UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Water Resources Division

Preliminary results of time-of-travel measurements on Wind/Bighorn River from Boysen Dam to Greybull, Wyoming

by

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In cooperation with the

Wyoming State Engineer

Open-file report 71-185

1971

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PRELIMINARY RESULTS OF TIME-OF-TRAVEL MEASUREMENTS ON WIND/BIGHORN RIVER FROM BOYSEN DAM TO GREYBULL, WYOMING

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ABSTRACT

This report contains basic data regarding the traveltime and dispersion characteristics of the Wind/Bighorn River, Wyoming, determined by dye-tracing techniques for two different river discharges. The study reach extended 112.7 river miles from Boysen Dam to Greybull. The discharge from Boysen Reservoir was 1,940 cfs (cubic feet per second) during the first measurement in March 1971 and 8,280 cfs during the second measurement in June 1971. A small quantity of a fluorescent dye, Rhodamine WT, was poured into the river downstream from Boysen Dam. The movement of the dye cloud was monitored by collecting water samples at frequent time intervals during passage of the dye at seven downstream sites. Traveltime of the peak dye concentration through the study reach was 56.00 hours in March and 33.08 hours in June.

INTRODUCTION

Time-of-travel characteristics of a stream can be important information in the event of an accidental spill of contaminant into the stream. Knowing the velocity and expected dispersion pattern of the contaminant, water users downstream from the spill can take necessary protective measures.

The U.S. Geological Survey made time-of-travel measurements on the Wind/Bighorn River March 21-24, 1971 and June 29-30, 1971. The work was done as part of a study of the water resources of the Bighorn Basin being carried out in cooperation with the Wyoming State Engineer. The purpose of this report is to make available the basic data obtained in the measurements. An analysis of the data is being made, and the results will be included in the report on the Bighorn Basin, which is in preparation, and in a separate report on time of travel, to be prepared later.

DISCHARGE CONDITIONS

During the March measurement, the discharge from Boysen Reservoir, at the upper end of the study reach (fig. 1), was 1,940 cfs (cubic feet per second), determined from the gaging station immediately downstream from Boysen Dam. The long-term average since completion of the dam in 1951 is 1,350 cfs. No water was being diverted from the river for irrigation. The discharge changed very little downstream, except for inflow of the Greybull River near the end of the study reach (fig. 1 and table 1).

During the June measurement, the discharge from Boysen Reservoir was 8,280 cfs, a flow that has been exceeded only a few times since 1951. A total of about 800 cfs was being diverted from the river into several irrigation canals between Thermopolis and Worland, and there was some return flow between Winchester and Greybull. The variation in discharge may be seen in table 1. Again, the largest change in discharge was that due to inflow of the Greybull River.

DATA COLLECTION

In each of the two measurements, a small quantity of a fluorescent dye, Rhodamine WT, was poured as an instantaneous slug into the Wind River just downstream from Boysen Dam. The dye is soluble and is an easily detected indicator of the movement of the water into which it is injected. Passage of the dye cloud was monitored at seven sites between Boysen Dam and Greybull, a distance of 112.7 river miles (fig. 1).

Monitoring of the dye cloud as it passed each site was done by collecting water samples from the river at frequent time intervals. Bridges at all sampling sites except the one in Wind River Canyon made it possible to sample at several points across the river by lowering the sampling device on a rope. At the canyon site samples were collected by throwing the sampling device into midstream and retrieving it.

The samples were tested in a fluorometer, an instrument which measures fluorescence. The concentration of dye in a sample is directly proportional to the amount of fluorescence measured. Samples collected before the dye arrived at each site were tested in the fluorometer to determine background readings. Background readings were subtracted from readings for subsequent samples, prior to determination of concentration.

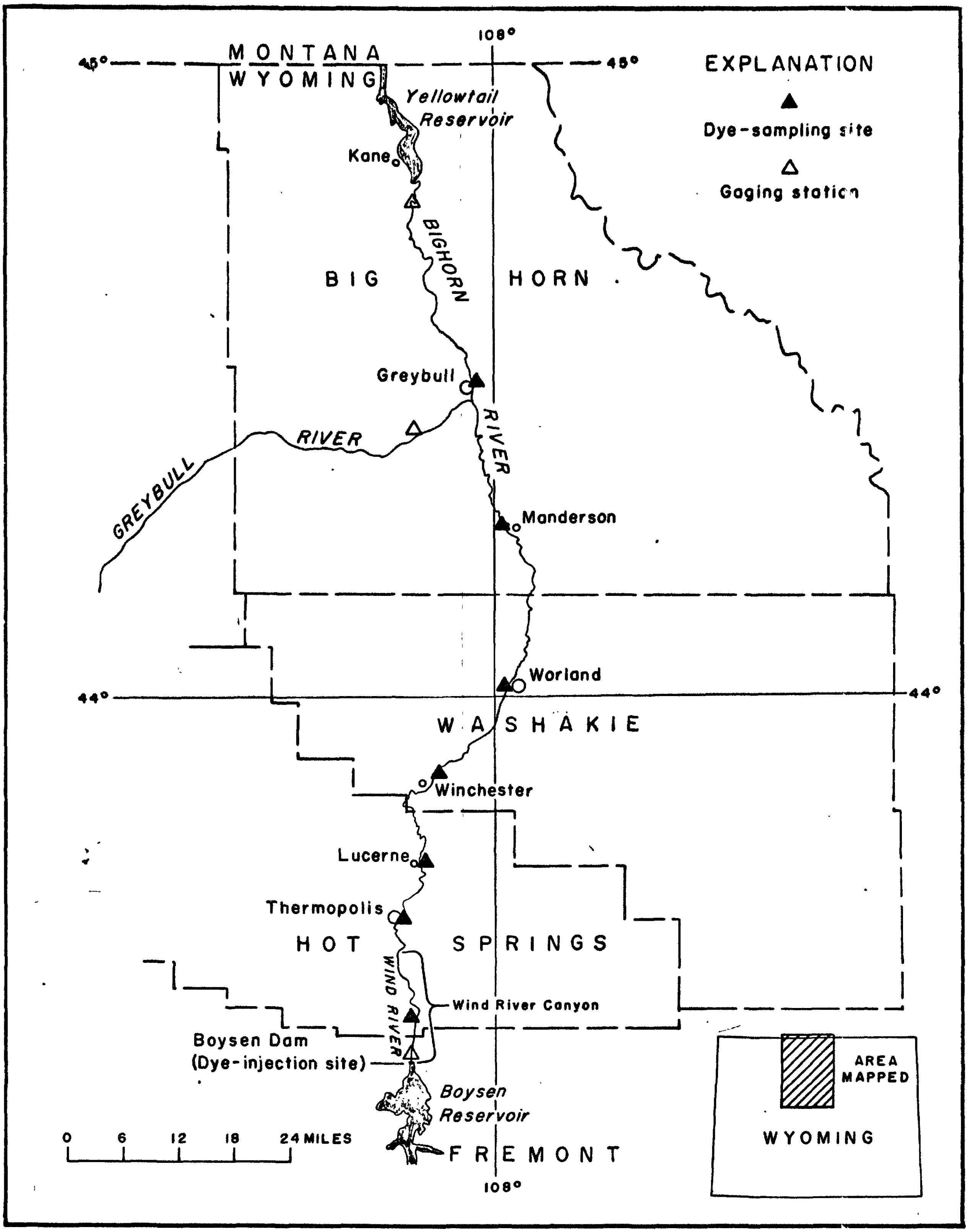

Figure 1.--Location of dye-injection site, dye-sampling sites, and gaging stations for time-of-travel measurements on Wind/Bighorn River, Wyoming.

Table 1.--Basic data for time-of-travel measurements on Wind/Bighorn River.

Site name	Distance downstream from Boysen Dam (river miles)	Elevation of streambed (feet)	Stream discharge (cfs)	Cumulative traveltime of dye cloud		Mean velocity of dye cloud between sites (mph)	Time for dye cloud to pass site (hours)	Observed peak dye concentration (µg/l)
				Leading edge (hours)	Peak concentration (hours)			
March 21-24, 1971 (42.5 lbs. dye injected)								
Boysen Dam	0	4,620	1,940	0	0		----	----
						1.93		
Wind River Canyon	5.7	4,520	1,940	2.05	2.75		2.4	26.5
						2.18		
Thermopolis	20.3	4,310	1,940	8.25	9.42		5.0	12.0
						1.50		
Lucerne	31.3	4,250	2,000	15.00	16.58		5.8	8.28
						1.85		
Winchester	46.8	4,170	2,000	22.75	25.00		7.0	6.12
						1.94		
Worland	62.1	4,050	2,000	29.75	32.67		10.2	5.16
						2.18		
Manderson	88.2	3,880	2,000	41.50	44.50		12.0	4.35
						2.08		
Greybull	112.7	3,790	2,430	53.00	56.00		12.0	3.05
June 29-30, 1971 (40.3 lbs. dye injected)								
Boysen Dam	0	4,620	8,280	0	0		----	----
						3.70		
Wind River Canyon	5.7	4,520	8,280	1.15	1.43		1.3	11.8
						4.18		
Thermopolis	20.3	4,310	8,300	4.20	4.87		3.0	5.80
						2.84		
Lucerne	31.3	4,250	8,300	7.67	8.62		4.2	2.92
						3.14		
Winchester	46.8	4,170	7,900	12.00	13.47		5.0	2.05
						3.28		
Worland	62.1	4,050	7,500	15.58	18.08		5.5	1.55
						3.42		
Manderson	88.2	3,880	7,700	24.25	25.97		5.8	1.20
						3.28		
Greybull	112.7	3,790	9,000	31.33	33.08		6.7	.85

The discharge at each site was determined from records at streamgaging stations directly or by adjusting the records for tributary inflow, diversions, and return flow. Active gaging stations are located below Boysen Reservoir, at Kane, and on several tributaries such as the Greybull River (fig. 1). In addition, stage-discharge ratings maintained for water-quality sampling at Lucerne and Worland were used. For the June measurement Kenneth Bower, State Superintendent of Water Division No. 3, provided data on the amount of water diverted into irrigation canals and the approximate amount of return flow between sampling sites.

TABULATION OF RESULTS

The basic data for the two measurements are shown in table 1. Distance downstream and elevation of the streambed were obtained from topographic maps. Graphs of dye concentration versus time were used to determine the traveltimes of the leading edge and peak concentration of the dye cloud, given in table 1, as well as that of the center of mass, or centroid, of the dye cloud. Because the concentration distribution within the dye cloud is asymmetrical, the velocity of the centroid (river distance divided by centroid traveltime), rather than that of the peak, is used for the mean velocity of both the dye and the water. The mean velocities in table 1 were computed using the distance and traveltimes between each pair of adjacent sites. Velocities of the leading edge and peak can be computed in a similar way with the data in the table.

As the dye clouds traveled downstream they continuously diffused, taking longer to pass each successive site, while the peak, or maximum, concentrations continuously decreased. Table 1 gives the time for the entire dye cloud to pass each site, from leading edge to the approximate trailing edge of detectable concentrations of dye. In this study, the lower limit of detectability of the dye was about 0.1 μg/l (microgram per liter). For example, in the March measurement the dye passed Thermopolis completely in 5.0 hours with an instantaneous peak of 12.0 μg/l. By the time the dye reached Greybull it took 12.0 hours to pass the sampling site, but the peak had decreased to 3.05 μg/l.