UNIFORMITY OF DISCHARGE OF MUDDY RIVER SPRINGS, SOUTHEASTERN NEVADA, AND RELATION TO INTERBASIN MOVEMENT OF GROUND WATER

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Abstract.—Flow measurements show that Muddy River Springs had uniform discharge during a period from September 1963 to April 1964; adjustments of the discharge record of Muddy River for local runoff and evapotranspiration show a long-term uniformity of springflow. Preliminary analysis of minor long-term variations suggests a 15- to 20-year lag in response to recharge from precipitation.

The Muddy River in southeastern Nevada is supplied principally by springs in the northwestern part of upper Moapa Valley. The ground water supplying the springs is inferred to be part of a regional ground-water system in Paleozoic carbonate rocks lying upgradient, or northward, from the Muddy River Springs. The area of the regional system provisionally is estimated to be roughly 7,700 square miles and includes 13 valleys in eastern and southeastern Nevada. Reconnaissance ground-water investigations for the specific valleys have been reported previously (Eakin 1961, 1962, 1963a, b, c, and 1964; Maxey and Eakin, 1949).

The inference that the Muddy River Springs are supplied from a large and complex regional ground-water system suggests that the discharge of the springs should tend to have a relatively uniform flow.

The flow of the Muddy River is gaged a short distance below the spring area. To utilize this record as a measure of the actual discharge of the springs, the record must be corrected for overland runoff resulting from local precipitation and losses of spring flow by evapotranspiration or diversion upstream from the gaging station.

DESCRIPTION AND RECORDS OF THE SPRINGS

The Muddy River Springs are at the head of the Muddy River, in upper Moapa Valley in southeastern Nevada (fig. 1). The springs issue from several groups of orifices and seep areas within the area shown on figure 2. Groups of orifices from which localized discharge occurs, such as the Iverson and Pederson groups, generally are along the margin of the flood plain. Others, such as Warm Spring and the group east of Warm Spring near U.S. Highway 93, however, issue from gravel ridges that extend into the general area of the flood plain. The seep areas are in the flood plain, downstream from the spring groups and along the natural and artificial channels. Along the main channel, flow derived from the spring area increases from zero near point 7 (fig. 2) to about 47 cubic feet per second at the gaging station, in a straight-line distance of 2 miles. Between the spring orifices and seep areas and the gaging station, evaporation and transpiration dissipate some of the spring discharge. Thus the flow of the river at the gaging station is less than the actual spring discharge. Evaporation and transpiration result from both natural effects and irrigation activities. The overall area in which evapotranspiration may have an effect on the flow at the gaging station probably is on the order of 750 acres.

U.S. GEOL. SURVEY PROF. PAPER 501-D, PAGES D171-D176

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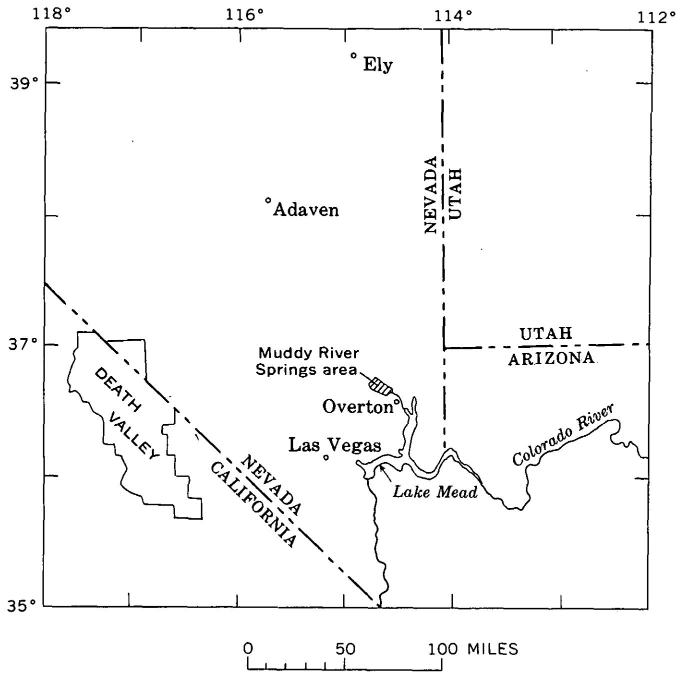

FIGURE 1.—Index map of southeastern Nevada, showing the Muddy River Springs area.

Although the springs issue from Recent alluvium in the flood plain and from conglomerate of the Muddy Creek (?) Formation in slopes bordering the flood plain, most of the water probably is transmitted to the spring area through Paleozoic carbonate rocks, which crop out close to some of the springs along the southwest side of the flood plain and which comprise most of the adjacent Arrow Canyon Range.

The records used in this analysis are for the flow of the Muddy River at U.S. Geological Survey gaging station 9-4160, Muddy River near Moapa, Nev., in the SE¼SE¼ sec. 15, T. 14 S., R. 65 E., Mt. Diablo base line and meridian. Long-term records have been published in Geological Survey water-supply papers.

As a part of a reconnaissance ground-water study of the area in September 1963 (Eakin, 1964), measurements or estimates of flow were made at 40 sites upstream from the gaging station to provide data on the relation of springflow to the gaging record. These sites included several springs and seep areas, main diversions, tributary confluences, and points along the main channel. Subsequently, measurements were made at the same sites in January 1964. Of these sites, 14 were selected and were measured again in March, April, and May 1964. Several sites of the 40 original sites, some the same as the present 14 sites, were measured in October and December 1963 and February 1964 for interim control. The present sites are sufficient to demonstrate the relative uniformity of spring discharge as compared to the seasonal fluctuations recorded at the gaging station.

RELATION OF SPRINGFLOW TO DISCHARGE OF THE MUDDY RIVER

The relation of the spring discharge to the flow of the Muddy River at the gaging station is illustrated for part of 1 year on figure 3, which shows a graph of measured discharge for 6 intervals of time between September 1963 and April 1964. The upper graph is a plot of the flow measured at the gaging station; the lower is a plot of the sum of the discharge at 6 points of measurement (points 1 to 6 on fig. 2) for the 6 intervals. The sum of spring-discharge measurements shows very little variation; the minimum is about 97 percent of the maximum. Measuring points 1 to 4 are close to spring orifices and are little affected by intermediate evapotranspiration. Measurements at points 5 and 6 show localized spring discharge and seepage gain along channel sections and may vary to a minor extent because of seasonal evapotranspiration. Together the discharge measured at the 6 points represents about 60 percent of the total spring discharge of the area and is considered to be reliable index of the uniformity of the total spring discharge. This is supported by the data obtained for the 2 series of measurements at the 40 sites upstream from the gaging station.

To reconstruct the spring discharge from the records of flow of the Muddy River at the gaging station, adjustments have been made for (1) streamflow at the gage resulting from local precipitation and runoff, (2) evapotranspiration between the springs and gaging station, (3) the effects of diversions that temporarily may bypass the gaging station and, (4) within-area changes of diversions which result in temporary modifications of the flow pattern. Ground-water underflow past the cross section of alluvium normal to the river at the gaging site is believed to be uniform and does not represent a significant accretion to streamflow downstream from the gaging station.

In large part the analysis concerns mean monthly and annual flow. Accordingly, item 4 above tends to be averaged out for present purposes, and item 3 probably was a minor factor during most of the period of record. Although past data are not available, the present diversion includes perhaps 1 cfs now carried in a pipeline to the town of Overton from one of the springs. Also, an irrigation well in the spring area north of the gaging station, which pumps about 3 cfs, is used for irrigation north and southeast of the gaging station. Although quantitative data are not available, the pattern of pumping of the well and the area

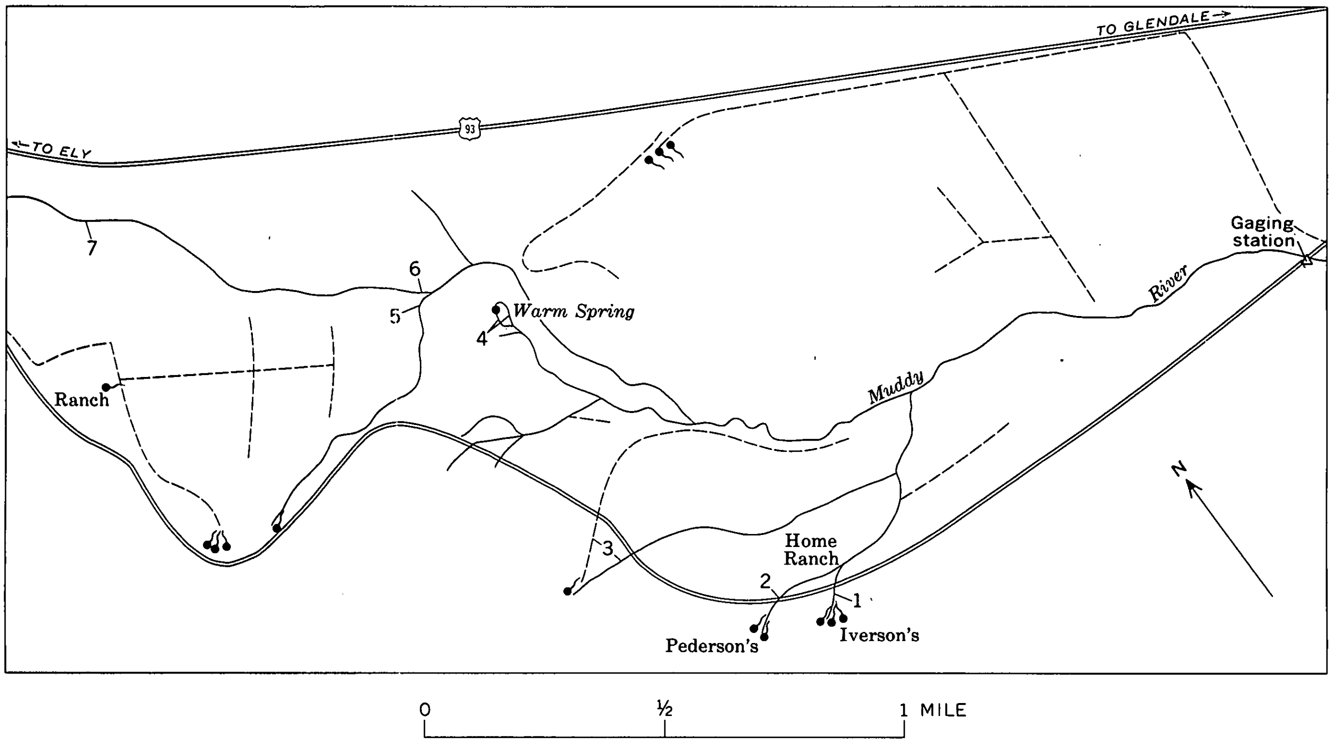

FIGURE 2.—Sketch map of the Muddy River Springs area, showing location of principal springs, stream channels (solid lines), and principal irrigation ditches (dashed lines). Numbers refer to selected measuring points.

irrigated suggest that, in effect, most of the water is evaporated or transpired from the area; however, a small amount may reach the main channel upstream from the gage from adjacent fields after periodic watering during the year. Evapotranspiration, both natural and from irrigation, between the springs and the gaging station is the principal factor resulting in differences between the total spring discharge and the flow of the river as measured at the gaging station.

Although streamflow generated from local runoff occasionally results in a very high peak discharge, the long-term effect on the flow of the Muddy River is small.

A simple correction for the effects of local precipitation on most of the streamflow was made for the 18-year period 1945–62. The adjustment was made by reducing the high flow shown for short intervals of storm runoff to values consistent with the immediately preceding and succeeding daily streamflow. The number of adjustments in mean monthly discharge is given in the accompanying table, together with the mean and median discharge. The distribution, by month, of the 24 adjustments shows 6 adjustments each for July and August, the principal months in which summer thundershowers occur.

As shown, the adjustment of streamflow to account for local precipitation has a minor effect on the record of annual flow of the Muddy River. However, the adjustment results in a month-to-month change in the record for the Muddy River at the gaging station that is more consistent with the expected pattern of the month-to-month change resulting from seasonal effects of temperature and evapotranspiration.

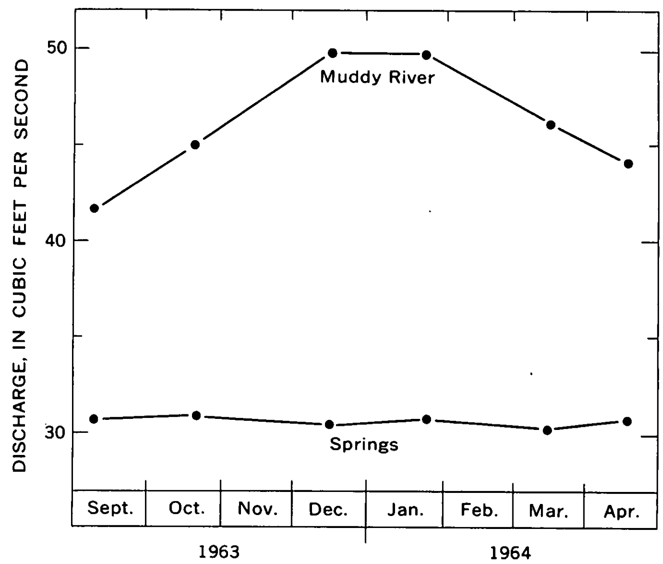

FIGURE 3.—Measured discharge at the gaging station, Muddy River near Moapa, and the sum of measurements of springs at 6 sites, numbers 1 to 6 inclusive on figure 2, for 6 time intervals during the period September 1963 to April 1964.

Long-term mean, median, and adjusted monthly discharge of Muddy River near Moapa for the period of water years 1945–62

Months	18-year mean discharge (cfs)	18-year median discharge (cfs)	18-year adjusted mean discharge [1] (cfs)	Number of adjustments, by month
October	46.5	46.5	46.4	1
November	49.5	48.2	48.8	3
December	50.2	50.1	50.1	2
January	50.2	49.5	50.2	0
February	49.4	49.6	49.1	2
March	48.3	47.8	48.2	1
April	46.6	46.6	46.6	0
May	45.3	45.6	45.2	1
June	43.4	43.7	43.3	2
July	43.4	43.6	42.9	6
August	44.7	43.3	43.7	6
September	44.4	44.4	44.4	0
Year	46.8	46.9	46.6	24

[1] Adjusted to eliminate the amount of runoff derived from local precipitation from the gage record.

Adjustment for evapotranspiration

Diurnal and seasonal fluctuations in streamflow occur in response to evapotranspiration, which in turn is related mainly to the seasonal variations in temperature.

Figure 4 shows daily fluctuations in the water-stage record for August 12 and 13, 1963, resulting from the diurnal variation in the rate of evapotranspiration. The graph for January 29 and 30, 1964, shows no such fluctuation. The two periods shown by the graphs are during maximum (June–August) and minimum (December–January) periods of evapotranspiration. The range in fluctuation of the August graph represents about 2 cfs, and is considered to be due primarily to the diurnal effect of evapotranspiration along the main and the principal tributary channels of the stream.

Seasonal variations in evapotranspiration in the area between the gaging station and the springs also affect the flow of the river. The adjusted mean monthly discharge (from the table), plotted on figure 5, shows that the minimum mean discharge occurs in July and the maximum in January, with moderately large changes in the intervening months. The mean monthly temperature at Overton is plotted for comparison. It, too, shows a change from month to month, but as might be expected, in an inverse pattern—the months of highest temperature correspond to the time of greatest stream loss through evapotranspiration.

Figure 6 shows an excellent correlation of discharge of the Muddy River at the gage with air temperature. The high degree of correlation, even though the adjusted mean monthly discharge of the river ranged from 42.9 to 50.2 cfs, clearly indicates that the input, or spring discharge, supplying the river is highly uniform from month to month. Thus, because the spring discharge is uniform, it is represented closely by the gaging record of the river during January, the month of minimum evapotranspiration. The adjusted mean January discharge is 50.2 cfs. Furthermore, if this is representative of the mean annual discharge of the springs, then the amount of spring discharge dissipated by evapotranspiration can be estimated by subtracting the adjusted mean annual discharge (46.6 cfs) of the Muddy River. Thus 3.6 cfs represents the part of the mean annual springflow that discharges at the land surface and is consumed by evapotranspiration between the springs and gaging station.

Long-term uniformity of discharge

Some variation in annual mean discharge of Muddy River Springs is evident from the published records of Muddy River streamflow. As noted in the table,

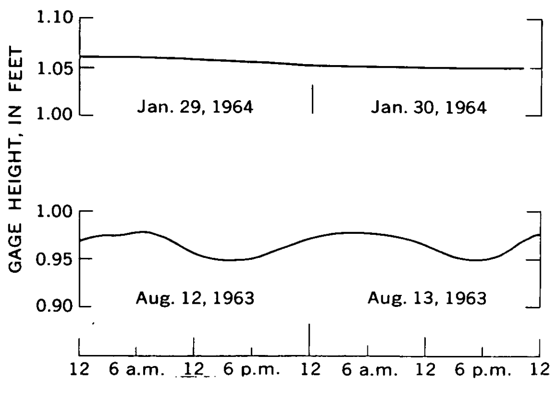

FIGURE 4.—Stage of the Muddy River for the 2-day periods January 29 and 30, 1964, and August 12 and 13, 1963, illustrating diurnal effect of evapotranspiration during the summer.

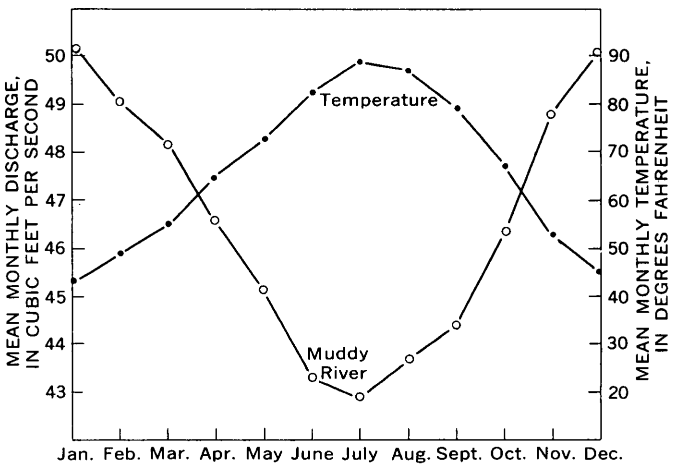

FIGURE 5.—Comparison of mean monthly discharge of Muddy River at the gaging station and mean monthly temperature at Overton, Nev., 1945–62.

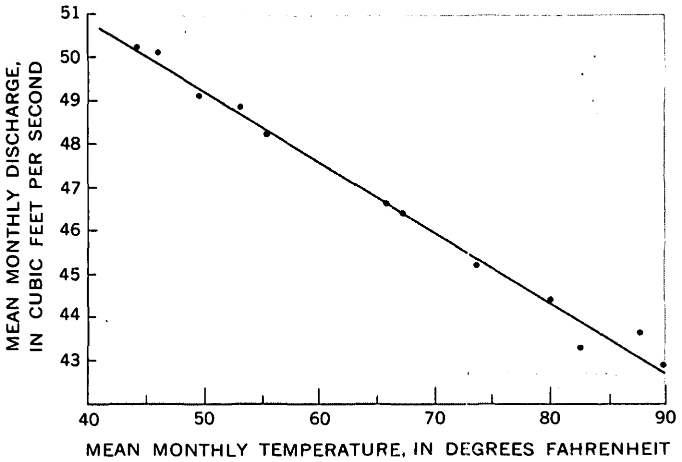

FIGURE 6.—Plot of the mean monthly discharge of Muddy River at the gaging station versus mean monthly temperature at Overton, Nev., without respect to time.

the mean annual discharge of Muddy River for the 1945 to 1962 period is 46.8 cfs, the median is 46.9, and the record adjusted for overland flow from local precipitation is 46.6. The minimum annual mean during the 18-year period was 44.5 cfs, in 1962, and the maximum was 49.6 cfs, in 1958. The small range in fluctuation is indicated by the fact that the discharge in the minimum year was about 90 percent of the maximum annual mean discharge uncorrected for locally derived streamflow. Thus, although some long-term variation occurs, the very small range of variation actually indicates a highly uniform long-term discharge characteristic of the Muddy River Springs.

Long-term variation of discharge

Although the Muddy River Springs have a highly uniform discharge, the small range of variation has long-time significance. Eakin (1964, fig. 4) compared a graph of cumulative departure from average annual precipitation at Adaven, Nev., for the period 1919–62 with a graph of cumulative departure from mean annual discharge of the Muddy River for the period 1945–62. A rising trend of discharge during the period 1957 to 1960 seemingly was related best to a noticeable rising trend of precipitation in the period 1937–41. Within these two periods, 1941 commonly was a year of much above normal precipitation in much of the Great Basin. The greatest increase in annual mean discharge over the prior year shown by the Muddy River record was in 1958. This suggests a possible timelag response of spring discharge to regional precipitation and consequent recharge of perhaps 15 to 20 years.

Additional simple tests of correlation between precipitation and spring discharge seem to support further a timelag response of the order indicated above. However, further analysis of the gaging record and of regional precipitation conditions is required and is in progress to evaluate this feature.

SUMMARY AND CONCLUSIONS

Several sets of measurements of the discharge of springs that supply the principal flow of the Muddy River in southeastern Nevada indicate that the spring discharge was much more uniform than was the flow of the Muddy River at the gage during the period September 1963 to April 1964. During the interval the flow of the river at the gaging station increased from a measured discharge of 42.8 cfs in September to 49.8 cfs in January and declined to 44.0 cfs in April, whereas the measured spring discharge was nearly constant. Comparison of mean monthly discharge at the gage for the period 1945–62 with mean monthly temperature for Overton, as a measure of evapotranspiration, shows a high correlation and indicates that, for practical purposes, the variation in mean monthly discharge is a function of evapotranspiration. From this it is inferred that the spring discharge supplying the Muddy River must be highly uniform or the correlation of discharge and temperature would not be so close. If this is the case, then the annual mean discharge of the springs in a given year should be approximately equal to the January mean discharge of the Muddy River for that year, as January is the month of minimum evapotranspiration. The adjusted mean January discharge of the river is 50.2 cfs for the period 1945 to 1962. The difference between the 50.2 cfs and 46.6 cfs, the adjusted mean annual discharge at the gaging station, is 3.6 cfs and approximately represents the mean annual evapotranspiration between the springs and the gaging station.

The long-term uniformity of spring discharge is suggested even by the uniformity of unadjusted mean annual discharge of the Muddy River. The minimum annual mean discharge for the period 1945–62 of gaging record is 90 percent of the maximum annual mean discharge.

Although long-term discharge of the springs is nearly uniform, some variation from year to year does occur. Preliminary tests suggest that spring discharge responds to pronounced variations in precipitation and consequent recharge with a timelag on the order of 15 to 20 years. These tests, though simple, are promising, and further studies are in progress.

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