2	0	0	238.4	97
Pitkin	271.8	0	0	0	271.8	225
Prowers	0	0	116.4	0	116.4	48
Pueblo	921.4	0	633.9	368.6	1,923.8	847
Rio Blanco	337.8	0	0	0	337.8	110
Rio Grande	170.2	0	79.9	0	250.1	149
Routt	1,346.8	7.0	2.0	0	1,355.9	385
Saguache	119.2	0	0	0	119.2	48
San Miguel	93.1	0	0	0	93.1	75
Sedgwick	0	119.2	0	0	119.2	48
Summit	490.5	53.6	0	0	544.1	385
Teller	238.3	0	0	0	238.3	97
Washington	0	59.0	0	0	59.0	25
Weld	2,612.4	0	217.5	30.0	2,859.9	1017
Yuma	0	110.6	221.1	0	331.7	105
Total	36,881.5	8,658.7	4,484.0	6,160.5	56,184.2	24,800

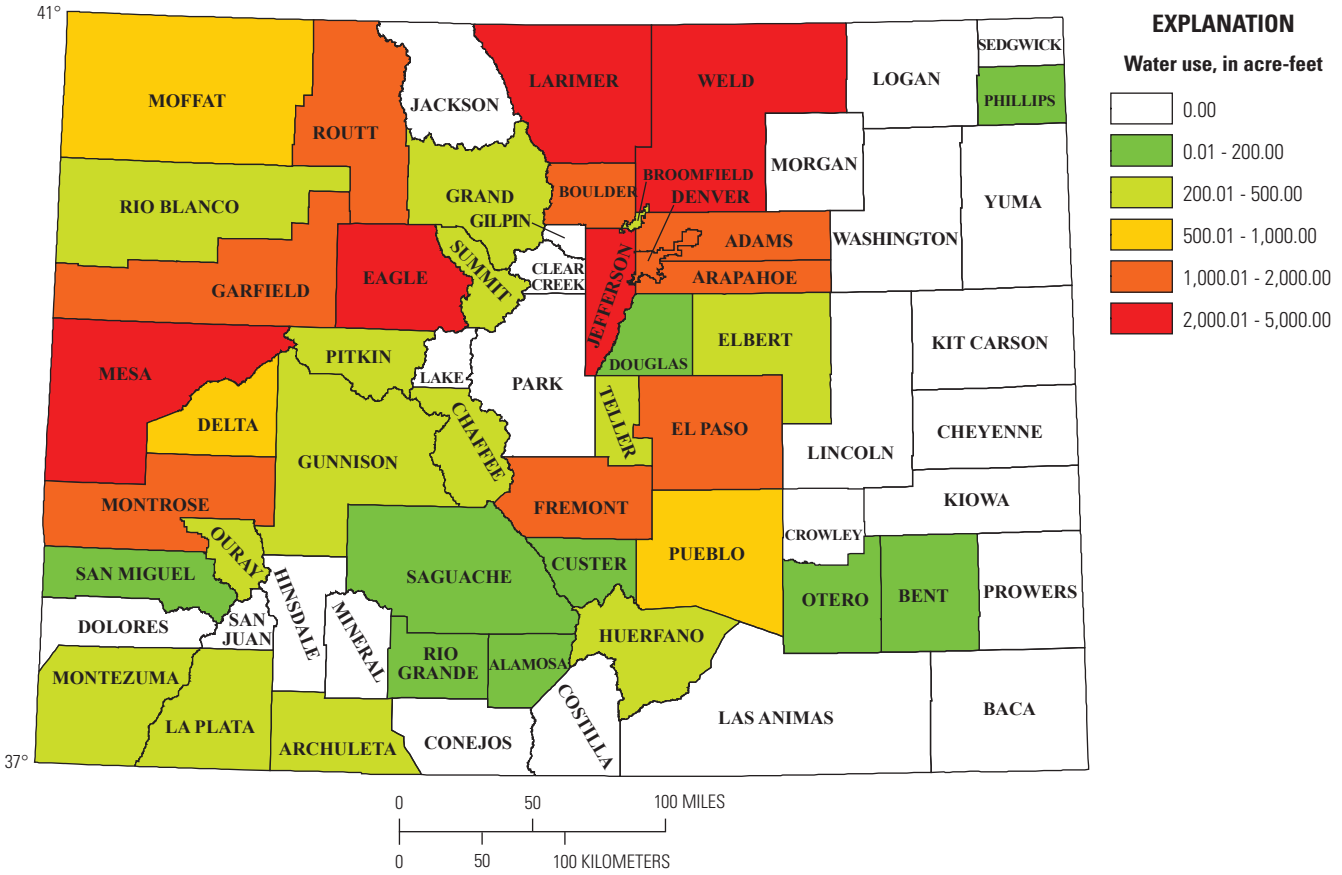

Figure 3. Surface-water golf course irrigation water use, by Colorado county, 2005.

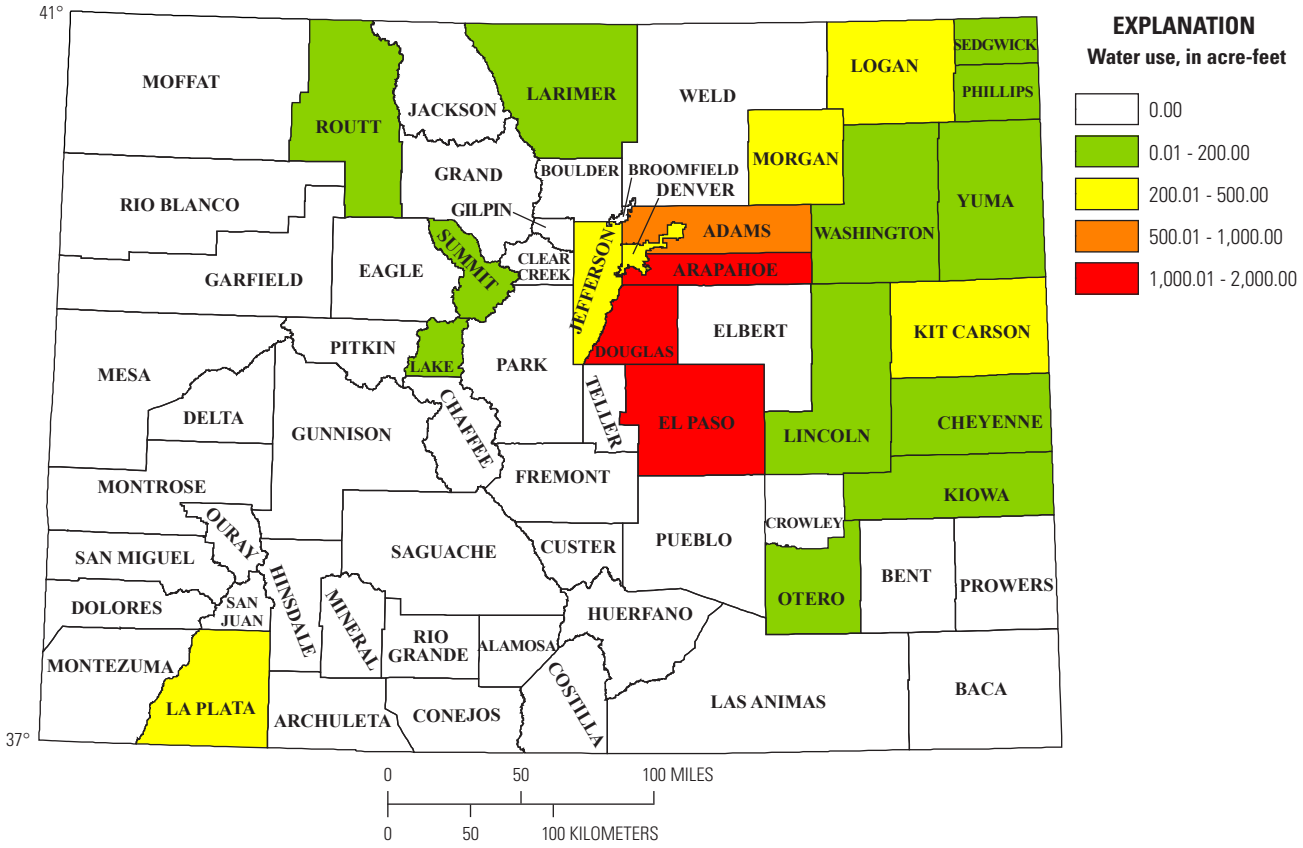

Figure 4. Ground-water golf course irrigation water use, by Colorado county, 2005.

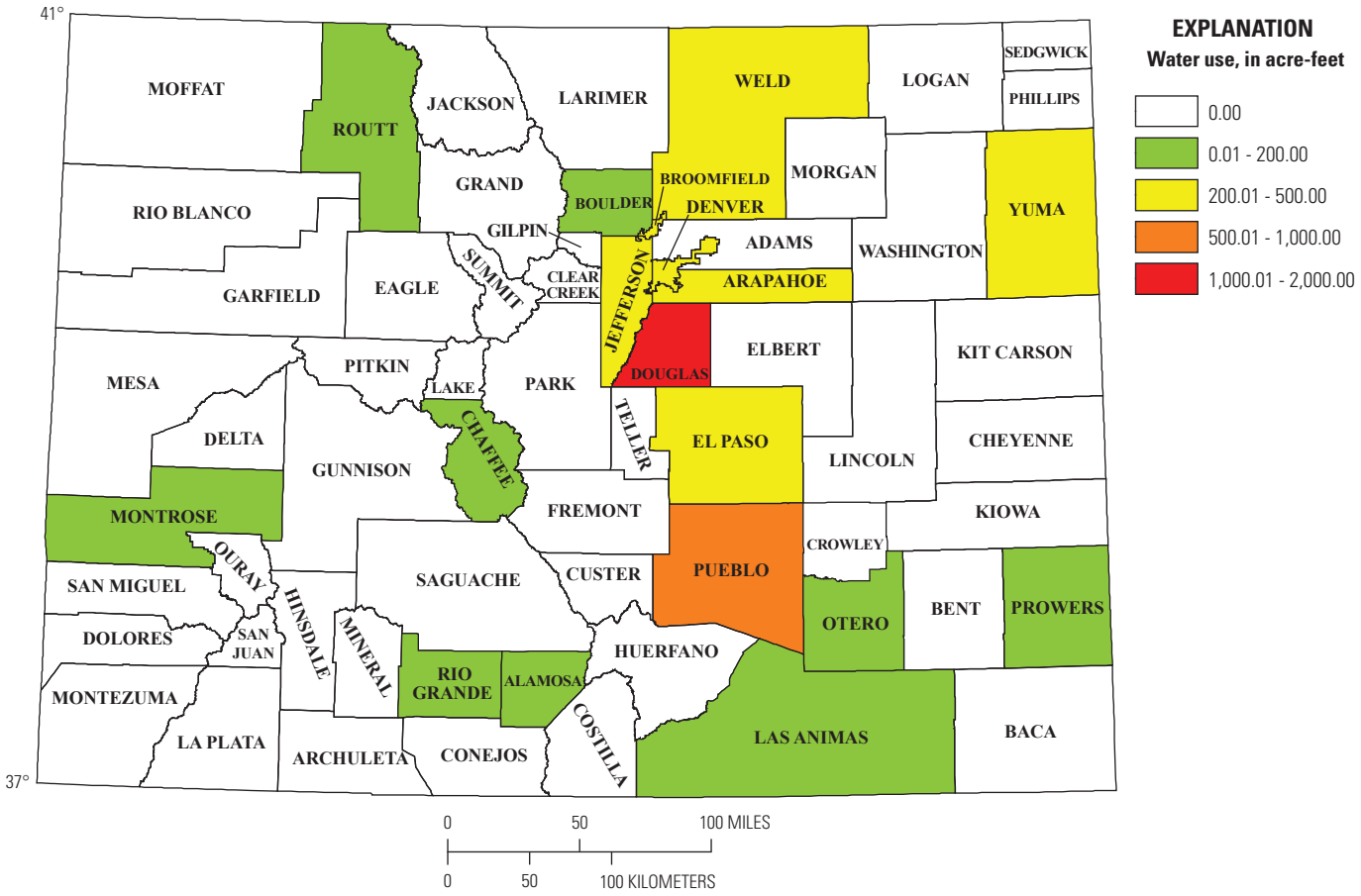

Figure 5. Potable (public-supply) water golf course irrigation water use, by Colorado county, 2005.

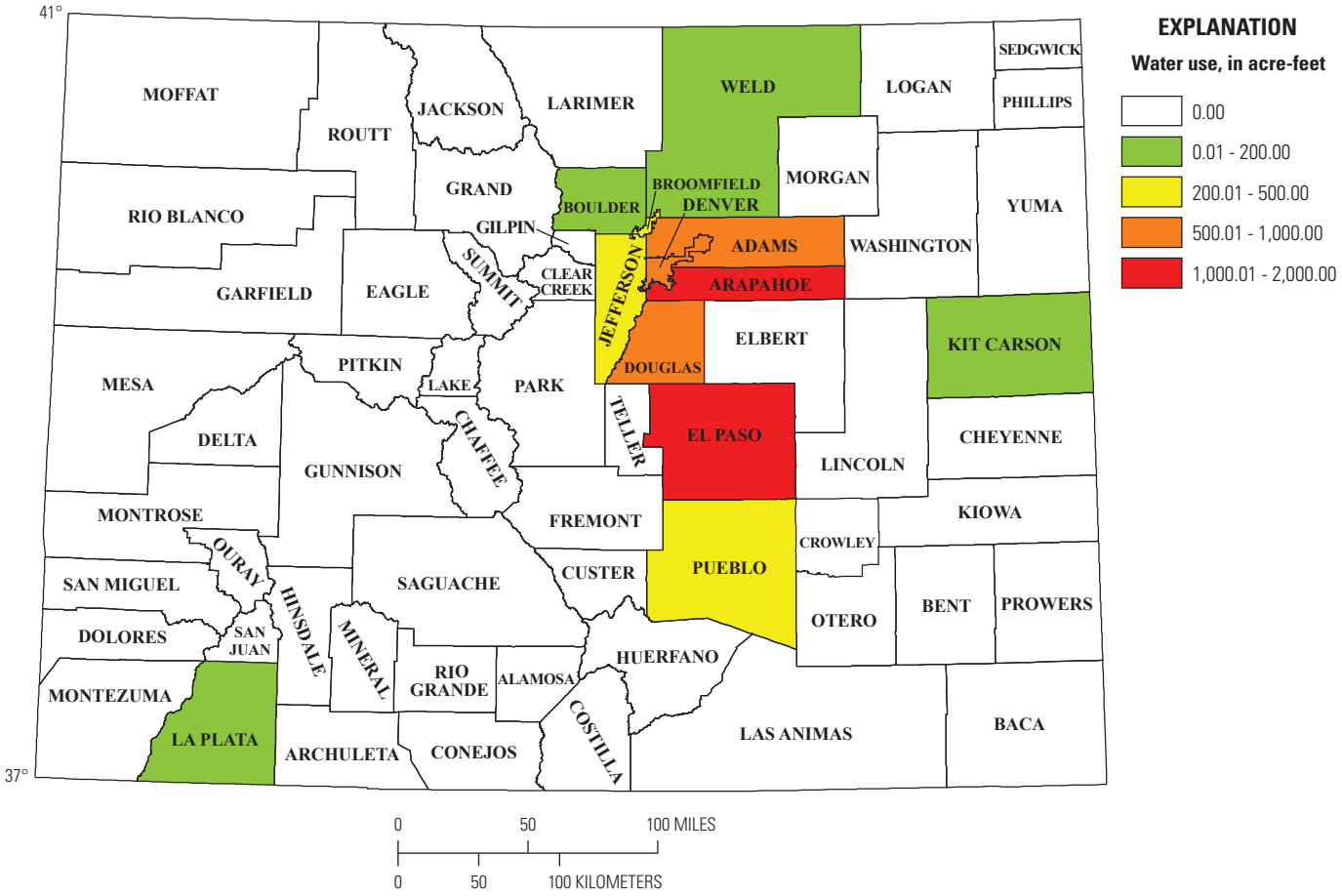

Figure 6. Reclaimed water golf course irrigation water use, by Colorado county, 2005.

Summary

Golf course irrigation water-use data were collected as part of the U.S. Geological Survey National Water Use Program's 2005 compilation to provide baseline information, as no golf course irrigation water-use information (separate from crop irrigation) has been reported in previous U.S. Geological Survey compilations. A Web-based survey, designed by the U.S. Geological Survey, in cooperation with the Rocky Mountain Golf Course Superintendents Association, was electronically distributed by the association to the 237 members in Colorado. Forty-three percent of the members returned the survey, and additional source water information was collected by telephone for all but 20 of the 245 association member and non-member golf courses. Source water for these 20 courses was inferred from returned survey and county information.

To estimate the amount of water used for irrigation in 2005 for the 142 golf courses, a "per hole" coefficient was used. These "per hole" values were calculated on the basis of returned survey information and were applied by county to other courses in the same county. In counties where no surveys were returned, a State average "per hole" value of 13.2 acre-feet was used as the coefficient.

In 2005, Colorado had 243 turf golf courses across the State that had an estimated 2.27 acre-ft per irrigated course acre, and 66 percent of the source water for these courses was surface water. Approximately 24,800 acres of course turf in 2005 were irrigated. Springfield Golf Course (Baca County) and Hugo Golf Course (Lincoln County) are not included in the statistics, as these are sand courses (no turf) and use little or no water for irrigation.

Ground water (15 percent), reclaimed wastewater (11 percent), and potable (public supply) water (8 percent), either partially or wholly, were tapped for the remaining water use. Fifty-three of the 64 counties in Colorado have at least one golf course, with the greatest number of courses in Jefferson (23 courses), Arapahoe (22 courses), and El Paso Counties (20 courses). In 2005, an estimated 5,647.8 acre-ft of water in Jefferson County, 5,402 acre-ft in Arapahoe County and 4,473.3 acre-ft in El Paso County were used to irrigate the turf grass.

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Appendix. The Web-based survey distributed by the U.S. Geological Survey, in cooperation with the Rocky Mountain Golf Course Superintendents Association, in 2005.

Colorado Golf Course Irrigation - Water Use

1

General Golf Course Information

Name of Golf Course:	
County Location:	
Contact Person:	
Title:	
Telephone:	

SUBMIT

Survey Page 1

Colorado Golf Course Irrigation - Water Use

2

Golf Course Area

Number of Acres Total:	
Number of Acres Irrigated:	
Number of Acres of Tees:	
Number of Acres of Greens:	

Number of Acres of Fairways:

Number of Acres of Rough:

SUBMIT

Survey Page 2

Colorado Golf Course Irrigation - Water Use

Surface Water Sources

3

Do you use Surface Water sources for irrigation?

YES NO

SUBMIT

Survey Page 3

Colorado Golf Course Irrigation - Water Use

Surface Water Source(s) - (Enter up to two surface water sources)

4

Surface Water Source 1

Name of Source 1:

Amount (total gallons used in 2005 or specify units):

5

Above Source is:

- Primary
- Secondary
- Tertiary

6

Surface Water Source 2

Name of Source 2:

Amount (total gallons used in 2005 or specify units):

7

Above Source is:

- Primary
- Secondary
- Tertiary

SUBMIT

Survey Page 4

Colorado Golf Course Irrigation - Water Use

USGS

Ground Water Sources

8

Do you use Ground Water sources for irrigation?

YES NO

SUBMIT

Survey Page 5

Colorado Golf Course Irrigation - Water Use

USGS

Groundwater Source(s) - (Enter up to four ground water sources)

9

Ground Water Source 1:

Number of Wells:	
Aquifer Name:	
Amount (total gallons used in 2005 or specify units):	

10

Above Source is:

- Primary
- Secondary
- Tertiary

11

Ground Water Source 2:

Number of Wells:	
Aquifer Name:	
Amount (total gallons used in 2005 or specify units):	

12

Above Source is:

- Primary
- Secondary
- Tertiary

13

Ground Water Source 3:

Number of Wells:

Aquifer Name:

Amount (total gallons used in 2005 or specify units):

14

Above Source is:

- Primary
- Secondary
- Tertiary

SUBMIT

Survey Page 6

Colorado Golf Course Irrigation - Water Use

USGS

Public Supply Water Sources

15

Do you use public supply water - water from a municipal/community water supplier for irrigation?

YES NO

SUBMIT

Survey Page 7

Colorado Golf Course Irrigation - Water Use

Public supply water - If you purchase potable water from a municipal/community water supplier(s) please provide water supplier name, county location and amount.

16

Public Water Supplier Information:

Public Water Supplier 1:	
County location of Public Water Supplier:	
Amount (total gallons used in 2005 or specify units):	

17

Above Source is:

- Primary
- Secondary
- Tertiary

18

Public Water Supplier Information:

Public Water Supplier 2:	
County location of Public Water Supplier:	
Amount (total gallons used in 2005 or specify units):	

19

Above Source is:

- Primary
- Secondary
- Tertiary

SUBMIT

Survey Page 8

Colorado Golf Course Irrigation - Water Use

Reclaimed Water Sources

20

Do you use Reclaimed Water Sources - purchase reclaimed wastewater from a municipal/industrial source for irrigation?

SUBMIT

Survey Page 9

Colorado Golf Course Irrigation - Water Use

Reclaimed Sources - If you purchase reclaimed wastewater from a municipal/industrial source(s), please provide the water supplier name, County location and amount. (Reclaimed Wastewater is wastewater that is not returned to a stream, but is used for some other purpose like irrigation.)

21

Reclaimed Water Supplier Information:

Name of Supplier 1:	
County location of Reclaimed Water Supplier:	
Amount (total gallons used in 2005 or specify units):	

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Above Source is:

- Primary
- Secondary
- Tertiary

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Reclaimed Water Supplier Information:

Name of Supplier 2:	
County location of Reclaimed Water Supplier:	
Amount (total gallons used in 2005 or specify units):	

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Above Source is:

- ○ Primary
- ○ Secondary
- ○ Tertiary

SUBMIT