Investigation of Water Quality in the Great Sand Dunes National Monument and Preserve, Saguache County, Colorado, February 1999 through September 2000: Qualifying for Outstanding Waters Designation

—By Sheryl A. Ferguson

INTRODUCTION

Great Sand Dunes National Monument and Preserve is located on the eastern side of the San Luis Valley in south-central Colorado. The monument covers 60.4 square miles in Saguache and Alamosa Counties and lies at the base of the Sangre de Cristo Mountains, where a unique combination of climate, topography, and hydrology has created and maintained the Nation's tallest inland sand dunes. The Sangre de Cristo Mountains, which rise to more than 14,000 feet to the north and east of the dunes, are the source of several streams that flow around the dunes and eventually recharge the aquifer beneath the valley. Sand Creek and Medano Creeks are the largest of the streams in the monument that originate in the Sangre de Cristo Mountains; several ephemeral streams flow into Sand Creek and Medano Creek.

Maintaining the high surface-water quality in the Great Sand Dunes National Monument and Preserve is identified as a critical issue by the National Park Service. Additionally, the National Park Service has indicated a desire to pursue an Outstanding Waters Designation, which offers the highest level of water-quality protection available under the Clean Water Act and Colorado regulations. This designation is designed to prevent any degradation from existing conditions (Chatman and others, 1997). Assessment is needed to evaluate whether the water quality of the streams in the monument meets the requirements for an Outstanding Waters Designation.

Historically, prospecting and mining activities have occurred in the watersheds of Sand and Medano Creeks; currently, however, there is no mining activity in those watersheds. In addition, the camping and recreation that occur upstream from the monument on national preserve lands and water activities that occur in Medano Creek during the summer are a potential source of human-waste contamination.

The U.S. Geological Survey (USGS), in cooperation with the National Park Service, investigated the water quality at 15 sites (fig. 1) from February 1999 through September 2000 to identify baseline water-quality conditions and to determine if the water met standards to qualify for the Outstanding Waters Designation. This report describes current water-quality conditions in streams in the

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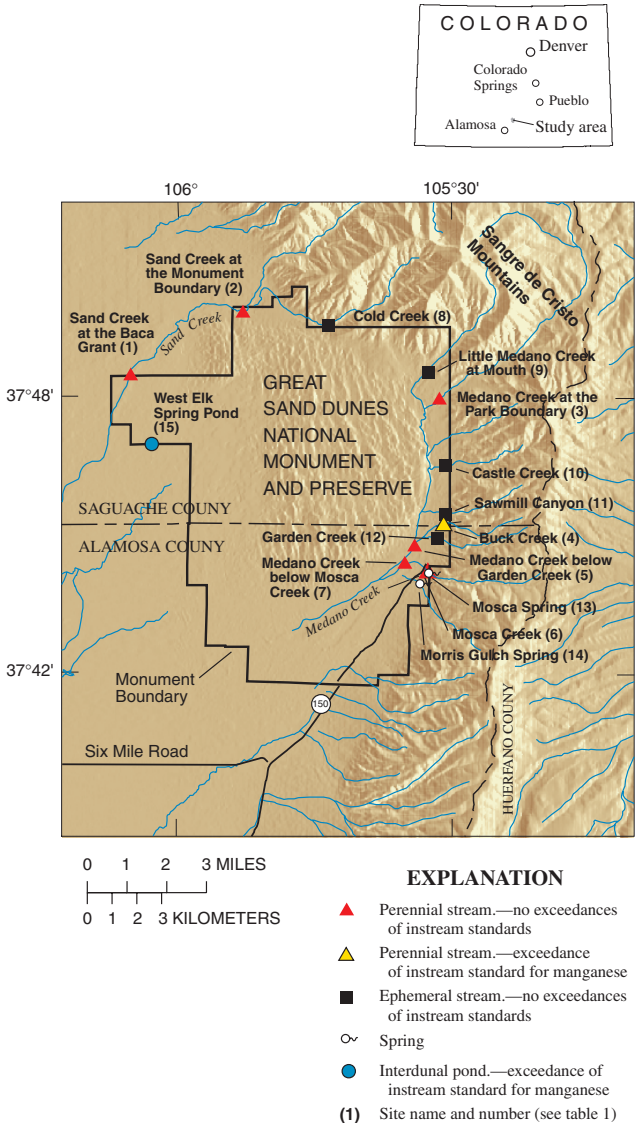

Figure 1. Location of study area, sampling sites, and indication of sites that meet or exceed instream standards.

monument and compares the water-quality data to Colorado instream standards to assist the State of Colorado Water Quality Control Commission in the determination of qualification for Outstanding Waters Designation.

CRITERIA FOR OUTSTANDING WATERS DESIGNATION

Currently (2002), the State of Colorado, Water Quality Control Commission, has assigned the streams in the monument the following use classifications: (a) Cold Water Aquatic Life–Class 1, (b) Recreation Class 2–secondary contact, (c) Domestic Water Supply, and (d) Agriculture. The classification of Cold Water Aquatic Life indicates that the waters presently support a wide variety of cold-water species. Recreation Class 2 indicates that waters are suitable for limited human contact, such as fishing and other streamside recreation, but not for ingestion. Domestic Water-Supply use is defined as suitable for potable water supplies that will meet Colorado drinking-water standards upon standard treatment, and Agricultural use is defined as suitable for irrigation of crops and would not be hazardous either to livestock or as drinking water (Colorado Department of Public Health and Environment, 2001a).

Specific waters may be designated as Outstanding Waters if the State of Colorado Water Quality Control Commission determines that (1) the existing quality for each of the 12 parameters listed below is equal to or better than that specified for the protection of Cold Water Aquatic Life–Class 1, Recreation Class 1, and Domestic Water-Supply uses; (2) the waters constitute an outstanding natural resource based on the fact that the waters are a significant attribute of a National Monument; (3) the waters have exceptional recreational or ecological significance and have not been modified by human activities in a manner that substantially detracts from their value as a natural resource; and (4) the waters require protection in addition to that provided by the combination of water-quality classification standards and the protection afforded water under Colorado Department of Public Health and Environment (CDPHE) guidelines (Colorado Department of Public Health and Environment, 2001a). Recreation Class 1 indicates that the waters are suitable or intended to become suitable for recreational activities when the ingestion of small quantities of water is likely to occur. The 12 water-quality parameters identified by the CDPHE for determining Outstanding Waters Designation are pH, dissolved oxygen, fecal coliform bacteria, un-ionized ammonia and nitrate, and dissolved cadmium, copper, lead, manganese, selenium, silver, and zinc (Colorado Department of Public Health and Environment, 2001b).

DATA COLLECTION

Water-quality samples were collected using USGS protocols (Wilde and others, 1998) for analysis of selected water-quality properties and constituents by the USGS National Water-Quality Laboratory (table 1). Dissolved oxygen and pH were measured onsite, and instantaneous streamflow measurements

Table 1. Selected water-quality data for the Great Sand Dunes National Monument, Colorado, 1999–2000

[mg/L, milligrams per liter (equivalent to parts per million); µg/L, micrograms per liter (equivalent to parts per billion); col/100 mL, colonies per 100 milliliters; n/a, not applicable E, estimated value; MRL, minimum reporting level; <, less than; >, greater than; %, percentage; **Bold** number, exceedance of instream standard [note: 15th and 85th percentiles used to determine exceedance of instream standard for pH; 15th percentile used to determine exceedance of instream standard for dissolved oxygen; geometric mean used to determine exceedance of instream standard for fecal coliform; 85th percentile used to determine exceedances of instream standards for other constituents (Colorado Department of Public Health and Environment, 2001b)]

Statistical parameters	pH (standard units)	Dissolved oxygen (mg/L)	Fecal coliform bacteria (col/100 mL water)	Un-ionized ammonia (mg/L)	Nitrate (mg/L)	Dissolved cadmium (µg/L)	Dissolved copper (µg/L)	Dissolved lead (µg/L)	Dissolved manganese (µg/L)	Dissolved selenium (µg/L)	Dissolved silver (µg/L)	Dissolved zinc (µg/L)
PERENNIAL STREAMS												
Sand Creek at the Baca Grant—Site 1												
Number of samples	4	4	4	4	4	4	4	4	4	4	4	4
Percentage less than MRL	n/a	n/a	n/a	100%	50%	100%	25%	100%	50%	100%	100%	75%
Minimum value	7.8	6.3	21	n/a	<0.05	<0.05	0.7	<1.0	E1.6	<1.0	<0.20	7.4
Maximum value	8.1	8.3	210	<0.001	.13	<.14	1.4	<1.0	7.0	<2.4	<.20	<20
85th percentile value	7.8–8.1	6.4	9.1	<.001	.10	<.10	1.2	<1.0	5.9	<1.8	<.20	<20
Instream standard	6.5–9.0	>6.0	200	0.02	10.0	.74	2.5	.48	50	17	.01	33
Sand Creek at the Monument Boundary—Site 2												
Number of samples	5	5	5	6	6	5	5	5	6	5	5	5
Percentage less than MRL	n/a	n/a	n/a	100%	50%	100%	40%	100%	67%	100%	100%	80%
Minimum value	7.3	7.9	<1	<.001	<.05	<.05	.5	<1.0	E1.5	<1.0	<.2	<1.0
Maximum value	8.1	14.0	36	<.001	.08	<.14	2.1	<1.0	6.8	<2.4	<.2	<20
85th percentile	7.5–8.0	8.1	1	<.001	.07	<.14	1.7	<1.0	4.8	<2.4	<.2	<20
Instream standard	6.5–9.0	>6.0	200	0.02	10.0	.86	3.0	.60	50	17	.01	39
Medano Creek at the Park Boundary—Site 3												
Number of samples	27	26	24	8	8	8	8	8	9	8	8	8
Percentage less than MRL	n/a	n/a	n/a	88%	75%	100%	75%	100%	0%	100%	100%	75%
Minimum value	7.2	6.0	<1	<.001	<.05	<.05	.5	<1.0	6.0	<1.0	<.2	<1.0
Maximum value	8.2	11.8	15	.001	.09	<.14	<1.3	<1.0	15.1	<2.4	<.2	<20
85th percentile	7.5–8.0	7.1	1.2	<.001	.07	<.14	<1.3	<1.0	12.5	<2.4	<.2	<20
Instream standard	6.5–9.0	>6.0	200	0.02	10.0	1.0	3.7	.79	50	17	.01	48
Buck Creek—Site 4												
Number of samples	27	25	25	8	8	8	8	8	8	8	8	8
Percentage less than MRL	n/a	n/a	n/a	100%	100%	100%	88%	100%	0%	100%	100%	88%
Minimum value	7.2	5.9	<1	<.001	<.05	<.05	<.5	<1.0	7.2	<1.0	<.2	<1.0
Maximum value	8.2	9.0	E140	<.001	<.05	<.14	.70	<1.0	386	<2.4	<.2	<20
85th percentile	7.6–7.9	7.0	1.0	<.001	<.05	<.14	<1.3	<1.0	201	<2.4	<.2	<20
Instream standard	6.5–9.0	>6.0	200	0.02	10.0	2.4	9.5	2.7	50	17	.08	124
Medano Creek below Garden Creek—Site 5												
Number of samples	21	19	19	7	7	6	6	6	6	6	6	6
Percentage less than MRL	n/a	n/a	n/a	100%	71%	83%	50%	100%	67%	100%	100%	83%
Minimum value	7.2	5.8	2[1]	<.001	<.05	<.05	<.5	<1.0	E1.2	<1.0	<.2	<1.0
Maximum value	8.2	10.5	1600[1]	<.001	.08	.39	1.6	<1.0	7.0	<2.4	<.2	<20
85th percentile	7.6–8.1	6.4	20.8	<.001	.08	<0.20	1.4	<1.0	5.2	<2.4	<.2	<20
Instream standard	6.5–9.0	>6.0	200	0.02	10.0	1.0	3.6	.78	50	17	.01	48

Table 1. Selected water-quality data for the Great Sand Dunes National Monument, Colorado, 1999–2000 (Continued)

[mg/L, milligrams per liter (equivalent to parts per million); µg/L, micrograms per liter (equivalent to parts per billion); col/100 mL, colonies per 100 milliliters; n/a, not applicable E, estimated value; MRL, minimum reporting level; <, less than; >, greater than; %, percentage; **Bold** number, exceedance of instream standard [note: 15th and 85th percentiles used to determine exceedance of instream standard for pH; 15th percentile used to determine exceedance of instream standard for dissolved oxygen; geometric mean used to determine exceedance of instream standard for fecal coliform; 85th percentile used to determine exceedances of instream standards for other constituents (Colorado Department of Public Health and Environment, 2001b)]

Statistical parameters	pH (standard units)	Dissolved oxygen (mg/L)	Fecal coliform bacteria (col/100 mL water)	Un-ionized ammonia (mg/L)	Nitrate (mg/L)	Dissolved cadmium (µg/L)	Dissolved copper (µg/L)	Dissolved lead (µg/L)	Dissolved manganese (µg/L)	Dissolved selenium (µg/L)	Dissolved silver (µg/L)	Dissolved zinc (µg/L)
PERENNIAL STREAMS—Continued												
Mosca Creek—Site 6												
Number of samples	27	26	25	8	8	8	8	8	8	8	8	8
Percentage less than MRL	n/a	n/a	n/a	100%	88%	100%	62%	100%	38%	100%	100%	75%
Minimum value	7.7	7.2	<1	<.001	<.05	<.05	<.5	<1.0	E1.2	<1.0	<.2	<1.0
Maximum value	8.2	10.5	62	<.001	.07	<.14	1.3	<1.0	3.6	<2.4	<.2	<20
85th percentile	7.8–8.2	7.9	1	<.001	<.05	<.14	1.3	<1.0	3.0	<2.4	<.2	<20
Instream standard	6.5–9.0	>6.0	200	0.02	10.0	1.9	7.4	2.0	50	17	.05	96
Medano Creek below Mosca Creek—Site 7												
Number of samples	26	25	25	7	7	7	7	7	7	7	7	7
Percentage less than MRL	n/a	n/a	n/a	86%	86%	100%	57%	100%	14%	100%	100%	88%
Minimum value	7.3	5.7	2[1]	<.001	<.05	<.05	<.5	<1.0	E2.3	<1.0	<.2	3.3
Maximum value	8.4	9.8	2500	.001	.08	<.14	3.2	<1.0	16.3	<2.4	<.2	20
85th percentile	7.8–8.1	6.8	47	<.001	<.05	<.14	1.5	<1.0	15	<2.4	<.2	<20
Instream standard	6.5–9.0	>6.0	200	0.02	10.0	1.4	5.2	1.2	50	17	.02	68
EPHEMERAL STREAMS												
Cold Creek—Site 8												
Number of samples	2	2	0	2	2	2	2	2	2	2	2	2
Percentage less than MRL	n/a	n/a	n/a	100%	50%	100%	50%	100%	100%	100%	100%	50%
Minimum value	7.9	8.8	n/a	<.001	.01	<.05	E.75	<1.0	E1.6	<1.0	<.2	3.0
Maximum value	7.9–8.0	9.8	n/a	<.001	<.05	<.14	1.7	<1.0	<2.2	<2.4	<.2	<20
85th percentile[2]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Instream standard	6.5–9.0	>6.0	n/a	0.02	10.0	1.1	4.0	.88	50	17	.02	52
Little Medano Creek at Mouth—Site 9												
Number of samples	4	4	0	4	4	4	4	4	4	4	4	4
Percentage less than MRL	n/a	n/a	n/a	100%	25%	100%	75%	100%	0%	100%	100%	50%
Minimum value	7.8	7.2	n/a	<.001	<.05	<.05	<1.3	<1.0	3.5	<1.0	<.2	2.3
Maximum value	8.0	9.6	n/a	<.001	.10	<.14	1.5	<1.0	14	<2.4	<.2	<20
85th percentile	7.9–8.0	7.4	n/a	<.001	.09	<.14	1.4	<1.0	13	<2.4	<.2	<12
Instream standard	6.5–9.0	>6.0	n/a	0.02	10.0	1.1	3.8	.83	50	17	.01	50
Castle Creek—Site 10												
Number of samples	2	2	0	2	2	2	2	2	2	2	2	2
Percentage less than MRL	n/a	n/a	n/a	100%	50%	100%	50%	100%	50%	100%	100%	50%
Minimum value	8.1	7.7	n/a	<.001	<.05	<.05	<1.3	<1.0	2.6	<1.0	<.2	4.6
Maximum value	8.1	7.9	n/a	<.001	.06	<.14	2.7	<1.0	<3.0	<2.4	<.2	<20
85th percentile[2]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Instream standard	6.5–9.0	>6.0	n/a	0.02	10.0	1.4	5.3	1.3	50	17	.03	70

Table 1. Selected water-quality data for the Great Sand Dunes National Monument, Colorado, 1999–2000 (Continued)

[mg/L, milligrams per liter (equivalent to parts per million); µg/L, micrograms per liter (equivalent to parts per billion); col/100 mL, colonies per 100 milliliters; n/a, not applicable E, estimated value; MRL, minimum reporting level; <, less than; >, greater than; %, percentage; **Bold** number, exceedance of instream standard [note: 15th and 85th percentiles used to determine exceedance of instream standard for pH; 15th percentile used to determine exceedance of instream standard for dissolved oxygen; geometric mean used to determine exceedance of instream standard for fecal coliform; 85th percentile used to determine exceedances of instream standards for other constituents (Colorado Department of Public Health and Environment, 2001b)]

Statistical parameters	pH (standard units)	Dissolved oxygen (mg/L)	Fecal coliform bacteria (col/100 mL water)	Un-ionized ammonia (mg/L)	Nitrate (mg/L)	Dissolved cadmium (µg/L)	Dissolved copper (µg/L)	Dissolved lead (µg/L)	Dissolved manganese (µg/L)	Dissolved selenium (µg/L)	Dissolved silver (µg/L)	Dissolved zinc (µg/L)
EPHEMERAL STREAMS—Continued												
Sawmill Canyon—Site 11												
Number of samples	1	1	0	1	1	1	1	1	1	1	1	1
Value	8.00	8.8	n/a	<.001	<.05	<.05	2.1	<1.0	<3.0	<1.0	<.2	<20
85th percentile[2]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Instream standard	6.5–9.0	>6.0	n/a	0.02	10.0	1.4	5.4	1.3	50	17	.03	71
Garden Creek—Site 12												
Number of samples	2	2	0	2	2	2	2	2	2	2	2	2
Percentage less than MRL	n/a	n/a	n/a	100%	100%	100%	50%	100%	100%	100%	100%	50%
Minimum value	7.8	7.6	n/a	<.001	<.05	<.05	<.67	<1.0	<3.0	<1.0	<.2	3.1
Maximum value	7.8	9.0	n/a	<.001	<.05	<.14	1.7	<1.0	<3.0	<2.4	<.2	<20
85th percentile[2]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Instream standard	6.5–9.0	>6.0	n/a	0.02	10.0	1.3	4.8	1.1	50	17	.02	63
SPRINGS												
Mosca Spring—Site 13												
Number of samples	16	15	16	3	3	3	3	3	3	3	3	3
Percentage less than MRL	n/a	n/a	n/a	100%	100%	67%	0%	100%	100%	100%	100%	100%
Minimum value	7.0	6.7	<1	<.001	<.05	.07	1.3	<1.0	E1.8	<1.0	<.2	E8.0
Maximum value	7.7	8.4	17	<.001	<.05	<.1	2.0	<1.0	<3.0	<1.0	<.2	<20
85th percentile	7.6	7.1	1.0	<.001	<.05	<.1	1.8	<1.0	E2.7	<1.0	<.2	<20
Instream standard	6.5–9.0	>6.0	200	0.02	10.0	2.1	8.3	2.3	50	17	.06	109
Morris Gulch Spring—Site 14												
Number of samples	25	24	23	7	7	7	7	7	7	7	7	7
Percentage less than MRL	n/a	n/a	n/a	100%	100%	100%	100%	100%	0%	88%	100%	71%
Minimum value	7.4	5.9	<1	<.001	<.05	<.05	<1.3	<1.0	5.6	1.1	<.2	4.3
Maximum value	8.4	10.4	390	<.001	<.05	<.14	<1.3	<1.0	17	<2.4	<.2	<20
85th percentile	8.14	7.0	1.1	<.001	<.05	<.14	<1.3	<1.0	13	<2.4	<.2	<20
Instream standard	6.5–9.0	>6.0	200	0.02	10.0	2.9	12	3.6	50	17	.13	155
INTERDUNAL POND												
West Elk Spring Pond—Site 15												
Number of samples	7	6	0	7	7	7	7	7	7	7	7	7
Percentage less than MRL	n/a	n/a	n/a	57%	86%	100%	86%	100%	0%	86%	100%	71%
Minimum value	6.9	10.2	n/a	<.001	<.05	<.05	.5	<1.0	3.9	1.1	<.2	1.0
Maximum value	9.5	18.9	n/a	.025	.05	<.14	<1.3	<1.0	150	<2.4	<.2	<20
85th percentile	8.60	10.7	n/a	.007	<.05	<.14	<1.3	<1.0	116	<2.4	<.2	<20
Instream standard	6.5–9.0	>6.0	n/a	0.02	10.0	1.6	6.3	1.6	50	17	.04	82

[1]Based on nonideal count.

[2]85th percentile value not given for samples sizes less than 3.

were made using standard measurement techniques (Rantz and others, 1982). Water-quality and fecal coliform samples were collected many times from February 1999 through September 2000 at 15 sites on the Great Sand Dunes National Monument and Preserve (fig. 1). Samples were collected at seven sites located on perennial streams and five sites on ephemeral streams. In addition, two springs and one interdunal pond were sampled. Interdunal ponds are areas where water accumulates in depressions in the sand sheets. The data are published in the USGS annual data report (Crowfoot and others, 1999, 2000). Samples were collected during varied streamflow conditions. Measurements of instantaneous streamflow at the time of sampling ranged from less than 0.1 cubic foot per second (ft^3/s) at several of the smaller tributaries to 76 ft^3/s in Sand Creek.

WATER-QUALITY CONDITIONS AND COMPARISON TO COLORADO INSTREAM STANDARDS

A water-quality standard defines the allowable concentration of various water-quality constituents and establishes the criteria necessary to maintain and protect water quality. Water-quality standards for some constituents are fixed values; standards for other constituents are calculated values. The calculated standards are computed using the average hardness at each site in an equation determined by the CDPHE Water Quality Control Commission. Determination of exceedances are made for each site using the 15th and 85th percentiles of the data for pH, the 15th percentile of the data for dissolved oxygen, the geometric mean of the data for fecal coliform, and the 85th percentile of the data for other constituents. Concentrations of many constituents were less than the minimum reporting level (MRL), the smallest measured concentration of a constituent that may be reliably reported using a given analytical method (Timme, 1995).

Field Measurements

Many chemical and biological reactions in surface water depend directly or indirectly on the pH and the amount of oxygen present in the water. The pH of water directly affects physiological functions of plants and animals, and it is, therefore, an important indicator of the health of a water system. Measurements of pH ranged from 6.9 to 9.5, and the 15th and 85th percentile values at each site met the instream standard (table 1). Dissolved oxygen is necessary in aquatic systems for the survival and growth of many aquatic organisms (Wilde and others, 1998). The instream standard for dissolved oxygen concentrations is a minimum of 6 milligrams per liter (mg/L). Prolonged exposure to dissolved oxygen concentrations less than 6 mg/L may be harmful to aquatic biota. Dissolved oxygen concentrations during the study ranged from 5.7 to 18.9 mg/L, and the 15th percentile of the data at each site met the Colorado instream standard (table 1).

Fecal Coliform

Fecal indicator bacteria are used to assess the quality of water, and the concentration fecal indicator bacteria is a measure of water safety for body-contact recreation or for consumption. Wastes from warm-blooded animals contribute a variety of intestinal bacteria that are pathogenic to humans (Wilde and others, 1998). Water samples were collected and

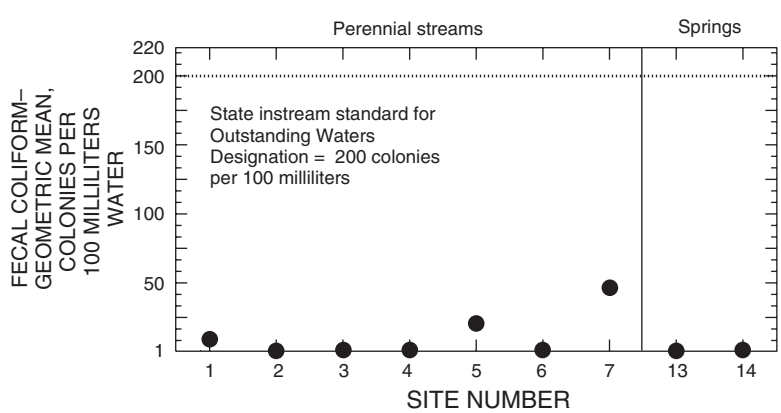

Figure 2. Geometric mean and instream standard for fecal coliform data for Outstanding Waters Designation. (Note: Current instream standard for fecal coliform is 2,000 colonies per 100 milliliters water.)

analyzed for fecal coliform bacteria from the perennial streams and springs approximately weekly and four to five times at Sand Creek at the Monument Boundary (site 2, fig. 1) and Sand Creek at the Baca Grant (site 1, fig. 1) from May 1999 through the first week in September 2000. Bacteria data were not collected from sites on ephemeral streams or the interdunal pond. Exceedances of the instream standard for fecal coliform are determined by comparing the geometric mean of the data for each site to the Colorado instream standard. The instream standard for fecal coliform is 2,000 colonies per 100 milliliters (col/100 mL) of sample water under the current classification; however, under Outstanding Waters Designation, the instream standard for fecal coliform would be 200 col/100 mL of sample water (fig. 2).

During the study period, only one fecal coliform bacteria sample from Medano Creek below Mosca Creek (site 7, fig. 1) exceeded 2,000 col/100 mL and the geometric mean for that site did not exceed the instream standard (fig. 2). Although some individual measurements of fecal coliform concentrations were greater than 200 col/100 mL of sample water, the geometric mean of the data did not exceed the instream standard of 200 col/100 mL. All of the samples that had concentrations greater than 200 col/100 mL were collected during the summer, which is also the peak visitor season at the monument.

Nutrients

Nitrogen is a nutrient that is essential for plant growth; however, excessive nutrient concentrations in water can accelerate the growth of algae and other aquatic plants. Also, high levels of un-ionized ammonia can be toxic to fish. More than 90 percent of samples analyzed for un-ionized ammonia had concentrations less than the MRL. The 85th percentile of the data did not exceed the chronic instream standard of 0.02 mg/L at any site. More than 75 percent of samples analyzed for nitrate had concentrations less than the MRL. The 85th percentile of the data for nitrate was 0.1 mg/L or less at all sites and did not exceed the instream standard of 10 mg/L.

Trace Elements

Trace elements occur naturally in water, generally at concentrations less than 1,000 micrograms per liter (µg/L), and may be derived from the weathering of rocks or acquired as the water moves through an aquifer or a stream channel. Nearly all dissolved cadmium and selenium and all dissolved lead and silver concentrations measured during the study were less than the MRL, and the 85th percentile values for those constituents were less than the MRL. Therefore, those constituents are considered to meet the chronic instream standards set by the CDPHE (Philip Hegeman, Colorado Department of Public Health and Environment, oral commun., 2001).

More than 60 percent of the analyses for dissolved copper were below the MRL, and the chronic instream standard was not exceeded at any site (table 1). The chronic instream standard for dissolved manganese (50 µg/L) was exceeded by the 85th percentile of the data at Buck Creek (site 4, fig. 3) and West Elk Spring Pond (site 15, fig. 3). Dissolved manganese concentrations at Buck Creek ranged from 7.2 to 386 µg/L, and the 85th percentile of the data was 201 µg/L. Dissolved manganese concentrations at West Elk Spring Pond ranged from 3.9 to 150 µg/L and the 85th percentile of the data was 116 µg/L. These higher dissolved manganese concentrations may be a result of geological or possible oxidation-reduction processes occurring in the water. Most of the dissolved zinc concentrations were less than the MRL; the highest concentration greater than the reporting limit was an estimated value of 8.0 µg/L.

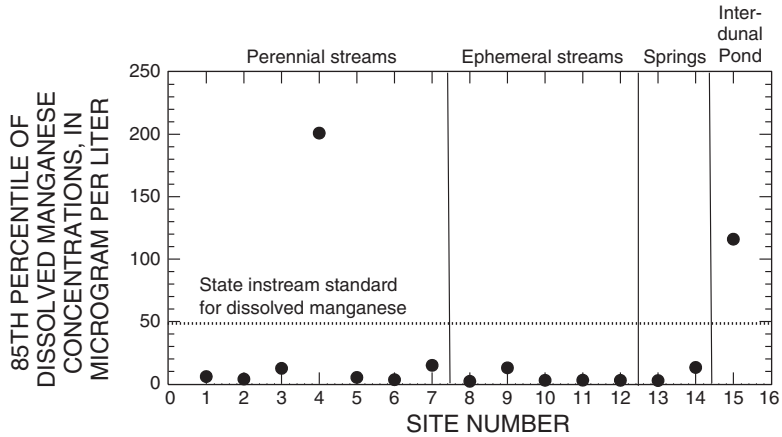

Figure 3. Instream standard for Outstanding Waters Designation and 85th percentile of dissolved manganese data.

SUMMARY AND SIGNIFICANT RESULTS

Concentrations of the 12 water-quality parameters for determining Outstanding Waters Designation did not exceed Colorado instream standards at most sites. The chronic instream standard for dissolved manganese was exceeded at two sites, and those exceedances likely are related to weathering of geologic materials or oxidation-reduction processes. Therefore, based on a comparison of the data collected during this study to instream water-quality standards established by the CDPHE, the existing water-quality criteria for determining Outstanding Waters Designation in the Great Sand Dunes National Monument and Preserve are being met.

- Instream standards of the 15th and 85th percentiles for pH and the 15th percentile for dissolved oxygen were not exceeded at any site during the study period.
- Most un-ionized ammonia concentrations were less than the minimum reporting level, and none exceeded the instream standard of 0.02 mg/L.
- The instream standard of 10 mg/L for nitrate was not exceeded at any site during the study period.
- The geometric mean of fecal coliform bacteria data did not exceed either the current CDPHE instream standard of 2,000 col/100 mL water or the Outstanding Waters Designation instream standard of 200 col/100 mL water at any site. A few samples collected during the summer months had measurements greater than 200 col/100 mL, and may be related to stream use by monument visitors.
- The chronic instream standards for dissolved cadmium, copper, lead, silver, zinc, and selenium were not exceeded.
- Exceedances of the instream standard for dissolved manganese occurred at two sites: West Elk Spring Pond and Buck Creek.

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