Hydrology of Small Watersheds in Western States

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1475-I

Prepared as part of the Soil and Moisture Conservation Program of the Department of the Interior

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By H. V. PETERSON

HYDROLOGY OF THE PUBLIC DOMAIN

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HYDROLOGY OF SMALL WATERSHEDS IN WESTERN STATES

By H. V. Peterson

ABSTRACT

This report presents results of observations of runoff and sediment yield made over a period of years at 200 reservoirs located on small drainage basins distributed throughout the western States. The records were obtained in drainage basins that are typical of much of the public domain. They are useful chiefly as an aid in assessing the need for conservation and in planning conservation programs and structures.

The observation reservoirs are located in the Missouri River, Colorado River, and Rio Grande drainage basins, and they are distributed from Montana to southern Arizona. Of the 120 observation reservoirs in the Missouri River basin in Wyoming and Montana, 102 have records of sediment yield only and 18 have records of both sediment and runoff. In the Colorado River basin of Wyoming, Colorado, Utah, and Arizona, records were collected at 48 reservoirs, at 25 the measurements were made of sediment yield only, and at 23 measurements were for both sediment yield and runoff. Of the 32 reservoirs in the Rio Grande basin, all in New Mexico, measurements of sediment yield only were obtained at 7 and records of both runoff and sediment were obtained at 25 reservoirs.

In the selection of observation reservoirs an effort was made to sample a wide range in climate, topography, geology, soil, and the types of vegetation associated with each factor within the semiarid western areas. The reservoirs range in capacity from 0.2 to 1,012 acre-feet, and the contributing drainage areas range from less than 0.1 to 55 square miles. The wide variation in unit rates of runoff and sediment yield reflect all the differences in drainage basin characteristics.

INTRODUCTION

The emphasis placed on programs for the conservation of soil and water on range lands in the western States during the past few years has created a need for more precise information on runoff and sediment yield from these lands. It is recognized that effective conservation of soil and water can be achieved only where information on both is available. The quantities of soil eroded, the runoff causing the erosion, and the disposal of the soil and water must be known as a basis both for justifying a conservation program and as background for designing suitable programs.

Except for forested areas at the higher altitudes, rangelands in the 11 Western States lie within the arid or semiarid zones. Water originating within the higher areas is used for irrigation of some of the lower drier lands but the irrigated tracts make up only a small part of the total area. The remaining land is used chiefly for grazing, and a large part of it is included in grazing districts and Indian reservations administered respectively by the Bureau of Land Management and the Bureau of Indian Affairs. Smaller acreages have been set aside for reclamation withdrawals, military reservations, and other public uses.

Because of low precipitation the total runoff from western grazing lands is small, but generally the sediment yield is relatively high. This condition is due mainly to the fact that the major part of the runoff occurs as flash floods generated by high-intensity summer storms. Erosion during such storms is intense, and the sediment yield tends to be proportionally higher than in other localities where approximately equal amounts of runoff occur at lower rates extended over longer periods. The condition of the land, whose sparse cover of vegetation reflects both the low rainfall and often a past history of misuse, chiefly overgrazing, is also an important factor in causing the high sediment yield. Effective conservation on these lands must include methods to control the flood runoff that directly causes the excessive erosion and to restore the vegetation to provide a protective ground cover and increase forage. Proper conservation likewise must visualize and plan the most efficient use of water, both on the watershed and at locations downstream.

In the soil and moisture conservation program of the U.S. Department of the Interior, increased attention is being directed to conservation on these arid rangelands and a variety of conservation methods are used. Among the current, more widely used practices are (a) clearing nonbeneficial vegetation and seeding to grass in areas where precipitation, topography, and soil conditions are favorable; (b) contour furrowing, pitting, and listing designed to increase infiltration and retard runoff; (c) water spreading used with or without flow-control structures; and (d) construction of retarding reservoirs used directly for flood control or in association with water spreading. For each of these practices, some knowledge of the amount of runoff and sediment that might be expected from the drainage area becomes an important consideration in determining the treatment program best suited for a particular area.

PURPOSE AND SCOPE OF THE STUDY

Although the runoff and sediment load of many streams in the West are measured by the U.S. Geological Survey and other Federal and State agencies, practically all the gaging stations are located on streams whose drainage areas range in size from several hundred to several thousand square miles. Comparison of the runoff and sediment yield obtained at these gaging stations with those that have been observed in the smaller areas, such as those tributary to conservation structures, disclosed such disparity that obtaining data for smaller areas has become a prerequisite for the design of effective conservation programs. To obtain the urgently needed information from small drainage basins the Geological Survey began collecting runoff and sediment data as soon after World War II as personnel and funds became available. This report presents a compilation of the data obtained to date.

All measurements of runoff and sediment yield included in this report were made at reservoirs constructed by the Federal land agencies or by individuals. Most of the reservoirs are used for watering stock, but others are used for land conservation or for flood control. The reservoirs made it possible to obtain measurements in many remote areas on ephemeral streams where records could not have been obtained otherwise because of the difficulties and great expense involved in operating conventional gaging stations in such locations.

The investigations described in this report are part of the program of the Geological Survey for the collection of data for hydrologic research on the public domain. The purpose of this program is to collect and compile data for use by other land agencies of the U.S. Department of the Interior in designing practical and effective land-conservation programs. The studies were started under the general direction of R. W. Davenport, chief, Technical Coordination Branch and were continued under the direction of C. C. McDonald, chief, Branch of General Hydrology. R. C. Culler, G. C. Lusby, F. W. Kennon, D. E. Burkham, K. R. Melin, R. F. Hadley, N. J. King, and S. A. Schumm participated in the field investigations and assisted in the computations and preparation of the report.

LOCATION OF THE STUDY AREAS

The growing interest and widespread activity in conservation measures has created a need for information on runoff and sediment yield from all parts of the public domain, including areas of different climate, topography, soil, geology, vegetation, and erosional conditions. Insofar as practical the study locations were selected to cover this range of conditions, although of necessity the locations had to be limited to those areas where reservoirs suitable for the measurement of runoff and sediment were available.

As the observation reservoirs are distributed through an area extending from Montana to southern Arizona, they cover a wide range of climate. In selecting the reservoirs for study an effort was made to obtain an equally representative range in slope, soil, vegetation, and types and severity of erosion. In general, the measurement programs were intensified in those areas where the Bureau of Land Management, the Bureau of Indian Affairs, or other agencies of the U.S. Department of the Interior had large-scale soil and moisture conservation programs in operation or had plans for programs and construction of conservation structures at an early date.

The general location of the 200 reservoirs used for measurements of either or both runoff and sediment yield is shown in figure 35, and the study areas are given by name, state, and drainage basin in table 1.

TABLE 1.—*Location of study areas and number and type of records obtained*

Study area	State	Subbasin	Number of records	Type of records	
				Sediment	Sediment and runoff
Missouri River basin					
Willow Creek	Montana	Milk River	4	3	1
Wind River	Wyoming	Yellowstone River	15		15
Fifteen Mile Creek	do	do	2		2
Cheyenne River above Angustora Reservoir.	Wyoming, South Dakota, and Nebraska.	do	99	99	
Colorado River basin					
Badger Wash	Colorado	Salt Creek	19		19
Middle Reservoir	do	Dolores River	1		1
Little Robber Creek	Wyoming	Yampa River	1		1
Price River and Saleratus Wash.	Utah	Green River	9	9	
San Rafael River	do	do	6	6	
Crescent Wash	do	do	1		1
Ivy Creek Bench Reservoir	do	Dirty Devil River	1	1	
Blue Point Reservoir	do	Bullfrog Creek	1	1	
Oak Creek Reservoir	New Mexico	Little Colorado River	1	1	
Railroad Wash Stanford Tank.	do	Gila River	1		1
Miscellaneous areas	Arizona	(1)	7	7	
Rio Grande basin					
Zia Reservoir	New Mexico	Jemez River	1		1
San Luis Wash	do	Rio Puerco	3		3
Cornfield Wash [2]	do	do	19		19
Rio Colorado	do	do	1		1
Victorino Wash	do	Rio Salado	1		1
Ladron Peak	do	(3)	2	2	
Hot Springs Wash	do	(3)	2	2	
Nordstrom Wash	do	(3)	3	3	

[1] Tributaries of the Gila River.
[2] Records of mean annual runoff and sediment yield only.
[3] Tributaries of the Rio Grande.

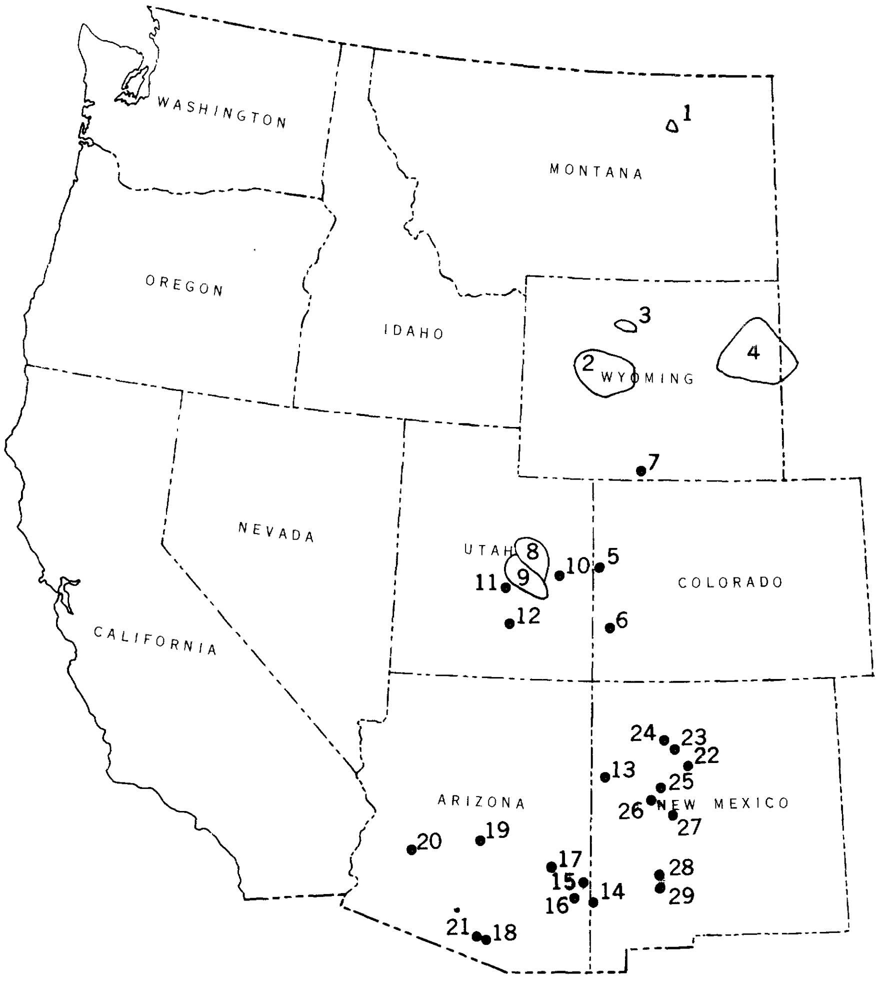

FIGURE 35.—Index maps of Western States showing study areas and number of reservoirs (in parenthesis).

1. Willow Creek basin (4)
2. Wind River basin (15)
3. Fifteen Mile Creek basin (2)
4. Cheyenne River basin (99)
5. Badger Wash basin (20)
6. Middle Reservoir (1)
7. Little Robber Creek basin (1)
8. Price River and Saleratus Wash basins (9)
9. San Rafael River basin (6)
10. Crescent Wash Reservoir (1)
11. Ivy Creek Bench Reservoir (1)
12. Blue Point Reservoir (1)
13. Oak Creek Reservoir (1)
14. Railroad Wash basin (1)
15–21. Miscellaneous areas in Arizona (8)
22. Zia Reservoir (1)
23. San Luis Wash basin (3)
24. Cornfield Wash basin (19)
25. Rio Colorado Reservoir (1)
26. Victorino Wash Reservoir (1)
27. Ladron Peak area (2)
28. Hot Springs Wash basin (2)
29. Nordstrom Wash basin (3)

Additional details relating to the reservoirs in each study area, together with a description of the drainage area and data on precipitation, runoff, and sediment yield are given further in the report.

PREVIOUS INVESTIGATIONS

Data pertaining to the rate of sediment deposition in reservoirs and to the unit rate of sediment yield from the drainage basins have been collected and reported upon by many investigators. Most of the data pertain to reservoirs on large perennial streams with large drainage basins, and for such streams, reliable information on both runoff and sediment yield is available. Considerable information is available on sediment yield for reservoirs on smaller drainage basins, but data on the accompanying runoff are meager. This is particularly true for ephemeral streams that drain western rangelands where conservation is now being intensified.

In an important paper Stevens (1936) presented basic data from a variety of sources on the rate of sediment deposition in large reservoirs throughout the world. More recent reports on the measurement of sediment deposition in small stock reservoirs located in the midwestern and western States include South Dakota, (Gottschalk, 1946); Iowa and Nebraska, (Gottschalk and Brune, 1950); Utah, (King and Mace, 1953); Arizona, (Hains, Van Sickle, and Peterson, 1952); Washington, Idaho, and Oregon, (Flaxman and Hobba, 1955) Equations for estimating the sediment yield from some small drainage basins have been developed by use of the detailed information contained in these reports. These equations have been discussed by Glymph (1955).

In addition to the above mentioned studies, data on sediment production measured in reservoirs with different sizes and types of drainage basins have been compiled separately for the southwestern States (Brown, 1945), the midwestern States (Brune, 1948), and the Missouri River basin (Glymph, 1951). Finally in 1953 a summary of sedimentation in reservoirs for the conterminous United States was compiled by the Federal Inter-Agency River Basin Committee, Subcommittee on Sedimentation (1953). The summary presents the results of all known reliable surveys on sedimentation of reservoirs located in conterminous United States through 1950. The present compilation summarizes the work of the General Hydrology Branch of the Geological Survey on studies of rangeland areas located in the western States.

ACKNOWLEDGMENTS

Although practically all data contained in the report have been compiled by the U.S. Geological Survey, several Federal land agencies and numerous individuals have assisted in various phases of the work. This assistance is gratefully acknowledged. Particular thanks is due to personnel of the following grazing districts of the Bureau of Land Management for their cooperation in making surveys of reservoirs and for generally assisting in the observation programs: Montana district 1; Wyoming districts 1, 2, 3, and 4; Utah district 3, and New Mexico districts 1 and 7. Similar assistance rendered by the Bureau of Indian Affairs in the Navajo Indian Reservation in Arizona and New Mexico is also gratefully acknowledged. Thanks are likewise due many ranchers and stockmen in all parts of the West for allowing measurements to be made on individually owned reservoirs and for assisting in other ways. The interest shown by many of these individuals in the data obtained and its relation to range use and conservation is commendable.

MEASUREMENT OF RUNOFF AND SEDIMENT

CRITERIA USED IN SELECTING THE RESERVOIRS

As noted previously, all measurements of runoff and sediment yield were made in small reservoirs. These ranged in capacity from 0.2 to 1,012 acre-feet. The contributing drainage areas ranged from less than 0.1 to 55 square miles. In the selection of the study reservoirs an effort was made to obtain as wide an areal distribution as possible and also to select drainage basins that were typical of large areas of rangelands in the vicinity. The selection was also planned to include a wide range in vegetation, topography, soil, geology and climate to determine the influence of these factors on runoff and sediment yield. Other features considered in making the selections included reasonable accessibility; large reservoir capacity in relation to drainage area, to avoid excessive spill; and stable dams to avoid failures or other accidents that might interrupt the record.

Measurements in reservoirs located in the Cheyenne River basin, Wyoming; Cornfield Wash, N. Mex.; Wind River basin, Wyoming; and Badger Wash, Colo., were made in connection with special studies under way at these localities. Except for Badger Wash, these records are available in other publications of the U.S. Geological Survey, but the summaries are repeated here for ready reference.

RESERVOIR SURVEYS

All reservoirs used for observation were surveyed by planetable and stadia, and stage-capacity curves were developed for each. Usually contours were drawn on 1-foot intervals for the lower parts of the reservoirs and on 2- to 5-foot intervals for the upper parts, depending on the terrain and the size of the reservoir. Following the initial survey, the accretion of sediment was measured either by use of monumented range lines spaced at selected intervals in the reservoir or by resurvey using contours. The first method has proved to be less troublesome yet fully as accurate as repeated contouring. When the rate of sediment deposition was needed for past years in reservoirs for which no original surveys were available, the total deposition of sediment was obtained by spudding. By use of a thin steel rod as a spudding tool, the interface between the deposited sediment and the original ground surface could be identified easily. Comparison of the original contours of the reservoir, as reconstructed in this manner, with present contours gives a measure of the total deposition since construction. This volume divided by the age of the reservoir, in years, gives the mean annual sediment yield. Reservoirs used for obtaining continuous runoff measurements are resurveyed yearly or more frequently to correct the stage-capacity curves and to obtain the sediment deposition since the previous survey.

METHODS OF MEASURING RUNOFF AND SEDIMENT

Runoff from the contributory drainage areas was measured volumetrically by frequent observations of reservoir stage. Increments of stage were converted to volume through use of the stage-capacity curves. A few of the reservoirs were equipped with continuous water-stage recorders that naturally gave a more accurate record. As the volume of inflow is represented by the maximum stage in the reservoir attained during the runoff period, special care was taken to locate the high-water mark for each storm. In some of the reservoirs crest-stage gages were installed for this purpose and in others the water level was observed on a section of the dam specially prepared to preserve evidence of the high-water mark. Typical gaging stations are shown on figures 36 and 37.

Where spill occurred the volume was determined by use of the equation developed by Kennon and Peterson (1960).

$$V=S\left[1+\frac{CQ\sqrt{A}}{S+S_1}\right]$$

in which

V=volume of spill, in acre-feet;
A=drainage area, in square miles;
S=surcharge: the volume of water temporarily stored in the reservoir above the spillway crest, in acre-feet;
S_1=volume of runoff impounded below spillway level, in acre-feet;
Q=maximum rate of spill, in cubic feet per second, determined by use of the broad-crested weir formula, $Q=cBH^{3/2}$, in which H is maximum depth over spillway shown by the high-water mark and B is width of spillway;
C=A coefficient relating the volume and rate of spill to the surcharge. Evaluated as 0.042 from studies of other reservoirs.

FIGURE 36.—Gaging-station structure on Windy Point Reservoir, Badger Wash, Colo. The drainage basin and reservoir are typical of those described in this report.

The volume of spill added to the volume stored in the reservoir during a given period gives the total runoff from the contributing drainage area.

For reservoirs provided with open outlet pipes but not equipped with a water-stage recorder, an error in measuring runoff is introduced because the discharge through the outlet pipe during the inflow period cannot be determined. The error is considered to be minor because most of the runoff caught in the reservoirs is the result of high-intensity rains that generally last less than an hour. As these storms produce a high peak flow of short duration, only a minor quantity of water escapes through the outlet pipe before the reservoir reaches its maximum stage for the storm. Studies made in reservoirs equipped with continuous water-stage recorders shown that the discharge through open outlet pipes during the rising stage is of importance only when slow runoff occurs as a result of spring snowmelt or of extended low-intensity rains. These conditions occurred infrequently in most of the reservoirs observed.

The sediment yield from the contributing drainage area was also measured volumetrically in the reservoirs. The reduction in the capacity of a reservoir, as shown by successive surveys, was considered as the sediment contribution from the drainage area for the period between surveys. The surveys included sediment that was deposited above the spillway level of the reservoir as part of the sediment contri-

FIGURE 37.—Gaging-station structure on Crescent Wash Reservoir, Utah. The basin drains a part of the steep and rugged Book Cliffs. The lower slopes of the cliff consist of shale. The massive capping is sandstone. Because of the high sediment yield the station had to be abandoned after 4 years.

bution from the drainage area. Two typical reservoirs used for studies of sediment yield in the Cheyenne River basin, Wyoming, are shown in figures 38 and 39.

In calculating the volume of sediment deposition, no consideration was given to the amount that may have escaped by spill or through open outlet pipes, or to an increase in the storage capacity of the reservoirs owing to compaction of the older sediments. Observations show that discharge from spillways and open-pipe outlets is generally relatively clear; therefore, the amount of sediment escaping is probably minor as compared to the total contribution.

The increase in storage capacity resulting from compaction of older sediments is likewise believed to be minor, except where the reservoirs are dry for protracted periods. Measurements made by King (1959) at the Graham Reservoir in the Wind River basin show that compaction decreased the total thickness of the deposits by about 15 to 20 percent after the reservoirs had been dry for 3 successive years. Compaction may result from the drying of sediments exposed to air or by dewatering caused by the pressure of successive sediment loads. Most of the observation reservoirs go dry only occasionally for short periods in the spring and early in summer. Because the maximum thickness of the sediments in the reservoirs ranges from only about 5 to 15 feet, the errors introduced in the yearly sediment yield because of an increase in storage capacity resulting from compaction of the deposits are of minor significance and are probably less than the errors inherent in surveying and computing the volume of the annual accretions.

RELIEF RATIOS

One objective of the study was to determine whether a relation could be developed between the measured sedimentation and the topography of the contributing drainage area. Accordingly, data were compiled on the topography of the basins, for which topographic maps were available or where the essential topographic data could be obtained readily. Schumm (1956) has demonstrated that sediment yield from an area is in some measure related to a dimensionless topographic index termed the "relief ratio," which is obtained by dividing the relief of the drainage basin by the length of the longest dimension.

In calculating values for the relief ratio, the relief was measured as the difference in elevation between the spillway of the reservoir and the mean level of the headwater divide. For this purpose, high and low points on the drainage divide were used only to obtain the general average elevation of the divide. The length of the basin was measured on a map or aerial photograph as the distance from the dam to the headwater divide in a straight line approximately parallel to the main drainage channel within the basin.

In selecting drainage basins for relief-ratio studies, some arbitrary discriminations were made. Drainage basins in which the width, measured normal to the main channel, was equal to or exceeded the length parallel to the channels were not used. The excessive width in such basins is generally due to the existence of two main tributaries that join at or slightly above the reservoir, thus greatly increasing the rate of sedimentation as measured in the reservoir. Also only reservoirs with records of 5 years or more were used, because this period is considered a minimum for establishing a mean annual rate of sediment yield. Drainage basins containing dams or other structures in the headwater areas that might complicate the record of sedimentation were likewise not included in the relief-ratio studies. Results and conclusions relating to the relief-ratio studies are given further in the report.

COMPILATION OF MEASUREMENTS

In the tabulations that follow, the sediment yield and runoff, where obtained, are given separately for each study area. The study areas are arranged in downstream order under the three major drainage basins.

FIGURE 38.—Coyle Reservoir, near Newcastle, Wyo. The reservoir is typical of those used to measure sediment yield from small drainage basins underlain by the Pierre shale in the Cheyenne River basin Wyo.

In reporting sediment yield and runoff, the total contribution measured during the period of observation has been converted to an average annual contribution, expressed as acre-feet and as acre-feet per square mile of drainage area, the latter for comparison between study areas. Where both runoff and sediment yield were measured, the ratio between acre-feet of runoff and acre-feet of sediment has been included.

At observation reservoirs not equipped with water-stage recorders, the reservoir stage was determined by measuring from a permanent reference point down a monumented line of uniform slope to the edge of the water. These measurements were then converted to gage height. The monumented line was usually located on the upstream face of the dam, and special care was taken after each measurement to clear the line and to obliterate any earlier marks so as to preserve subsequent high-water marks. Readings of stage were taken at least weekly. After a few measurements a uniform rate of recession for each reservoir became evident, and thus it was usually possible to determine the reservoir stage just before the inflow. The volume of storm runoff could then be calculated. Gage heights before the inflow are shown in the compilation. Where the gage height is not given it indicates that the reservoir was dry before the runoff event.

FIGURE 39.—Joss Reservoir, near Lance Creek, Wyo. The reservoir is used to measure the sediment yield from a small basin tributary to Twenty Mile Creek. The basin is underlain by the Fort Union formation which consists of sandstone and shale.

A generalized description of the drainage basin, including topography, geology, vegetation, erosion, and precipitation, is given for each study area. Although brief and incomplete, the descriptions permit some basis for comparison between areas and give some indication of the reason for differences in runoff and sediment yield.

MISSOURI RIVER BASIN

MILK RIVER BASIN

WILLOW CREEK BASIN, MONTANA

The Willow Creek basin, with a drainage area of 536 square miles, is tributary to Milk River and lies just northwest of the Fort Peck Reservoir on the Missouri River. Willow Creek flows in a northerly direction and joins Milk River near Glasgow, Mont. Most of the basin is public land on which intensive conservation programs of several different types, including several moderate-sized structures have been installed by the Bureau of Land Management. The structures include about 15 retarding and stock-water reservoirs located on tributaries of Willow Creek. Four of these, so located as to give a good areal distribution and a range of terrain characteristics, were selected as measuring stations for runoff and sediment yield. The selected reservoirs are: the Burnett Northwest Reservoir in the northwestern part, the West Road and Willow Flat Reservoirs in the southeastern part, and the Wittmayer Reservoir in the southwestern part of the basin. Observation on sediment yield was started on the four reservoirs at various times between 1952 and 1954. Runoff measure-

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ments were obtained in the Burnett Northwest Reservoir during the summers of 1954–59, but sediment measurements were obtained for only 2 years, 1954–55. A stream-gaging and sediment-sampling station was installed on Willow Creek near Glasgow in 1953 and has been operated since. The data obtained are being used to evaluate the influence of the extensive conservation programs on runoff and sediment yield from the basin.

TOPOGRAPHY

The Willow Creek basin has a low to moderate relief with elevations ranging from 2,000 to 2,800 feet. Gently rolling upland and relatively wide stream valleys of low gradient are prevalent. In places, particularly in the western part of the basin, the rolling upland is interspersed by low sandstone-capped escarpments. One of these extends across the drainage basin of the Wittmayer Reservoir. A significant feature found in each of the basins is the large expanse of nearly barren terraces, locally called hardpan flats. These range in size from a few acres to more than a hundred acres. Considerable research and experimental work in progress is aimed at developing methods for returning the tracts to production of range forage.

No topographic maps are available for any of the study areas, but relief ratios for two of the basins were obtained by scaling areal photographs for length and by obtaining elevation differences with an aneroid barometer.

GEOLOGY

The greater part of the upland is underlain by the Bearpaw shale, which is a typical black shale of marine origin. It has a high content of sodium salts. The shale weathers to a heavy-textured residual soil that is moderately productive, except in local areas of high-salt concentration. On some of the higher ridges in the western part of the basin the Bearpaw shale is capped by light-colored sandstone and siltstone of the Fox Hills and Hell Creek formations. Soils resulting from weathering of these formations are the most productive in the basin.

Glacial boulders are scattered throughout the basin, but there are no glacial deposits of appreciable thickness or areal extent. The stream valleys are underlain by alluvium consisting of clay and silt derived from the weathered Bearpaw shale. Reflecting the character of the parent rock, the alluvium is fine textured and dense. Most of the hardpan flats are located on the alluvial deposits adjacent to the streams.

VEGETATION

The principal species of vegetation found in the basin are typical of the northern Great Plains. They include wheatgrass, needle-and-thread grass, bluegrass, several species of grama, sagebrush, saltsage, and greasewood. In type and density the vegetation ranges from a very sparse growth of saltsage on the hardpan flats and upland shale slicks to dense stands of wheat grass and other grasses intermingled with sagebrush on the upland slopes and some of the lower stream terraces. The Wittmayer and Burnett basins have a good cover throughout, in which grass and sagebrush predominate. In contrasts, nearly barren hardpan flats make up a considerable part of the other observation basins.

EROSION

The outstanding feature of erosion in the Willow Creek basin is the deep gullying along the larger streams and some of the smaller tributaries. Unlike the conditions in many other areas, however, the gullying does not appear to have induced any serious erosion in areas adjacent to the stream. The stream terraces, including the hardpan flats, show little evidence of erosion, although sheet erosion, which is not readily detectable in barren areas, probably accounts for the removal of appreciable quantities of soil. Rilling, sheet erosion, and some gullying are active on the poorly vegetated steeper slopes. Upland slopes in the Burnett Northwest and Wittmayer drainage basins show a moderate amount of erosion, but a part of the removed soil is redeposited in the central and lower reaches of the basin, which consists of wide grassy draws. A considerable amount of gullying and sheet erosion is evident in the East Road and Willow Flat basins, and there is less deposition than in either of the other basins.

PRECIPITATION

Both the annual and the growing-season precipitation at Willow Creek are high, as compared to other areas covered by this report. Winter temperatures are among the lowest recorded at any of the areas, but the summer temperature is favorable to the growth of range forage; the growing season averages about 4 months. Nearly 70 percent of the annual precipitation occurs as rain during the growing season from May to September and most of the remainder occurs as snow. The following data on precipitation, based on records of the U.S. Weather Bureau at Glasgow, are believed to be representative of the Willow Creek area.

Mean precipitation, 1931–55

	Inches
Annual	13. 26
April through October	10. 84
November through March	[1] 3. 48
Maximum month (June)	3. 48

[1] Mostly snow.

Frequency of 1-day precipitation of selected magnitude at Glasgow, April through October

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Percent of years in which at least one event occurred, 1920–54	100	68	37	27
Average number of events per year during—				
1920–59	5. 9	1. 4	. 6	. 3
June 1952–September 1959	5. 4	1. 2	. 4	. 1

RUNOFF

Most runoff in the area results from storms in the period May to September, but a part results from snowmelt, ordinarily in March or April. The maximum peak discharge and the largest daily volume of runoff for the year may result from either cause. Runoff also results occasionally from the rapid melting of snow accumulated from storms during the spring or fall. Owing to the fine texture and impervious character of the soil and rock in most of the area, rates of runoff are relatively high.

Willow Creek has a small perennial flow throughout most of its length, but flow in the tributaries is ephemeral and occurs only in response to storms or snowmelt. There is no sustained flow to either of the observation reservoirs.

Storm runoff to the Burnett Northwest Reservoir during the summer seasons 1954–59 is shown in the following table, and sediment yield measured in the four study reservoirs is given in table 2, which shows all measurements made at reservoirs in the Missouri River basin.

Storm runoff and sediment yield measured in Burnett Northwest Reservoir, Mont.

Location.—Lat 48°05′, long 107°08′, in SE¼ sec. 24, T. 27 N., R. 35 E., on Lone Tree Creek, about 18 miles upstream from the confluence with Willow Creek, Mont.

Drainage area.—5.0 sq mi.

Records available.—1954–59, summer months only.

Gage.—Water-stage recorder.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir. Discharge determined approximately from runoff hydrograph.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys. Total sediment yield for period August 1954 to September 1955, 3.0 acre-ft.

Capacity.—

Date	At overflow spillway		At sill of outlet pipes	
	Gage height (ft)	Capacity (acre-ft)	Gage height (ft)	Capacity (acre-ft)
Aug. 4, 1954	9.9	146	4.4	4.3
Sept. 26, 1955	[1] 9.7	133	4.4	4.1

[1] Spillway lowered by erosion.

Maximums.—Apr. 22, 1954, to Nov. 1, 1959: Inflow rate, about 430 cfs or 86 cfs per sq mi, May 16, 1955. Inflow volume, 279 acre-ft or 55.8 acre-ft per sq mi, May 15–17, 1955, duration, 45 hours. Outflow rate, about 110 cfs, May 16, 1955.

Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
May 3-6	(*)	(*)	0	44.6	44.6	
June 10-12	(*)	(*)	0	138.0	138.0	
June 29-30	(*)	(*)	.8	13.7	14.5	
July 9-10	(*)	(*)	.3	15.2	15.5	
Aug. 5-6	(*)	5.20	6.0	0	6.0	
Aug. 9-10	5.20	7.78	47.9	0	47.9	
Aug. 15-21	7.67	9.90	91.6	18.4	110.0	
Sept. 5-6	9.60	9.78	9.0	0	9.0	
Sept. 15-16	9.56	9.90	18.0	.5	18.5	
Sept. 17-24	9.90	(*)	[1] −142	142.0	0	
Total			31.6	372.4	404.0	80.8
1955						
May 2-5	(*)	(*)	0	104.0	104.0	
May 15-19	(*)	(*)	0	279	279.0	
July 25-27	(*)	(*)	0	59.1	59.1	
Total			0	442.1	442.1	88.4
1956						
Mar. 16-20	(*)	6.52	0	106.3	106.3	
May 6	(*)	4.40	0	14.2	14.2	
May 28-29	(*)	4.83	0	9.2	9.2	
June 22-23	(*)	5.81	0	38.9	38.9	
July 29-Aug. 3	(*)	5.22	3.5	24.7	28.2	
Aug. 31	(*)	4.40	1.8	26.6	28.4	
Total			5.3	219.9	225.2	45.0
1957						
Mar. 19-26	(*)	7.07	4.6	156.9	161.5	
Apr. 22-24	(*)	5.24	2.7	9.5	12.2	
May 22-23	(*)	5.33	2.9	27.6	30.5	
June 9-10	(*)	4.87	2.9	3.5	6.4	
June 12-17	(*)	5.13	6.4	29.5	35.9	
June 21-22	(*)	7.20	2.2	60.8	63.0	
Aug. 30-Sept. 1	(*)	6.60	3.9	47.5	51.4	
Sept. 4-5	(*)	5.49	2.8	16.2	19.0	
Sept. 18-19	(*)	5.30	2.8	13.3	16.1	
Oct. 28-29	(*)	4.92	2.9	2.3	5.2	
Total			34.1	367.1	401.2	80.2
1958						
July 8-9	(*)	4.99	1.7	13.3	15.0	
Dec. 3-4	(*)	6.24	2.4	40.5	42.9	
Total			4.1	53.8	57.9	11.6

See footnotes at end of table.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1959						
Apr. 18-19	(*)	4.99	2.6	2.3	4.9	
June 17	(*)	4.40	0	15.5	15.5	
June 26-27	(*)	4.85	0	3.6	3.6	
July 4	(*)	4.40	1.9	0	1.9	
Sept. 28	(*)	4.40	2.0	0	2.0	
Oct. 6	(*)	4.40	2.3	4.3	6.6	
Oct. 9	(*)	4.40	2.4	1.3	3.7	
Total			11.2	27.0	38.2	7.6

[1] Withdrawal from storage.

NOTE.—An asterisk (*) indicates that gage height is below recorder well (4.5 ft); contents estimated.

YELLOWSTONE RIVER BASIN

WIND RIVER BASIN, WYOMING

In 1947 studies were begun in the Wind River basin, located in west-central Wyoming, to provide quantitative data on erosion and upland sources of sediment. The scope of the studies was broadened in 1951 to include an evaluation of the effects of land-treatment practices in reducing sediment movement from upland areas into Boysen Reservoir. The land treatment consisted mainly of retarding reservoirs designed primarily to reduce flood crests. These were constructed on small streams that drain only a small part of the basin.

As a part of the evaluation study, records of runoff and sediment yield are being obtained on 15 of the retarding reservoirs. (See table 2.) Of these, 8 are located on the west side of the basin in Fivemile Creek, which drains a part of the Wind River Indian Reservation, and 7 are located on 5 small secondary tributaries that drain public lands in the southeastern part of the basin. (See pl. 18.) Because the reservoirs were constructed in different years, the records are of varying length.

Streams rising in the Wind River and Absaroka Ranges along the southwest and west margins of the Wind River basin have a large perennial flow and furnish water to the extensive irrigation projects located in the central part of the valley. Other parts of the basin, including the high slopes of the Copper Mountains and Owl Creek Mountains on the north, the Beaver Rim on the south, and the Rattlesnake Mountains on the east, furnish only minor amounts of runoff—all ephemeral. These mountains, together with the central nonirrigated parts of the basin, have desertlike characteristics with low precipitation, sparse vegetation, and highly erodible soils. Therefore, erosion is a serious problem and runoff resulting from the high-intensity summer storms and from the occasional spring snowmelt can contribute large quantities of sediment to the Boysen Reservoir located on Wind River at the head of Wind River Canyon.

TOPOGRAPHY

The eight reservoirs in the Five Mile Creek basin are located on two tributaries known as Paintpot Draw and Teapot Draw. Both are elongated basins cut in the foothills of the Owl Creek Mountains. Elevations in Paintpot Draw range from 6,250 feet at the lowest reservoir to 6,700 at the western divide. The central part of the basin, underlain by shale, has been eroded into a series of low ridges separated by wide gently sloping valleys. The terrain gradually becomes steeper and more rugged in the higher parts of the basin; at the divide, which is underlain by massive sandstone, the slopes are precipitous. All the measuring reservoirs are located within the gently sloping central part of the basin, but the drainage basin of each reservoir extends to the steeper marginal area. The general location of reservoirs in Paintpot Draw is shown in figure 40. Reservoirs 2 and 3 shown in figure 40 have been combined and are now designated as No. 3.

Teapot Draw, located just south of Paintpot Draw, has about the same elevation, but the topography is more subdued and has a maximum relief of about 500 feet. The lower central part of the basin, where the study reservoirs are located, has a wide gently sloping floor, but the terrain is steep near the northern and western divides.

Reservoirs in the southeastern part of the Wind River basin are located on tributaries of Muskrat Creek. The headwaters of Muskrat Creek drain the steep slopes of the Beaver Rim. The remainder of the basin is characterized by rolling moderately dissected terrain containing small areas of badlands. Slopes along the Beaver Rim commonly have gradients of 40–50 percent; but at lower elevations and within a few miles of the reservoirs, they seldom exceed 100–200 feet per mile except for the short steep slopes in the badlands. The drainage areas above Rongis and Signor Reservoirs extend to the crest of Beaver Rim and the elevations range from 5,700 feet at the reservoirs to 7,100 feet at the divide. The third reservoir in this area is located on Mahoney Draw, which heads in the foothills of Beaver Rim. The elevation in the drainage basin ranges from 5,800 to 6,275 feet.

The three remaining reservoirs on the east side are located on Graham Draw, a minor tributary of Poison Creek. Graham Draw has a moderate relief with low valley slopes and a steep but narrow peripheral rim. The elevation ranges from 5,450 to 5,700 feet.

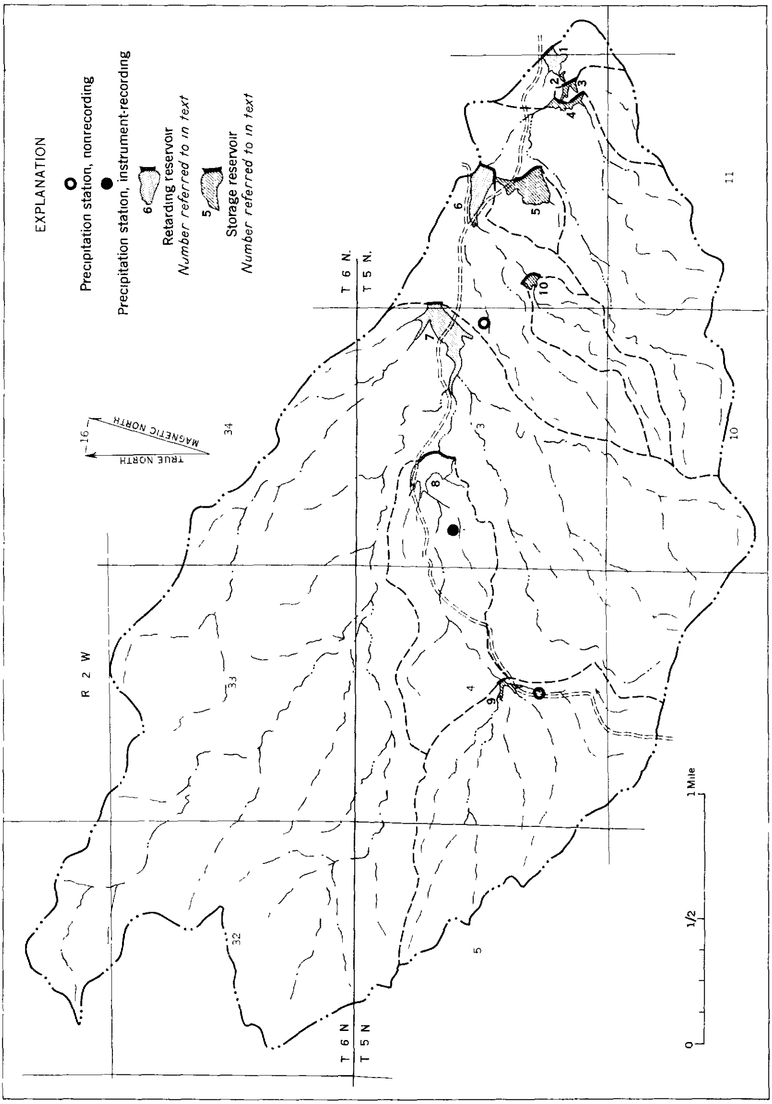

FIGURE 40.—Index map of Paintpot Draw, Wyo., showing location of study reservoirs. Adapted from King (1959, pl. 1).

GEOLOGY

Each of the Wind River reservoir basins is underlain by the Wind River formation of Tertiary age, which consists of continental deposits of interbedded, poorly indurated lenticular sandstone and shale. The hard, more resistant sandstone forms the crest of the divides and caps the ridges and mesas within the interior of the basins. The valleys are cut in the shale. Extensive deposits of alluvium occur on the valley floor above the reservoirs. Soils formed by weathering of the bedrock have no recognizable structure or profile and consist virtually of disintegrated bedrock. Reflecting the character of the underlying bedrock, the soils range from coarse and highly permeable materials on sandstone areas to fine-textured relatively impermeable mantles on areas underlain by shale. The latter are commonly found along the floors and lower side slopes of the valleys. The alluvium also reflects the character of the source rock, although owing to intermixing, differences are not so extreme and the soils are more uniform.

VEGETATION

Each of the study areas in the Wind River basin has a sparse cover of vegetation consisting of grass (mainly western wheat and blue grama) intermixed with scattered sagebrush. Grass generally predominates on the slopes, sagebrush on the valley floor. The density of the cover ranges from less than 1 percent to 20 percent and probably averages less than 10 percent. Because of the sparseness, the cover of vegetation probably has no appreciable influence on runoff or the rate and extent of erosion, except along the valley floors where the density is highest.

EROSION

There is a notable contrast in erosional conditions between study areas located in the eastern part of the basin and those in the western part. Study areas in the southeastern part of the basin along Mahoney and Logan Draws are characterized by rolling, slightly dissected terrain and stabilized channels with low, gently sloping banks. There is no evidence of excessive gullying or heavy sheet erosion in either of the study areas. In contrast, the study areas located along Paintpot and Teapot Draws in the northwestern part of the basin are severely eroded, as indicated by gullied channels, active rilling and sheet erosion along the valley side slopes, and badlands covering a large part of each basin. Erosion in the two study areas in Graham Draw, located in the central part of the valley, is intermediate, as indicated by a little erosion in the central parts of the basin, a few badland areas along some of the steeper divides, and discontinous gullied channels.

PRECIPITATION

Records from stations located at various places in the basin indicate that the precipitation generally shows a decrease from the Wind River Range toward the northeast. At Fort Washakie, near the base of the mountains, the mean annual precipitation is 11.76 inches; at Riverton, 30 miles east, the mean is 8.90 inches; and at Shoshoni, 25 miles northeast of Riverton, it is 7.71 inches. The Owl Ceeek and Rattlesnake Mountains on the north and Beaver Rim on the south side of the basin cause local increases in precipitation; but over the interior of the basin, the mean annual precipitation is probably between 7 and 8 inches. More than 70 percent of the annual precipitation falls in the 6-month period April through September, and cloudbursts are common during July and August.

The following precipitation data, obtained at U.S. Weather Bureau stations at Pavillion and Riverton, Wyo., are believed to be representative of conditions over the entire basin.

Mean precipitation, 1921–59

	Inches
Annual	8. 82
April through September	6. 38
October through March	2. 44
Maximum month (May)	1. 72

Frequency of 1-day precipitation of selected magnitude from April through September

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Pavillion, 1921–59:				
Percent of years in which at least one event occurred	97. 4	46. 2	12. 8	7. 7
Average number of events per year	3. 80	. 80	. 18	. 10
Riverton, 1921–25:				
Percent of years in which at least one event occurred	100	56. 4	15. 4	10. 2
Average number of events per year	3. 49	. 92	. 23	. 13

RUNOFF

Most of the runoff originating within the interior of the basin results from occasional torrential summer storms, although in some years small amounts of runoff are produced by snowmelt and spring rains, generally in April and May. The summer storms cause most of the erosion and produce the major part of the sediment. The storm runoff and sediment yield are given in the following tables. The mean annual runoff and sediment yield are given in table 2.

Storm runoff and annual sediment yield measured in Mahoney storage reservoir, Wyoming

Location.—Lat 42°55′, long 107°44′, in W½ sec. 15, T. 34 N., R. 91 W., on Mahoney Draw, about 16 miles south of Moneta, Fremont County, Wyo.
Drainage area.—9.82 sq mi (6,290 acres).
Records available.—1952–57, summer months only.
Gage.—Reference mark. Slope measurements made weekly or after storms. Elevation of reference mark is 5,800 ft (from topographic map.)

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
June 1951 to October 1955	1.0
October 1955 to October 1958	.0

Capacity.—At spillway (gage height, 100.0 ft): 138 acre-ft, June 1951; 137 acre-ft, October 1958.
Maximums.—Inflow volume, 19.5 acre-ft or 1.99 acre-ft per sq mi, July 22, 1955.
Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1952						
April	82.10	85.25	1.5	0	[1] 1.5	0.1
1953						
April	81.80	84.90	1.3	0	[1] 1.3	0.1
1954						
April	81.95	86.00	2.4	0	[1] 2.4	0.2
1955						
June 12	84.50	86.20	2.2	0	2.2	
July 22	85.60	90.73	19.5	0	19.5	
Aug. 6	89.64	90.30	3.8	0	3.8	
Total			25.5	0	25.5	2.6
1956 [2]						
1957						
May 11	82.00	91.00	24.0	0	24.0	
May 31	89.80	90.50	4.3	0	4.3	
June 15	89.90	90.70	5.4	0	5.4	
Total			33.7	0	33.7	2.4

[1] Runoff from spring snowmelt.
[2] No flow.

Storm runoff and sediment yield measured in Signor storage reservoir, Wyoming

Location.—Lat 42°52′, long 107°54′, in NW¼ sec. 6, T. 33 N., R. 92 W., on Signor Draw, about 22 miles southwest of Moneta, Fremont County Wyo.
Drainage area.—7.15 sq mi (4,580 acres).
Records available.—1952–60, summer months only.
Gage.—Reference mark. Slope measurements made weekly or after storms.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
May 1951 to October 1955	0.1
October 1955 to October 1958	1.7
October 1958 to October 1960	.1

Capacity.—At spillway (gage height, 98.8 ft): 9.8 acre-ft, May 1951; 7.9 acre-ft, October 1960.
Maximums.—Inflow volume, 7.15 acre-ft or 1.0 acre-ft per sq mi, Sept. 25, 1955.
Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1952 [1]						
1953						
April		98.60	9.3	0	9.3	1.3
1954						
April		96.30	4.3	0	4.3	
May 30	94.97	95.17	.3	0	.3	
June 26	93.98	94.30	.3	0	.3	
Total			4.9	0	4.9	0.7
1955						
June 12	96.62	96.81	.3	0	.3	
July 22	95.30	95.92	.9	0	.9	
Aug. 6	95.37	95.51	.2	0	.2	
Sept. 25	93.74	98.13	7.1	0	7.1	
Total			8.6	0	8.6	1.2
1956						
May 13	93.76	94.24	.5	0	.5	
May 28	93.66	94.80	1.2	0	1.2	
Total			1.7	0	1.7	0.2
1957						
April 23		99.28	9.6	1.3	10.9	
May 11	98.60	99.36	.5	1.5	2.0	
June 15	98.63	98.95	.4	.4	.8	
July 19	98.55	98.78	.6	0	.6	
Total			11.1	3.2	14.3	2.0
1958						
May 14	96.81	98.28	3.2	0	3.2	
July 18	96.20	97.12	1.7	0	1.7	
Aug. 18	96.24	96.47	.4	0	.4	
Total			5.3	0	5.3	0.7
1959						
April 19	96.19	98.58	5.1	0	5.1	
May 3	98.11	98.85	1.9	0	1.9	
May 25	98.06	98.66	1.5	0	1.5	
Total			8.5	0	8.5	1.2
1960						
Mar. 20	94.65	98.70	7.4	0	7.4	1.0

[1] No flow.

Storm runoff and sediment yield measured in Rongis retarding reservoir, Wyoming

Location.—Lat 42°51′, long 107°58′, in S½ sec. 3, T. 33 N., R. 93 W., on Logan Draw, about 24 miles southwest of Moneta, Fremont County, Wyo.
Drainage area.—37.0 sq mi (23,600 acres).
Records available.—1954–60, summer months only.
Gage.—Reference mark. Slope measurements made weekly or after storms.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
September 1952 to October 1955	12. 0
October 1955 to October 1958	28. 0
October 1958 to October 1960	9. 0

Capacity.—At spillway (gage height, 84.8 ft): 1,012 acre-ft, September 1952; 963 acre-ft, October 1960.
Maximums.—Inflow volume, 125.0 acre-ft or 3.4 acre-ft per sq mi, May 28, 1956.
Remarks.—Records good. Reservoir equipped with two gated 24-inch outlet pipes (gage height of sills, 63.3 ft).

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
April	61. 05	65. 84	32. 0	0	[1] 32. 0	
May 1–4	65. 11	67. 40	26. 1	0	[1] 26. 1	
May 10	67. 10	68. 22	15. 7	0	[1] 15. 7	
June 26	65. 90	66. 35	5. 0	0	5. 0	
July 19	63. 35	63. 84	3. 3	0	3. 3	
Aug. 3	63. 05	63. 29	1. 5	0	1. 5	
Total			83. 6	0	83. 6	2. 3
1955						
July 22	64. 66	66. 62	18. 8	0	18. 8	
Sept. 24	63. 35	67. 10	32. 9	0	32. 9	
Total			51. 7	0	51. 7	1. 4
1956						
Apr. 8	65. 41	66. 28	8. 6	0	8. 6	
May 13	64. 20	65. 30	8. 5	0	8. 5	
May 28	63. 15	71. 72	125. 0	0	125. 0	
Oct. 24	63. 00	63. 48	2. 1	0	2. 1	
Total			144. 2	0	144. 2	3. 9
1957 [2]						
1958						
Apr. 3	67. 00	67. 20	2. 0	0	2. 0	
July 4	66. 20	67. 20	9. 7	0	9. 7	
April–October				[1] 77. 8		
Total			11. 7	0	11. 7	0. 3
1959						
May 22–Oct. 30 [3]	66. 70	67. 20	5. 6	92. 1	97. 7	
Total			5. 6	92. 1	97. 7	2. 6
1960						
Mar. 16–Oct. 17 [3]			27. 0	90. 4	117. 4	3. 2

[1] Outflow through canal mainly from storage of previous years.
[2] No flow.
[3] Calculated from changes in reservoir elevation and canal outflow; dates of inflow usually not known.

Storm runoff and sediment yield measured in reservoir 9 in Paintpot Draw, Wyo.

Location.—Lat 43°26′, long 109°00′, in SE¼ sec. 4, T. 5 N., R. 2 W., on Paintpot Draw near Maverick Spring oil field, Fremont County, Wyo.
Drainage area.—0.640 sq mi (409 acres).
Records available.—1953–60, summer months only.

Gage.—Reference mark and slope pins. Measurements made weekly or after storms. Elevation of reference mark is 6,570 ft (from topographic map).

Runoff and discharge determinations.—Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
October 1955 to August 1956	0.8
October 1955 to October 1958	.7

Capacity.—At spillway (gage height, 100.0 ft): 8.8 acre-ft, August 1952; 7.3 acre-ft, October 1958.

Maximums.—Inflow volume, 2.78 acre-ft or 4.34 acre-ft per sq mi, July 22, 1955.

Remarks.—Records fair.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1953 [1]						
1954						
May 10		85.67	0.1	0	0.1	
June 27		85.50	.1	0	.1	
July 17	84.32	91.08	.8	0	.8	
Total			1.0	0	1.0	1.6
1955						
July 22		96.00	2.8	0	2.8	
Sept. 19	93.15	95.16	1.2	0	1.2	
Total			4.0	0	4.0	6.2
1956						
May 28	91.28	93.61	.8	0	.8	
July 12	91.48	94.06	1.0	0	1.0	
July 29	93.10	93.64	.2	0	.2	
Total			2.0	0	2.0	3.1
1957						
May 15		93.25	.9	0	.9	
June 15	92.50	96.14	2.3	0	2.3	
Aug. 27	94.86	95.15	.2	0	.2	
Oct. 15	94.16	94.28	.1	0	.1	
Total			3.5	0	3.5	5.5
1958						
May 14	89.11	91.04	.3	0	.3	
June 25		91.90	.5	0	.5	
July 30		100.00	7.4	.6	8.0	
Aug. 21	99.72	100.00	1.2	0	1.2	
Total			9.4	.6	10.0	15.6
1959						
June 15	93.97	94.25	.2	0	.2	
June 30	93.83	93.96	.1	0	.1	
Total			.3	0	.3	.5
1960						
July 10		100.00	7.9	1.1	9.0	14.0

[1] No flow.

Storm runoff and sediment yield measured in reservoir 8 in Paintpot Draw, Wyo.

Location.—Lat 43°26′, long 108°59′, in NW¼ sec. 3, T. 5 N., R. 2 W., on Paintpot Draw near Maverick Spring oil field, Fremont County, Wyo.

Drainage area.—0.364 sq mi (233 acres).

Records available.—1953–60, summer months only.

Gage.—Reference mark and slope pins. Measurements made weekly or after storms. Elevation of reference mark is 6,430 ft (from topographic map).

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
August 1952 to October 1955	0.7
October 1955 to October 1958	1.7

Capacity.—At spillway (gage height, 100.00 ft): 46.5 acre-ft, August 1952; 44.1 acre-ft, October 1958.

Maximum.—Inflow volume, 15.9 acre-ft or 43.7 acre-ft per sq mi, July 10, 1960.

Remarks.—Records good. Spills into reservoir 7. Reservoir equipped with an ungated 9-inch outlet pipe (gage height of sill, 92.6 ft).

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1953						
Date unknown [1]			3.7	0	3.7	10.2
1954						
May 10	89.47	89.72	.2	0	.2	
May 17	89.62	89.75	.1	0	.1	
June 27	89.03	89.28	.2	0	.2	
July 17	88.67	89.07	.2	0	.2	
Total			.7	0	.7	1.9
1955						
May 25		89.61	1.5	0	1.5	
July 22		92.17	4.9	0	4.9	
Sept. 19	90.49	92.75	3.7	0	3.7	
Total			10.1	0	10.1	27.8
1956						
May 28	91.88	93.60	2.2	.9	3.1	
July 12	91.92	92.54	1.2	0	1.2	
July 28	92.23	92.80	1.2	0	1.2	
Total			4.6	.9	5.7	15.7
1957						
Apr. 6	89.28	91.09	1.9	0	1.9	
May 1	89.91	90.80	1.0	0	1.0	
May 15	89.72	93.30	5.7	.2	5.9	
June 15	92.50	93.30	.2	1.7	1.9	
July 20	91.70	92.38	1.3	0	1.3	
Aug. 22	91.20	92.35	2.0	0	2.0	
Sept. 19	91.22	91.50	.5	0	.5	
Oct. 15	90.55	92.50	3.1	0	3.1	
Total			15.7	1.9	17.6	48.4

See footnote at the end of table.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1958						
May 14	91.35	92.88	2.8	0	2.8	
June 25	92.03	92.85	1.7	0	1.7	
July 30	92.02	93.30	0	2.8	2.8	
Aug. 21	92.68	93.02	.9	0	.9	
Total			5.4	2.8	8.2	22.6
1959						
Apr. 9	90.71	92.08	1.9	0	1.9	
May 3	91.50	92.02	.8	0	.8	
July 25	90.78	91.28	.6	0	.6	
Sept. 17	90.72	90.82	.1	0	.1	
Total			3.4	0	3.4	9.3
1960						
Apr. 24	89.00	89.62	.3	0	.3	
June 9		90.10	.7	0	.7	
July 10	89.67	95.76	15.9	0	15.9	
Total			16.9	0	16.9	46.5

[1] One storm only during season.

Storm runoff and sediment yield measured in reservoir 7 in Paintpot Draw, Wyo

Location.—Lat 43°26′, long 108°58′, in sec. 3, T. 5 N., R. 2 W., near Maverick Spring oil field, Fremont County, Wyo.

Drainage area.—3.57 sq mi (2,285 acres).

Records available.—1952–56, summer months only. (Runoff measurements discontinued.)

Gage.—Reference mark and slope pins. Measurements made weekly or after storms. Elevation of reference mark is 6,380 ft (from topographic map).

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
July 1952 to October 1955	5.0
October 1955 to October 1960	16.8

Capacity.—At spillway (gage height, 100.0 ft): 116.5 acre-ft, July 1952; 94.7 acre-ft, October 1960.

Remarks.—Records fair. Receives outflow from reservoir 8.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1952 [1]						
1953						
Date unknown			[2] 3.0	0	3.0	0.8
1954						
May 10	83.21	83.79	.6	0	.6	
May 22	83.58	83.68	.1	0	.1	
May 3	83.54	83.61	.1	0	.1	
June 27	83.22	83.77	.6	0	.6	
July 17	83.32	86.00	3.8	.7	4.5	
Total			5.2	.7	5.9	1.7
1955						
May 25	82.38	83.75	1.4	0	1.4	
July 22	82.55	86.11	5.5	11.2	16.7	
Sept. 19		87.45	5.2	2.3	7.5	
Total			12.1	13.5	25.6	7.2
1956						
Apr. 27	84.70	85.20	.4	0	.4	
May 28	85.00	85.60	.7	0	.7	
July 12		87.65	5.9	0	5.9	
July 28	87.05	88.05	3.1	0	3.1	
Total			10.1	0	10.1	2.8

[1] No flow.
[2] Spring snowmelt, no summer flow.

Storm runoff and sediment yield measured in reservoir 10 in Paintpot Draw, Wyo.

Location.—Lat 43°26′, long 108°58′, in SW¼ sec. 2, T. 5 N., R. 2 W., on Paintpot Draw near Maverick Spring oil field, Fremont County, Wyo.

Drainage area.—0.126 sq mi (80.9 acres).

Records available.—1954–60, summer months only.

Gage.—Reference mark and slope pins. Measurements made weekly or after storms. Elevation of reference mark is 6,370 ft (from topographic map).

Runoff and discharge determinations.—Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
September 1954 to October 1955	0.2
October 1955 to October 1958	.6
October 1958 to October 1960	.5

Capacity.—At spillway (gage height, 100.0 ft): 8.7 acre-ft, September 1954; 7.4 acre-ft, October 1960.

Maximums.—Inflow volume, 5.1 acre-ft or 40.5 acre-ft per sq mi, May 15, 1957.

Remarks.—Records good.

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Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
June 27		94.06	0.1	0	0.1	
July 17	93.74	94.43	.2	0	.2	
Total			.3	0	.3	2.4
1955						
May 25		94.59	.3	0	.3	
July 22	94.30	95.89	1.1	0	1.1	
Sept. 19		95.22	.7	0	.7	
Total			2.1	0	2.1	16.7
1956						
Mar. 28	95.53	95.67	.1	0	.1	
May 28	94.74	96.10	1.1	0	1.1	
July 12	95.20	96.07	.7	0	.7	
July 28	95.67	96.93	.2	0	.2	
Total			2.1	0	2.1	16.7
1957						
Mar. 27	93.80	95.04	.6	0	.6	
May 15	94.56	98.57	5.1	0	5.1	
June 15	97.75	99.02	2.6	0	2.6	
Aug. 27	97.67	97.73	.1	0	.1	
Sept. 19	97.47	97.62	.3	0	.3	
Oct. 15	97.39	97.57	.3	0	.3	
Total			9.0	0	9.0	71.7
1958						
May 14	96.60	97.60	1.5	0	1.5	
June 25	96.91	97.00	.4	0	.4	
July 30	96.67	97.69	1.5	0	1.5	
Aug. 21	97.41	97.83	.7	0	.7	
Total			4.1	0	4.1	32.5
1959						
Apr. 9	96.72	97.22	.6	0	.6	
May 3	96.54	97.00	.5	0	.5	
May 20	96.56	96.82	.3	0	.3	
June 30	95.88	96.30	.4	0	.4	
Total			1.8	0	1.8	14.3
1960						
June 9		95.33	.3	0	.3	
July 10	94.99	98.05	3.4	0	3.4	
Sept. 16	96.38	97.57	1.5	0	1.5	
Sept. 20	97.47	98.09	1.1	0	1.1	
Total			6.3	0	6.3	50.0

Storm runoff and sediment yield measured in reservoir 6 in Paintpot Draw, Wyo.

Location.—Lat 43°26′, long 108°58′, in sec. 2, T. 5 N., R. 2 W., near Maverick Spring oil field, Fremont County, Wyo.

Drainage area.—0.374 sq mi (239 acres).

Records available.—1954–57, summer months only. (Runoff measurements discontinued.)

Gage.—Reference mark and slope pins. Measurements made weekly or after storms. Elevation of reference mark is 6,330 ft (from topographic map).

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
October 1953 to October 1955	2.3
October 1953 to October 1960	3.6

Capacity.—At spillway (gage height, 100.0 ft): 42.4 acre-ft, September 1953; 36.5 acre-ft, October 1960.

Remarks.—Records fair. Receives spill from reservoir 7.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
May 10	91.35	91.77	0.7	0	0.7	
May 22	91.45	91.92	.8	0	.8	
May 30	91.72	91.86	.2	0	.2	
June 27	91.12	91.70	.9	0	.9	
July 17	91.07	93.80	5.5	.4	5.9	
Aug. 4	93.40	93.51	.2	0	.2	
Total			8.3	.4	8.7	23.2
1955						
May 25		94.20	8.6	0	8.6	
July 22	93.40	95.30	5.0	2.9	7.9	
Sept. 19	94.00	95.30	3.8	2.3	6.1	
Total			17.4	5.2	22.6	60.5
1956						
May 28	93.74	95.11	3.5	.3	3.8	
July 12	94.20	95.46	2.3	1.6	3.9	
July 28	94.50	95.09	1.5	.3	1.8	
Total			7.3	2.2	9.5	25.3
1957						
May 23	93.87	95.00	3.1	0	3.1	
May 25	95.00	96.00	0	3.7	3.7	
June 15	94.66	96.42	1.1	5.6	6.7	
July 15	94.41	95.08	1.8	.1	1.9	
Total			6.0	9.4	15.4	41.2

Storm runoff and sediment yield measured in reservoir 5 in Paintpot Draw, Wyo.

Location.—Lat 43°26′00″, long 108°57′30″, in S1/2 sec. 2, T. 5 N., R. 2 W., on Paintpot Draw near Maverick Spring oil field, Fremont County, Wyo.

Drainage area.—0.069 sq mi (44.1 acres).

Records available.—1954–60, summer months only.

Gage.—Reference mark and slope pins. Measurements made weekly or after storms. Elevation of reference mark is 6,310 ft (from topographic map).

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
September 1952 to October 1955	0
October 1955 to October 1958	0

Capacity.—At spillway (gage height, 100.0 ft): 36.2 acre-ft, September 1953; 36.2 acre-ft, October 1958.
Maximums.—Inflow volume, 6.7 acre-ft or 97.2 acre-ft per sq mi, May 15, 1957.
Remarks.—Records good. Receives spill from reservoir 6, but no spill occurred during period of record. Spills into reservoir 4.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
May 10	92.81	92.99	0.1	0	0.1	
May 22	92.75	93.02	.1	0	.1	
May 30	92.85	93.00	.1	0	.1	
June 27	92.75	92.93	.1	0	.1	
July 17	92.75	93.02	.2	0	.2	
Total			.6	0	.6	8.7
1955						
May 25		93.78	1.0	0	1.0	
July 22		94.16	1.6	0	1.6	
Sept. 19		93.80	1.2	0	1.2	
Total			3.8	0	3.8	55.0
1956						
Mar. 22–Apr. 14	94.00	94.21	.3	0	.3	
May 28	93.48	94.67	1.9	0	1.9	
July 12	93.85	94.33	.8	0	.8	
July 28	93.95	94.31	.6	0	.6	
Total			3.6	0	3.6	52.4
1957						
Mar. 27	92.20	93.77	1.0	0	1.0	
May 15	93.50	96.16	6.7	0	6.7	
June 15	95.85	96.38	2.3	0	2.3	
Aug. 27	95.38	95.54	.5	0	.5	
Sept. 19	95.16	95.52	1.1	0	1.1	
Oct. 15	95.12	95.53	1.3	0	1.3	
Total			12.9	0	12.9	187.0
1958						
May 14	94.95	95.97	3.3	0	3.3	
June 25	95.32	95.58	.9	0	.9	
July 30	95.22	95.78	1.8	0	1.8	
Aug. 21	95.58	95.73	.5	0	.5	
Total			6.5	0	6.5	94.0
1959						
May 3	94.50	94.89	.9	0	.9	
June 15	94.42	94.54	.3	0	.3	
June 30	94.37	94.65	.6	0	.6	
Sept. 17	93.17	93.44	.2	0	.2	
Total			2.0	0	2.0	29.0
1960						
Apr. 10		92.50	.1	0	.1	
Apr. 24		93.17	.2	0	.2	
June 9		94.19	1.4	0	1.4	
July 10	93.65	95.27	3.3	0	3.3	
Sept. 16	94.24	95.37	2.7	0	2.7	
Sept. 20	95.30	95.82	1.8	0	1.8	
Total			9.5	0	9.5	137.0

Storm runoff and sediment yield measured in reservoir 4 in Paintpot Draw, Wyo.

Location.—Lat 43°26′, long 108°57′, in sec. 2, T. 5 N., R. 2 W., near Maverick Spring oil field, Fremont County, Wyo.

Drainage area.—0.631 sq mi (404 acres).

Records available.—1952–57, summer months only. (Runoff measurements discontinued.)

Gage.—Reference mark and slope pins. Measurements made weekly or after storms. Elevation of reference mark is 6,265 ft (from topographic map).

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
August 1951 to October 1955	2.8
October 1955 to October 1957	.8

Capacity.—At spillway (gage height, 108.9 ft): 5.2 acre-ft, August 1951; 1.6 acre-ft, October 1959.

Remarks.—Records fair. Receives spill from reservoir 6.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1952 [1]						
1953						
Date of storm unknown			0.8	0	0.8	1.3
1954						
May 27	106.63	106.90	.3	0	.3	
June 27	106.14	106.98	.3	0	.3	
July 17	106.48	108.37	2.6	0	2.6	
Total			3.2	0	3.2	5.1
1955						
May 25	105.94	107.95	2.1	0	2.1	
July 22	107.53	109.14	2.4	0	2.4	
Sept. 19	107.43	109.19	2.0	0	2.0	
Total			6.5	0	6.5	10.3
1956						
Apr. 28	107.92	108.87	1.0	0	1.0	
May 28	108.12	109.10	1.0	.3	1.3	
July 12	107.97	109.39	1.1	.8	1.9	
July 28	108.61	109.05	.4	.2	.6	
Total			3.5	1.3	4.8	7.6
1957						
May 15	107.83	108.90	1.3	0	1.3	
June 15	108.56	108.75	.3	0	.3	
July 6	108.49	108.95	.6	0	.6	
Total			2.2	0	2.2	3.5

[1] No flow.

Storm runoff and sediment yield measured in reservoir 3 in Paintpot Draw, Wyo.

Location.—Lat 43°26′, long 108°57′, in sec. 2, T. 5 N., R. 2 W., near Maverick Spring oil field, Fremont County, Wyo.
Drainage area.—0.065 sq mi (41.3 acres).
Records available.—1952–57, summer months only. (Runoff measurements discontinued.)
Gage.—Reference mark and slope pins. Measurements made once weekly or after storms. Elevation of reference mark is 6,260 ft (from topographic map).
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Sediment yield.—Computed from deposition in reservoir as shown by successive surveys. Total sediment yield for period August 1951 to October 1955, 0.1 acre-ft.
Capacity.—At spillway (gage height, 100.0 ft): 0.6 acre-ft, August 1951; 0.5 acre-ft, October 1955.
Remarks.—Records poor. Receives spill from reservoir 4.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1952–53 [1]						
1954						
June 27		98.71	0.2	0	0.2	
July 17	98.20	99.20	.3	0	.3	
Total			.5	0	.5	7.3
1955						
May 25		99.45	.4	0	.4	
July 22	98.15	100.22	.6	0	.6	
Sept. 19	98.20	99.92	.5	0	.5	
Total			1.5	0	1.5	23.2
1956						
May 28	98.67	100.38	.4	.2	.6	
July 12	98.85	100.36	.3	.2	.5	
July 28	99.42	100.18	.2	.1	.3	
Total			.9	.5	1.4	21.7
1957						
May 15		100.62	.8	0	.8	
June 15	99.50	100.27	.3	0	.3	
July 11	99.39	100.40	.4	0	.4	
Total			1.5	0	1.5	23.2

[1] No flow.

Storm runoff and sediment yield measured in reservoir 1 in Paintpot Draw, Wyo.

Location.—Lat 43°26′, long 108°57′, in sec. 2, T. 5 N., R. 2 W., near Maverick Spring oil field, Fremont County, Wyo.
Drainage area.—0.067 sq mi (43.2 acres).
Records available.—1954–57, summer months only. (Runoff measurements discontinued.)
Gage.—Reference mark and staff gage. Measurements made once weekly or after storms. Elevation of reference mark is 6,250 ft (from topographic map).
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
September 1954 to October 1955	0
October 1955 to October 1958	.5

Capacity.—At spillway (gage height, 100.0 ft): 26.7 acre-ft, September 1954; 26.2 acre-ft, October 1958.
Remarks.—Records fair. Receives spill from reservoir 3.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954 [1]						
1955						
Date unknown		95.30	2.6	4.4	7.0	104.0
1956						
May 28	94.38	95.88	1.8	1.5	3.3	
July 12	94.52	95.85	1.6	1.4	3.0	
July 28	95.17	95.60	.4	.7	1.1	
Total			3.8	3.6	7.4	110
1957						
May 15	92.84	96.27	3.7	2.7	6.4	
June 15	94.85	94.87	1.0	4.9	5.9	
Total			4.7	7.6	12.3	183.0

[1] No flow.

Storm runoff and sediment yield measured in East Fork reservoir, Wyoming

Location.—Lat 43°11′07″, long 107°42′15″, in SE¼ sec. 12, T. 37 N., R. 91 W., on East Fork Graham Draw near Moneta, Fremont County, Wyo.
Drainage area.—0.81 sq mi (518 acres).
Records available.—1949–60, summer months only.
Gage.—Staff gage. High-water marks observed; measurements made weekly or after storms. Elevation of gage is 5,550 ft (from topographic map).
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
June 1949 to October 1955	1.5
October 1955 to October 1957	.2

Capacity.—At spillway (gage height, 28.9 ft): 12.3 acre-ft, June 1949; 10.6 acre-ft, October 1957.
Maximums.—Inflow volume, 7.55 acre-ft or 9.32 acre-ft per sq mi, June 4–9, 1949.
Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1949						
June 4–9		26.60	7.5	0	7.5	
July 9	23.65	26.43	3.9	0	3.9	
Aug. 9	23.18	25.80	3.3	0	3.3	
Oct. 8	19.70	23.10	2.3	0	2.3	
Total			17.0	0	17.0	21.0
1950						
Sept. 20–21	18.38	21.96	1.1	0	1.1	
Oct. 1	21.00	21.96	.6	0	.6	
Total			1.7	0	1.7	2.1
1951–53 [1]						
1954						
June 26		19.40	.1	0	.1	.1
1955						
June 17		19.81	.2	0	.2	
July 22	18.72	24.76	4.1	0	4.1	
Aug. 13	22.47	22.84	.3	0	.3	
Sept. 25	20.60	21.30	.4	0	.4	
Total			5.0	0	5.0	6.2
1956 [1]						
1957						
Apr. 1	19.20	20.86	.5	0	.5	
May 9	19.20	20.92	.5	0	.5	
May 11	20.80	21.78	.7	0	.7	
May 24	20.83	22.00	.7	0	.7	
June 5	21.30	21.90	.4	0	.4	
June 16	21.30	24.92	3.4	0	3.4	
June 21	24.41	24.66	.3	0	.3	
Total			6.5	0	6.5	8.0
1958						
June 24		21.32	.7	0	.7	.9
1959 [1]						
1960						
June 6		21.50	.8	0	.8	
June 9	21.34	22.32	.7	0	.7	
Total			1.5	0	1.5	1.8

[1] No flow.

Storm runoff and sediment yield measured in West Fork reservoir, Wyoming

Location.—Lat 43°10′50″, long 107°43′30″, in NW¼ sec. 14, T. 37 N., R. 91 W., on West Fork Graham Draw near Moneta, Fremont County, Wyo.

Drainage area.—0.38 sq mi (243 acres).

Records available.—1947–60, summer months only.

Gage.—Staff gage. High-water marks observed; measurements made weekly or after storms. Elevation of gage is 5,515 ft (from topographic map).

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
May 1947 to July 1948	0.2
July 1948 to November 1949	.2
November 1949 to May 1952	.3
May 1952 to October 1955	0
October 1955 to October 1956	.03
October 1956 to October 1957	.1

Capacity.—At spillway (gage height, 13.1 ft): 3.4 acre-ft, May 1947; 2.5 acre-ft, October 1960.

Maximums.—Inflow volume, 3.1 acre-ft or 8.16 acre-ft per sq mi, July 13–14, 1948.

Remarks.—Records good, except that those for spill are poor.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1947 [1]						
May 27			0.7	0	0.7	
June 22			.4	0	.4	
July 22			.3	0	.3	
Aug. 10			.3	0	.3	
Total			1.7	0	1.7	4.5
1948						
June 20–23		10.75	1.3	0	1.3	
July 13–14	9.00	13.10	3.1	0	3.1	
Sept. 19	8.20	9.40	.3	0	.3	
Total			4.7	0	4.7	12.3
1949						
June 4–9		11.00	1.5	0	1.5	
Aug. 9	6.60	9.90	.8	0	.8	
Oct. 8	6.90	8.75	.3	0	.3	
Total			2.6	0	2.6	6.8
1950						
Sept. 20–21		8.30	.2	0	.2	.5
1951–53 [2]						
1954						
June 26		7.20	.1	0	.1	.3
1955						
June 17		8.67	.3	0	.3	
July 22		11.94	1.9	0	1.9	
Aug. 13	9.09	9.25	.1	0	.1	
Total			2.3	0	2.3	6.1
1956						
June 15		8.97	.4	0	.4	1.0
1957						
June 29	6.30	7.43	.1	0	.1	.3
1958–59 [2]						
1960		10.68	1.0	0	1.0	2.9

[1] No gage height record; inflow estimated.
[2] No flow.

Storm runoff and sediment yield measured in Graham Reservoir, Wyo.

Location.—Lat 43°10'20'', long 107°43'20'', in SE¼ sec. 14, T. 37 N., R. 91 W., on Graham Draw near Moneta, Fremont County.

Drainage area.—2.74 sq mi (1,760 acres), excluding area upstream from West Fork reservoir; 1.93 sq mi (1,240 acres) after construction of East Fork reservoir in May 1949.

Records available.—1947–60, summer months only.

Gage.—Staff gage. High-water marks observed; measurements made weekly or after storms. Elevation of gage is 5,460 ft (from topographic map).

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
May 1947 to July 1948	2.9
July 1948 to November 1949	3.1
November 1949 to September 1950 [1]	+1.3
September 1950 to May 1951	.5
May 1951 to April 1954 [1]	+1.7
April 1954 to October 1955	0
October 1955 to October 1957	.6
October 1957 to October 1960	.7

[1] Increase in capacity of reservoir due to drying and compaction of sediment.

Capacity.—At spillway (gage height, 26.5 ft): 19.8 acre-ft, May 1947; 15.0 acre-ft, October 1960.

Maximums.—Inflow volume, before construction of East Fork reservoir, 20.4 acre-ft or 7.44 acre-ft per sq mi, July 13–14, 1948; after construction of East Fork reservoir, 14.7 acre-ft or 7.62 acre-ft per sq mi, June 4–9, 1949.

Remarks.—Records good, except that those for spill are poor.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1947						
May 27	23.34	23.60	0.9	0	0.9	
June 22	22.88	24.40	5.4	0	5.4	
July 22	23.65	27.70	4.2	0	4.2	
Aug. 10	24.20	24.85	3.0	0	3.0	
Sept. 9–10	23.80	24.24	1.4	0	1.4	
Total			14.9	0	14.9	5.5
1948						
June 20–23	21.92	26.50	17.0	.8	17.8	
July 13–14	25.80	26.50	2.6	17.8	20.4	
Aug. 2	25.95	26.34	1.7	0	1.7	
Sept. 19	24.62	26.50	8.1	1.7	9.8	
Total			29.4	20.3	49.7	18.0

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1949						
Apr. 13	24.10	24.48	1.5	0	1.5	
May 22	23.38	23.60	.6	0	.6	
June 4–9	23.25	26.50	13.9	.8	14.7	
July 9	25.65	26.08	2.2	0	2.2	
Aug. 9	24.95	26.04	5.1	0	5.1	
Sept. 2	25.18	25.30	.6	0	.6	
Sept. 4	25.20	25.46	1.1	0	1.1	
Oct. 8	24.13	24.90	2.9	0	2.9	
Total			27.9	.8	28.7	10.5
1950						
May 19	23.42	23.96	1.6	0	1.6	
June 14	23.12	23.66	1.0	0	1.0	
Sept. 20–21		23.70	2.8	0	2.8	
Oct. 1	23.60	24.02	1.4	0	1.4	
Total			6.8	0	6.8	2.5
1951–53 [1]						
1954						
May 1–3		20.60	.2	0	.2	
June 16		20.55	.2	0	.2	
Total			.4	0	.4	.1
1955						
June 17	21.40	21.52	.1	0	.1	
July 22	21.23	25.09	9.7	0	9.7	
Total			9.8	0	9.8	3.6
1956 [1]						
1957						
May 9	21.70	23.80	3.9	0	3.9	
May 24	23.25	24.02	2.2	0	2.2	
June 5	23.62	23.94	1.0	0	1.0	
June 16	23.58	24.23	2.1	0	2.1	
Total			9.2	0	9.2	3.3
1958						
June 29		22.34	.7	0	.7	.3
1959 [1]						
1960						
July 23		22.07	.4	0	.4	.1

[1] No flow.

FIFTEEN MILE CREEK BASIN, WYOMING

Fifteen Mile Creek basin is located west of Worland in the south-central part of the Bighorn River basin. The three main forks of the stream drain the south and east slopes of Tatman Mountain and the adjacent low hills east of Meeteetse. Drainage is eastward to the Bighorn River at Worland. The stream is ephemeral, and runoff occurs only during the summer in response to heavy rains or as a result of rapid snowmelt in winter or early spring.

As the basin area consists almost wholly of public land on which extensive conservation programs are either installed or planned, two reservoirs were selected to measure runoff and sediment yield. The contributing areas of the two reservoirs are believed to be representative of conditions over most of the basin. One of the reservoirs, Red Spires Reservoir, is located on Rockwater Hole Creek in the western part of the basin, the other, Big Gin Reservoir, is located on a small unnamed tributary in the eastern part.

To obtain the runoff and sediment contribution from the entire basin (drainage area, 523 square miles) a stream-gaging and sediment station, Fifteen Mile Creek near Worland, Wyo., has been operated since 1951. Data obtained at this station will be used in an effort to appraise the effect of the conservation program on runoff and sediment yield.

TOPOGRAPHY

A large part of the Fifteen Mile Creek basin is composed of badlands, which are interspersed with sandstone-capped ridges and mesas and remnants of gravel-capped slightly eroded terraces. The main stream valleys, which seldom exceed a few hundred feet in width, have steep side slopes that generally are eroded into badlands. The Rock Waterhole Creek basin is typical of the northwestern part of the Fifteen Mile Creek basin. It includes both mountains and valleys and ranges in elevation from 4,700 feet at the Red Spires Reservoir to 6,000 feet at the top of Tatman Mountain. About 80 percent of the area is badlands. The drainage area of Big Gin Reservoir has a more subdued topography and ranges in elevation from 4,280 feet at the reservoir to 4,400 feet at the divide. Badlands make up more than 30 percent of the area.

GEOLOGY

All the Fifteen Mile Creek basin is underlain by the Willwood and Tatman formations of Tertiary age, which consists of continental deposits of poorly indurated shale and mudstone and interbedded lenses of sandstone. The sandstone caps most of the slopes and mesa within the drainage basins of the two reservoirs, as there are only small areas of gravel-capped terraces. Most of the badlands have been eroded in the soft shale that crops out in the slopes underlying the sandstone and gravel capping. Soil in the two areas is thin and is composed almost completely of disintegrated but only slightly weathered bedrock. Deposits of fine-textured colluvium and alluvium occur at the base of the steeper slopes and on the valley floors adjacent to the stream channels.

VEGETATION

The vegetation in the drainage basins of both reservoirs is so poor and scattered that it probably has little or no influence on erosion and sediment yield. Most of the steeper slopes, both in the badlands and along the mountains, are barren, and in other parts of the two basins the cover is so sparse that the density averages less than 10 percent. In general, grasses (western wheat, grama, and Indian rice) mixed with scattered sagebrush grow on the more gentle slopes, but on the valley floors sagebrush predominates with minor quantities of grass.

EROSION

Badlands comprise a large percentage of the drainage area in both the Red Spires and the Big Gin Reservoirs. The barren badland slopes are subject to excessively high rates of erosion whenever runoff occurs. Most of the larger channels are controlled by bedrock, and gully erosion is of minor importance except for an area along the base of the Tatman Mountains where an alluvial terrace nearly a mile in width separates the mountain front from badlands located in the central part of Rock Waterhole Creek basin. Channels draining from the mountains and crossing the alluvial slope are deeply incised in their lower reaches and each has an active head cut.

PRECIPITATION

No precipitation stations are located within the Fifteen Mile Creek basin, but the records obtained at the station at Worland are believed to be representative of the lower eastern part of the basin. The western part of the basin near Tatman Mountain probably has a considerably higher precipitation, owing to proximity of the mountains. The average annual precipitation over the lower part of the Fifteen Mile Creek basin should be about the same as at Worland, or between 8 and 9 inches. Judging from the frequency and magnitude of runoff, it may be several inches higher in the western part. About 70 percent of the annual precipitation falls in the 6-month period April through September. The following precipitation data, taken from the U.S. Weather Bureau records for the station at Worland for the period 1923–55, indicate the distribution and frequency of storms.

Mean precipitation, 1931–58

	Inches
Annual	8.15
April through September	5.98
October through March	2.17
Maximum month (June)	1.47

Frequency of 1-day precipitation event of selected magnitude at Worland, April through September

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Percent of years in which at least one event occurred, 1923–59	89.2	46	13.5	5.4
Average number of events per year during—				
1923–59	2.46	.57	.16	.05
1954–59	1.17	0	0	0

RUNOFF

Most runoff occurs during intense summer storms, although occasionally appreciable amounts have been known to result from rapid spring snowmelt. The magnitude of the larger summer storms is indicated by a cloudburst that occurred over the central part of the basin on June 26, 1954. Measurements taken from cans show that more than 3 inches of rain fell in 30 minutes. The runoff and sediment yield from this storm, measured in an unnamed reservoir that subsequently failed, were respectively 57.7 and 3.18 acre-feet per square mile of drainage area. Storm runoff measured at the two reservoirs and the annual sediment yields are shown in the following tables.

Storm runoff and sediment yield measured in Red Spires Reservoir, Wyo.

Location.—Lat 44°14′, long 108°26′, in SE¼ sec. 7, T. 49 N., R. 96 W., on Rock Waterhole Creek, about 28 miles northwest of Worland, Washakie County, Wyo.

Drainage area.—5.24 sq mi (3,354 acres).

Records available.—1954–59, summer months only.

Gage.—Continuous water-stage recorder referred to permanent reference mark. Elevation of reference is 4,720 ft (from topographic map).

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
October 1954 to October 1955	2.0
October 1955 to October 1958	15.0

Capacity.—At spillway (gage height, 100.0): 193 acre-ft, October 1954; 176 acre-ft, October 1958.

Maximums.—Inflow volume, 54.6 acre-ft or 10.4 acre-ft per sq mi, June 16, 1957.

Remarks.—Records good. Reservoir equipped with an ungated 18-inch outlet pipe (gage height of sill, 81.3 ft).

Date of flow	Gage height (feet)			Spill (acre-ft)	Inflow	
	Before inflow	After inflow	Inflow stored (acre-ft)		Total (acre-ft)	Acre-ft per sq mi
1954 [1]						
May 2-5			2.0	10.7	12.7	
May 26			.1	.5	.6	
June 1-2			.1	.6	.7	
June 6-7			0	1.3	1.3	
June 26-27			0	5.5	5.5	
July 15			.1	35.2	35.3	
Aug. 5				5.5	5.5	
Sept. 5				2.2	2.2	
Sept. 12				.5	.5	
Total			2.3	62.0	64.3	12.3
1955 [1]						
June 1			0	4.7	4.7	
June 3			0	6.3	6.3	
June 13			0	5.1	5.1	
June 16			0	1.1	1.1	
June 24			0	20.6	20.6	
July 22			0	4.9	4.9	
July 28			0	21.7	21.7	
Sept. 24			0	1.5	1.5	
Total			0	65.9	65.9	12.6
1956						
July 12		81.34	0	2.9	2.9	
Sept. 12		81.35	0	6.7	6.7	
Total			0	9.6	9.6	.2
1957						
Apr. 22-23		82.80	0	34.0	34.0	
May 13-15		94.69	0	155.8	155.8	
May 20-21		89.81	0	49.2	49.2	
May 30		81.34		16.9	16.9	
June 10		81.34	0	35.9	35.9	
June 15-17		90.41	0	71.4	71.4	
June 20		81.34	0	16.5	16.5	
Aug. 31		81.34	0	9.6	9.6	
Total			0	389.3	389.3	74.4
1958						
Apr. 22-23		86.99	9.8	0	9.8	
May 7	86.68	87.44	3.1	0	3.1	
May 23	87.03	87.19	.7	0	.7	
June 2-3	86.99	88.32	1.3	16.1	17.4	
June 13-14	88.09	90.43	1.3	25.9	27.2	
June 19-20	88.32	89.10	0	6.8	6.8	
June 24-25	88.18	88.97	.7	9.2	9.9	
July 3-4	88.06	88.56	1.5	15.3	16.8	
July 7-9	88.23	89.22	.3	14.7	15.0	
July 26	87.83	88.32	1.3	19.8	21.1	
July 29-30	88.11	89.73	.6	33.0	33.6	
Aug. 12	87.87	88.32	1.2	10.5	11.7	
Total			21.8	151.3	173.1	33.1
1959						
Apr. 15-16	90.46	90.58	.9	0	.9	
Apr. 17-27	90.52	92.0	5.5	39.1	44.6	
May 2-4	91.18	91.70	.6	13.7	14.3	
June 22	90.43	90.52	.8	0	.8	
June 28-30	90.46	91.51	6.5	57.7	64.2	
July 15	91.04	91.23	1.5	34.9	36.4	
Sept. 16	90.07	90.39	2.2	0	2.2	
Sept. [2]	90 23	90.41	1.3	0	1.3	
Sept. [2]	90.36	91.23	7.2	10.1	17.3	
Total			26.5	155.5	182.0	34.8

[1] Reservoir contents in 1954 and 1955 computed from recorder graph; gage heights not used.
[2] No definite date determined, but inflow registered on recorder graph.

Storm runoff and sediment yield measured in Big Gin Reservoir, Wyo.

Location.—Lat 44°04′, long 108°05′, in NW¼ sec. 6, T. 47 N., R. 93 W., on unnamed tributary, about 7 miles northwest of Worland, Washakie County, Wyo.

Drainage area.—0.942 sq mi (603 acres).

Records available.—1954–59, summer months only.

Gage.—Continuous water-stage recorder referred to permanent reference mark. Elevation of reference mark is 4,260 ft (from topographic map).

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
October 1954 to October 1955	1.2
October 1955 to October 1958	2.0

Capacity.—At spillway (gage height, 100.0 ft): 99.4 acre-ft, October 1954; 96.2 acre-ft, October 1958.

Maximums.—Inflow volume, 6.49 acre-ft or 6.90 acre-ft per sq mi, June 13, 1958.

Remarks.—Records good. Reservoir is equipped with an ungated 8-inch outlet pipe (gage height of sill, 87.5 ft).

Date of flow	Gage height (feet)			Spill (acre-ft)	Inflow	
	Before inflow	After inflow	Inflow stored (acre-ft)		Total (acre-ft)	Acre-ft per sq mi
1954						
June 25–26	83.32	86.20	2.6	0	2.6	
July 21	85.39	85.94	.5	0	.5	
Aug. 25	84.83	85.68	.9	0	.9	
Total			4.0	0	4.0	4.2
1955						
May 22–23	85.89	87.42	2.5	0	2.5	
May 25	87.40	87.54	.4	4.9	5.3	
June 1	87.38	87.54	.3	3.4	3.7	
June 3–4	87.54	87.54	0	6.2	6.2	
June 27	87.09	87.44	.7	0	.7	
July 24	86.70	87.54	1.4	.6	2.0	
Aug. 8	87.08	87.54	.8	.5	1.3	
Aug. 14	87.38	87.54	.4	1.0	1.4	
Aug. 18	87.44	87.54	.2	2.5	2.7	
Sept. 19	86.88	87.23	.5	0	.5	
Sept. 24	87.13	87.54	.7	.9	1.6	
Sept. 25	87.54	87.54	0	.7	.7	
Total			7.9	20.7	28.6	30.4
1956						
Aug. 27	84.62	85.41	0.7	0	0.7	
Oct. 24	84.74	86.00	1.1	0	1.1	
Total			1.8	0	1.8	1.9
1957						
May 14–15	83.40	87.98	4.8	0	4.8	
May 30	87.56	88.31	1.5	0	1.5	
June 13	87.94	88.53	1.5	0	1.5	
June 15–16	88.45	88.54	1.8	1.1	2.9	
June 29	88.25	88.53	.8	0	.8	
Aug. 17	87.13	87.35	.3	0	.3	
Aug. 24	87.21	87.27	.1	0	.1	
Aug. 31–Sept. 1	87.13	87.84	1.2	0	1.2	
Sept. 12–13	87.54	87.54	.1	0	.1	
Sept. 19	87.49	87.55	.1	0	.1	
Oct. 19	87.10	87.50	.6	0	.6	
Oct. 27	87.41	87.82	.7	0	.7	
Total			13.5	1.1	14.6	15.5

Date of flow	Gage height (feet)			Spill (acre-ft)	Inflow	
	Before inflow	After inflow	Inflow stored (acre-ft)		Total (acre-ft)	Acre-ft per sq mi
1958						
June 12–13	85.32	88.53	10.8	.3	11.1	
July 23	87.72	88.11	.7	0	.7	
July 26	88.07	88.53	4.6	.3	4.9	
July 29	88.23	88.53	1.6	.1	1.7	
Aug. 15	88.09	88.44	.7	0	.7	
Sept. 9	87.87	88.02	.3	0	.3	
Total			18.7	.7	19.4	20.6
1959						
Apr. 17–19	88.60	89.43	2.1	0	2.1	
Apr. 20–22	89.41	89.51	.9	1.8	2.7	
May 3–4	89.27	89.51	4.6	.7	5.3	
June 14	88.43	88.86	1.0	0	1.0	
June 22	88.64	89.01	.9	0	.9	
June 25	88.93	89.51	3.3	.1	3.4	
June 30	89.33	89.51	11.8	.7	12.5	
Sept. 16	87.55	88.13	1.0	0	1.0	
Sept. 27	88.00	88.38	.8	0	.8	
Oct. 16	88.15	88.69	1.1	0	1.1	
Total			27.5	3.3	30.8	32.8

CHEYENNE RIVER BASIN

The part of the Cheyenne River basin considered in this report lies above the Angustora Reservoir. It has an area of approximately 9,000 square miles and includes parts of three States: east-central Wyoming, southwestern South Dakota, and northwestern Nebraska. Measurements of runoff and sediment yield made in stock-water reservoirs were carried out as part of a more detailed study to determine the influence of these structures on the operation of Angustora Reservoir. Of the several thousand stock reservoirs in the basin, 99 were selected for sedimentation studies in areas presenting differences in topography, geology, and erosion. The location of the reservoirs is shown in plate 19. The basic data for the sedimentation studies are given in this report, but the relation between sediment yield and drainage basin characteristics is treated in greater detail by Hadley and Schumm (1961). In addition to the measurement of sediment yield, measurement of spring and summer runoff from upland areas was made at 55 reservoirs during the 4-year period 1951–54. Runoff data for this period are given by Culler (1961).

TOPOGRAPHY

The upper part of the Cheyenne basin is included in the Missouri Plateau section of the Great Plains physiographic province. The elevation ranges from 3,150 feet at Angustora Dam to 9,250 feet at the summit of the Black Hills. A low ridge that averages 5,200 feet in elevation forms the western divide. The major part of the basin is composed of flat or gently rolling uplands, broken by steep-walled

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tributary stream valleys with flat floors cut by recently formed gullies. Within this area the relief seldom exceeds 150 feet. Steeper, more rugged topography occurs along the Pine Ridge escarpment, which bounds the basin on the south in Nebraska and Wyoming, where the relief is as much as 500 feet within a distance of 1–2 miles. Similar steep topography, whose relief is as much as 2,000 feet, occurs along the flank of the Black Hills on the north side of the basin.

GEOLOGY

The central part of the upper Cheyenne River basin is underlain with sedimentary rocks, consisting mainly of shale and lesser amount of sandstone and limestone, each of which exhibits wide differences in erosional characteristics. Because all the observation reservoirs are located within the central part of the basin, no consideration is given to the erosional characteristics of lands within the Black Hills underlain by igneous and metamorphic rock.

The sedimentary formations dip away from the Black Hills uplift. Older formations crop out along the flanks of the hills, and successive younger ones appear at greater distances, thus forming a series of approximately parallel belts, each underlain by a different formation. A belt from 10 to 15 miles wide extending southwestward from the mountain front is underlain by a group of formations of Cretaceous age, including the Granerous, Carlile, Niobrara, and Pierre shales. The formations are composed largely of dark-gray to black fissile shale that weathers to a heavy compact soil. Areas underlain by these formations have similar erosional characteristics.

In stratigraphic succession the Pierre shale is overlain by the Lance and Fort Union formations of Tertiary age, which together form a belt that underlies nearly 40 percent of the basin. The Lance formation, although composed largely of shale and clay and minor amounts of sandstone, has a gently rolling topography and pervious soils. Erosion generally is not serious in the belt underlain by the Lance formation.

The overlying Fort Union formation is divided into three members, each having distinctive erosional characteristics. The lower member, the Tullock, is similar to the Lance formation, except that it contains a greater proportion of sandstone. Erosion is not serious on areas underlain by this member. In contrast, the Lebo shale member is soft and easily eroded and has the highest sediment yield of any area underlain by the Fort Union formation. Characteristically, the shale weathers to a tight impervious soil that supports little vegetation. Erosion of these unprotected soils forms lowlands of slight relief that often develop into badlands. The Tongue River member has a relatively small areal distribution and is most prominent as the caprock on the Rochelle Hills. It weathers to a sandy soil that supports good vegetation and generally erosion is negligible.

The western part of the Cheyenne River basin, extending from the Rochelle Hills to the drainage divide, is underlain by the Wasatch formation of Tertiary age, which is composed of soft sandstone and shale. The rocks weather into a gently rolling plain that in most places supports a good cover of vegetation. Erosion is negligible and the sediment yield as indicated by measurements in reservoirs is the lowest in the upper Cheyenne River basin. Runoff is also among the lowest measured in the basin.

Because of its effect on erosional conditions, the White River group of Tertiary age merits special mention. This formation occupies a belt about 4 miles wide crossing the southern part of the basin directly in front of the Pine Ridge escarpment. The soft clays and siltstones making up the formation weather to a fertile but unstable soil that is highly vulnerable to erosion and particularly to the formation of badlands.

VEGETATION

Chiefly because of relat vely high precipitation, the vegetation in the Cheyenne River basin is classed as one of the best in any of the areas studied. Both density and forage production are high. Most of the basin supports a mixed growth of sagebrush and perennial and annual grasses. Steeper and higher parts of the basin including the sandstone-capped ridges, the interstream divides, and the infacing Pine Ridge slopes, are wooded with a relatively abundant growth of scrub yellow pine and juniper. Flood plains of the major channels support a dense growth of cottonwood trees with an understory of grass and sagebrush. In a few parts of the basin, the vegetation has been injured or destroyed by overgrazing. This is generally reflected by increased erosion and sediment yield from such areas.

EROSION

Erosion in the Cheyenne River basin ranges from very slight in the western part underlain by the Wasatch formation to almost complete denudation and the formation of large expanses of badlands in areas underlain by the White River formation in the southern part of the basin. Other parts of the basin exhibit intermediate degrees of erosion in which the underlying rock and, to some extent, the type of land use appear to be the controlling factors.

Sheet erosion of varying severity is prevalent throughout most of the basin and probably accounts for a large part of the sediment yield in most areas. It is most active in sparsely vegetated areas underlain by heavy soils derived from underlying shales, but even well grassed undissected tracts show a moderately high sediment yield from sheet erosion. Gullying is generally not serious in the basin, although locally many small tributary streams have active gullied channels. As none of the observation reservoirs were constructed on a gullied channel, there has been no opportunity to measure the direct effect of gullying on sediment yield; but it has been shown that wherever an active gully is located within a reservoir drainage area, a markedly higher rate of sediment yield can be expected.

The formation of badlands is the most destructive type of erosion found in the basin. The principal badlands are confined to the belt underlain by the White River formation, but other scattered areas of local importance are located on terrain underlain by the Pierre shale in the northeastern part of the basin. It is estimated that badlands comprise about 15 percent of the outcrops of the White River. The tracts of badlands are gradually expanding as cutting extends to the surrounding terrain, but this condition is in part offset by the gradual filling and healing that is taking place in the lower parts of some of the tracts. Measurements in reservoirs show that the sediment yield from badlands is the highest in the basin (Hadley and Schumm, 1961).

The following summary of sediment measurements made in the upper Cheyenne River basin shows the influence of the underlying bedrock on sediment yield:

Summary showing rates of sediment yield measured in reservoirs located on different geologic formations in Cheyenne River basin

Geologic formation	Number of reservoirs measured	Mean annual sediment yield (acre-ft per sq mi)
Wasatch formation	4	0.13
Lance formation	9	.5
Fort Union formation:		
Tullock member	50	1.1
Lebo shale member	23	1.4
Pierre shale and associated Cretaceous shale	9	1.4
White River group	4	1.8
Total or average	99	1.02

PRECIPITATION

The long-term average annual precipitation over the Cheyenne River basin is about 14 inches. It is somewhat higher around the margins, particularly along the flanks of the Black Hills on the north and on the Pine Ridge in the south, but it is lower in the central and western parts. About 75 percent of the total precipitation occurs between April and October, mainly in the spring and early fall. The midsummer period is generally dry, although localized storms of high intensity frequently produce flash floods on minor tributaries.

Precipitation records collected by the U.S. Weather Bureau at three stations, two located within the basin at Dull Center and New Castle and one just outside the basin at Kirtley, are believed to be fairly representative of conditions within the basin. The following data are taken from records obtained at these stations.

Mean precipitation, 1926–58

	Inches
Annual	[1] 14.62
April–October	[1] 12.07
November–October	[1] 2.53
Maximum months:	
May [2]	2.69
June [3]	2.69

[1] Average at three stations.
[2] Dull Center.
[3] Kirtley and New Castle.

Frequency of 1-day precipitation events of selected magnitude from April to October

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0
Dull Center, 1926–55:				
Percent of years in which at least one event occurred	100	83.5	50	30
Average number of events per year	7.1	1.7	.7	.4
New Castle, 1921–55:				
Percent of years in which at least one event occurs	100	88.5	51.5	20
Average number of events per year	7.9	2.5	1	.3
Kirtley, 1926–55:				
Percent of years in which at least one event occurs	100	80	28.5	11.4
Average number of events per year	7.4	1.7	.43	.09

RUNOFF

Although many storms in the basin produce runoff locally, only a few of the flows reach the Angustora Reservoir as indicated by the gaging station records for the Cheyenne River near Hot Springs, S. Dak. The reason for this appears to be the high rate of dissipation in the dry stream channels and storage in the several thousand stock reservoirs located throughout the basin. The effect of the reservoirs, together with other possible unidentified factors on runoff, is suggested by changes in flow of the river as measured at the gaging station near Hot Springs. During the 11-year period 1944–54, the mean annual runoff from the drainage area of 8,710 square miles was 95,790 acre-feet, equal to 11.00 acre-feet per square mile. The mean runoff from the same area during the period 1914–20 was equivalent to 57.1 acre-feet per square mile. A comparison between the few available records shows that, although the precipitation during the earlier period was somewhat greater than during the later period, the disparity hardly seems sufficient to account for the great contrast in runoff. The stock reservoirs may in part be responsible for the difference, as suggested by the fact that during the early period only a few reservoirs of small capacity had been constructed, whereas by 1950 the basin contained more than 9,000 reservoirs with an aggregate storage capacity of 60,000 acre-feet (Culler, 1961). These reservoirs probably intercept the flow of many of the storms, so that they do not contribute to the supply of the basin.

Records of runoff to 44 reservoirs, widely distributed throughout the basin, are given by Culler (1961, table 5).

The sediment yield in various parts of the basin, as measured in the 99 reservoirs, is given in table 2. In most of the reservoirs the sediment accumulation was obtained by spudding, as previously described, and the average annual sediment yield was computed by dividing the total sediment accumulation by the age of the reservoir, in years.

COLORADO RIVER BASIN

SALT CREEK BASIN

BADGER WASH BASIN, COLORADO

The study of Badger Wash, conducted cooperatively by the U.S. Geological Survey, the Rocky Mountain Forest and Range Experiment Station, the Bureau of Land Management, and the Bureau of Reclamation, is designed to give information on the effect of grazing exclusion on runoff, erosion, and sediment yield for a large area of depleted range land in west-central Colorado and east-central Utah. The area was selected for study because of the availability of 22 small storage reservoirs that could be used for measuring runoff and sediment yield, and also because the basin is typical of the wide belt of intricately incised terrain of moderate relief extending along the base of the Book Cliffs for several hundred miles in western Colorado and eastern Utah. Cooperative reports covering all phases of the study are to be issued periodically. Only the records of runoff and sediment yield are given in this report.

At the beginning of the study, observations were made on all the 22 reservoirs in the basin, but later the measurements were discontinued on 2 reservoirs because of frequent spilling, which made the records unreliable. Currently storm runoff and sediment yield are being measured in the remaining 20 reservoirs. Four of the reservoirs are equipped with water-stage recorders, and measurements at the others are made manually at least weekly. The location of the reservoirs is shown in figure 41.

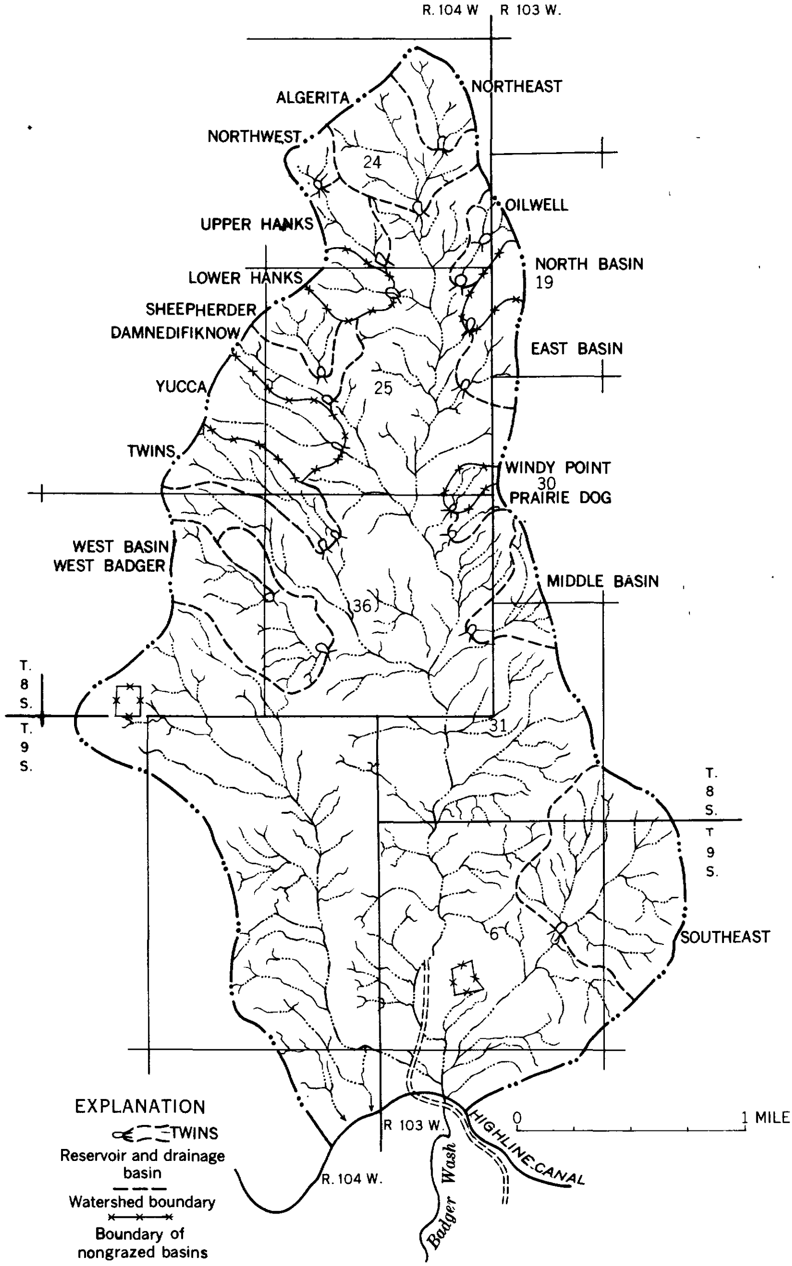

FIGURE 41.—Index map of Badger Wash basin, Colo., showing location of study reservoirs.

TABLE 2.—*Summary of storm runoff and sediment yield at reservoirs in the Missouri River basin*

[Discharge over spillway: L, large; M, Medium; S, small; N, none]

Reservoir	No. on pl. 19	Location			Period of record	Drainage basin data				Reservoir capacity			Sediment yield for period of record			Runoff for period of sediment record			Ratio runoff to sediment yield	Discharge over spill way
										Original		Most recent survey (acre-ft)	Total (acre-ft)	Average annual		Total (acre-ft)	Average annual			
		Sec.	T.	R.		Area (sq mi)	Max relief (ft)	Length (ft)	Relief ratio	Acre-ft	Acre-ft per sq mi			Acre-ft	Acre-per sq mi		Acre-ft	Acre-ft per sq mi		
MILK RIVER BASIN																				
Willow Creek basin, Montana [Area 1 on fig. 35]																				
Wittmayer	----	7	24N	37E	1952–55	1.12	350	9,500	0.037	27.4	24.5	23.4	4.0	1.21	1.08	----	----	----	----	M
Burnett Northwest [1]	----	24	27N	35E	1954–59	5.00	----	18,000	----	146.0	29.2	143.0	3.0	----	----	632.6	----	----	210.9	N
West Road [2]	----	6	25N	29E	1952–55	1.27	----	11,600	----	40.9	33.2	31.6	9.3	2.82	2.22	----	----	----	----	L
Willow Flat [3]	----	29	26N	39E	do	1.05	150	10,000	.015	153.0	145.7	146.0	7.0	2.12	2.02	----	----	----	----	S
Wind River basin, Wyoming [Area 2 on fig. 35. Location of study areas shown on pl. 18]																				
Mahoney	----	15	34N	91W	1949–51	[4] 13.40	410	38,000	0.011	143.7	10.7	138.4	5.3	0.48	0.04	----	----	----	----	S
					1952–57	9.82	----	----	----	138.0	14.0	137.0	1.0	.16	.02	64.4	10.7	1.08	64.4	N
Signor	----	6	33N	92W	1946–51	7.15	----	----	----	11.3	1.6	9.8	1.5	.27	.04	----	----	----	----	S
					1952–55	7.15	----	----	----	9.8	1.4	7.9	1.9	.21	.03	60.0	6.6	0.92	31.5	N
Rongis [5]	----	3	33N	93W	1954–60	37.0	1,340	45,400	.030	1,012.0	30.3	963.0	49.0	7.0	.19	506.3	72.3	1.95	10.4	N
Paintpot,[6] No. 9	----	4	5N	2W	1953–60	.64	400	6,580	.061	8.8	13.7	7.3	1.5	.25	.39	20.5	3.4	5.30	13.7	N
No. 8 [7]	----	3	5N	2W	do	.36	----	----	----	46.5	129.0	44.1	2.4	.40	1.11	46.0	7.6	21.2	19.2	N
No. 7 [8]	----	3	5N	2W	1952–56	3.57	----	----	----	116.5	32.7	111.2	5.3	1.3	.37	34.5	8.6	2.42	6.5	N
No. 10	----	2	5N	2W	1954–60	.126	----	----	----	8.7	68.8	7.4	1.3	.19	1.47	25.7	3.7	29.30	19.7	N
No. 6 [9]	----	2	5N	2W	1954–57	.374	----	----	----	42.4	113.5	36.5	5.9	1.47	.84	31.3	15.6	41.80	13.6	N
No. 5	----	2	5N	2W	1954–60	.069	----	----	----	36.2	525.8	36.2	0	0	0	38.9	5.6	81.20	----	N
No. 4	----	2	5N	2W	1952–57	.631	----	----	----	5.2	8.2	1.6	3.6	.6	.95	17.5	2.9	4.64	4.9	N
No. 3 [10]	----	2	5N	2W	do	.065	----	----	----	0.6	9.2	0.5	.1	.02	3.86	2.0	.5	7.68	20.0	N
No. 1	----	2	5N	2W	1954–57	.067	----	----	----	26.7	398.5	26.2	.5	.12	1.85	26.7	6.7	100.00	53.5	N
East Fork	----	12	37N	91W	1949–57	.81	190	5,370	.035	12.3	15.2	10.6	1.7	.09	.11	30.3	3.4	4.15	1.78	N
West Fork	----	14	37N	31W	1947–60	.38	265	4,950	.053	3.4	8.9	2.5	.9	.06	.17	13.1	.9	2.47	14.6	S
Graham [11]	----	14	37N	91W	1947–48	2.74	----	----	----	19.8	7.2	16.9	2.9	1.45	.53	66.1	33.0	12.2	23.4	M
					1949–60	[12] 1.93	----	----	----	16.9	8.8	15.0	1.9	.16	.08	54.5	4.5	2.3	28.6	S

Fifteen Mile Creek basin, Wyoming

[Area 3 on fig. 35]

Red Spires [11]		7	49N	96W	1954–59	5.24	1,280	29,200	0.044	193.0	36.9	176.0	17.0	2.83	0.54	702.2	144.4	27.7	41.30	N
Big Gin [13]		6	47N	93W	do	.94	120	8,550	.014	99.4	105.7	96.2	3.2	.64	.68	66.6	13.3	14.1	20.8	N
Lower Detention		28	48N	94W	[14] 1956	4.06				[15]234.3	57.8	221.4	12.9			234.0			18.1	

CHEYENNE RIVER BASIN

Antelope Creek basin, Wyoming

Moore Cattle Co	1	30	41N	75W	1931–54	0.60	225	6,100	0.036	9.0	15.0	7.6	1.4	0.06	0.10	(16)				M
Manning No. 12	2	26	38N	74W	1946–54	.48	140	7,920	.018	11.7	24.4	11.2	.5	.06	.13	(17)				N
Cosner	3	28	43N	72W	1949–54	.20	55	3,000	.018	1.2	6.0	1.0	.2	.04	.20	(18)				N
Schmitt Bros	4	25	40N	67W	1939–50	.34				19.7	57.9	11.4	8.3	.75	2.21	(19)				L

Black Thunder Creek basin, Wyoming

Field Bros	5	17	43N	66W	1939–50	1.40	240	10,560	0.024	9.8	7.0	8.1	1.7	0.15	0.11	(20)				M
Darlington	6	13	43N	67W	1927–50	.23	120	3,695	.033	2.5	10.9	1.8	.7	.03	.33	(21)				M

Lodgepole Creek basin, Wyoming

Sellers No. 2	7	36	45N	67W	1946–50	4.40				0.9	0.2	0.3	0.6	0.15	0.03					L
Popham	8	24	45N	67W	1938–50	.06	85	1,848	0.046	.9	15.0	.4	.5	.04	.61					M
Sellers No. 1	9	12	44N	66W	1939–50	28.15				32.8	1.2	21.7	11.1	1.01	.03					L

Boggy Creek basin, Wyoming

Zerbst	10	10	39N	64W	1950–56	7.52				402.0	53.5	366.6	35.4	5.43	0.72	(22)				N

Lance Creek basin, Wyoming

Jake Johnson	11	21	36N	70W	1934–54	1.27	145	7,920	0.018	10.0	7.8	7.2	2.8	0.14	0.11	(23)				M
Lee Moore	12	10	36N	68W	1933–50	.15				1.1	7.3	.7	.4	.02	.14					M
Perrano No. 1	13	20	33N	67W	1942–51	.081				2.7	33.8	2.2	.5	.06	.70					N
No. 2	14	19	33N	67W	1940–51	0.28	130	4,415	0.029	1.9	6.8	0.7	1.2	0.11	0.28					L
No. 3	15	18	33N	67W	1938–51	.06				3.1	51.8	1.8	1.3	.10	1.57					M
No. 4	16	18	33N	67W	1946–51	.03	100	1,380	.072	1.7	56.6	1.1	.6	.12	4.21					M
Rocky Top, No. 2	17	5	33N	67W	1942–51	.43	100	4,225	.024	3.3	7.7	2.0	1.3	.14	.33					L
No. 3	18	31	34N	67W	1949–51	.09				5.7	63.4	5.0	.7	.35	4.13					N
No. 4	19	33	34N	67W	do	.21	125	2,375	.053	23.9	110.4	22.9	1.0	.50	2.27					N
No. 5	20	29	34N	67W	1945–51	.21	100	3,300	.030	6.0	28.6	5.2	.8	.13	.67					M
No. 1	21	26	34N	67W	1941–51	1.13				10.8	9.6	8.3	2.5	.25	.22					S

See footnotes on page 272.

TABLE 2.—*Summary of storm runoff and sediment yield at reservoirs in the Missouri River basin*—Continued

Reservoir	No. on pl. 19	Location			Period of record	Drainage basin data				Reservoir capacity			Sediment yield for period of record			Runoff for period of sediment record			Ratio runoff to sediment yield	Discharge over spillway
										Original		Most recent survey (acre-ft)	Total (acre-ft)	Average annual		Total (acre-ft)	Average annual			
		Sec.	T.	R.		Area (sq mi)	Max relief (ft)	Length (ft)	Relief ratio	Acre-ft	Acre-ft per sq mi			Acre-ft	Acre-ft per sq mi		Acre-ft	Acre-ft per sq mi		
CHEYENNE RIVER BASIN—continued																				
Lance Creek basin, Wyoming—Continued																				
Nuttall No. 1	22	27	34N	67W	1939–51	.13	140	3,035	.046	2.7	20.4	1.6	1.1	.09	.75					S
Joss No. 11	23	35	34N	67W	1941–51	2.3				6.0	2.6	3.2	2.8	.28	.12					M
Mitchell No. 2	24	25	34N	67W	1943–51	.29				1.4	4.8	.8	.6	.08	.25					L
No. 1	25	19	34N	67W	1938–51	.17				2.7	15.9	2.2	.5	.04	.26					S
Wanek No. 3	26	30	35N	67W	do	.06				6.8	113.2	5.4	1.4	.11	1.70					M
Meinzer No. 2	27	25	34N	68W	1936–51	.02				4.0	100.0	3.1	.9	.06	2.75					N
Wanek No. 4	28	36	35N	68W	1938–51	.10				6.2	62.0	4.0	2.2	.17	1.70					M
Dickau	29	2	34N	68W	1945–51	.13				3.7	28.4	2.8	.9	.15	1.18					L
Edison	30	10	34N	68W	1936–51	.04				1.7	42.5	1.0	.7	.05	1.26					L
Rankin No. 5	31	16	34N	68W	1941–51	.39				3.4	8.7	1.9	1.5	.15	.36					L
No. 4	32	21	34N	68W	1946–51	.03				.7	23.4	.5	.2	.04	1.25					L
No. 3	33	21	34N	68W	1944–51	.20				2.5	12.5	1.5	1.0	.14	.67					M
No. 2	34	21	34N	68W	1949–51	.23				4.4	19.1	3.2	1.2	.60	2.56					M
No. 1	35	20	34N	68W	1941–51	.20				3.1	15.5	2.2	.9	.09	.44					M
Hoffmann No. 4	36	32	34N	68W	1944–51	.51				4.7	9.2	2.6	2.1	.30	.60					L
No. 3	37	33	34N	68W	1938–51	1.19				4.9	4.1	.4	4.5	.35	.29					L
No. 2	38	33	34N	68W	1941–51	.25				27.5	110.0	19.0	8.5	.85	3.44					L
No. 1	39	32	34N	68W	1943–51	1.30				5.0	3.8	1.9	3.1	.39	.29					L
Brock No. 9	40	20	35N	67W	do	.08				4.8	60.0	3.4	1.4	.18	2.40					L
Wanek No. 2	41	20	35N	67W	1941–51	.11				2.1	19.1	1.2	.9	.09	.81					L
No. 1	42	30	35N	67W	1940–51	.08	95	2,904	0.033	1.7	21.2	1.0	.7	.06	.82					L
Brock No. 8	43	20	35N	67W	do	.21	85	2,760	.030	14.4	68.5	7.3	7.1	.65	3.06					L
No. 7	44	16	35N	67W	1948–51	.58				6.3	10.9	3.6	2.7	.90	1.50					L
Smith No. 1	45	16	35N	67W	1941–51	.90				7.4	8.2	4.8	2.6	.26	.29					L
Nuttall No. 2	46	33	34N	67W	1939–51	.10	60	1,850	.033	1.7	17.0	1.2	.5	.04	.40					M
Manning No. 9	47	2	35N	67W	1941–51	.11				1.3	11.8	1.0	.3	.03	.34					N
No. 8	48	3	35N	67W	do	.08				4.1	51.3	3.3	.8	.08	1.65					L
No. 7	49	14	35N	67W	1937–51	.42				.7	1.7	.2	.5	.03	.09					S
No. 6	50	15	35N	67W	do	1.10				6.5	5.9	.8	5.7	.41	.14					L
Bauer No. 1	51	3	34N	67W	1940–51	.04				3.8	95.0	3.1	.7	.06	1.44					N
No. 2	52	3	34N	67W	1942–51	.05				3.2	64.0	2.1	1.1	.12	2.37					N
Brock No. 6	53	34	35N	67W	1945–51	.15	180	4,140	.043	6.4	42.6	4.9	1.5	.25	1.53					S
No. 5	54	22	35N	67W	1936–51	.42				2.9	6.9	1.4	1.5	.10	.22					L
No. 2	55	35	35N	67W	1947–51	1.31				2.6	2.0	.4	2.2	.55	.40					S
No. 3	56	23	35N	67W	1945–51	.40				6.1	15.2	4.2	1.9	.32	.78					L
Manning No. 5	57	25	35N	67W	1941–51	1.70	300	15,840	.019	8.1	4.8	6.7	1.4	.14	.12					L
No. 4	58	24	35N	67W	1943–51	1.37				6.9	5.0	4.9	2.0	.25	.18					L

Joss No. 3	59	31	36N	66W	1939–51	.09	-----	-----	-----	4.5	50.0	3.4	1.1	.09	1.05	-----	-----	-----	-----	S
Brock No. 1	60	26	35N	67W	1941–51	.08	-----	-----	-----	3.4	42.5	2.4	1.0	.10	1.26	-----	-----	-----	-----	S
Joss No. 1	61	3	35N	66W	1935–51	.06	60	1,426	.042	2.6	43.4	1.7	.9	.06	1.05	-----	-----	-----	-----	S
No. 2	62	3	35N	66W	1940–50	.08	-----	-----	-----	4.6	57.5	3.8	.8	.08	1.00	-----	-----	-----	-----	N
Manning No. 1	63	20	35N	66W	1938–51	.06	90	1,320	.068	3.8	63.4	2.3	1.5	.12	1.97	-----	-----	-----	-----	L
No. 2	64	19	35N	66W	1931–50	0.04	-----	-----	-----	1.7	42.5	0.8	0.9	0.05	1.25	-----	-----	-----	-----	S
No. 3	65	19	35N	66W	do	.16	-----	-----	-----	9.9	61.8	5.3	4.6	.24	1.54	-----	-----	-----	-----	N
Brock No. 4	66	1	35N	67W	1943–51	2.34	-----	-----	-----	3.8	1.6	1.6	2.2	.28	.12	-----	-----	-----	-----	L
Joss No. 4	67	34	36N	66W	1940–51	.33	175	3,430	.051	15.2	46.0	10.7	4.5	.41	1.26	(24)	-----	-----	-----	L
No. 5	68	19	36N	65W	1930–51	.18	70	2,640	.026	4.0	22.2	2.9	1.1	.05	.29	-----	-----	-----	-----	S
No. 6	69	5	36N	65W	1945–51	.10	-----	-----	-----	11.4	114.0	9.3	2.1	.35	3.70	-----	-----	-----	-----	S
No. 7	70	2	35N	67W	1939–51	.31	120	3,150	.038	13.1	42.3	10.2	2.9	.24	.83	-----	-----	-----	-----	S
Emery	71	32	37N	66W	1938–51	.04	-----	-----	-----	3.7	92.6	2.1	1.6	.12	2.92	-----	-----	-----	-----	L
Baker	72	25	37N	66W	1936–51	.19	-----	-----	-----	1.3	6.8	.1	1.2	.08	.42	-----	-----	-----	-----	L
Joss No. 9	73	27	36N	66W	1945–51	.39	145	2,480	.058	10.2	26.2	8.8	1.4	.23	.59	-----	-----	-----	-----	M
No. 10	74	14	36N	66W	1944–51	.05	-----	-----	-----	.2	4.0	.1	.1	.01	.19	-----	-----	-----	-----	M
No. 8	75	25	36N	67W	1936–51	.19	-----	-----	-----	3.0	15.8	.4	2.6	.17	.87	-----	-----	-----	-----	L
No. 12	76	35	36N	67W	1940–51	.19	100	3,170	.032	7.4	38.9	5.9	1.5	.13	.73	-----	-----	-----	-----	S
Kruse No. 5	77	18	37N	65W	1938–51	.06	-----	-----	-----	1.8	30.0	1.7	.1	.008	.11	-----	-----	-----	-----	M
No. 4	78	18	37N	65W	1946–51	.39	-----	-----	-----	19.6	50.0	12.5	7.1	1.42	3.66	-----	-----	-----	-----	L
No. 3	79	18	37N	65W	1940–51	.23	-----	-----	-----	7.2	31.3	1.8	5.4	.49	2.18	-----	-----	-----	-----	L
No. 2	80	29	37N	65W	1939–51	.12	-----	-----	-----	1.0	8.3	.6	.4	.03	.29	-----	-----	-----	-----	L
No. 1	81	30	37N	65W	1944–51	.06	-----	-----	-----	2.7	45.0	2.0	.7	.10	1.73	-----	-----	-----	-----	L
Manning No. 10	82	13	35N	66W	1940–50	.05	-----	-----	-----	1.6	32.0	1.1	.5	.05	.81	-----	-----	-----	-----	L
No. 11	83	2	35N	66W	do	.05	-----	-----	-----	1.6	32.0	1.1	.5	.05	.81	-----	-----	-----	-----	L
Roscoe Ross	84	13	38N	65W	1934–50	.17	-----	-----	-----	8.0	47.0	4.7	3.3	.20	1.21	-----	-----	-----	-----	L
Slagle No. 2	85	33	39N	66W	1940–50	.21	-----	-----	-----	10.2	48.5	6.9	3.3	.33	1.50	-----	-----	-----	-----	M
No. 1	86	27	39N	66W	1935–50	.07	-----	-----	-----	6.7	95.8	4.8	1.9	.13	1.70	-----	-----	-----	-----	S
Kimbrough	87	24	35N	64W	1941–50	.18	120	3,160	.037	19.1	106.0	14.0	5.1	.57	3.19	-----	-----	-----	-----	L
David Ranch	88	6	36N	63W	1940–50	.20	125	2,640	.047	8.3	41.5	4.9	3.4	.34	1.70	-----	-----	-----	-----	L
Johnson	89	23	36N	64W	1943–50	11.9	-----	-----	-----	42.0	35.3	27.3	14.7	2.10	0.17	-----	-----	-----	-----	L
Mule Creek basin, Wyoming																				
Pfister No. 1	90	14	38N	61W	1940–51	0.54	-----	-----	-----	7.8	14.4	6.5	1.3	0.12	0.22	-----	-----	-----	-----	L
Mule Creek No. 2	91	3	38N	61W	1944–50	.25	-----	-----	-----	14.1	56.4	10.7	3.4	.57	2.23	-----	-----	-----	-----	M
Beaver Creek basin, Wyoming																				
Bock	92	12	45N	63W	1944–50	0.25	-----	-----	-----	13.1	52.4	9.3	3.8	0.63	2.60	-----	(25)	-----	-----	M
Skull Creek No. 1	93	4	44N	62W	1944–54	.13	80	3,160	0.035	4.2	32.3	2.8	1.4	.14	1.04	-----	-----	-----	-----	M
No. 2	94	32	45N	62W	1947–54	.14	95	3,160	.042	3.9	27.8	1.9	2.0	.29	2.12	-----	-----	-----	-----	M
Coyle	95	27	45N	62W	1948–50	.11	35	1,585	.022	3.83	34.8	3.82	.01	.005	.03	-----	(26)	-----	-----	N
Hat Creek basin, Nebraska and South Dakota																				
Schaeffer	96	12	32N	56W	1940–50	0.39	-----	-----	-----	6.9	17.7	3.2	3.7	0.37	0.96	-----	-----	-----	-----	L
Andrews	97	6	32N	55W	1949–50	.42	660	8,800	0.023	11.2	26.6	10.0	1.2	1.20	2.85	(27)	-----	-----	-----	M
Coffee	98	21	33N	56W	1920–50	.64	200	5,280	.038	8.9	13.9	2.7	6.2	.20	.32	-----	-----	-----	-----	L
Dank	99	17	10S	4E	1939–50	.30	-----	-----	-----	14.3	47.6	12.2	2.1	.19	.63	-----	-----	-----	-----	M

See footnotes on page 272.

(Footnotes for table 2.)

[1] Two 24-inch outlet pipes.
[2] 36-inch outlet pipe.
[3] 12-inch outlet pipe.
[4] Drainage area reduced by construction of upstream reservoir, 1952.
[5] Two gated 24-inch outlet pipes.
[6] Location of reservoirs in Paintpot Draw shown on figure 40.
[7] 9-inch outlet pipe.
[8] 18-inch outlet pipe. Runoff and sediment records, 1952–56.
[9] 24-inch outlet pipe. Runoff and sediment records, 1954–55.
[10] Runoff and sediment records.
[11] 18-inch outlet pipe.
[12] Drainage area reduced by construction of East Fork reservoir, 1949.
[13] 8-inch outlet pipe.
[14] Single storm July 26, 1956.
[15] Capacity surveyed only to high water marks of flood.
[16] Runoff data for 1951–54 obtained by U.S. Geological Survey (1961, reservoir 13).
[17] Runoff data for 1951–54 obtained by U.S. Geological Survey (1961, reservoir 36).
[18] Runoff data for 1951–54 obtained by U.S. Geological Survey (1961, reservoir 10–B).
[19] Runoff data for 1951–54 obtained by U.S. Geological Survey (1961, reservoir 25).
[20] Runoff data for 1951–54 obtained by U.S. Geological Survey (1961, reservoir 7–B).
[21] Runoff data for 1952–54 obtained by U.S. Geological Survey (1961, reservoir 7–A).
[22] Runoff data for 1951–54 obtained by U.S. Geological Survey (1961, reservoir 35).
[23] Runoff data for 1951–54 obtained by U.S. Geological Survey (1961, reservoir 41).
[24] Runoff data for 1951–54 obtained by U.S. Geological Survey (1961, reservoir 42).
[25] Runoff data for 1951–54 obtained by U.S. Geological Survey (1961, reservoir 3).
[26] Runoff data for 1951–54 obtained by U.S. Geological Survey (1961, reservoir 4).
[27] Runoff data for 1951–54 obtained by U.S. Geological Survey (1961, reservoir 54).

TOPOGRAPHY

The Badger Wash basin is characterized by three types of topography. The central alluvium filled stream valley which approximately bisects the basin, has a low gradient and a gullied channel. The area west of the central valley has a steplike topography in which sandstone-capped benches of low gradient are separated by short steep shale risers, resulting in alternate steep and gentle slopes. In general, the drainage network is moderately incised on the steeper slopes, but on the sandy benches the channels are wide and shallow. The eastern half of the basin contains no sandstone; in consequence, the topography is not steplike but consists of very steep hillside slopes that merge at the base with gently sloping colluvial deposits. The steep slopes are incised with deep, narrow trenches.

Relief ratios were compiled at 10 reservoirs, for which detailed topographic maps were available. These are shown in table 3.

Badger Wash basin does not reach the Book Cliffs proper, and in consequence the maximum slopes are not so steep and the area is somewhat less rugged; but except for these minor differences, it is in most respects typical of the terrain of the Book Cliffs.

GEOLOGY

The entire Badger Wash basin is underlain by Mancos shale of Late Cretaceous age. In the western part of the basin the shale contains several thin lenticular sandstone layers, which are responsible for the step topography. The benches, capped by sandstone, have a thin sandy soil mantle that absorbs water readily, and in consequence runoff is low and erosion is negligible. On the intervening shale slopes the opposite conditions prevail, the soils are heavy and tight, runoff is rapid, and erosion is excessive.

The shale in the eastern part of the basin is uniform throughout and has no interbedded layers of sandstone. Colluvial deposits, which may be as much as several feet thick, occur at the base of the steeper slopes, but in other locations where the deposits are absent the soil is thin, fine textured, devoid of organic material, and practically impervious. Because of the high sodium content, the soils tend to become fluffy when dry. The larger stream valleys in the basin are floored with fine-textured alluvium as much as 20 feet thick.

VEGETATION

A detailed inventory of vegetation and periodic measurement of changes in density and plant species is being carried out by the U.S. Forest Service as part of the cooperative study now under way. The inventory of the U.S. Forest Service lists the principal plants as low, growing shrubs including Gardner's saltbush, shadscale, sagebrush, greasewood and other salt-tolerant species, and scattered grasses including Indian rice, blue grama, and galleta. Except along stream channels and other locations that receive additional water, the vegetation is so sparse that it probably has little effect on either runoff or erosion. The very poor cover of vegetation appears to have been in part due to land abuse in the past, particularly overgrazing by sheep.

EROSION

Erosion is active throughout the Badger Wash basin. Steep slopes and the sparsity of vegetation contribute to the prevalence of both gullying and sheet erosion. Most of the larger gullied channels have cut through the alluvium into the bedrock and further deepening is proceeding slowly, but there is evidence of bank cutting and channel widening in many places. Sheet erosion is active on the steeper slopes of shale as evidenced by pedestaled plants and numerous shallow rills. The colluvial slopes appear to be fairly stable, and deposition is occurring in some localities. Owing to the complete integration of the drainage network, sediment that reaches any of the channels is funneled directly to the reservoir below as there is no opportunity for deposition en route.

PRECIPITATION AND RUNOFF

Badger Wash has a mean annual rainfall of less than 10 inches, of which about 60 percent falls in the 6-month period from April to October. Most of the summer rainfall occurs as storms of short duration and high intensity. These produce most of the runoff. Winter precipitation is generally in the form of snow, which rarely produces runoff.

The nearest precipitation station with a long-term record is at Fruita, Colo., about 15 miles southeast. Precipitation has also been measured at 10 gages located within Badger Wash since the studies were begun in 1954. The following precipitation data were obtained in part from the U.S. Weather Bureau station at Fruita and in part from gages within the basin.

Mean precipitation at Fruita, 1934–59

	Inches
Annual	8. 31
April to October	5. 03
November to March	3. 28
Maximum month (August)	. 96

Frequency of 1-day precipitation of selected magnitude from April to October

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Fruita, 1920–59:				
Percent of years in which at least one event has occurred	84	18	7.9	0.6
Average number of events per year	2.0	.21	.08	.03
Badger Wash basin, April 1954 to October 1959: Average number of events per year	2.0	.17	0	0

Storm runoff and sediment yield measured in the 20 reservoirs in Badger Wash during the summer months for the period 1954–59 are given in the following tables. Average annual runoff and sediment yield for the same period are given in table 3.

Storm runoff and sediment yield measured in Northeast Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°21′, long 108°56′, in sec. 24, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.
Drainage area.—0.10 sq mi (64 acres).
Records available.—1954–59, summer months only.
Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage capacity curve of the reservoir.
Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1953 to November 1955	0.45
November 1955 to November 1956	(1)
November 1956 to October 1957	.1
November 1958 to November 1959	(1)

1 No measurable deposition.

Capacity.—Original, at spillway (gage height, 26.7 ft.): 4.5 acre-ft, December 1953; 4.0 acre-ft, November 1959
Maximums.—Inflow volume, 2.4 acre-ft or 24.0 acre-ft per sq mi, July 25, 1955.
Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 12		22.6	1.0	0	1.0	
Sept. 23	20.8	23.1	1.1	0	1.1	
Oct. 7	22.2	22.5	.2	0	.2	
Oct. 9	22.4	23.0	.4	0	.4	
Total			2.7	0	2.7	27.0
1955						
July 25		24.6	2.4	0	2.4	
Aug. 24	21.3	21.6	.1	0	.1	
Sept. 18	20.4	20.7	.1	0	.1	
Total			2.6	0	2.6	26.0
1956 [1]						
1957						
May 16		20.8	.1	0	.1	
June 15		21.9	.3	0	.3	
Aug. 5	19.9	21.3	.2	0	.2	
Aug. 8	20.4	22.7	.6	0	.6	
Aug. 20	21.4	22.6	.4	0	.4	
Aug. 26	22.1	22.4	.1	0	.1	
Aug. 29–30	22.2	22.8	.3	0	.3	
Oct. 12	21.0	21.9	.2	0	.2	
Oct. 18	21.5	22.0	.1	0	.1	
Oct. 20	21.9	22.7	.3	0	.3	
Total			2.6	0	2.6	26.0
1958 [1]						
1959						
Aug. 19		22.4	.4	0	.4	
Aug. 26	21.2	22.1	.2	0	.2	
Sept. 16		22.4	.5	0	.5	
Sept. 23	21.6	22.1	.1	0	.1	
Oct. 28	21.2	22.7	.5	0	.5	
Nov. 4	22.6	22.7	.1	0	.1	
Total			1.8	0	1.8	18.0

[1] No flow.

Storm runoff and sediment yield measured in Algerita Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°20′, long 108°56′, in sec. 24, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.

Drainage area.—0.220 sq mi (141 acres).

Records available.—1954–59, summer months only.

Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1953 to November 1955	1. 6
November 1955 to November 1956	0
November 1956 to October 1957	1. 1
November 1958 to November 1959	. 04

Capacity.—Original, at spillway (gage height, 71.5 ft): 18.3 acre-ft, December 1953; 15.6 acre-ft, October 1959.
Maximums.—Inflow volume, 7.70 acre-ft or 35.0 acre-ft per sq mi, July 25, 1955.
Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 12		63. 7	2. 9	0	2. 9	
Sept. 23	62. 2	65. 9	4. 7	0	4. 7	
Oct. 7	64. 6	65. 0	. 6	0	. 6	
Oct. 9	65. 0	65. 8	1. 2	0	1. 2	
Total			9. 4	0	9. 4	42. 7
1955						
July 25	62. 1	67. 5	7. 7	0	7. 7	
Aug. 24	65. 6	65. 9	. 6	0	. 6	
Total			8. 3	0	8. 3	37. 8
1956 [1]						
1957						
May 24		62. 4	. 3	0	. 3	
June 15		63. 2	1. 0	0	1. 0	
July 18		61. 9	. 1	0	. 1	
Aug. 5		62. 9	. 7	0	. 7	
Aug. 8	62. 4	64. 2	1. 8	0	1. 8	
Aug. 20	62. 9	64. 5	1. 8	0	1. 8	
Aug. 26	64. 1	64. 5	. 5	0	. 5	
Aug. 29–30	64. 4	65. 2	1. 1	0	1. 1	
Oct. 12	63. 3	64. 2	1. 1	0	1. 1	
Oct. 18	64. 0	64. 3	. 3	0	. 3	
Oct. 20	64. 3	65. 4	1. 5	0	1. 5	
Total			10. 2	0	10. 2	46. 3
1958 [1]						
1959						
Aug. 19		62. 2	1. 4	0	1. 4	
Aug. 26	61. 6	61. 7	. 1	0	. 1	
Sept. 15	60. 9	62. 0	. 9	0	. 9	
Sept. 21	61. 8	62. 2	. 3	0	. 3	
Oct. 1–5	61. 4	62. 8	1. 4	0	1. 4	
Total			4. 1	0	4. 1	18. 6

[1] No flow.

Storm runoff and sediment yield measured in Northwest Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°21′, long 108°57′, in sec. 24, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.
Drainage area.—0.055 sq mi (35 acres).
Records available.—1954–59, summer months only.
Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener.

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Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
June 1954 to November 1955	0.2
November 1956 to November 1958	(1)
November 1958 to November 1959	.05

[1] No measurable deposition.

Capacity.—Original, at spillway (gage height, 28.4 ft): 2.4 acre-ft, December 1953; 2.2 acre-ft, November 1956. Dam raised November 1956 and capacity increased to 6.3 acre-ft; 6.25 acre-ft, November 1959.

Maximums.—Inflow volume, 1.53 acre-ft or 27.8 acre-ft per sq mi, July 25, 1955.

Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 12		24.9	0.6	0	0.6	
Sept. 23	24.0	27.2	1.2	0	1.2	
Oct. 7	26.4	26.6	.1	0	.1	
Oct. 9	26.6	27.0	.2	0	.2	
Total			2.1	0	2.1	38.2
1955						
July 25		27.0	1.5	0	1.5	
Aug. 7	25.7	26.1	.3	0	.3	
Aug. 24	25.0	25.2	.1	0	.1	
Sept. 18	24.1	24.4	.1	0	.1	
Total			2.0	0	2.0	36.4
1956 [1]						
1957						
May 24		23.7	.2	0	.2	
June 15–18		24.1	.3	0	.3	
Aug. 5		24.0	.2	0	.2	
Aug. 8	23.5	24.4	.2	0	.2	
Aug. 20	23.9	25.5	.4	0	.4	
Aug. 26–30	25.4	26.0	.2	0	.2	
Oct. 12	24.1	25.6	.4	0	.4	
Oct. 20	25.3	26.1	.3	0	.3	
Total			2.2	0	2.2	40.1
1958						
Sept. 24		22.4	.1	0	.1	18.2
1959						
Aug. 19		25.6	.7	0	.7	
Aug. 26	25.1	25.2	.1	0	.1	
Sept. 15	24.1	25.5	.4	0	.4	
Sept. 23	25.0	25.6	.1	0	.1	
Sept. 28	24.5	26.0	.5	0	.5	
Total			1.8	0	1.8	32.7

[1] No flow.

Storm runoff and sediment yield measured in Upper Hanks Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°20′, long 108°56′, in sec. 24, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.

Drainage area.—0.066 sq mi (42 acres).

Records available.—1954–59, summer months only.

Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener. Elevation of reference mark is 5,055.8 ft above mean sea level.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	Total sediment yield (acre-ft)
November 1953 to November 1955	0.8
November 1956 to November 1957	.2
November 1957 to November 1959	.3

Capacity.—Original, at spillway (gage height, 54.7 ft): 8.3 acre-ft, December 1953; 7.0 acre-ft, November 1959.

Maximums.—Inflow volume, 3.3 acre-ft or 49.8 acre-ft per sq mi, July 25, 1955.

Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 8		44.0	0.1	0	0.1	
Sept. 12		47.1	1.0	0	1.0	
Sept. 23	46.1	49.8	2.2	0	2.2	
Oct. 7	48.8	49.1	.2	0	.2	
Oct. 9	49.0	49.5	.3	0	.3	
Total			3.8	0	3.8	59.0
1955						
July 25		50.4	3.3	0	3.3	
Aug. 24	48.0	48.7	.5	0	.5	
Total			3.8	0	3.8	57.5
1956 [1]						
1957						
June 15		47.4	.5	0	.5	
Aug. 4		47.6	.6	0	.6	
Aug. 8	46.8	47.3	.2	0	.2	
Aug. 20	46.3	47.9	.7	0	.7	
Aug. 26	47.4	48.0	.3	0	.3	
Aug. 29–30	47.8	48.5	.5	0	.5	
Oct. 12–13	46.1	47.5	.5	0	.5	
Oct. 18	47.4	47.6	.1	0	.1	
Oct. 20	47.6	48.6	.6	0	.6	
Total			4.0	0	4.0	60.3
1958 [1]						
1959						
Aug. 19		47.4	.4	0	.4	
Aug. 26	46.4	46.6	.1	0	.1	
Sept. 16		47.1	.3	0	.3	
Sept. 23	46.8	47.2	.1	0	.1	
Oct. 28		48.1	.7	0	.7	
Total			1.6	0	1.6	24.2

[1] No flow.

Storm runoff and sediment yield measured in Lower Hanks Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°20′, long 108°56′, in sec. 25, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.
Drainage area.—0.085 sq mi (54 acres).
Records available.—1954–59, summer months only.
Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener. Elevation of reference mark is 5,023.7 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1953 to July 1955	0.6
July 1955 to October 1957	(1)
October 1957 to November 1959	.005

[1] No measurable deposition.

Capacity.—Original, at spillway (gage height, 19.5 ft): 19.8 acre-ft, December 1953; 19.2 acre-ft, November 1959.
Maximums.—Inflow volume, 3.30 acre-ft or 38.8 acre-ft per sq mi, July 25, 1955.
Remarks.—Records good. Grazing has been excluded in this drainage basin since measurements were started.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 12		11.0	1.5	0	1.5	
Sept. 23	10.2	12.9	2.1	0	2.1	
Oct. 7	12.4	12.7	.3	0	.3	
Oct. 9	12.6	13.0	.4		.4	
Total			4.3	0	4.3	50.3
1955						
July 25		13.5	3.3	0	3.3	
Aug. 24	12.5	12.9	.4	0	.4	
Total			3.7	0	3.7	43.4
1956 [1]						
1957						
May 19		11.0	.3	0	.3	
June 15		10.2	.1	0	.1	
Aug. 5		10.3	.1	0	.1	
Aug. 8		11.9	.9	0	.9	
Aug. 20	10.0	12.2	1.2	0	1.2	
Aug. 26	10.2	11.8	.8	0	.8	
Aug. 30	11.3	12.4	1.0	0	1.0	
Oct. 12	10.6	11.3	.4	0	.4	
Oct. 20	11.2	12.3	1.0	0	1.0	
Total			5.8	0	5.8	68.2
1958 [1]						
1959						
Aug. 19		10.5	.8	0	.8	
Sept. 15		10.9	.3	0	.3	
Oct. 28		11.5	.5	0	.5	
Total			1.6	0	1.6	18.9

[1] No flow.

Storm runoff and sediment yield measured in Upper Oilwell Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°20′, long 108°56′, in sec. 24, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.
Drainage area.—0.034 sq mi (22 acres).
Records available.—1954–55, summer months only.
Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener. Elevation of reference mark is 5,060 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Sediment yield.—Computed from deposition in reservoir as shown by successive surveys. Total sediment yield for period October 1953 to July 1955, 0.5 acre-ft.
Capacity.—Original, at spillway (gage height, 58.0 ft): 1.5 acre-ft, December 1953; 1.0 acre-ft, July 1955.
Maximums.—Inflow volume, 1.48 acre-ft or 43.5 acre-ft per sq mi, July 25, 1955.
Remarks.—Records good. Overflows to Lower Oilwell Reservoir. The dam was removed in 1956 and the flow is now routed to Lower Oilwell Reservoir.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 12		55.4	0.4	0	0.4	
Sept. 23	52.0	53.1	.9	0	.9	
Oct. 7	54.9	55.5	.1	0	.1	
Oct. 9	55.3	56.0	.3	0	.3	
Total			1.7	0	1.7	49.7
1955						
July 25		58.0	1.5	0	1.5	
Aug. 24		55.6	.6	0	.6	
Total			2.1	0	2.1	62.0

Storm runoff and sediment yield measured in Lower Oilwell Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°20′, long 108°56′, in sec. 25, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.
Drainage area.—0.025 sq mi (16 acres), 1954; 0.059 sq mi (38 acres), Sept. 1955.
Records available.—1954–59, summer months only.
Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener. Elevation of reference mark is 5,031.5 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1953 to July 1955	0.3
November 1956 to October 1957	.1
November 1957 to November 1959	.2

Capacity.—Original, at spillway (gage height, 29.5 ft): 12.9 acre-ft, December 1953; 12.3 acre-ft, November 1959.
Maximums.—Inflow volume, 1.50 acre-ft or 60.0 acre-ft per sq mi, July 25, 1955.
Remarks.—Records good. Received spill from Upper Oilwell Reservoir in 1954–55.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 12		19.8	0.3	0	0.3	
Sept. 23		20.4	.6	0	.6	
Oct. 7	20.1	20.3	.1	0	.1	
Oct. 9	20.3	20.6	.3	0	.3	
Total			1.3	0	1.3	52.0
1955						
July 25		21.9	1.5	0	1.5	
Aug. 24	20.9	21.2	.2	0	.2	
Total			1.7	0	1.7	68.0
1956						
Aug. 15		19.2	.1	0	.1	1.7
1957						
June 15		20.0	.1	0	.1	
Aug. 5		20.0	.1	0	.1	
Aug. 8	19.7	23.4	2.5	0	2.5	
Aug. 20	21.7	22.9	1.0	0	1.0	
Aug. 26	22.0	22.7	.5	0	.5	
Aug. 29–30	22.2	23.4	1.1	0	1.1	
Oct. 12	22.0	23.4	1.2	0	1.2	
Oct. 20–21	22.8	23.6	.9	0	.9	
Total			7.4	0	7.4	125.0
1958 [1]						
1959						
Sept. 15–16		21.2	.7	0	.7	
Sept. 23	20.2	20.5	.1	0	.1	
Oct. 1	20.1	20.5	.2	0	.2	
Oct. 28	19.5	21.7	1.1	0	1.1	
Nov. 2	21.5	21.7	.1	0	.1	
Nov. 4	21.6	21.7	.1	0	.1	
Total			2.3	0	2.3	39.0

[1] No flow.

Storm runoff and sediment yield measured in North Basin Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°20′, long 108°56′, in sec. 25, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.
Drainage area.—0.049 sq mi (31 acres).
Records available.—1954–59, summer months only.
Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener. Elevation of reference mark is 5,013.67 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1953 to July 1955	0.4
July 1955 to October 1957	.04
October 1957 to November 1959	.14

Capacity.—Original, at spillway (gage height, 9.5 ft): 8.10 acre-ft, December 1953; 7.5 acre-ft, November 1959.

Maximums.—Runoff volume, 2.38 acre-ft or 48.6 acre-ft per sq mi, July 25, 1955.

Remarks.—Records good. Grazing has been excluded in this drainage basin since measurements were started.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 12		3.5	0.7	0	0.7	
Sept. 23	2.9	4.4	.8	0	.8	
Oct. 7	4.0	4.3	.2	0	.2	
Oct. 9	4.3	4.8	.4	0	.4	
Total			2.1	0	2.1	43.0
1955						
July 25	1.9	5.8	2.4	0	2.4	
Aug. 24	5.0	5.3	.2	0	.2	
Sept. 18	4.1	4.3	.1		.1	
Total			2.7	0	2.7	55.2
1956						
Aug. 15		2.5	.1	0	.1	2.0
1957						
May 24		3.0	.1	0	.1	
June 15	2.5	3.3	.2	0	.2	
Aug. 5		3.2	.2	0	.2	
Aug. 8	3.1	5.6	1.7	0	1.7	
Aug. 20	4.8	5.2	.3	0	.3	
Aug. 26	4.9	5.3	.3	0	.3	
Aug. 30	5.1	5.6	.4	0	.4	
Oct. 12	4.4	5.5	.9	0	.9	
Oct. 20–21	5.3	5.7	.4	0	.4	
Total			4.5	0	4.5	92.0
1958 [1]						
1959						
Aug. 19		2.3	.1	0	.1	
Sept. 15–16		3.2	.2	0	.2	
Sept. 23	3.0	3.2	.1	0	.1	
Oct. 28	2.8	3.6	.3	0	.3	
Nov. 2	3.4	3.5	.1	0	.1	
Nov. 4	3.4	3.5	.1	0	.1	
Total			.9	0	.9	18.2

[1] No flow.

Storm runoff and sediment yield measured in East Basin Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°20′, long 108°56′, in sec. 25, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.

Drainage area.—0.089 sq mi (57 acres).
Records available.—1954–59, summer months only.
Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1953 to November 1956	0.5
November 1956 to October1957	.2
October 1957 to November 1959	.1

Capacity.—Original, at spillway (gage height, 27.20 ft): 5.6 acre-ft, December 1953; 4.8 acre-ft, November 1959.
Maximums.—Runoff volume, 4.13 acre-ft or 46.3 acre-ft per sq mi, July 25, 1955.
Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Aug. 13		20.4	0.1	0	0.1	
Sept. 12	20.1	23.6	1.6	0	1.6	
Sept. 23	23.0	24.7	1.4	0	1.4	
Oct. 7	24.1	24.6	.5	0	.5	
Oct. 9	24.6	25.5	.9	0	.9	
Total			4.5	0	4.5	50.6
1955						
July 25	23.2	27.1	4.1	0	4.1	
Aug. 7	26.4	27.1	1.0	0	1.0	
Aug. 24	26.4	26.9	.8	0	.8	
Sept. 18	26.0	26.1	.2	0	.2	
Total			6.1	0	6.1	68.5
1956						
July 30		21.9	.1	0	.1	
Aug. 15		23.2	.7	0	.7	
Aug. 19	22.6	23.3	.4	0	.4	
Oct. 24		22.2	.2	0	.2	
Total			1.4	0	1.4	15.6
1957						
Apr. 23	21.7	22.2	.1	0	.1	
May 16		22.7	.4	0	.4	
May 24	22.4	23.2	.4	0	.4	
June 15	22.7	24.4	1.3	0	1.3	
Aug. 5	23.1	24.7	1.2	0	1.2	
Aug. 8	24.5	27.0	3.0	0	3.0	
Aug. 20	26.4	27.0	.8	0	.8	
Aug. 26	26.8	27.1	.4	0	.4	
Aug. 29–30	27.0	27.2	.7	0	.7	
Oct. 12	26.2	26.8	.9	0	.9	
Oct. 18	26.7	27.0	.4	0	.4	
Oct. 20	27.0	27.5	.8	0	.8	
Total			10.4	0	10.4	117.0

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1958						
Sept. 24		22.2	.1	0	.1	
Nov. 12		22.6	.2	0	.2	
Total			.3	0	.3	3.4
1959						
Aug. 19	22.0	23.0	.4	0	.4	
Sept. 15	22.0	24.2	1.4	0	1.4	
Sept. 28	23.9	24.2	.4	0	.4	
Oct. 16	23.8	24.0	.2	0	.2	
Oct. 28	23.6	25.3	1.5	0	1.5	
Nov. 2	25.2	25.3	.1	0	.1	
Total			4.0	0	4.0	45.0

Storm runoff and sediment yield measured in Sheepherder Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°20′, long 108°57′, in sec. 25, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.

Drainage area.—0.094 sq mi (60 acres).

Records available.—1954–59, summer months only.

Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
November 1953 to November 1955	0.7
November 1955 to October 1957	.1
October 1957 to October 1959	.2

Capacity.—Original, at spillway (gage height, 28.5 ft): 6.4 acre-ft, December 1953; 5.4 acre-ft, November 1959.

Maximums.—Inflow volume, 2.83 acre-ft or 30.1 acre-ft per sq mi, July 25, 1955.

Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 8		19.2	0.1	0	0.1	
Sept. 12	18.0	22.0	.9	0	.9	
Sept. 23	20.7	24.3	1.8	0	1.8	
Oct. 7	23.2	23.5	.2	0	.2	
Oct. 9	23.5	24.1	.4	0	.4	
Total			3.4	0	3.4	36.0

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1955						
July 25		25.3	2.8	0	2.8	
Aug. 7	23.7	24.4	.4	0	.4	
Aug. 24	22.6	23.5	.5	0	.5	
Total			3.7	0	3.7	39.3
1956 [1]						
1957						
May 24		21.3	.1	0	.1	
June 15		22.0	.3	0	.3	
Aug. 5		22.0	.3	0	.3	
Aug. 8	21.3	23.2	.7	0	.7	
Aug. 20	22.6	23.0	.5	0	.5	
Aug. 26	22.3	22.9	.3	0	.3	
Aug. 30	22.7	23.6	.4	0	.4	
Oct. 12	20.9	22.2	.4	0	.4	
Oct. 20–21	21.8	23.4	.7	0	.7	
Total			3.7	0	3.7	39.3
1958 [1]						
1959						
Aug. 19		22.3	.4	0	.4	
Sept. 15		22.6	.3	0	.3	
Sept. 23	21.5	21.8	.1	0	.1	
Oct. 1		22.3	.4	0	.4	
Total			1.2	0	1.2	12.7

[1] No flow.

Storm runoff and sediment yield measured in Damnedifiknow Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°20′, long 108°57′, in sec. 25, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.

Drainage area.—0.109 sq mi (70 acres).

Records available.—1954–59, summer months only.

Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1953 to November 1955	0.7
November 1955 to October 1957	.2
October 1957 to November 1959	.2

Capacity.—Original, at spillway (gage height, 28.6 ft): 8.0 acre-ft, December 1953; 6.9 acre-ft, November 1959.

Maximums.—Inflow volume, 3.91 acre-ft or 35.9 acre-ft per sq mi, July 25, 1955.

Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 8		19.3	0.1	0	0.1	
Sept. 12	18.5	21.7	1.0	0	1.0	
Sept. 23	20.5	23.5	1.7	0	1.7	
Oct. 7	22.7	23.1	.3	0	.3	
Oct. 9	23.1	23.8	.6	0	.6	
Total			3.7	0	3.7	33.8
1955						
July 25	20.9	26.0	3.9	0	3.9	
Aug. 7	24.9	25.3	.4	0	.4	
Aug. 24	24.4	24.9	.5	0	.5	
Total			4.8	0	4.8	44.0
1956 [1]						
1957						
May 24		20.9	.1	0	.1	
June 15		21.5	.4	0	.4	
Aug. 5		21.8	.5	0	.5	
Aug. 8	21.0	23.4	1.3	0	1.3	
Aug. 20	22.1	23.3	.7	0	.7	
Aug. 26	22.5	23.1	.4	0	.4	
Aug. 30	23.0	23.6	.4	0	.4	
Oct. 12	21.1	22.9	.9	0	.9	
Oct. 20–21	22.5	23.4	.6	0	.6	
Total			5.3	0	5.3	48.6
1958 [1]						
1959						
Aug. 19		22.3	.4	0	.4	
Aug. 26	21.1	21.5	.1	0	.1	
Sept. 16		22.5	.5	0	.5	
Sept. 23	21.7	22.2	.2	0	.2	
Oct. 28		22.9	.7	0	.7	
Total			1.9	0	1.9	17.4

[1] No flow.

Storm runoff and sediment yield measured in Yucca Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°20′, long 108°57′, in sec. 25, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.

Drainage area.—0.157 sq mi (101 acres).

Records available.—1954–59, summer months only.

Gage.—Water-stage recorder. Elevation of reference mark is 4,970.86 ft above mean sea level.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1953 to July 1955	2.4
July 1955 to October 1957	.1
October 1957 to November 1959	.3

Capacity.—Original, at spillway (gage height, 68.8 ft): 8.4 acre-ft, December 1953; 5.6 acre-ft, October 1959.

Maximums.—Inflow volume, 6.29 acre-ft or 40 acre-ft per sq mi, July 25, 1955; duration, 90 minutes.

Remarks.—Records excellent. Grazing has been excluded in this drainage basin since measurements were started.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Aug. 13		62.0	0.7	0	0.7	
Sept. 8	60.5	61.2	.3	0	.3	
Sept. 12	61.0	64.9	2.7	0	2.7	
Sept. 23	64.3	67.3	3.5	0	3.5	
Oct. 7	66.8	67.3	.6	0	.6	
Oct. 9	67.2	68.1	1.3	0	1.3	
Total			9.1	0	9.1	58.0
1955						
July 25	63.8	68.7	6.3	0	6.3	
July 31	68.2	68.4	.3	0	.3	
Aug. 2	68.3	68.4	.1	0	.1	
Aug. 7	68.2	69.0	.8	0	.8	
Aug. 24	67.9	68.3	.6	0	.6	
Total			8.1	0	8.1	51.5
1956 [1]						
1957						
May 24		63.3	.2	0	.2	
June 15		63.9	.5	0	.5	
Aug. 5	62.7	63.7	.3	0	.3	
Aug. 8	63.6	65.3	1.2	0	1.2	
Aug. 20	64.6	65.1	.4	0	.4	
Aug. 26	64.9	65.4	.4	0	.4	
Aug. 29–31	65.3	66.3	.9	0	.9	
Oct. 12–13	64.8	65.4	.5	0	.5	
Oct. 18	65.3	65.4	.1	0	.1	
Oct. 20–21	65.3	66.3	1.0	0	1.0	
Total			5.5	0	5.5	35.0
1958 [1]						
1959						
Aug. 19		64.5	.8	0	.8	
Sept. 15–16	63.4	64.9	.9	0	.9	
Sept. 23	64.4	64.7	.3		.3	
Oct. 28	63.7	65.2	1.0	0	1.0	
Nov. 2	64.9	65.1	.2	0	.2	
Nov. 4	65.1	65.2	.1	0	.1	
Total			3.3	0	3.3	21.0

[1] No flow.

Storm runoff and sediment yield measured in Windy Point Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°19′, long 108°56′, in sec. 36, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.

Drainage area.—0.019 sq mi (12 acres).

Records available.—1954–59, summer months only.

Gage.—Water-stage recorder. Elevation of reference mark is 4,969.96 ft above mean sea level.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1953 to July 1955	0. 3
July 1955 to October 1957	. 1
October 1957 to November 1959	. 05

Capacity.—Original, at spillway (gage height, 68.5 ft): 4.5 acre-ft, December 1953; 4.1 acre-ft, November 1959.

Maximums.—Inflow rate, 48.0 cfs, 5:45 p.m., July 25, 1955. Inflow volume, 0.8 acre-ft or 42.0 acre-ft per sq mi, July 25, 1955.

Remarks.—Records excellent. Grazing has been excluded in this drainage basin since measurements were started.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 12		59. 6	0. 2	0	0. 2	
Sept. 23	57. 6	60. 2	. 3	0	. 3	
Sept. 25	60. 0	60. 2	. 1	0	. 1	
Oct. 7	59. 1	60. 1	. 2	0	. 2	
Oct. 9	60. 0	60. 2	. 1	0	. 1	
Total			. 8	0	. 9	42. 0
1955						
July 25		61. 8	. 8	0	. 8	
Aug. 7	60. 4	60. 9	. 1	0	. 1	
Total			. 9	0	. 9	47. 2
1956 [1]						
1957						
June 15–16		59. 9	. 1	0	. 1	
Aug. 5		59. 9	. 1	0	. 1	
Aug. 8	59. 7	61. 3	. 3	0	. 3	
Aug. 26	59. 9	60. 3	. 1	0	. 1	
Aug. 29–30	60. 1	60. 8	. 1	0	. 1	
Oct. 12–13	58. 8	60. 4	. 1	0	. 1	
Oct. 18–20	60. 0	60. 4	. 1	0	. 1	
Oct. 21–22	60. 4	60. 8	. 1	0	. 1	
Total			1. 0	0	1. 0	52. 6
1958 [1]						
1959						
Aug. 19		59. 8	. 1	0	. 1	
Sept. 16	58. 9	60. 2	. 1	0	. 1	
Oct. 28	59. 0	60. 2	. 1	0	. 1	
Total			. 3	0	. 3	15. 7

[1] No flow.

Storm runoff and sediment yield measured in Prairie Dog Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°19′, long 108°56′, in sec. 36, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.

Drainage area.—0.022 sq mi (14 acres).

Records available.—1954–59, summer months only.

Gage.—Water-stage recorder. Elevation of reference mark is 4,944.83 ft above mean sea level.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1953 to July 1955	0.5
July 1955 to October 1957	.2
October 1957 to November 1959	.1

Capacity.—Original, at spillway (gage height, 44.5 ft): 3.0 acre-ft, December 1953; 2.2 acre-ft, November 1959.

Maximums.—Inflow volume, 1.20 acre-ft or 54.5 acre-ft per sq mi, July 25, 1955; duration, 45 minutes.

Remarks.—Records excellent.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 12		37.8	0.3	0	0.3	
Sept. 23	36.4	39.0	.4	0	.4	
Sept. 25	38.7	39.0	.1	0	.1	
Oct. 7	37.8	38.8	.2	0	.2	
Oct. 9	38.6	38.9	.1	0	.1	
Total			1.1	0	1.1	50.0
1955						
July 25		41.0	1.2	0	1.2	
Aug. 2–8	39.9	40.3	.2	0	.2	
Aug. 24	39.2	39.6	.1	0	.1	
Total			1.5	0	1.5	68.2
1956 [1]						
1957						
May 19–26		38.5	.1	0	.1	
June 15		39.4	.2	0	.2	
Aug. 5		39.0	.1	0	.1	
Aug. 8	38.9	40.7	.5	0	.5	
Aug. 20	39.3	39.7	.1	0	.1	
Aug. 26–30	39.3	40.0	.3	0	.3	
Oct. 12–13	38.0	39.5	.1	0	.1	
Oct. 18–22	39.1	39.8	.2	0	.2	
Total			1.6	0	1.6	72.6
1958 [1]						
1959						
Aug. 19		39.1	.1	0	.1	
Sept. 15–16	38.6	39.6	.2	0	.2	
Oct. 1	38.9	39.6	.1	0	.1	
Oct. 28	38.5	39.6	.2	0	.2	
Nov. 2–4	39.2	39.4	.1	0	.1	
Total			.7	0	.7	31.9

[1] No flow.

Storm runoff and sediment yield measured in Middle Basin Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°19′, long 108°56′, in sec. 36, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.

Drainage area.—0.092 sq mi (59 acres).

Records available.—1954–59, summer months only.

Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed as deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
June 1954 to November 1956	1.1
November 1956 to October 1957	.5
October 1957 to November 1958	(1)
November 1958 to November 1959	.1

[1] No measurable deposition.

Capacity.—Original, at spillway (gage height, 31.7 ft): 16.9 acre-ft, December 1953; 15.2 acre-ft, November 1959.

Maximums.—Runoff volume, 5.70 acre-ft or 62.0 acre-ft per sq mi, July 25, 1955.

Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 12		21.2	1.5	0	1.5	
Sept. 23	20.1	22.8	1.8	0	1.8	
Oct. 7	21.8	22.4	.4	0	.4	
Oct. 9	22.3	23.4	.8	0	.8	
Total			4.5	0	4.5	48.8
1955						
July 25	20.4	26.4	5.7	0	5.7	
July 31	25.5	25.8	.5	0	.5	
Aug. 7	25.4	26.3	1.2	0	1.2	
Aug. 24	25.4	26.0	.7	0	.7	
Total			8.1	0	8.1	87.6
1956						
July 30		23.4	2.1	0	2.1	
Aug. 15	22.0	25.1	2.9	0	2.9	
Oct. 24	22.3	26.5	.2	0	.2	
Total			5.2	0	5.2	55.3
1957						
Apr. 23	20.8	21.3	.2	0	.2	
May 16	20.8	21.2	.2	0	.2	
May 24	21.0	22.3	.7	0	.7	
June 15	21.7	23.7	1.5	0	1.5	
July 18	22.2	22.5	.2	0	.2	
Aug. 5	22.0	23.3	1.0	0	1.0	
Aug. 8	21.8	24.9	2.7	0	2.7	
Aug. 20	24.2	24.9	.7	0	.7	
Aug. 26	24.7	24.9	.3	0	.3	
Aug. 29–30	24.9	25.4	.7	0	.7	
Oct. 12	23.8	24.5	.7	0	.7	
Oct. 18	24.4	24.6	.2	0	.2	
Oct. 20	24.5	25.4	.9	0	.9	
Total			10.0	0	10.0	108.6

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1958						
June 6	22.1	22.5	.2	0	.2	
Sept. 12		21.4	.4	0	.4	
Nov. 12		21.6	.5	0	.5	
Total			1.1	0	1.1	11.9
1959						
Aug. 19		22.4	.9	0	.9	
Sept. 15	21.5	22.7	.7	0	.7	
Sept. 23	22.4	22.7	.1	0	.1	
Oct. 1	22.4	22.5	.1	0	.1	
Nov. 1–5	22.0	22.9	.6	0	.6	
Total			2.4	0	2.4	26.1

Storm runoff and sediment yield measured in West Twin Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°19′, long 108°57′, in sec. 36, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.

Drainage area.—0.148 sq mi (95 acres).

Records available.—1954–59, summer months only.

Gage.—Water-stage recorder. Elevation of reference mark is 4,946.43 ft above mean sea level.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1953 to July 1955	1.8
July 1955 to November 1956	(1)
November 1956 to October 1957	.5
October 1957 to November 1958	(1)
November 1958 to November 1959	.2

[1] No measurable deposition.

Capacity.—Original, at spillway (gage height, 43.5 ft): 6.3 acre-ft, December 1953; 3.8 acre-ft, November 1959.

Maximums.—Inflow rate, about 310 cfs, 5:41 p.m., July 25, 1955. Inflow volume, 6.7 acre-ft or 45.1 acre-ft per sq mi, July 25, 1955; duration, 50 minutes.

Remarks.—Records excellent. Spills into East Twin Reservoir.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Aug. 13	----------	37.4	0.2	0	0.2	----------
Sept. 8	36.0	37.1	.2	0	.2	----------
Sept. 12	----------	42.0	2.8	0	2.8	----------
Sept. 23	40.6	44.3	3.3	0	3.3	----------
Sept. 24	44.2	44.3	.1	0	.1	----------
Oct. 7	42.7	43.4	.7	0	.7	----------
Oct. 9	43.3	44.6	1.5	0	1.5	----------
Total	----------	----------	8.8	0	8.8	59.5
1955						
July 25	38.1	45.3	5.9	.8	6.7	----------
July 31	44.5	45.1	.7	0	.7	----------
Aug. 2	44.9	45.0	.1	0	.1	----------
Aug. 7	44.6	45.1	.7	0	.7	----------
Aug. 24	43.8	44.4	.7	0	.7	----------
Total	----------	----------	8.1	.8	8.9	60.2
1956 [1]						
1957						
Apr. 16	----------	39.5	.1	0	.1	----------
May 11	----------	39.6	.1	0	.1	----------
May 15–16	----------	40.0	.2	0	.2	----------
May 19	39.8	40.5	.2	0	.2	----------
May 23–24	40.2	41.3	.5	0	.5	----------
June 15	40.0	42.1	1.0	0	1.0	----------
July 18	40.2	40.5	.1	0	.1	----------
Aug. 5	39.9	41.7	.8	0	.8	----------
Aug. 7–8	41.5	44.0	1.9	0	1.9	----------
Aug. 20	42.8	43.6	.7	0	.7	----------
Aug. 26	43.2	43.7	.5	0	.5	----------
Aug. 29–30	43.5	44.6	1.3	0	1.3	----------
Oct. 12–13	41.9	42.6	.6	0	.6	----------
Oct. 18	42.3	42.4	.1	0	.1	----------
Oct. 20–21	42.4	43.7	1.2	0	1.2	----------
Total	----------	----------	9.3	0	9.3	62.8
1958						
Nov. 12	----------	40.6	.1	0	.1	6.7
1959						
Aug. 19	----------	42.5	1.1	0	1.1	----------
Aug. 26	42.0	42.1	.1	0	.1	----------
Sept. 15–16	41.4	43.3	1.3	0	1.3	----------
Sept. 23	42.4	42.9	.4	0	.4	----------
Oct. 28	41.8	43.5	1.2	0	1.2	----------
Nov. 2–4	43.0	43.3	.3	0	.3	----------
Total	----------	----------	4.4	0	4.4	29.7

[1] No flow.

Storm runoff and sediment yield measured in East Twin Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°19′, long 108°57′, in sec. 36, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.

Drainage area.—0.019 sq mi (12 acres).

Records available.—1954–59, summer months only.

Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener. Elevation of reference mark is 4,940 ft (from topographic map).

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1953 to July 1955	0.4
July 1955 to November 1956	(1)
November 1956 to October 1957	(1)
October 1957 to November 1958	(1)
November 1958 to November 1959	.1

1 No measurable deposition.

Capacity.—Original, at spillway (gage height, 44.7 ft); 6.1 acre-ft, December 1953; 5.6 acre-ft, November 1959.
Maximums.—Inflow volume, 1.86 acre-ft or 98.0 acre-ft sq mi, July 25, 1955.
Remarks.—Records good. Receives spill from West Twin Reservoir.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Aug. 13		37.4	0.3	0	0.3	
Sept. 12	36.4	38.4	.4	0	.4	
Sept. 23	38.0	38.6	.2	0	.2	
Oct. 7	38.4	38.5	.1	0	.1	
Oct. 9	38.5	38.9	.1	0	.1	
Total			1.1		1.1	58.0
1955						
July 25	36.4	41.2	1.9	0	1.9	
July 31	40.6	41.1	.4	0	.4	
Aug. 7	40.7	41.1	.3	0	.3	
Aug. 24	40.1	40.5	.2	0	.2	
Total			2.8	0	2.8	147.0
1956						
July 30		37.3	.1	0	.1	
Aug. 15		37.4	.1	0	.1	
Total			.2	0	.2	10.1
1957						
May 16		38.0	.1	0	.1	
May 24	37.9	39.1	.3	0	.3	
June 15	38.3	39.0	.2	0	.2	
Aug. 5	37.3	38.6	.2	0	.2	
Aug. 8	38.5	39.6	.4	0	.4	
Aug. 20	39.1	39.6	.2	0	.2	
Aug. 26	39.4	39.7	.1	0	.1	
Aug. 29–30	39.6	40.6	.5	0	.5	
Oct. 12	38.8	39.4	.2	0	.2	
Oct. 20	39.2	40.0	.3	0	.3	
Total			2.5	0	2.5	131.0
1958						
Nov. 12		37.4	.1		.1	2.6
1959						
Aug. 19		37.9	.1	0	.1	
Sept. 16		38.5	.2	0	.2	
Sept. 23	38.3	38.5	.1	0	.1	
Oct. 28	38.1	38.9	.3	0	.3	
Total			.7		.7	37.0

Storm runoff and sediment yield measured in West Badger Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°19′, long 108°57′, in sec. 36, T. 8 S., R. 104 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.
Drainage area.—0.141 sq mi (90 acres), 1954–56; 0.313 sq mi (200 acres), 1957–59.
Records available.—1954–59, summer months only.
Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
June 1954 to November 1956	2. 3
November 1956 to October 1957	. 1
October 1957 to November 1959	. 4

Capacity.—Original, at spillway (gage height, 32.2 ft): 22.4 acre-ft, December 1953; 19.6 acre-ft November 1959.
Maximums.—Inflow volume (combined area), 12.92 acre-ft or 41.3 acre-ft per sq mi, July 25, 1955.
Remarks.—Records good. Receives spill from West Basin Reservoir. Reservoirs combined to show runoff from both drainage areas, because spill from West Basin Reservoir cannot be determined accurately.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954 [1]						
Sept. 12			3. 8	0	3. 8	
Sept. 23			4. 0	0	4. 0	
Oct. 7			1. 2	0	1. 2	
Oct. 9			2. 4	0	2. 4	
Total			11. 4	0	11. 4	36. 5
1955 [1]						
July 25			12. 9	0	12. 9	
July 31			3. 5	0	3. 5	
Aug. 7			. 4	0	. 4	
Aug. 24			1. 7	0	1. 7	
Sept. 18			. 6		. 6	
Total			19. 1	0	19. 1	61. 0
1956 [1]						
Aug. 15			. 5	0	. 5	
Aug. 19			. 6	0	. 6	
Oct. 24			. 3	0	. 3	
Total			1. 4	0	1. 4	4. 5

See footnotes at end of table.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1957						
Apr. 25 [2]	------------	21.3	.1	0	.1	------------
May 16	------------	21.7	.4	0	.4	------------
May 19	21.3	22.0	.3	0	.3	------------
May 24	21.8	24.1	.6	0	.6	------------
June 15	21.2	24.9	2.8	0	2.8	------------
Aug. 5	22.2	24.4	1.7	0	1.7	------------
Aug. 8	24.3	27.3	4.1	0	4.1	------------
Aug. 20	26.2	26.7	.7	0	.7	------------
Aug. 26	26.4	27.0	1.0	0	1.0	------------
Aug. 30	26.9	27.9	2.0	0	2.0	------------
Oct. 12	25.3	26.5	1.7	0	1.7	------------
Oct. 20	26.2	27.7	2.7	0	2.7	------------
Total	------------	------------	18.1	0	18.1	57.6
1958 [3]						
1959						
Aug. 19	------------	24.2	2.1	0	2.1	------------
Aug. 26	23.4	23.7	.3	------------	.3	------------
Sept. 15	21.8	24.7	2.3	0	2.3	------------
Sept. 23	24.2	24.7	.5	0	.5	------------
Oct. 1–5	23.0	25.3	2.3	0	2.3	------------
Total	------------	------------	7.5	0	7.5	24.0

[1] Flow to West Basin and West Badger Reservoirs combined, gage heights do not apply.
[2] All flow measured in West Badger Reservoir.
[3] No flow.

Storm runoff and sediment yield measured in Southeast Reservoir, Badger Wash basin, Colorado

Location.—Lat 39°18′, long 108°55′, in sec. 6, T. 9 S., R. 103 W., on unnamed tributary of Badger Wash near Mack, Mesa County, Colo.

Drainage area.—0.484 sq mi (310 acres).

Records available.—1954–59, summer months only.

Gage.—Reference mark. High-water marks observed; measurements made weekly or oftener.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
June 1954 to November 1956	2.4
November 1956 to October 1957	1.4
October 1957 to November 1958	(1)
November 1958 to November 1959	1.2

[1] No measurable deposition.

Capacity.—Original, at spillway (gage height, 27.7 ft): 10.5 acre-ft, June 1954; 8.1 acre-ft, November 1956. Dam raised November 1956. Capacity at spillway (gage height, 30.0 ft): 27.3 acre-ft, November 1956; 24.7 acre-ft, November 1959.

Maximums.—Inflow volume, 9.70 acre-ft or 20.1 acre-ft per sq mi, July 30, 1956.

Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 12	----------	21.5	2.1	0	2.1	----------
Sept. 23	19.8	25.5	5.7	0	5.7	----------
Oct. 7	22.2	24.0	1.9	0	1.9	----------
Oct. 9	23.9	26.5	3.8	0	3.8	----------
Total	----------	----------	13.5	0	13.5	28.0
1955						
June 14	19.8	22.4	2.0	0	2.0	----------
July 25	19.6	27.3	8.9	0	8.9	----------
July 31	25.4	26.2	1.2	0	1.2	----------
Aug. 7	25.0	25.3	.5	0	.5	----------
Aug. 25	23.5	23.8	.4	0	.4	----------
Total	----------	----------	13.0	0	13.0	26.8
1956						
July 30	----------	27.7	8.1	1.6	9.7	----------
Aug. 15	25.2	27.7	4.4	.9	5.3	----------
Oct. 24	23.3	23.7	.4	0	.4	----------
Total	----------	----------	12.9	2.5	15.4	31.9
1957						
Apr. 23	----------	22.2	.5	0	.5	----------
May 16	----------	21.7	.2	0	.2	----------
May 24	21.5	22.7	.8	0	.8	----------
June 15	22.0	25.1	3.4	0	3.4	----------
Aug. 5	22.1	23.1	.9	0	.9	----------
Aug. 8	22.8	23.9	1.1	0	1.1	----------
Aug. 20	22.6	23.8	1.2	0	1.2	----------
Aug. 26	22.9	24.6	1.9	0	1.9	----------
Aug. 30	24.3	28.3	7.7	0	7.7	----------
Oct. 12	24.9	26.4	2.6	0	2.6	----------
Oct. 18	25.9	26.1	.4	0	.4	----------
Oct. 20	26.0	27.0	2.0	0	2.0	----------
Oct. 22	26.9	27.0	.2	0	.2	----------
Total	----------	----------	22.9	0	22.9	47.4
1958						
June 6	----------	24.0	1.4	0	1.4	2.9
1959						
Aug. 19	----------	26.7	5.2	0	5.2	----------
Aug. 26	25.6	25.9	.4	0	.4	----------
Sept. 15	24.2	27.2	5.1	0	5.1	----------
Sept. 23	26.9	27.1	.4	0	.4	----------
Oct. 28–Nov. 4	25.0	27.3	3.7	0	3.7	----------
Total	----------	----------	14.8	0	14.8	30.6

DOLORES RIVER BASIN

DRY CREEK BASIN, COLORADO

Measurements were made in Middle Reservoir to obtain data on runoff and sediment yield from small drainage basins in the high-plateau country of western Colorado. The reservoir is located on an unnamed ephemeral stream that drains one of several small parallel basins on the south side of Dry Creek Valley. Streams draining these parallel basins combine to form Dry Creek, which flows north to San Miguel River, a tributary of the Dolores River. The area is typical of large areas in the high-plateau country of western Colorado and eastern Utah.

TOPOGRAPHY

Dry Creek basin occupies a broad shallow synclinal trough with a northwestward trending axis. The basin has a wide floor of gentle gradient and is bordered on both sides by slopes that rise to steep ridges at the perimeter. The Middle Reservoir basin is located in the south end of Dry Creek basin. It slopes northward from high prominent buttes on the southern divide. Although the valley side slopes are steep, the interior of the basin is relatively flat and slopes average about 2 percent. The elevation ranges from 6,400 to 7,400 feet. Most of the relief occurs along the border areas.

GEOLOGY

Bedrock formations underlying the Middle Reservoir basin include the Mancos shale and Mesaverde formations of Late Cretaceous age. The basal sandstone member of the Mesaverde formation forms the buttes in the southern part, and the wide interior of the basin is underlain by the Mancos shale. A large area in the central part of the basin is covered by recent alluvium, which has a maximum thickness of about 12 feet.

VEGETATION

The basin supports a good stand of vegetation, consisting of intermixed sagebrush and grass with a density of about 30 percent. Moderately dense stands of pinyon and juniper, covering about 20 percent of the basin, occupy the higher ridges and buttes in the south end of the basin.

EROSION

Sheet erosion is active in parts of the basin, but gullying is the most destructive and probably accounts for the major part of the erosion in the basin. Discontinuous gullies as much as 11 feet deep and some several thousand feet long have formed along the floor of the basin. Many of these have cut through the alluvium into the underlying shale. The reach of the channel immediately above the reservoir is not gullied and shows definite evidence of aggradation. Deposition of sediment from upstream sources in this reach doubtless is responsible for the low sediment yield measured in the reservoir.

PRECIPITATION

The climate of this area is typical of the high-plateau country of western Colorado. Precipitation is relatively high, sufficient to produce good range forage and support dry farming in some years. Slightly more than half of the average annual precipitation occurs in the winter period, most of it as snow. A typical summer storm is of short duration but high intensity. July and August are the months of greatest precipitation.

The nearest weather station is located at Norwood, 21 miles northeast of the reservoir at an elevation of 7,017 feet. Precipitation at this station is believed to be representative of the Middle Reservoir basin. The following data are taken from records of the U.S. Weather Bureau station at Norwood.

Mean precipitation, 1932–59

	Inches
Annual	15.92
May to September	7.24
October to April	8.68
Maximum month (August)	2.17

Frequency of 1-day precipitation events of selected magnitude at Norwood, April to October, 1932–55

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Percent of years in which at least one event occurred	91	34.7	17.4	0
Average number of events per year	4.3	.4	.17	0

RUNOFF

The major part of the runoff is produced by summer and fall rainstorms; a smaller amount is produced from snowmelt in late winter and spring. The summer storms produce both the maximum peak discharges and the greater part of the volume. Measurement of runoff from both summer storms and snowmelt are shown in the following table. The average annual runoff and sediment yield from the contributing area are given in table 3.

Storm runoff, snowmelt and sediment yield measured in Middle Reservoir, Colorado

Location.—Lat 38°03′, long 108°37′, in SE¼ sec. 22, T. 44 N., R. 16 W., on unnamed tributary of Dry Creek near Naturita, San Miguel County, Colo.

Drainage area.—1.9 sq mi.

Records available.—October 1948 to September 1955.

Gage.—Staff gage. Measurements made after each storm and occasionally between storms.

Runoff determinations.—Contents of reservoir and volume of stored inflow computed from a stage-capacity curve for reservoir. Spill based on computation.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
1938 to October 1949	3.3
October 1949 to August 1953	3.4

Capacity.—At spillway (elevation, 10.8 ft in 1948, 10.6 ft in 1949, 10.3 ft in 1954; gage height, 10.8 ft): 47.3 acre-ft, 1938; 40.6 acre-ft, August 1954.

Maximums.—Inflow volume, 43.1 acre-ft or 22.7 acre-ft per sq mi, Aug. 3, 1953.
Remarks.—Records fair, except that those for spill are poor.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Total inflow (acre-ft)
	Before inflow	After inflow			
1949					
Nov. 10	3.2	3.4	0.3	0	0.3
1950					
Feb. 11	2.4	3.0	.5	0	.5
Sept. 19	2.4	5.7	7.3	0	7.3
Total			7.8	0	7.8
1951					
Aug. 3	2.4	3.4	1.0	0	1.0
Aug. 20	3.0	3.6	.8	0	.8
Aug. 28	3.3	6.6	10.4	0	10.4
Oct. 10	4.0	4.9	2.3	0	2.3
Nov. 11	4.2	4.6	1.1	0	1.1
Total			15.6	0	15.6
1952					
Jan. 14–18	4.1	4.4	.7	0	.7
Jan. 19–25	4.4	4.7	.8	0	.8
Mar. 1–13	3.8	5.7	5.6	0	5.6
Mar. 14–28	5.6	5.8	.7	0	.7
Total			7.8	0	7.8
1953					
July 18	2.4	6.5	10.8	0	10.8
Aug. 3	5.8	10.3	31.1	12.0	43.1
Oct. 23	5.8	9.3	22.1	0	22.1
Total			64.0	12.0	76.0
1954					
Sept. 4	2.4	5.0	2.0	0	2.0
Sept. 25	4.6	9.2	23.5	0	23.5
Total			25.5	0	25.5

YAMPA RIVER BASIN

LITTLE ROBBER CREEK, WYOMING

The Little Robber Creek basin is in south-central Wyoming about 12 miles northwest of Baggs. The area is tributary to Muddy Creek and the Little Snake River. In 1953 the Bureau of Land Management constructed a retarding reservoir to control runoff used in a water spreader located about 1 mile downstream in the lower part of the basin. This reservoir, with a capacity of 666 acre-feet, is used for the measurement of sediment and runoff.

TOPOGRAPHY

The drainage divide in the Little Robber Creek basin is formed by steep sandstone-capped ridges. From the divide the terrain slopes abruptly to a large central area of uniform gentle slopes that is incised by Little Robber Creek and its tributaries, which occupy relatively narrow valleys with moderately sloping sides. In its lower reaches, next to Muddy Creek, the stream has formed a large outwash plain, part of which is used for water spreading. The total relief in the basin is about 1,000 feet most of it in the steep slopes leading from the stream to the central area and from there to the divide.

GEOLOGY

The entire Little Robber Creek basin is underlain by the Wasatch and Green River formations of Tertiary age, consisting mainly of shale, siltstone, marlstone, and sandstone. Sandstone and marlstone cap the ridges and form the steep to precipitous slopes common to these parts. The shale and siltstone underlie the gently sloping central area and crop out along the valley sides. Alluvium, as much as 20 feet thick, occurs along the floors of both the main and tributary streams.

The residual soil formed on the shale is heavy and impervious but is not particularly erodible, except by sheet erosion, as indicated by the general lack of rills and other types of erosional scars in the central area and on the valley sides. Soils developed on the colluvial deposits, located along the base of the steeper slopes, and on the alluvium are more pervious than the residual soil and are less susceptible to sheet erosion but are vulnerable to gullying.

VEGETATION

The predominant vegetation in the basin consists of sagebrush mixed with grass. Scattered saltsage grows on some of the more impervious flats in the area and the higher, steeper slopes are occupied by phlox, one of the lesser known range plants. Dense growths of large sagebrush cover the narrow terraces that parallel both sides of the main channel above the dam. In general, the vegetation throughout the basin is sparse, owing chiefly to the low rainfall but also in part to past overgrazing by sheep.

EROSION

Sparse vegetation appears to be the main cause of the severe erosion within the basin. Sheet erosion is active on the thinly vegetated hillside slopes; most of the stream channels are deeply gullied and many are incised through the full thickness of the alluvium and into the bedrock. Where this has occurred the channels are stabilized and bank cutting has practically ceased. However, many of these gullies are still advancing headward and therefore contribute to the sediment load of the stream.

PRECIPITATION AND RUNOFF

Records from nearby U.S. Weather Bureau stations indicate that the long-term average precipitation in the area is about 13 inches.

Of this, slightly less than half falls as snow in the winter period, but this amount is the more important in providing runoff. The snow, which generally accumulates as drifts in stream channels and other low spots, commonly remains on the ground until March or April. Melting of these drifts generally constitutes the major part of the annual runoff. Summer rains occur frequently from July to mid-September. Those of high intensity produce the summer runoff.

There were no precipitation stations in the vicinity of Little Robber Creek basin until 1954, when a recording gage was installed in the lower part of the basin. A second recording gage was located in the upper part of the basin in 1955. Both gages are operated during the summer season only. The long-term precipitation data given in the following tabulation were obtained from the U.S. Weather Bureau station at Dixon, Wyo., about 40 miles southeast of the basin.

Mean precipitation at Dixon, 1920–58

	Inches
Annual	12. 95
May to October	6. 90
November to April	6. 05
Maximum months:	
May	1. 34
October	1. 34

Frequency of 1-day precipitation events of selected magnitude at Dixon, May to October

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Percent of years in which at least one event occurred, 1939–55	100	30. 0	15. 0	15. 0
Average number of events per year during—				
1939–58	2. 5	. 35	. 15	. 15
1954–58 [1]	2. 0	0	0	0

[1] Recording precipitation gages in Little Robber Creek basin.

Between 1954 and 1957, the spring runoff was stored in the reservoir for release at a later date when it could be used more efficiently in water spreading. This runoff was measured by converting change in stage to volume by use of the stage-capacity curve. The summer runoff is routed directly through the reservoir and is measured at a gaging station equipped with a water-stage recorder located 0.5 mile below the dam and at about an equal distance above the spreader area. Beginning in 1957, all runoff was routed through the reservoir and measured at this gaging station. The spring snow-melt, the summer storm runoff, and the annual sediment yield are shown in the following tabulation. The mean annual sediment yield from the drainage area for the period 1954–1957 is given in table 3. Measurements of sediment yield were discontinued in 1958, when the flow was routed directly through the reservoir.

Storm runoff and sediment yield measured in Little Robber Creek retarding reservoir, Wyoming

Location.—Lat 41°13′, long 107°43′ in sec. 14, T. 14 N., R. 92 W., 2 miles upstream from bridge on U.S. Highway 130 near Baggs, Carbon County, Wyo.

Drainage area.—8.5 sq mi.

Records available.—1954-58, no dates of inflow for winter months.

Gage.—Reference mark and crest-stages observed. Gage read about once weekly. Continuous water-stage recorder located on outflow channel of reservoir, about 0.5 mile below reservoir.

Runoff and discharge determinations.—Capacity of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir. Gaging station on main channel 0.5 mile downstream from reservoir used to compute outflow from reservoir.

Sediment yield.—Computed from deposition in reservoir shown by successive surveys. Total sediment yield for period August 1954 to June 1956, 11.0 acre-ft.

Capacity.—Original, at spillway (gage height, 106.7 ft): 666 acre-ft, August 1954; 655 acre-ft, June 1956. Only slight change in capacity after June 1956, when outlet pipe remained open.

Maximums.—Inflow volume, 288 acre-ft or 33.9 acre-ft per sq mi, July 28 to Aug. 2, 1956.

Remarks.—Records good, except those for small inflows, which are fair. Reservoir equipped with gated 24-inch outlet pipe (gage height of sill, 68.0 ft). Gate on reservoir left open after 1956 season. Runoff computed on basis of records from gaging station below reservoir.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
May 7	71.6	68.0	0	6.1	0	
May 22	67.3	68.0	.5	3.5	4.0	
Oct. 8	66.2	68.0	2.6	4.0	6.6	
Oct. 9	68.0	68.0	0	3.0	3.0	
Total			3.1	16.6	13.6	1.6
1955						
Nov. 1954–Apr	66.9	87.3	148.0	0	148.0	
May 13	86.3	86.0	0	2.3	0	
June 13	84.8	68.0	0	111.0	0	
July 11	67.9	68.0	.2	11.3	11.5	
Aug. 6	67.8	68.0	.3	17.4	17.7	
Aug. 17	67.7	68.0	.4	37.6	38.0	
Sept. 17	67.4	68.0	.8	2.5	3.3	
Sept. 20	68.0	68.0	.0	1.8	1.8	
Sept. 25	67.8	68.0	.3	24.6	24.9	
Total			150.0	208.5	245.2	28.8

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1956						
Nov. 1955–Mar. 14	68.3	75.0	23.7	0	23.7	
Mar. 17–20	75.0	100.2	401.0	0	401.0	
April 17–18	100.0	96.2	0	103	0	
April 27–May 2	96.1	68.0	0	338	19.6	
June 9–10	68.0	68.0	0	5.0	5.0	
July 2–3	68.0	68.0	0	19.7	19.7	
July 12–13	68.0	68.0	0	11.3	11.3	
July 28–Aug. 2	68.0	68.0	0	288.0	288.0	
Oct. 24	68.0	68.0	0	9.5	9.5	
Total			424.7	774.5	777.8	91.5
1957 [1]						
Mar. 14–31					138.4	
April 1–17					26.1	
April 23–25					4.6	
April 28–May 15					34.2	
May 21–25					2.6	
June 13					5.8	
June 15–17					8.4	
July 19					1.6	
Aug. 8					1.2	
Aug. 27–31					1.6	
Sept. 14					2.0	
Total					226.5	26.6
1958 [1]						
July 21–22					6.8	
July 26–27					1.2	
Sept. 12					1.6	
Sept. 13					19.6	
Sept. 14					7.1	
Sept. 23					.6	
Sept. 24					5.8	
Total					42.7	5.0

[1] Gage heights not used; flow measured at gaging station downstream.

GREEN RIVER BASIN

PRICE RIVER AND SALERATUS WASH BASINS, UTAH

The Price River, which heads on the Wasatch Plateau in central Utah north and west of Price, flows southeastward through a broad irregularly dissected strike valley to a low east-west divide near Woodside, where it swings abruptly east and cuts through the Book Cliffs in a deep canyon to its junction with Green River. The continuation of the strike valley southeastward from the low divide is drained by Saleratus Wash. Except for the low divide separating the two, the Price River and Saleratus Wash basin virtually compose a single physiographic unit with similar drainage-basin characteristics throughout.

In 1945–50 studies were made on 15 small reservoir basins located in central Utah to evaluate rates of sediment yield in relation to drainage-basin characteristics (King and Mace, 1953). Of the 15 reservoirs, 7 are located in the Price River basin and 2 in the Saleratus Wash basin. Each of these study areas is considered representative of the valley floors but not of the adjacent steep slopes of the Book

Cliffs. The rate of sediment yield and a brief description of the basin characteristics are repeated here for comparison with other areas.

TOPOGRAPHY

The drainage basin of each reservoir is limited to the relatively smooth valley floor. A few of the basins contain sizeable areas of the gently dipping gravel-capped terraces of low to moderate relief alined along the front of the Book Cliffs, but none include any part of the rugged and steep slopes of the Book Cliffs. Elevations in the basins range from 4,200 to 5,700 feet. The basins in which Dugout, Chuck Valley No. 2, and Spider Reservoirs (see table 3 for locations) are located have a gently rolling subdued topography, whereas the other basins are characterized by low interior valley slopes and a steep peripheral area near the boundaries. Relief ratios obtained at eight of the basins range from 0.007 to 0.048.

GEOLOGY

The drainage basins of the nine reservoirs are underlain by shale and sandstone of Jurassic and Cretaceous age. The areas lie along the north margin of the San Rafael Swell uplift and the rocks have structural dips that average from 2° to 5°. Cuestas, separated by intervening well-dissected areas, are the dominant surface features, except for a belt along the base of the Book Cliffs that is, in part, occupied by many pediment remnants. The smooth gravel-capped pediments contrast sharply with the rough bedrock surfaces of the intervening areas.

Except for the gravel-capped pediments, the soils reflect the character of the bedrock. Loose sandy soils occur on the three drainage basins underlain by the Entrada sandstone and the Ferron sandstone member of the Mancos shale. The remaining six reservoirs are underlain either by the Morrison formation or the Mancos shale, both of which weather to a fine-textured, relatively impermeable residual soil that is highly vulnerable to erosion. The locally extensive alluvial deposits along the larger stream channels are likewise generally fine grained, owing to the preponderance of shale in the drainage basin.

VEGETATION

Elevation and type of soil appear to control vegetation to a considerable extent. Pinyon and juniper trees grow on the sandy ridges and higher cuestas, but the lower sandy slopes support several varieties of grass. Rabbitbrush, greasewood, shadscale, and sagebrush predominate on the alluvial fills along the stream channels. The residual soils derived from shale support a sparse growth of saltsage, pricklypear cactus, and some grass, but many large areas are barren. Owing to its sparsity, vegetation probably has little influence on either runoff or erosion.

EROSION

The lack of rills and other kinds of erosional scars on most of the residual soils indicate that the sediment contribution from this source is low, except for localized areas where active sheet erosion is evident. Gullying in the alluvium is the most prominent type of erosion in each of the basins and appears to be responsible for most of the sediment carried by the streams. The alluvial deposits, which are as much as several hundred feet in width, 20 feet in depth, are extensive and are distributed along the principal streams and their tributaries. Reservoir basins with intricately dissected gully systems have the highest rate of sediment yield.

Measurements made by King and Mace (1953) show conclusively that in the areas studied drainage basins underlain by shale have consistently higher rates of sediment yield than do basins underlain by sandstone. This condition is attributed to the fact that areas of shale have less permeable soils and correspondingly higher runoff rather than to any inherent difference in resistance to erosion of the sediments themselves. It is significant that within lithologic groups highest sediment yields are associated with gullying and not sheet erosion.

PRECIPITATION

The climate throughout the area containing the reservoirs is classed as semiarid with precipitation generally decreasing southward and eastward from the Book Cliffs. Records obtained at U.S. Weather Bureau stations show that at Hiawatha, located at the base of the Book Cliffs, the mean annual precipitation is 12.95 inches (1918–58); at Price, in the west-central part of the Price River valley, 9.37 inches (1912–58); and at Green River, 40 miles southeast of Price on the east side of the San Rafael Swell, 5.91 inches (1896–1958). Approximately two-thirds of the annual precipitation falls in the 6-month period April through September, mostly during thunderstorms. Practically all the runoff occurs as a result of these storms and is local in character since the storms generally cover only a few square miles. Snowmelt is not an important source of runoff in any of the basins.

The following precipitation data are taken from records obtained at the three stations.

Mean precipitation,[1] 1918–58

	Inches
Annual	9. 40
April through September	5. 06
October through March	4. 36
Maximum month (August)	1. 28

[1] Average at 3 stations.

Frequency of 1-day precipitation events of selected magnitude from April to September

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Hiawatha, 1918–50:				
Percent of years in which at least 1 event occurred	95.3	61.9	19	4.8
Average number of events per year	4.2	.8	.2	.05
Price, 1912–50:				
Percent of years in which at least 1 event occurred	81.0	33.3	0	0
Average number of events per year	2.5	.4	0	0
Green River, 1896–1950:				
Percent of years in which at least 1 event occurred	61.9	23.8	0	0
Average number of events per year	1.1	.2	0	0

No runoff records were obtained at any of the reservoirs, but the average sediment yield from the drainage basins, obtained by spudding the reservoirs, is shown in table 3.

SAN RAFAEL RIVER BASIN, UTAH

The studies made by King and Mace (1953) included six small reservoir basins located on tributaries of the San Rafael River in east-central Utah. These basins are considered typical of larger areas of similar lithology in the San Rafael River basin and of other parts of the Colorado Plateau characterized by steep terrain and low precipitation.

TOPOGRAPHY

The six reservoirs are located in the central part of the San Rafael Swell on tributaries of the San Rafael River. This is an area of rugged and picturesque topography formed by differential erosion of moderate- to steep-dipping shale and sandstone beds. The result is a series of deep canyons and narrow strike valleys, separated by high cliffs and hogback ridges. Each of the drainage basins of the reservoirs, with the exception of Millers Pond basin (see table 3), has this general type of terrain. The basins range in elevation from 4,900 to 6,400 feet and several are traversed by prominent erosional scarps, many exceeding 200 feet in height. In contrast, the Millers Pond basin has gently rolling topography and a maximum relief of 75 feet. The average relief ratio for all the basins is greater than 0.04.

GEOLOGY

Extensive outcrops of the San Rafael group and the overlying Morrison formation of Jurassic age, and the Mancos shale of Late Cretaceous age encircle the central part of the San Rafael Swell, and either individually or in combination underlie the basins of the reservoirs. Sandstones in the San Rafael group, including the Entrada, Curtis, and Summerville formations, generally cap the ridges and form the cliffs and steeper slopes, and the shales underlie the valleys. Soils developed on the formations are similar to those found in the Price River and Saleratus Wash basins. They range from light-textured sandy soils developed on the sandstones to heavy impermeable clay soils on the Carmel, Morrison, and Mancos formations. Alluvial deposits occupy the lower central parts of the basin along the stream channels.

VEGETATION

The type and density of vegetation in these basins are similar to those in the Price River and Saleratus Wash basins. Juniper and pinyon trees predominate on the high sandy ridges and grasses on the lower sandy areas. Sparse growths of saltsage, shadscale, and pricklypear cactus mixed with grass grow on the heavy shale soils. The alluvial fills support vigorous growths of rabbitbrush and big sagebrush.

EROSION

Sheet erosion and rilling are the major types of erosion in the four basins that show the lowest sediment yield, and gullying predominates in the two basins, Cinderella and Summit, with the highest yield (see table 3). Considering the very steep topography and high relief ratio of these basins, the sediment yield is unusually small as compared to other basins of similar lithology. One suggested explanation for this condition is the fact that basins with the steeper slopes seldom have extensive alluvial fills along the channels, and hence gullying erosion does not develop.

PRECIPITATION

The precipitation pattern in the San Rafael basin is similar to that in the Price River basin to the north, except that the annual average is somewhat lower. At Castle Dale, located near the base of the Book Cliffs west of the San Rafael Swell, the long-term average rainfall (1904–50) obtained at the U.S. Weather Bureau station, is 8.96 inches. As noted previously, the average at Green River, about 50 miles to the east, is 6.10 inches. There are no precipitation gages in the central part of the San Rafael Swell; but, judging from the vegetation and other evidence, the annual average probably does not exceed 6 inches.

As indicated in the following table, about two-thirds of the annual precipitation falls in the 6-month period April–October, mostly during small storms that produce less than 0.5 inch of precipitation. The occasional storms of larger magnitude produce the small amount of local runoff that originates in the area.

The following precipitation data are taken from the records of U.S. Weather Bureau stations at Castle Dale and Green River and represent an average of the two stations.

Mean precipitation, 1930–50

	Inches
Annual	6. 70
April to October	4. 62
November to March	2. 08
Maximum months:	
July [1]	. 96
August [2]	. 96

[1] Castle Dale.
[2] Green River.

Frequency of 1-day precipitation events of selected magnitude at Castle Dale, April to October, 1930–50

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Percent of years in which at least one event occurred	85. 8	7. 1	0	0
Average number of events per year	3. 0	. 1	0	0

No records of runoff were obtained at the four reservoirs. The average annual sediment yield from the reservoir basins is shown in table 3.

CRESCENT WASH BASIN, UTAH

Crescent Wash, located in Grand County, eastern Utah, drains a part of the Book Cliffs. It is considered typical of the many ephemeral streams that rise along the Book Cliffs and was purposely selected to obtain information on rates of runoff and sediment yield from this type of terrain. Measurements were made in a reservoir, located about half a mile below the base of the Book Cliffs, constructed by the Bureau of Land Management to regulate the flow for use in water spreading downstream.

TOPOGRAPHY

The drainage basin of Cresent Wash Reservoir extends from relatively flat terrain at the base of the Book Cliffs through the cliff line to somewhat lesser slopes above. From the flat area at the base, which is only a small fraction of the entire area, the cliffs rise several hundred feet on a slope equivalent to the angle of repose for shale to a massive sandstone layer 50 to 100 feet thick with a precipitous slope. Above the massive sandstone the terrain is composed of a series of benches formed by alternate beds of shale and sandstone.

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Maximum relief in the basin is 3,000 feet, and the elevation ranges from 5,000 to 8,000 feet. The length of the basin is 8.5 miles, and the slope averages about 350 feet per mile.

GEOLOGY

The upper part of the basin is underlain by the Mesaverde group of Late Cretaceous age, consisting of alternate layers of sandstone, shale, and coal beds. The basal member of this group is the massive sandstone that caps the Book Cliffs. The Mancos shale is exposed in the steep slopes below the sandstone and underlies the flats at the base of the cliffs. The more gentle slopes in the area have a thin residual soil mantle, consisting mainly of disintegrated shale mixed with angular sandstone spalls dislodged from the higher sandstone ledges. The steeper slopes are practically devoid of any mantle, except for colluvium at the base of the cliffs.

VEGETATION

Vegetation in the basin is sparse and is largely confined to the more gently sloping benchlands in the upper part of the basin and to the flat area in the lower part. Juniper and pinyon trees mixed with scattered clumps of grass predominate in the upper part of the basin, and sparse grass mixed with brush and annual weeds forms a fair cover on the flats below the cliffs. The cliffs are barren, except for a few hardy shrubs at the base and scattered pinyon trees growing in joints in the bedrock. The vegetation appears to have little if any effect on runoff or erosion.

EROSION

Owing to the steep slopes and sparse cover of vegetation, erosion is active throughout the basin, and possibly the most important factor controlling the rate of sediment yield is the scarcity of easily erodible material. The thin mantle of weathered rock present on the more gently sloping part of the basin is vulnerable to sheet erosion, as evidenced by the many rills and channels cutting through the deposits. There are no deep deposits of alluvium in the basin, and consequently no gullies have developed. Practically all stream channels, including the smaller ones, have cut through the mantle and are incised in the bedrock. These probably are not deepening or widening to any extent, but they do tend to keep the slopes clear and they prevent any large accumulation of loose material. Because of the steep slopes and the close integration of the drainage network, sediment reaching any of the channels is funneled directly to the reservoir since it has practically no chance for deposition en route.

PRECIPITATION

Owing to the range in elevation within the basin, precipitation in the upper parts is probably considerably greater than in the lower part. Two precipitation gages were installed in the basin, one at the reservoir near the base of the Book Cliffs and the other upstream on top of the "Cliffs" about 300 feet higher, but records obtained during the 4 years of operation failed to show any appreciable difference in yearly amounts. However, rainfall in this period was below average.

Based on records from the U.S. Weather Bureau station at Thompson, located 6 miles southeast of the reservoir and 1 mile from the Book Cliffs, more than half of the annual precipitation falls during the 6-month period May through October. High-intensity cloudburst storms are common from July through early October and furnish the major part of the runoff. The winter precipitation, which consists of light snows, seldom produces appreciable runoff.

The following data are taken from records obtained at Thompson and are believed to be representative of precipitation along the base of the Book Cliffs. As noted previously, the variation in precipitation between the lower and higher parts of the basin is not clearly defined by the short-term records obtained at the two gages installed during the study.

Mean precipitation, 1911–13, 1916, 1921–51

	Inches
Annual	8.60
May through October	4.84
November to April	3.76
Maximum month (October)	1.40

Frequency of 1-day precipitation events of selected magnitude at Thompson, April to October, 1911–13

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Percent of years in which at least one event occurred	94	44	14	0
Average number of events per year	3.1	.53	.14	0

RUNOFF

Storm runoff was measured in the reservoir by converting changes in stage, taken from a recording gage, to volume by use of stage-capacity curve. It was necessary to discontinue the station in 1958 because of the loss of storage in the reservoir by sedimentation and the resultant heavy damage to the spillway. The mean annual runoff and sediment yield for the period of record are given in table 3.

Storm runoff and annual sediment yield measured in Crescent Wash Reservoir, Utah

Location.—Lat 38°59′, long 109°49′, in sec. 16, T. 21 S., R. 19 E., on Crescent Wash, 2¾ miles upstream from bridge on U.S. highway 6 and 5 miles west of Thompson, Grand County, Utah.

Drainage area.—19.0 sq mi.

Records available.—1954–57, summer months only. Station discontinued in 1958 because of low reservoir capacity and cutting in spillway.

Gage.—Water-stage recorder. Datum of gage is 5,033.66 ft above mean sea level.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
July 1954 to July 1955	56.0
July 1955 to December 1957	70.0

Capacity.—Original, at spillway (gage height, 24.5 ft): 160 acre-ft, July 11, 1954; 34 acre-ft, December 1957.

Maximums.—Inflow volume, 662 acre-ft or 34.9 acre-ft per sq mi. Aug. 30, 1957.

Remarks.—Records fair. Reservoir equipped with 30-inch ungated outlet pipe (gage height of sill, 12.1 ft). Elevation of sill changed in winter of 1954–55; new gage height of sill, about 13.5 ft. Gage heights vary because of sediment deposition in reservoir.

Date of flow	Gage height (feet)			Spill (acre-ft)	Inflow	
	Before inflow	After inflow	Inflow stored (acre-ft)		Total (acre-ft)	Acre-ft per sq mi
1954						
Sept. 13	5.00	22.81	131.0	0	131.0	
Sept. 23	20.82	24.30	53.5	0	53.5	
Sept. 24	24.30	24.43	1.5	0	1.5	
Oct. 1–2	22.92	16.78	0	78.0	0	
Oct. 9	14.00	16.86	11.0	0	11.0	
Oct. 24	16.56	16.64	1.0	0	1.0	
Oct. 27	16.61	15.36	0	10.8	0	
Total			198.0	88.8	198.0	10.4
1955 [1]						
1956						
July 22	7.54	14.26	0	2.7	2.7	
Aug. 1	12.26	13.76	0	.2	.2	
Aug. 16	12.10	14.61	0	17.3	17.3	
Oct. 23	11.04	14.61	0	13.8	13.8	
Total			0	34.0	34.0	1.8
1957						
May 24	14.00	14.00	0	3.4	3.4	
June 10–11	14.00	14.10	0	.7	.7	
June 15–16	14.00	14.23	0	1.3	1.3	
Aug. 8	14.00	14	0	3.4	3.4	
Aug. 20, 21	14.00	14.35	0	73.1	73.1	
Aug. 30	15.13	20.30	81.0	581.0	662.0	
Oct. 20–22	20.12	24.73	2.4	206.2	208.6	
Nov. 2–4	20.49	25.24	0	141.4	141.4	
Total			83.4	1010.5	1093.9	57.6

[1] No flow.

DIRTY DEVIL RIVER BASIN

IVY CREEK BASIN, UTAH

The Ivy Creek Bench Reservoir is located about 12 miles southeast of Emery on a small tributary of Ivy Creek that is tributary to Muddy Creek, a branch of the Dirty Devil River. Erosional characteristics of the drainage basin of the reservoir are typical of a considerable area underlain by Mancos shale in the upper reaches of the Dirty Devil River basin.

TOPOGRAPHY

The so-called Ivy Creek bench is bordered on the northwest by the deeply incised channel of Ivy Creek and on the southeast by an elongated scarp that rises sharply about 100 feet to a second smaller bench. The scarp is formed by a sill of hard rock, and the two benches represent erosion surfaces cut above and below this sill. The reservoir is located on the lower bench on a tributary stream that slopes toward the north at about 85 feet per mile. The elevation of the reservoir is 6,580 feet and the maximum relief in the basin is 175 feet.

GEOLOGY

The basin is underlain by the Mancos shale, whose beds dip at a low angle northwestward. Along the southeast margin of the basin, the Ferron sandstone member of the Mancos shale has been intruded by a diabase sill whose outcrop forms the prominent scarp previously mentioned. The lower bench area, which constitutes about two-thirds of the basin, is covered by highly erodible fine-textured alluvium of undetermined depth.

VEGETATION

Moderately dense stands of juniper trees grow along the sandstone and diabase escarpment, but vegetation is sparse over the remainder of the basin. Range plants growing on the bench include rabbitbrush, Russian thistle, and saltsage intermixed with scattered clumps of galleta. The overall density of vegetation on the bench is probably less than 10 percent.

EROSION

Rilling, gullying, and sheet erosion, locally very severe, are all active in the basin. Saltsage hummocks, many more than a foot high, indicate the severity of sheet erosion, but rilling and gullying probably are the more destructive basin-wide. Large angular blocks of diabase protect the escarpment against erosion, but at some distance the surface is scarred with numerous small rills that merge to form active gullies as much as 15 feet wide and 6 feet deep. As the gullies are not cut to bedrock, no indication is given of the depth of the alluvium. The presence of the igneous sill probably has little effect on erosion within the basin, other than to reduce the area subject to rilling and sheet erosion.

PRECIPITATION AND RUNOFF

The amounts of precipitation and runoff in the area appear to be similar to those in the San Rafael River basin. The mean annual precipitation should approximate that at Emery, which is 7.43 inches. About two-thirds of this amount occurs in the period April through October. The late summer and early fall rains commonly occur as high-intensity storms that produce runoff. The precipitation in winter generally occurs as snow, but the snowmelt seldom produces runoff.

The following precipitation data, which are believed to be representative of the area, are taken from records of the U.S. Weather Bureau station at Emery.

Mean precipitation, 1930–58

	Inches
Annual	7. 22
April to October	4. 96
November to March	2. 26
Maximum month (August)	1. 26

Frequency of 1-day precipitation events of selected magnitude at Emery, April to October, 1930–50

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Percent of years in which at least one event occurs	90. 5	28. 6	9. 5	4. 8
Average number of events per year	2. 8	. 4	. 1	. 05

No records of runoff were obtained in the basin, but the annual sediment yield obtained by spudding the reservoir as previously described is given in table 3.

BULLFROG CREEK BASIN

BLUE POINT RESERVOIR, UTAH

Blue Point Reservoir is located on a small tributary of Bullfrog Creek that drains the southern slopes of the Henry Mountains in southeastern Utah. The reservoir basin, although small, is typical of an extensive severely dissected area underlain by shale extending westward and southward from the Henry Mountains. It is also a good example of the excessive rate of sediment yield from these areas that can occur during a single season.

TOPOGRAPHY

The drainage basin is fan shaped and is bounded by a roughly semicircular 100-foot shale cliff that has been eroded into an intricate pattern of V-shaped valleys and sharp ridges. Below the cliff the slope is about 2 percent, but this area also is closely dissected by many shallow channels with nearly vertical banks. The elevation of the reservoir is 4,820 feet and the maximum relief in the basin is 180 feet.

GEOLOGY

The entire basin is underlain by nearly horizontal beds of Mancos shale. Shale bedrock is exposed on some of the steeper slopes and in the floor of some of the channels, but the remainder of the area is covered with a thin layer of fine-textured highly impermeable residual mantle. There are no alluvial deposits of any size in the basin.

VEGETATION

Vegetation in the area is unusually sparse. On the gently sloping area below the cliffs, it consists of scattered clumps of saltsage and has a density of 5 percent or less. The steeper slopes are barren.

EROSION

Owing to the extreme sparsity of vegetation and the highly erodible character of the mantle, the rate of erosion in the basin is governed mainly by the magnitude and intensity of the rain and the quantity of runoff produced. This is verified by the fact that the reservoir was almost completely filled in one season as a result of one or two large storms. Sheet erosion and rilling furnish the major part of the sediment. Most of the channels are floored with bedrock, and hence little sediment is derived from deepening or widening.

PRECIPITATION AND RUNOFF

The closest precipitation station to the area is at Hanksville, about 45 miles north on the north side of the Henry Mountains; but judging from vegetation and other evidence, precipitation in the two areas is about the same. Records at Hanksville show that the mean annual precipitation is 5.22 inches, of which more than two-thirds falls in the 6-month period from April to October, mostly in late summer and early fall.

The following rainfall data are taken from U.S. Weather Bureau records at Hanksville.

Mean precipitation, 1930–42, 1944–58

	Inches
Annual	5. 12
April to October	3. 06
November to March	2. 16
Maximum month (August)	. 87

Frequency of 1-day precipitation events of selected magnitude at Hanksville, April to October, 1930–42 and 1944–50

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Percent of years in which at least one event occurred	85	25	5	0
Average number of events per year	2. 0	3	. 05	0

No record of runoff from the basin was obtained. The reservoir was surveyed first in the late fall of 1949 and again in the early spring of 1951. Runoff during the summer of 1950 caused extensive spill and practically filled the reservoir with sediment. The dam was subsequently breached to eliminate danger to livestock, and measurements were discontinued. The rate of sediment yield for the 1 year of operation is shown in table 3.

LITTLE COLORADO RIVER BASIN

OAK CREEK BASIN, NEW MEXICO

The Oak Creek Reservoir is located about 1 mile north of Zuni, N. Mex., on Oak Creek, a tributary to Zuni River. Measurements of sediment yield were made on the reservoir to obtain information on erosion and the rate of sediment yield in a large area in western New Mexico underlain by rocks of Triassic age.

TOPOGRAPHY

The drainage basin of the reservoir generally has well dissected, moderately steep uniform slopes extending from near the divide to the drainage channels. Around the head of the basin the divide is formed by a steep sandstone escarpment that rises sharply above the surrounding area.

GEOLOGY

The major part of the drainage basin is underlain by horizontal beds of the Chinle formation of Triassic age, composed of relatively soft shale and siltstone. The infacing escarpment at the divide is formed by the massive resistant Wingate sandstone, which overlies the Chinle formation. Narrow stringers of alluvium occur along the stream channels.

VEGETATION

This is an area of moderate rainfall, and vegetation generally is good on upland slopes throughout the basin. Blue grama and tobosa grasses mixed with scattered desert shrubs are the chief varieties found. The sandstone ridges have a fair cover of pinyon and juniper trees.

EROSION

Slopes underlain by shale of the Chinle formation are being eroded actively and doubtless account in large measure for the very high rate of sediment yield from the basin. Sheet erosion and rilling are the dominant type of erosion, but some gully cutting is occurring in the alluvium along the valley floors.

PRECIPITATION

A U.S. Weather Bureau station is located at Zuni, N. Mex., about 1 mile south of the reservoir, and the following precipitation data are taken from records of this station.

Mean precipitation, 1915–59

	Inches
Annual	11.68
April to October	7.62
November to March	4.06
Maximum month (July)	2.08

Frequency of 1-day precipitation events of selected magnitude at Zuni, April to October, 1915–59

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Percent of years in which at least one event occurred	95.5	41.3	8.7	0
Average number of events per year	3.3	.5	.1	0
Number of events during 1955	2.8	.3	0	0

RUNOFF

Runoff is produced by the occasional high-intensity storms occurring during the summer months and infrequently from winter snowmelt. Measurements of annual runoff and sediment yield for the 3-year period 1957–59 are shown below. Mean annual runoff and sediment yield are shown in table 3.

Storm runoff and sediment yield measured in Oak Creek Reservoir, New Mexico

Location.—Lat 35°06′, long 108°48′, in sec. 15, T. 10 N., R. 19 W., (projected) in Zuni Indian Reservation near Zuni, N. Mex.

Drainage area.—9.4 sq mi.

Records available.—January 1957 to October 1959. Record of sediment, 1954–59.

Gage.—Water-stage recorder. Datum of gage is about 6,350 ft above mean sea level.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from stage-capacity curve of reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
October 1956 to December 1957	44.1
December 1957 to April 1959	36.3
April 1959 to May 1960	10.5

Capacity.—Original, 238.9 acre-ft, October 1956; 148.0 acre-ft, May 1960.

Maximum.—Inflow volume, more than 222 acre-ft or 236 acre-ft per sq mi, Sept. 6–8, 1958. Inflow rate, about 3,100 cfs or 330 cfs per sq mi, Aug. 17, 1957.

Remarks.—Records fair, except that those for periods with no gage-height record and for periods of spill are poor. Reservoir equipped with 24-inch drop outlet pipe. Heavy sedimentation in the reservoir has resulted in excessive spill and deterioration of the spillway. Station abandoned in 1959, but measurement of sediment at 5-year intervals will continue.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1957						
Jan. 6–9	75.00	78.82	35.7	0	35.7	
Jan. 9–Feb. 17	78.82	75.51	[1]−35.7	35.7	0	
Feb. 18–Mar. 1	75.51	77.29	0	19.7	19.7	
July 5		80.70	54.4	0	54.4	
July 5–31	80.70	79.64	[1]−35.8	39.7	3.9	
July 31–Aug. 17	79.64	76.96	[1]−10.2	10.2	0	
Aug. 17–24	76.96	83.37	28.6	58.1	86.7	
Aug. 25	82.63	85.21	53.7	0	53.7	
Aug. 25–29	85.21	84.90	[1]−8.5	9.8	1.3	
Aug. 29–Oct. 11	84.90	78.50	[1]−114.7	114.7	0	
Oct. 12	78.50	86.00	116.2	14.9	131.1	
Total			83.7	302.8	386.5	41.2
1958						
Aug. 4–5		80.63	12.6	3.0	15.6	
Aug. 6–7	80.39	81.86	19.0	2.0	21.0	
Aug. 7–12	81.84	81.18	[1]−10.3	10.3	0	
Aug. 13–16	81.18	80.75	[1]−4.0	6.5	2.5	
Aug. 16–21	80.75	81.74	16.8	20.0	36.8	
Sept. 6–8	81.74	89.26	190.3	31.8	222.1	
Sept. 8–12	89.26	85.64	[1]−125.8	125.8	0	
Sept. 12–13	85.64	88.08	70.5	40.2	110.7	
Sept. 13–Oct. 5	88.08	83.26	[1]−129.5	132.3	2.8	
Oct. 5–6	83.26	83.93	4.6	2.0	6.6	
Oct. 6–30	83.93	78.40	[1]−44.2	44.2	0	
Total			0	418.1	418.1	44.5
1959						
July 26		81.14	12.1	0	12.1	
July 27–Aug. 5	81.14	80.40	[1]−6.0	6.0	0	
Aug. 6	80.40	82.44	20.8	0	20.8	
Aug. 20	82.44	82.23	[1]−2.7	2.7	0	
Aug. 20–22	82.23	83.79	23.0	5.0	28.0	
Aug. 23–24	83.79	84.29	8.4	1.2	9.6	
Aug. 25–26	84.29	85.68	28.8	2.0	30.8	
Aug. 26–Oct. 2	85.68	81.12	[1]−80.3	80.3	0	
Oct. 3	81.12	77.4	[1]−4.1	32.7	18.6	
Total			0	119.9	119.9	21.3

[1] Withdrawal from storage.

GILA RIVER BASIN

RAILROAD WASH BASIN, NEW MEXICO

The Railroad Wash basin is located along the boundary between Arizona and New Mexico and lies between the Gila River on the north and the Peloncillo Mountain on the southwest. A low inconspicuous divide separates the basin on the east and southeast from the drainage areas of the Lordsburg and Animas playas. From this divide, Railroad Wash flows northwestward to join the Gila River just above the town of Duncan, Ariz. Many tributary washes drain the flanks of the Peloncillo Mountains, and a few smaller ones drain the flat areas on the northeast. Stanford No. 1 Reservoir is located on one of the northeast tributaries and was selected to obtain measurements of runoff and sediment yield from the extensive area of flat lands in the vicinity for use in design of conservation structures.

TOPOGRAPHY

The basin above Stanford No. 1 Reservoir is part of an almost featureless plain that extends for several miles eastward and southeastward to the Lordsburg and Animas playas. The basin is typical of the bolson and playa topography that extends eastward in New Mexico as a broad flat on both sides of the Southern Pacific Railroad to the Rio Grande valley above El Paso. The drainage basin of the reservoir has a maximum relief of less than 100 feet, most of which is accounted for in the uniform gentle slope that extends from the reservoir to the divide.

GEOLOGY

On the geologic map of New Mexico (Darton, N.H., 1928) the geologic formations found in the drainage basin of the Stanford No. 1 Reservoir are described as alluvium, bolson deposits, and dune sand. There are no bedrock exposures within the area. In general, soils in the basin are fine textured and have low permeability.

VEGETATION

Grass, consisting mainly of sacaton, tobosa, and blue grama, is the principal vegetation in the basin. In places it is interspersed with minor growths of cholla, pricklypear cactus, snakeweed, and annual weeds. Some of the higher parts of the basin having caliche deposits near the surface are occupied by creosotebushes. In general, the cover over the basin can be classed as good, although in the past it has been severely overgrazed. There is marked evidence of improvement, owing to the conservative grazing practices followed by the present allottee. Former areas damaged by overgrazing are gradually healing and other evidence of misuse of land is being eliminated.

EROSION

Because of the good cover of vegetation and the gentle slopes, erosion and sediment yield in the area are at a minimum. Practically the only evidence of active erosion is the few small rills cut on the upstream slope of the borrow pit above the dam, but these show no tendency to enlarge. Sheet erosion, probably limited mainly to areas of poorest vegetation, appears to account for most of the sediment produced in the basin but is of minor consequence, as indicated by the low rate of sedimentation measured in the reservoir and by the very low ratio of sediment to runoff.

PRECIPITATION

No measurements of rainfall have been obtained within the basin, but a long term record of precipitation is available at the U.S. Weather Bureau station at Lordsburg, about 20 miles southeast of the reservoir. As the Lordsburg area has a similar topography and about the same elevation as the drainage basin of the reservoir, the precipitation at both localities is probably about equal. The following data are taken from the Weather Bureau record at Lordsburg.

Mean precipitation, 1925–58

	Inches
Annual	9. 88
June through October	5. 87
November through May	4. 01
Maximum month (August)	2. 02

RUNOFF

All measured runoff occurred during the summer as a result of torrential storms; but on rare occasions in the past, winter storms have also produced some runoff. The reservoir is equipped with a water-stage recorder and runoff is computed by converting changes in stage to volume by use of a stage-capacity curve. The mean annual runoff and sediment yield for the period of record are given in table 3. Storm runoff and sediment yield are given in the following table.

Storm runoff and sediment yield measured in Stanford Reservoir No. 1, New Mexico

Location.—Lat 32°33′, long 109°00′, in sec. 27, T. 20 S., R. 21 W., near Lordsburg, Hidalgo County, N. Mex.

Drainage area.—14.8 sq mi.

Records available.—May 1953 to October 1959.

Gage.—Water-stage recorder. Datum of gage is approximately 4,100 ft above mean sea level.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and pipe outflow computed from a stage-capacity curve of the reservoir. Spillway discharge determined by application of formula for a broad-crested weir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
May 1953 to April 1955	3.0
April 1955 to November 1955	2.0
November 1955 to November 1956	([1])
November 1956 to June 1959	1.0

[1] No measurable deposition.

Capacity.—Original, at spillway (gage height, 98.0 ft): 303 acre-ft, May 1953; 297 acre-ft, June 1959.

Maximums.—Inflow rate, about 4,700 cfs or 318 cfs per sq mi, July 11, 1955. Inflow volume, 1,176 acre-ft or 79.5 acre-ft per sq mi, July 10–13, 1955; duration, 67 hours.

Remarks.—Records poor 1953 and 1958, good 1954–57 and 1959. Reservoir equipped with an ungated 24-inch outlet pipe (gage height of sill, 89.0 ft). Three upstream reservoirs with a combined capacity of 283 acre-ft control flow from 9.4 sq mi of the 14.8 sq mi drainage area. One of the upstream reservoirs is equipped with a 12-inch outlet pipe, the other two with 21-inch outlet pipes.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1953						
July 14 [1]		89.80	[2] 41.9	[3] 25.0	66.9	4.8
1954						
June 30 [1]		89.50	39.1	18.0	57.1	4.1
July 19–20	86.41	92.25	14.6	217.9	232.5	16.6
July 23	88.90	94.13	.8	162.7	163.5	11.7
Aug. 10	88.14	89.66	5.9	126.0	131.9	9.4
Aug. 12	89.04	90.30	0	81.4	81.4	5.8
Aug. 24	88.48	89.96	3.6	36.0	39.6	2.8
Sept. 2	88.50	93.71	3.5	130.6	134.1	9.6
Oct. 4	87.43	89.63	9.6	10.5	20.1	1.4
Total			77.1	783.1	860.2	61.4
1955						
July 10	80.30	100.78	32.0	1,143.0	1,175.0	83.9
July 22	88.36	93.76	4.4	197.6	202.0	14.4
July 28	88.80	92.43	4.6	88.3	92.9	6.6
July 29	89.40	91.60	0	86.2	86.2	6.2
Aug. 8	88.51	88.83	2.2	0	2.2	.2
Aug. 19	88.15	89.64	5.6	13.8	19.4	1.4
Total			48.8	1,528.9	1,577.7	112.7
1956						
Aug. 14		89.80	30.0	76.6	106.6	7.6
Aug. 16	89.03	89.80	0	106.4	106.4	7.6
Aug. 22	88.11	88.56	3.3	0	3.3	.2
Total			33.3	183.0	216.3	15.4
1957						
July 19		84.42	6.7		6.7	.5
July 25	84.00	91.97	23.8	184.2	208.0	14.9
Aug. 6	87.80	88.05	1.5		1.5	.1
Aug. 8	87.89	88.01	.6		.6	
Aug. 13	87.64	88.28	3.8		3.8	.3
Aug. 22	87.62	89.15	8.7	24.2	32.9	2.3
Aug. 30	88.33	91.59	4.6	252.6	257.2	18.4
Total			49.7	461.0	510.7	36.5

See footnotes at end of table.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1958						
Aug. 29 [1]		92.06	31.9	720.0	751.9	53.7
1959						
Aug. 7		90.33	31.9	505.8	537.7	38.4
Aug. 25	87.72	88.68	7.6		7.6	.5
Total			39.5	505.8	545.3	38.9

[1] Recorder inoperative for all or part of the period of inflow.
[2] Inflow storage obtained from high-water marks.
[3] Spill estimated.

MISCELLANEOUS AREAS IN ARIZONA

Measurements of sediment deposition were made in eight reservoirs located in the eastern and central parts of the Gila River basin in Arizona to obtain an estimate of the rate of sediment yield from range lands having different topography, geology, and vegetation. The drainage basins of the reservoirs are located both north and south of the river and include mountains and plains; some are underlain by bedrock, others by alluvium and bolson deposits. The sediment deposition in the reservoirs was measured by spudding in some places and by repeat surveys in others. The mean annual yield, given in table 3, was computed by dividing total sediment deposition by the age of the reservoir. Runoff was not measured. The general location of the reservoirs is shown on figure 35. A brief description of the basin characteristics for each reservoir and data on precipitation taken from the nearest U.S. Weather Bureau station are given. The reservoirs are here designated as tanks, in compliance with local usage.

DAVIS TANK

The Davis Tank is located about 9 miles southeast of Clifton on one of the many washes that drain the mountainous area north of the Gila River. The upper part of the basin is underlain by volcanic rock and has a moderately steep, well dissected topography. In its lower part the basin becomes a wide, flat valley that slopes northward about 2 percent toward the river. The valley is underlain by alluvium consisting mostly of gravel mixed with sand and silt, but the surface mantle is compact and infiltration losses are small. The stream channel is wide and shallow. Vegetation in the basin is generally sparse and consists mainly of creosotebush with scrub mesquite along the channels in the lower part and scattered grass mixed with desert shrubs on the upper slopes. Precipitation data for the basin are given with the description of the following tank.

KENNEDY TANK

The Kennedy Tank is located about 18 miles south of Davis Tank in the foothills along the north side of Whitlock Valley. Drainage is southward to the Whitlock Valley playa. The basin is underlain by volcanic rocks and is covered by a thin layer of soil on the steeper slopes and alluvial deposits on the flatter areas. The topography is steep, and total relief in the basin is about 1,600 feet. The valley side slopes have a gradient of about 20 percent, but the slope of the main channel is less than 4 percent. Vegetation is sparse and consists of scattered galleta and clumps of grama interspersed with creosotebush, snakeweed, and cactus on the upper slopes and scrub mesquite trees on the valley floor. Sheet erosion is active, but the channels are not gullied.

The precipitation station nearest to both the Davis and Kennedy Tanks is at Clifton, but the type and density of the cover of vegetation in both basins indicates that the rainfall is probably somewhat less than at Clifton and approaches the amount shown for one of the valley stations. The next nearest station having approximately the same elevation is located at Bowie in the upper San Simon Valley about 40 miles southwest of the two basins. The following precipitation data are taken from records of the Weather Bureau stations located at Clifton and Bowie.

Mean precipitation

Clifton, 1894-1904, 1908-52

	Inches
Annual	11. 79
May through October	8. 35
November through April	3. 44
Maximum month (August)	2. 42

Bowie, 1872-1952

	Inches
Annual	11. 27
May through October	6. 72
November through April	4. 55
Maximum month (August)	2. 27

Frequency of 1-day precipitation events of selected magnitude at Bowie, June through September, 1914-52

	1-day precipitation greater than—		
	0.5 in.	1.0 in.	2.0 in.
Percent of years in which at least one event occurred	88	62	4. 77
Average number of events per year	2. 95	. 95	. 07

JUNIPER TANK

The Juniper Tank is located in the San Carlos Indian Reservation, and the basin is a part of the foothills that extend for several miles north of the Gila River toward the Mogollon Rim. The basin is roughly rectangular with a flat central area bounded by high ridges on the sides. Slopes on the valley floor are gentle, but the side slopes range from 10 to 15 percent. Elevations range from 4,800 feet at the tank to 5,450 feet on the divides. The area is underlain by massive volcanic rocks that have weathered to form a deep, fine-textured, but moderately pervious residual soil. The higher slopes support a fairly dense forest cover of oak and juniper trees; the stream channels are bordered by oak trees, and the valley supports a considerable acreage of grassy meadows. The drainage basin shows little evidence of erosion, which is reflected in the low sediment yield.

The nearest precipitation station to the area is located at Globe, about 38 miles directly west. The two areas have similar topography; and although Globe has a slightly lower elevation, rainfall is believed to be similar. The following precipitation data are taken from the U.S. Weather Bureau station at Globe.

Mean precipitation, 1917–58

	Inches
Annual	15. 40
May through October	7. 91
November through April	7. 49
Maximum month (August)	2. 81

Frequency of 1-day precipitation events of selected magnitude at Globe, June through September, 1914–52

	1-day precipitation greater than—		
	0.5 in.	1.0 in.	2.0 in.
Percent of years in which at least one event occurred	95. 5	69	11. 9
Average number of events per year	4. 38	1. 29	. 14

ALHAMBRA TANK

The Alhambra Tank is located on the east side of Quinlan Mountains in the Papago Indian Reservation, about 40 miles southwest of Tucson. The drainage basin is fan shaped; it is 3 miles long and as much as 4 miles wide. Most of the basin is mountainous, and slopes range from 5 to 10 percent in the lower part and from 20 to 50 percent in the upper part. Elevations range from 3,900 to 4,200 feet. Vegetation on the mountain slopes consists mainly of oak trees and brush;

at lower elevations mesquite and desert shrubs predominate. Granitic rocks, exposed in many localities, underlie the entire basin. Weathering has produced a coarse-textured granitic soil. The main channel and its principal tributaries are well defined with steep banks and a thin flooring of gravel and coarse sand. There is no indication of deepening or widening of the channels or of any other erosion, probably because of the generally coarse texture of the soil.

Precipitation in this area appears to be approximately the same as at Tucson, which is the nearest U.S. Weather Bureau station. The following precipitation data are taken from the records of the Tucson station.

Mean precipitation, 1867–1958

	Inches
Annual	10. 43
May through October	6. 20
November through April	4. 23
Maximum month (August)	2. 26

Frequency of 1-day precipitation events of selected magnitude at Tucson, June through September, 1914–52

	1-day precipitation greater than—		
	0.5 in.	1.0 in.	2.0 in.
Percent of years in which at least one event occurred	90	57	14. 3
Average number of events per year	2. 52	. 86	. 17

BLACK HILLS TANK

The Black Hills Tank is located about 20 miles north and slightly east of Phoenix in an area where low but rugged mountains alternate with alluvium-filled valleys. The basin is approximately 25 miles long and 0.6 mile wide and ranges in elevation from 2,600 feet at the tank to 3,200 feet at the divide. Upper parts of the basin include mountain slopes, but the lower part is underlain with alluvium. The mountain area is underlain by granitic rocks, which weather to a thin, coarse residual mantle. Soil on the valley areas is also coarse textured. The vegetation includes mountain brush on the upper slopes and scattered desert shrubs on the valley areas; mesquite grows along the channels. The main drain consists of a network of small channels whose gradient is about 2 percent. These channels doubtless erode during periods of high runoff.

Precipitation in the area is believed to be similar to that at Phoenix, and the following precipitation data are taken from records of the U.S. Weather Bureau at Phoenix.

628680 O—62——8

Mean precipitation, 1877–1958

	Inches
Annual	7. 16
May through October	3. 27
November through April	3. 89
Maximum month (August)	1. 00

Frequency of 1-day precipitation events of selected magnitude at Phoenix, June through September, 1914–52

	1-day precipitation greater than—		
	0.5 in.	1.0 in.	2.0 in.
Percent of years in which at least one event occurred	69	36	14. 2
Average number of events per year	1. 59	. 64	. 14

MESQUITE TANK

The Mesquite Tank is located in the broad Centennial Valley that extends southeastward from Salome to the Gila River just above Gillespie Dam. The entire drainage area is a featureless alluvial plain and slopes less than 1 percent. Vegetation consists of desert shrubs interspersed with scattered clumps of grass. Several small channels, most of them less than a foot deep, enter the reservoir, but they show no evidence of recent cutting.

Precipitation in the basin is believed to be similar to that at Salome, located about 22 miles northwest. The following precipitation data are taken from the records of the U.S. Weather Bureau station at Salome.

Mean precipitation, 1914–55

	Inches
Annual	8. 78
May through October	3. 86
November through April	4. 92
Maximum month (August)	1. 44

Frequency of 1-day precipitation events of selected magnitude at Salome, June through September, 1914–52

	1-day precipitation greater than—		
	0.5 in.	1.0 in.	2.0 in.
Percent of years in which at least one event occurred	78. 5	37. 7	4. 77
Average number of events per year	1. 83	. 45	. 05

TANK 76

Tank 76 is located on the west side of the Quinlan Mountains in the Papago Indian Reservation about 12 miles northeast of Sells. Drainage is eastward through Sells Wash, then southward through San Simon Wash into Mexico. The basin is 1.9 miles long and in the upper part it extends across the foothills of the Quinlan Mountains for 1.1 miles. Elevations in the basin range from 3,000 feet at the tank to 4,000 feet at the divide. Slopes range from 2 to 5 percent in the lower valley to as much as 20 percent in the uplands. The basin is underlain by granite, which has weathered to a thin coarse-textured soil. Vegetation in the basin is fairly dense, and it includes mesquite and Palo Verde trees in the valley and desert shrubs on the slopes. The channels are all shallow; during floods the flow spreads across the valley floor and causes some sheet erosion.

Precipitation at this basin should be approximately similar to that at Ajo, located about 50 miles north. The following precipitation data are taken from records of the U.S. Weather Bureau station at Ajo.

Mean precipitation, 1913–58

	Inches
Annual	9. 13
June through September	4. 63
October through May	4. 50
Maximum month (August)	2. 29

Frequency of 1-day precipitation events of selected magnitude at Ajo, June through September, 1914–52

	1-day precipitation greater than—		
	0.5 in.	1.0 in.	2.0 in.
Percent of years in which at least one event occurred	90	57	14. 3
Average number of events per year	2. 52	. 86	. 17

TABLE 3.—*Summary of storm runoff and sediment yield at reservoirs in the Colorado River basin*

[Discharge over spillway: L, large; M, medium; S, small; N, none]

Reservoir	No. on fig. 35	Location			Period of record	Drainage basin data				Reservoir capacity			Sediment yield for period of record			Runoff for period of sediment record			Ratio runoff to sediment	Discharge over spillway
		Sec.	T.	R.		Area (sq mi)	Max relief (ft)	Length (ft)	Relief ratio	Original: Acre-ft	Original: Acre-ft per sq mi	Most recent survey (acre-ft)	Total (acre-ft)	Average annual: Acre-ft	Average annual: Acre-ft per sq mi	Total (acre-ft)	Average annual: Acre-ft	Average annual: Acre-ft per sq mi		
SALT CREEK BASIN																				
Badger Wash basin, Colorado																				
[Area 5 on fig. 35. Location of study areas shown on fig. 41]																				
Northeast	----	24	8S	104W	1954–59	0.10	-------	-------	-------	4.5	45.1	4.0	0.5	0.08	0.8	9.7	1.6	16.0	19.3	N
Algerita	----	24	8S	104W	do	.22	-------	-------	-------	18.3	83.0	15.6	2.7	.45	2.05	32.0	5.4	24.1	11.9	N
Northwest	----	24	8S	104W	do	.055	-------	-------	-------	2.4	43.7	[1] 6.2	.2	.03	5.58	8.1	1.35	24.6	40.5	S
Upper Hanks	----	24	8S	104W	do	.066	100	2,000	0.050	8.3	126.0	7.0	1.3	.21	3.64	13.2	2.2	33.1	10.1	N
Lower Hanks	----	25	8S	104W	do	.085	90	2,150	.042	19.8	233.0	19.2	.6	.10	1.18	15.4	2.6	30.1	25.7	N
Upper Oilwell	----	24	8S	104W	1954–55	.034	65	1,100	.059	1.5	43.8	1.0	.5	.25	7.35	3.8	1.9	55.9	7.6	N
Lower Oilwell	----	25	8S	104W	1954–59	.025	100	1,900	.053	12.9	516.0	12.3	.6	.10	4.00	12.8	2.1	85.6	21.4	N
North Basin	----	25	8S	104W	do	.049	100	1,900	.053	8.1	165.0	7.5	.6	.10	2.40	10.3	1.7	35.2	17.2	N
East Basin	----	25	8S	104W	do	.089	-------	-------	-------	5.6	63.0	4.8	.8	.13	1.49	26.7	4.5	50.1	33.4	N
Sheepherder	----	25	8S	104W	do	.094	-------	-------	-------	6.4	68.1	5.4	1.0	.17	1.77	12.0	2.0	21.3	12.0	N
Damnedifiknow	----	25	8S	104W	do	.109	-------	-------	-------	8.0	73.3	6.9	1.1	.17	1.58	15.7	2.6	24.0	14.3	N
Yucca	----	25	8S	104W	do	.157	135	3,550	.038	8.4	53.8	5.6	2.8	.47	2.98	27.0	4.5	28.7	9.6	N
Windy Point	----	36	8S	104W	do	.019	70	1,050	.066	4.5	237.0	4.1	.4	.07	3.50	3.0	.5	26.3	7.5	N
Prairie Dog	----	36	8S	104W	do	.022	90	1,200	.075	3.0	136.0	2.3	.7	.12	5.45	4.9	.8	37.2	7.0	N
Middle Basin	----	36	8S	104W	do	.092	-------	-------	-------	16.9	184.0	15.2	1.7	.28	3.08	31.3	5.2	56.8	18.5	N
West Twin	----	36	8S	104W	do	.148	185	4,300	.043	6.3	42.5	3.8	2.5	.42	2.81	31.5	5.3	36.0	12.6	S
East Twin	----	36	8S	104W	do	.019	70	1,600	.044	6.1	320.0	5.6	.5	.08	4.38	7.4	1.2	65.0	14.7	N
West Badger	----	36	8S	104W	1954–56	.141	-------	-------	-------	22.4	158.9	20.1	2.3	.77	5.45	31.9	10.6	75.5	13.8	N
					1957–59	.313	-------	-------	-------	20.1	64.1	19.6	.5	.17	.53	25.6	8.5	27.1	51.2	N
Southeast	----	6	9S	103W	1954–59	.484	-------	-------	-------	10.5	21.7	[1] 24.7	5.0	.84	1.74	81.0	13.5	27.9	16.2	S
Dolores River basin, Colorado																				
Middle	6	22	44N	16W	1938–48	1.90	1,000	1,840	0.054	47.3	24.9	44.0	3.3	0.33	0.17	-------	-------	-------	-------	M
					1949–54	1.90	1,000	1,840	.054	44.0	23.1	40.6	3.4	.57	.30	133.0	22.2	11.7	39.0	M

GREEN RIVER BASIN

Yampa River basin, Wyoming

Little Robber [2]	7	14	14N	19W	1954–56	8.5	------	------	------	666.0	78.4	655.0	11.0	(3)	------	699.1	(3)	------	63.5	N
					1954–58	8.5	------	------	------	------	------	------	------	------	------	1,305.8	261.1	30.7	------	N

Price River basin, Utah

[Area 8 on fig. 35]

Demonstration	----	10	14S	10E	1947–49	0.54	------	------	------	5.8	10.8	1.6	4.2	2.1	3.9	------	------	------	------	L
School Section	----	2	16S	9E	1940–50	3.45	500	17,950	0.028	35.6	10.3	16.5	19.1	1.9	.54	------	------	------	------	L
Winters Pond	----	27	17S	10E	1938–50	.11	120	3,270	.036	6.2	56.2	6.0	.2	.01	.10	------	------	------	------	S
Clark Valley 1	----	30	14S	12E	1939–50	.99	215	9,770	.022	4.2	4.2	2.3	1.9	.17	.17	------	------	------	------	L
Dugout	----	5	15S	12E	---do---	.13	65	3,170	.021	5.1	39.4	4.9	.2	.02	.12	------	------	------	------	S
Clark Valley 2	----	23	14S	12E	---do---	.46	250	8,070	.031	5.0	10.8	4.0	1.0	.09	.20	------	------	------	------	M
Spider	----	19	15S	12E	1942–50	.12	125	4,170	.030	19.0	158.0	11.3	7.7	.96	8.03	------	------	------	------	N

Saleratus Wash basin, Utah

[Area 8 on fig. 35]

Saleratus	----	8	19S	13E	1938–50	0.54	50	6,860	0.007	13.0	24.1	6.8	6.2	0.52	0.96	------	------	------	------	M
South Green River	----	20	21S	16E	1939–50	.34	190	3,910	.048	14.5	42.7	6.0	8.5	.71	2.08	------	------	------	------	S

San Rafael River basin, Utah

[Area 9 on fig. 35]

Cinderella	----	26	20S	8E	1936–50	0.92	525	6,600	0.078	21.0	22.8	4.6	16.4	1.17	1.27	------	------	------	------	L
Sand Bench	----	17	22S	8E	1940–50	.25	325	3,960	.082	9.3	37.2	6.8	2.5	.25	1.00	------	------	------	------	S
Red Tank	----	16	22S	8E	1943–50	.10	150	3,430	.044	2.0	20.0	1.9	.1	.14	1.40	------	------	------	------	L
Millers Pond	----	7	18S	10E	1938–50	.14	75	3,380	.022	3.8	27.1	2.9	.9	.08	.57	------	------	------	------	M
Wedge Pond	----	35	19S	10E	1936–50	.80	260	8,450	.031	9.3	11.6	7.5	1.8	.14	.17	------	------	------	------	M
Summit Pond	----	24	19S	11E	1938–50	.75	1,500	7,660	.196	26.2	34.9	12.1	14.1	1.08	1.45	------	------	------	------	M

Ten Mile Wash basin, Utah

Crescent Wash [4]	10	16	21S	19E	1954–57	19.0	3,000	44,880	0.067	160.0	8.4	34.0	126.0	31.5	1.6	1,325.9	331.5	17.4	10.5	L

See footnotes at end of table.

TABLE 3.—*Summary of storm runoff and sediment yield at reservoirs in the Colorado River basin*—Continued

Reservoir	No. on fig. 35	Location			Period of record	Drainage basin data				Reservoir capacity			Sediment yield for period of record			Runoff for period of sediment record			Ratio runoff to sediment	Discharge over spillway
		Sec.	T.	R.		Area (sq mi)	Max relief (ft)	Length (ft)	Relief ratio	Original: Acre-ft	Original: Acre-ft per sq mi	Most recent survey (acre-ft)	Total (acre-ft)	Average annual: Acre-ft	Average annual: Acre-ft per sq mi	Total (acre-ft)	Average annual: Acre-ft	Average annual: Acre-ft per sq mi		
GREEN RIVER BASIN—Continued																				
Dirty Devil River basin, Utah																				
Ivy Creek Bench	11	35	23S	5E	1938–50	0.24	175	4,010	0.044	5.2	21.7	2.4	2.8	0.23	0.96	-------	-------	-------	-------	M
Bullfrog Creek basin, Utah																				
Blue Point	12	27	35S	10E	1950	0.28	180	3,700	0.048	2.0	7.1	0.6	1.3	1.30	4.65	-------	-------	-------	-------	L
LITTLE COLORADO RIVER BASIN																				
Zuni River basin, New Mexico																				
Oak Creek [5]	13	10	10N	19W	1955–56	9.4	800	23,400	0.034	335.0	35.7	239.0	96.0	48.0	5.10	-------	-------	-------	-------	L
GILA RIVER BASIN																				
Railroad Wash basin, New Mexico																				
Stanford Tank [5]	14	27	20S	21W	1953–59	[6] 14.8	100	21,900	0.004	303.0	20.5	297.0	6.0	0.86	0.06	4,529.0	647.0	43.7	754.8	L
Unnamed Wash, Arizona																				
Davis Tank	15	25	5S	30E	1945–50	0.21	-------	-------	-------	3.2	15.2	2.3	0.9	0.18	0.96	-------	-------	-------	-------	M

Parks Lake basin,[7] Arizona																				
Kennedy Tank	16	23	8S	30E	1945–50	0.97	-------	-------	-------	5.6	5.8	4.3	1.3	0.26	0.27	-------	-------	-------	-------	
San Carlos River basin, Arizona																				
Juniper Tank	17	4	1S	22E	1945–50	2.00	650	10,000	0.065	20.0	10.0	17.1	2.9	0.58	0.29	-------	-------	-------	-------	M
Santa Cruz River basin, Arizona																				
Alhambra Tank	18	19	17S	8E	1942–50	6.61	2,300	15,800	0.145	17.6	2.7	16.0	1.6	0.20	0.03	-------	-------	-------	-------	-------
Verde River basin, Arizona																				
Black Hills Tank	19	25	5N	5E	1945–49	1.14	600	13,200	0.046	34.8	30.5	31.7	3.1	0.78	0.68	-------	-------	-------	-------	N
Centennial Wash basin, Arizona																				
Mesquite Tank	20	9	3N	10W	1945–50	3.0	-------	-------	-------	8.7	0.9	7.2	1.5	0.30	0.03	-------	-------	-------	-------	L
San Simon Wash Valley, Arizona																				
Tank 76	21	35	16S	6E	1947–48	1.17	1,160	9,500	0.122	9.4	8.0	8.9	0.5	0.25	0.21	-------	-------	-------	-------	M

[1] Dam raised November 1956.
[2] 24-inch gated outlet pipe.
[3] Average annual quantities not computed due to method of measuring.
[4] 30-inch ungated outlet pipe.
[5] 24-inch ungated outlet pipe.
[6] 9.4 sq. mi. partly controlled by upstream reservoirs.
[7] Closed basin within Gila River basin.

RIO GRANDE BASIN

JEMEZ RIVER BASIN

ZIA RESERVOIR, NEW MEXICO

The Zia Reservoir is located just above the Zia Pueblo on an unnamed tributary of the Jemez River. The drainage basin is typical of a large area of dissected pediments and terraces lying between the Nacimiento and Jemez Mountains and the Rio Grande. The reservoir was constructed for stock-water use by the Zia Pueblo Indians.

TOPOGRAPHY

The drainage basin of the reservoir is part of the dissected pediment lying south of the Jemez Mountains and is composed mainly of low rolling gravel-capped hills separated by narrow stream valleys. The hills have moderately steep slopes that for the most part are protected by coarse gravel derived from the pediment surfaces. The valley floors have a low gradient, and the channels are well defined but gullying is not active.

GEOLOGY

Horizontal beds of the Santa Fe group, consisting mainly of poorly consolidated sandstone and siltstone, underlie the basin. The beds are exposed in the steeper slopes in the headwater area, but they are covered by pediment gravel and sandy alluvial deposits in the lower part. Soils throughout the basin are sandy with moderate to high permeability.

VEGETATION

The dominant vegetation in the basin is a mixture of short grass and desert shrubs. Piñon and juniper trees with an understory of grass grow on the higher gravel-capped hills and ridges. The density of the cover of vegetation is less than 15 percent, but in general the cover here is superior to that in other areas in this vicinity.

EROSION

The relatively permeable sandy soils in the stream valleys and the gravel deposits along hilltops and slopes have prevented extensive rilling or gullying within the basin. Sheet erosion is active in parts of the area and is doubtless responsible for the relatively high rate of sediment yield from the basin. The well developed drainage network results in rapid movement of sediment from its source to the reservoir.

PRECIPITATION

The vegetation and other evidence indicates that the precipitation in this area is about equivalent to that at Bernalillo, the nearest precipitation station located about 16 miles southeast. The following precepitation data are taken from the records of the U.S. Weather Bureau station at Bernalillo 1 NNE.

Mean precipitation, 1941–59	*Inches*
Annual	8. 49
April through October	6. 10
November through March	2. 39
Maximum month (July)	1. 19

Frequency of 1-day precipitation events of selected magnitude at Bernalillo 1 NNE from April through October

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Percent of years in which at least one event occurred, 1941–59	100	72. 2	22. 2	5. 6
Average number of events per year during—				
1941–59	3. 2	. 8	. 2	. 1
1954–59	2. 7	. 5	. 2	0

RUNOFF

All runoff in the area during the period of measurement was the result of torrential summer storms; none occurred in the winter. The average annual runoff and sediment yield are shown in table 4; the storm runoff and sediment yield are shown in the following table.

Storm runoff and sediment yield measured in Zia Reservoir, New Mexico

Location.—Lat 35°32′, long 106°44′, in sec. 16, T. 15 N., R. 2 E., on unnamed tributary of Jemez River near San Ysidro, Sandoval County, N. Mex.

Drainage area.—2.4 sq mi.

Records available.—June 1954 to October 1959.

Gage.—Water-stage recorder. Datum of gage is approximately 5,550 ft above mean sea level.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and pipe outflow computed from a stage-capacity curve of the reservoir. Spillway discharge obtained by application of formula for a broad-crested weir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
June 1954 to October 1954	2. 9
October 1954 to October 1955	13. 8
October 1955 to December 1957 [1]	+1. 0
December 1957 to October 1959	. 5

[1] Capacity of reservoir increased by 1.0 acre-ft owing to compaction and drying of sediments.

Capacity.—Original, at spillway (gage height, 19.8 ft): 59.9 acre-ft, June 1954; 42.7 acre-ft, Oct. 10, 1959.

Maximums.—Inflow rate, about 2,700 cfs or 1,120 cfs per sq mi, July 27, 1955. Inflow volume, 77.5 acre-ft or 32.3 acre-ft per sq mi, July 27, 1955; duration, about 2 hours.

Remarks.—Records good. Reservoir equipped with an ungated 8-inch outlet pipe (gage height of sill, 16.85 ft).

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
July 23		8.56	2.0	0	2.0	
July 23	8.14	14.35	13.6	0	13.6	
Total			15.6	0	15.6	6.5
1955						
July 11		14.60	14.4	0	14.4	
July 27	13.21	19.80	30.8	46.7	77.5	
Aug. 6	16.04	16.09	.2	0	.2	
Total			45.4	46.7	92.1	38.4
1956 [1]						
1957						
Aug. 17		10.75	1.5	0	1.5	
Aug. 29–30	9.84	10.03	.2	0	.2	
Aug. 30	10.01	11.99	2.7	0	2.7	
Oct. 20	8.96	9.95	.6	0	.6	
Oct. 21	9.92	10.85	1.0	0	1.0	
Nov. 4	10.18	11.68	2.0	0	2.0	
Total			8.0	0	8.0	3.3
1958						
Sept. 6		9.97	0.5	0	0.5	0.2
1959						
Aug. 5–6		9.69	0.3	0	0.3	
Aug. 8		14.51	8.5	0	8.5	
Total			8.8	0	8.8	3.7

[1] No flow.

RIO PUERCO BASIN

SAN LUIS WASH, NEW MEXICO

San Luis Wash is one of the small tributaries of the Rio Puerco, entering just above the abandoned village of Cabezon in Sandoval County. The basin is typical of a large area of dissected plateaus in north-central New Mexico. Measurements of runoff and sediment yield were started in 1953 in three reservoirs located on contiguous tributaries of San Luis Wash as part of a cooperative program with the U.S. Forest Service and the Bureau of Land Management to study the effect of various types of grazing use on forage yield, runoff, erosion, and sediment yield.

TOPOGRAPHY

San Luis Wash is located within the Colorado Plateaus physiographic province and has many of its common characteristics, including horizontal sedimentary beds of varying hardness that have eroded to form a succession of flat valleys and mesas separated by steep escarpments. The lower part of each of the three study basins is a featureless plain; but at the extreme upper end, each is crossed by a precipitous escarpment rising 350 feet or more to a small flat mesa above. Total relief in each of the basins is about 500 feet.

GEOLOGY

Sedimentary rocks of Late Cretaceous age, including the Lewis shale and the Pictured Cliff sandstone, underlie the three basins. The shale is found only in the area directly above the reservoirs, and the sandstone forms the escarpment separating the plain from the upper mesa. Broad alluvial fan deposits, derived in part from the shale and in part from the sandy mesa, slope gently from the base of the cliffs down the stream channels. Soils on the shale areas are dense and impervious, but they are sandy and permeable on the mesa.

VEGETATION

Although the rainfall is moderately high, vegetation in the area is sparse. Scattered clumps of galleta and blue grama mixed with sagebrush and other desert shrubs is the predominate type. Thin stands of pinyon and juniper trees grow on the sandy mesa. The density of the vegetation is less than 10 percent and large tracts on the flats above the reservoirs are barren. The poor vegetation can in part be attributed to severe overgrazing in the past.

EROSION

Erosion is active throughout the three basins, although the measurements indicate a relatively low rate of sediment yield. The low yield is not due to the absence of erosion, but apparently results from the fact much of the sediment is deposited on the broad alluvial fans and does not reach the reservoirs. Evidence of active sheet erosion is shown by the numerous pedestaled plants and the dense network of shallow rills on many of the barren areas. Some gullying is occurring in the lower area, but most of the channels are discontinuous and sediment is being deposited on fans downstream. Sheet erosion directly above the reservoir probably is the source for most of the sediment being deposited in the reservoir.

PRECIPITATION

The nearest precipitation station with a record of any length is located at Cuba, about 20 miles north of the basin. Because the topography is similar and the elevation is about the same at both locations, the precipitation is believed to be similar. The following data are taken from records of the U.S. Weather Bureau at Cuba.

Mean precipitation, 1939–41, 1944–46, 1948–59

	Inches
Annual	8.63
May through October	7.04
November through April	1.59
Maximum month (July)	1.79

Frequency of 1-day precipitation events of selected magnitude at Cuba, May through October

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Percent of years in which at least 1 event occurred, 1939–59	100	36.8	0	0
Average number of events per year, 1941–59	4.5	.6	0	0
Average number of events per year, 1953–59	4.1	.7	0	0

RUNOFF

Measurements show that practically all runoff in the basin is produced by torrential summer thunderstorms, although infrequently a small flow results from spring snowmelt. The mean annual runoff and sediment yield for the 3-year period for the three basins are shown in table 4; the storm runoff and the annual sediment yield are given in the following tables.

Storm runoff and sediment yield measured in San Luis Reservoir 1, New Mexico

Location.—Lat 35°44′, long 107°04′, in sec. 4, T. 17 N., R. 2 W., on unnamed tributary of San Luis Wash near San Luis, Sandoval County, N. Mex.

Drainage area.—1.06 sq mi.

Records available.—June 1953 to December 1959.

Gage.—Water-stage recorder. Datum of gage is approximately 6,780 ft above mean sea level. Before June 29, 1955, records obtained from periodic readings of a crest-stage gage in reservoir.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir. Spillway discharge obtained by application of formula for a broad-crested weir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
August 1952 to November 1954	0.5
November 1954 to June 1956	1.1
June 1956 to August 1956	.6
August 1956 to August 1957	.4
August 1957 to October 1958	2.0
October 1958 to October 1959 [1]	+.2

[1] Capacity of reservoir increased by 0.2 acre-ft owing to drying of sediments between October 1958 and August 1959.

Capacity.—Original, at spillway (gage height, 29.8 ft): 16.3 acre-ft, August 1952; 11.9 acre-ft, October 1959.

Maximums.—Inflow rate, about 570 cfs or 539 cfs per sq mi, July 27, 1955. Inflow volume, 32.8 acre-ft or 30.9 acre-ft per sq mi, July 26–27, 1955.

Remarks.—Records poor for 1953, fair for 1954, good for 1955–59.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1953						
July 16–17		16.6	0.1	0	0.1	0.1
1954						
June 26		19.08	.7	0	.7	
July 8	17.85	21.14	1.2	0	1.2	
July 22	19.70	26.34	5.2	0	5.2	
Aug. 5	24.23	26.45	2.9	0	2.9	
Aug. 19	24.00	25.20	1.2	0	1.2	
Sept. 7	23.50	26.70	3.9	0	3.9	
Sept. 18	25.30	27.00	2.8	0	2.8	
Oct. 4	25.20	26.50	2.0	0	2.0	
Total			19.9	0	19.9	18.8
1955						
July 26		28.07	0	9.7	9.7	
July 27	27.93	29.80	6.2	17.0	23.2	
Aug. 17	27.50	27.66	.4	0	.4	
Aug. 27	27.14	27.83	1.7	0	1.7	
Total			8.3	26.7	35.0	33.0
1956						
July 31		20.34	.2	0	.2	
Aug. 2	20.32	27.63	6.6	0	6.6	
Aug. 19	26.22	26.30	.1	0	.1	
Total			6.9	0	6.9	6.5
1957						
Jan. 9–May 11 [1]			0.1	0	0.1	
June 11	20.99	25.32	2.7	0	2.7	
July 25–26	23.60	26.95	3.8	0	3.8	
July 29	26.70	27.20	1.0	0	1.0	
Aug. 5–6	26.60	27.95	3.1	0	3.1	
Aug. 9–10	27.55	27.73	.1	0	.1	
Aug. 23	26.73	27.53	1.6	0	1.6	
Aug. 31	27.13	29.35	6.2	0	6.2	
Oct. 12	26.65	28.30	3.8	0	3.8	
Oct. 18–21	27.76	29.80	6.8	60.0	66.8	
Nov. 4–5	29.45	29.55	.4	0	.4	
Total			29.6	60.0	89.6	84.5
1958						
Mar. 6–7	26.49	27.56	2.1	0	2.1	
Mar. 22–Apr. 12 [2]			.3	0	.3	
July 18	24.31	24.32	.0	0	.0	
July 24	24.16	24.18	.0	0	.0	
Aug. 5	23.90	25.44	1.1	0	1.1	
Aug. 9	25.30	25.31	.0	0	.0	
Aug. 19–22	25.08	26.61	1.8	0	1.8	
Sept. 12–13	25.72	27.91	3.7	0	3.7	
Sept. 18	27.23	27.25	.0	0	.0	
Oct. 5–6	26.49	26.86	.6	0	.6	
Total			9.6	0	9.6	9.1
1959						
Apr. 7–8	24.43	24.61	.1	0	.1	
Aug. 8		25.49	1.7	0	1.7	
Aug. 14–15	25.29	27.36	3.1	0	3.1	
Aug. 24–25	26.68	28.14	3.5	0	3.5	
Sept. 17	26.66	26.69	.1	0	.1	
Oct. 1–3	26.13	26.89	.2	0	.2	
Oct. 29–30	26.17	29.83	10.1	0	10.1	
Nov. 2	29.22	29.23	.0	0	.0	
Dec. 14	26.89	26.92	.1	0	.1	
Total			18.9	0	18.9	17.8

[1] 10 small storms. [2] Four small storms.

Storm runoff and sediment yield measured in San Luis Reservoir 2, New Mexico

Location.—Lat 35°44′, long 107°04′, in sec. 5, T. 17 N., R. 2 W., on unnamed tributary of San Luis Wash near San Luis, Sandoval County, N. Mex.
Drainage area.—0.92 sq mi.
Records available.—June 1953 to October 1959.
Gage.—Water-stage recorder. Datum of gage is approximately 6,790 ft above mean sea level. Before June 30, 1955, records obtained from periodic readings of a crest-stage gage in reservoir.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir. Spillway discharge obtained by application of formula for a broad-crested weir.
Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
August 1952 to November 1954	0.5
November 1954 to June 1956	.5
June 1956 to August 1956	.5
August 1956 to August 1957	.4
August 1957 to June 1958	2.7
June 1958 to October 1959	.3

Capacity.—Original, at spillway (gage height, 23.9 ft): 13.0 acre-ft, August 1952; 8.1 acre-ft, October 1959.
Maximums.—Inflow rate, about 800 cfs or 860 cfs per sq mi, Oct. 18, 1957. Inflow volume from four storms, 24.2 acre-ft or 26.3 acre-ft per sq mi, July 26–27, 1955.
Remarks.—Records poor for 1953, fair for 1954, good for 1955–59 except that those for spill are poor. Reservoir equipped with an ungated 10-inch outlet pipe (gage height of sill, 19.02 ft).

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1953						
July 16–17		17.35	0.6	0	0.6	
July 31–Aug. 1	16.70	18.45	.7	0	.7	
Total			1.3	0	1.3	1.40
1954						
June 26		19.20	.8	1.9	2.7	
July 8	18.64	20.30	.1	1.1	1.2	
July 22	18.88	22.20	.2	5.6	5.8	
Aug. 5	19.07	20.07	0	.7	.7	
Aug. 19	19.10	21.35	.2	3.0	3.2	
Sept. 7	19.00	20.50	.2	1.2	1.4	
Sept. 18	19.20	21.75	0	4.2	4.2	
Oct. 4	19.20	19.80	0	.4	.4	
Total			1.5	18.1	19.6	21.3
1955						
July 26–27		21.66	2.4	2.8	5.2	
July 27	20.38	21.66	.4	4.0	4.5	
July 28–Aug. 1	20.68	24.24		15.8	15.8	
Aug. 4	19.42	19.51	.1	0	.1	
Aug. 27–28	19.02	19.68	.3	.3	.6	
Total			3.2	22.9	26.2	28.4

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1956						
Aug. 2		22.67	1.9	7.5	9.4	
Aug. 16	19.15	19.60	.4	0	.4	
Aug. 19	19.50	19.62	.1	0	.1	
Sept. 30	18.34	18.50	.1	0	.1	
Total			2.5	7.5	10.0	10.1
1957						
June 11–16		22.33	2.0	7.0	9.0	
July 13	18.72	18.86	.1	.0	.1	
July 25–26	18.60	20.57	.9	1.6	2.5	
July 26–Aug. 1	19.65	20.24	.0	.8	.8	
Aug. 5–6	19.53	20.64	.1	1.8	1.9	
Aug. 6–13	19.75	20.21	0	1.1	1.1	
Aug. 23–25	19.41	21.25	.3	3.2	3.5	
Aug. 30–Sept. 2	19.60	21.92	.1	4.8	4.9	
Oct. 12–14	18.83	22.23	.6	5.7	6.3	
Oct. 18–19	19.56	25.39				
Oct. 19–21	23.88	24.88	0.5	58.0	58.5	
Oct. 21–28	22.67	24.92				
Nov. 4–8	19.91	21.56	.1	9.9	10.0	
Total			4.7	93.9	98.6	107.0
1958						
Feb. 5–Mar. 23 [1]			1.1	0	1.1	
Aug. 5–6		22.43	1.4	5.0	6.4	
Aug. 9	19.88	20.00	.1	0	.1	
Aug. 19–22	20.00	20.78	0	3.0	3.0	
Sept. 12–14	19.46	22.30	.4	5.1	5.5	
Sept. 18	19.87	19.99	.1	0	.1	
Oct. 5–6	19.67	20.57	.3	1.8	2.1	
Total			3.4	14.9	18.3	20.0
1959						
June 21–23		20.35	.9	.7	1.6	
Aug. 8–9	18.50	21.19	1.9	1.0	2.9	
Aug. 14–15	19.75	21.97	.2	3.8	4.0	
Aug. 20	19.87	19.92	0	0	0	
Aug. 24–26	19.81	21.82	.1	4.2	4.3	
Oct. 3–7	19.45	20.59	.5	.9	1.4	
Oct. 29–Nov. 2	19.59	22.83	.3	10.2	10.5	
Total			3.9	20.8	24.7	27.0

[1] Eight small storms.

Storm runoff and sediment yield measured in San Luis Reservoir 3, New Mexico

Location.—Lat 35°44′, long 107°05′, in sec. 6, T. 17 N., R. 2 W., on unnamed tributary of San Luis Wash near San Luis, Sandoval County, N. Mex.

Drainage area.—0.671 sq mi.

Records available.—June 1953 to December 1959.

Gage.—Water-stage recorder. Datum of gage is approximately 6,800 ft above mean sea level. Before June 29, 1955, record obtained from periodic readings of a crest-stage gage in the reservoir.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
August 1952 to November 1954	0.5
November 1954 to June 1956	.6
June 1956 to August 1956	.5
August 1956 to August 1957	.3
August 1957 to October 1958	.6
October 1958 to October 1959	.3

Capacity.—Original, at spillway (gage height, 17.6 ft): 22.6 acre-ft, August 1952; 19.8 acre-ft, October 1959.

Maximums.—Inflow rate, about 280 cfs or 420 cfs per sq mi, Oct. 18, 1957. Inflow volume from four storms, 18.2 acre-ft or 27.2 acre-ft per sq mi, Oct. 18–19, 1957.

Remarks.—Records poor for 1953, fair for 1954, good for 1955–59.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1953						
July 16–17	8.90	12.50	2.30	0	2.3	
Aug. 31	11.8	13.30	1.9	0	1.9	
Total			4.2	0	4.2	6.3
1954						
June 26	9.96	10.57	0.4	0	0.4	
July 8	9.85	12.46	2.0	0	2.0	
July 22	11.97	15.50	8.0	0	8.0	
Aug. 5	13.86	15.07	3.4	0	3.4	
Aug. 19	14.00	15.79	5.8	0	5.8	
Sept. 7	14.90	16.30	5.6	0	5.6	
Sept. 18	15.60	16.60	4.7	0	4.7	
Oct. 4	16.00	16.82	4.1	0	4.1	
Total			34.0	0	34.0	50.7
1955						
July 26	11.51	13.07	1.6	0	1.6	
July 27	13.04	16.88	13.3	0	13.3	
Aug. 4	16.51	16.53	.1	0	.1	
Aug. 13	16.33	16.35	.1	0	.1	
Aug. 27	16.03	16.06	.1	0	.1	
Total			15.2	0	15.2	22.7
1956						
Aug. 2	10.00	13.39	2.9	0	2.9	
Aug. 16	12.79	13.53	1.0	0	1.0	
Sept. 30	12.35	12.66	.3	0	.3	
Total			4.2	0	4.2	6.3
1957						
May 10–11	10.5	12.13	1.1	0	1.1	
June 11	11.44	14.14	3.5	0	3.5	
July 25–26	12.67	12.98	.3	0	.3	
July 29	12.91	13.03	.2	0	.2	
Aug. 5–6	12.83	13.31	.7	0	.7	
Aug. 9–10	13.20	13.47	.4	0	.4	
Aug. 23–29	12.17	14.20	1.9	0	1.9	
Aug. 30–31	14.01	15.09	3.2	0	3.2	
Oct. 12	13.96	15.71	5.5	0	5.5	
Oct. 18–20	15.53	18.04	7.3	13.2	20.5	
Oct. 20	17.25	17.99	4.2	4.4	8.6	
Oct. 21–25	17.99	18.02	0	18.5	18.5	
Nov. 4–9	17.03	17.41	1.5	1.8	3.3	
Dec. 28	16.79	16.83	.2	0	.2	
Total			30.0	37.9	67.9	101.0

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1958						
Feb. 6	16.62	16.65	0.1	0	0.1	
Mar. 6-9	16.42	16.50	.5	0	0.5	
Mar. 22	16.38	16.42	.2	0	.2	
Apr. 8	16.22	16.27	.3	0	.3	
Apr. 11-13	16.23	16.32	.4	0	.4	
July 18	13.82	14.21	.9	0	.9	
Aug. 5	13.75	17.63	16.3	0	16.3	
Aug. 6-10	17.53	18.02		4.9	4.9	
Aug. 19-20	17.46	17.55	.8	0	.8	
Aug. 21-23	17.55	17.80	.1	1.9	2.0	
Sept. 12-15	17.25	18.24	3.7	5.1	8.8	
Sept. 18-19	17.62	17.75	0	1.0	1.0	
Oct. 5-6	17.40	17.70	2.1	0	2.1	
Total			25.4	12.9	38.3	57.0
1959						
April 7-8	15.58	15.75	.7	0	.7	
June 15	14.19	14.21	0	0	0	
June 21-22	14.10	15.21	3.1	0	3.1	
July 28	14.24	14.27	.1	0	.1	
Aug. 8	14.06	14.81	1.9	0	1.9	
Aug. 14-15	14.67	15.55	2.9	0	2.9	
Aug. 20	15.49	15.68	.9	0	.9	
Aug. 24-26	15.58	16.22	2.9	0	2.9	
Sept. 3	15.35	15.65	.8	0	.8	
Oct. 29-30	15.24	17.02	8.3	0	8.3	
Nov. 2	16.96	16.99	.2	0	.2	
Dec. 14	16.40	16.44	.2	0	.2	
Total			22.0	0	22.0	33.0

CORNFIELD WASH, NEW MEXICO

Cornfield Wash is a small tributary of Chico Arroyo, one of the major tributaries of the upper Rio Puerco. Although small in size as compared to the total drainage area of Chico Arroyo, Cornfield Wash is considered to be typical of most of the Chico Arroyo basin as well as other parts of the upper Rio Puerco basin because of similarity in precipitation, vegetation, topography, geology, and erosional conditions. Rates and amounts of runoff and the annual rates of sediment yield measured in Cornfield Wash are therefore believed to be representative of other large parts of the Chico Arroyo and upper Rio Puerco basins.

MEASUREMENTS OF RUNOFF AND SEDIMENT YIELD

Measurements of rainfall, runoff, and sediment yield in Cornfield Wash were carried out as part of a program for the collection of hydrologic data and research in hydrologic processes in arid areas for use in the design of structures and land-treatment programs for conservation of range lands on the public domain. The measurements were made in 19 reservoirs, with an aggregate drainage area of 22.9 square miles, constructed by the U.S. Bureau of Land Management between 1950 and 1957. Details of the study including descriptions of the climate, vegetation, topography, and geology in the drainage area, together with records of precipitation, storm runoff, and the annual sediment yield for the warm summer seasons during the 5-year period, 1951–55, are given by Kennon and Peterson (1960) and need not be repeated here. The mean annual runoff and sediment yield for all stations for the period 1951–59 are given in table 4. The location of the stations is shown in figure 42.

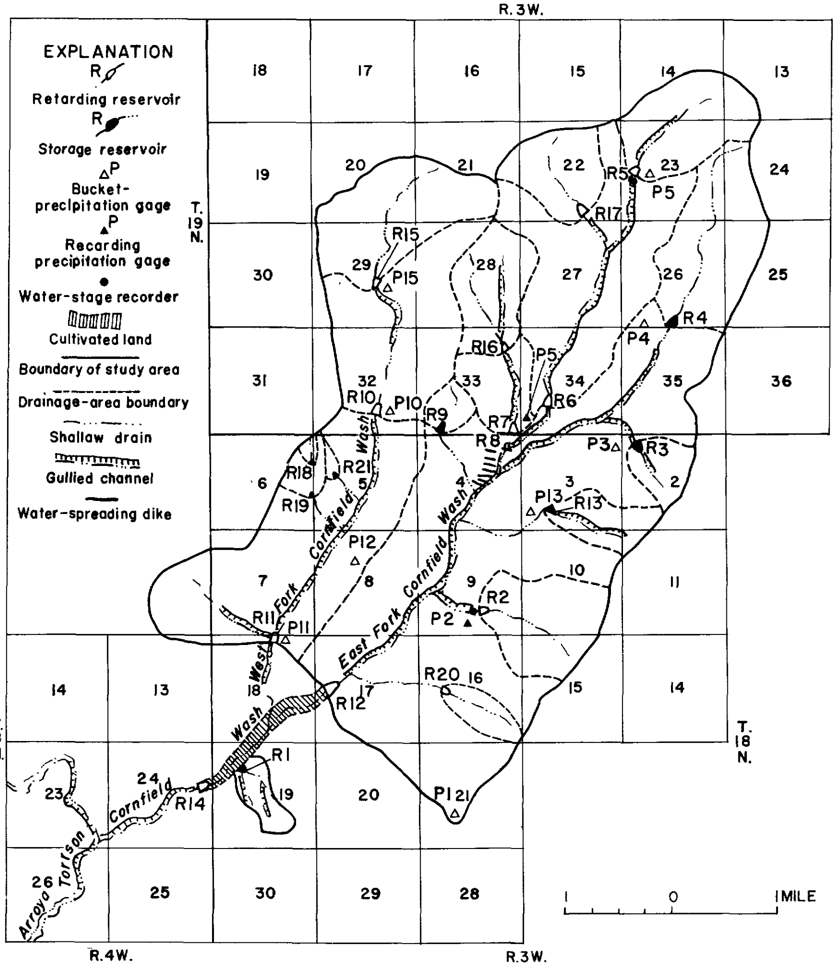

FIGURE 42.—Map showing location of reservoirs, precipitation gages, and water-stage recorders, Cornfield Wash, Sandoval County, N. Mex. Map adapted from Kennon and Peterson (1960, pl. 7).

RIO COLORADO BASIN, NEW MEXICO

The Rio Colorado is a tributary of San Jose River, entering a short distance above the settlement of Correo. Measurements of runoff and sediment yield are made in a reservoir constructed by the Bureau of Indian Affairs to regulate and store the flow of the Rio Colorado for use in irrigation of hay and pasture lands. The reservoir has the largest drainage area of any included in the study and its capacity is exceeded only by the Rongis Reservoir in Wyoming.

TOPOGRAPHY

The topography of the Rio Colorado basin is controlled in large measure by the underlying rock formations. The central part of the basin is a flat alluvial plain that ranges from 2 to more than 10 miles wide. Bordering the plain are steep slopes, in places precipitous, made up of alternate shale and sandstone beds that form a series of large mesas. Total relief in the basin is about 1,100 feet and most of the rise is represented in the steep slopes leading to the mesas. The basin floor is featureless, except for the gentle colluvial slopes leading from the flood plain of the channel to the base of the bordering slopes.

GEOLOGY

As previously noted, the central part of the basin is an alluvial plain. In the bordering slopes, shale of the Chinle formation of Triassic age is exposed at the base and is capped by the massive Wingate sandstone. The high mesas are in the form of steps; the lowest step is formed on the Wingate sandstone and successive higher ones on the Navajo sandstone of Jurassic age and the Dakota sandstone of Late Cretaceous age. A mesa of several square miles along the southeast side of the basin is underlain by volcanic rocks. These rocks are very young, and on large tracts sufficient soil to support vegetation has not yet formed. Because of the prevalence of sandstone in the basin, most of the soils are sandy and moderately pervious. The shale of the Chinle formation weathers to a heavy impervious mantle that is extremely vulnerable to erosion.

VEGETATION

In general, the lower central section of the basin has a good cover of sacaton and galleta, but many of the bordering areas have a sparse vegetation. Large areas underlain by shales are barren. These appear to have always been in this condition, but similar extensive barren areas along the outer edges of the alluvial plain obviously are the result of recent deterioration, probably due to a combination of severe overgrazing and drought. Vegetation on the mesas is sparse, consisting mainly of grama and galleta. Thin stands of pinyon and juniper intermixed with grass grow on the more sandy spots. Except in the central plains, the vegetation is probably too thin to influence significantly runoff or sediment movement.

EROSION

Sheet erosion is the predominating type in the basin. Rilling and minor gullying are visible on the steeper slopes of shale, but the valley floor has not been trenched. The prevalence of the barren tracts reflects the importance and areal extent of sheet erosion. In each of these tracts the soil has been stripped off to depths of as much as a foot, as indicated by pedestaled plants. The present surface is an almost flat clay slick that is vulnerable to attack by rain splash and overland flow. The erosion in these tracts is in large part offset by deposition within the areas of grass along the valley floor, resulting in a relatively low sediment yield per unit area as measured at the reservoir.

PRECIPITATION

The nearest precipitation station with a long-term record is located at Laguna, about 15 miles directly north of the basin. The following precipitation data are summarized from records of the U.S. Weather Bureau station at Laguna.

Mean precipitation, 1927–59

	Inches
Annual	8.63
May through October	7.04
November through April	1.59
Maximum month (July)	1.64

Frequency of 1-day precipitation events of selected magnitude at Laguna, May through October

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Percent of years in which at least one event occurred, 1927–59	85.0	54.5	12.1	0
Average number of events per year during—				
1927–59	3.6	.9	.1	0
1945–55	2.9	1.0	.1	0

The storm runoff and sediment yield are shown in the following table, and the mean annual runoff and sediment yield are shown in table 4.

Storm runoff and sediment yield measured in Rio Colorado Reservoir, N. Mex.

Location.—Lat 34°53′, long 107°23′, in sec. 29, T. 8 N., R. 5 W., near Correo, N. Mex.

Drainage area.—55 sq mi.

Records available.—June 15, 1956, to October 1959.

Gage.—Water-stage recorder. Datum of gage is about 5,600 ft above mean sea level.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
December 1956 to May 1958	41.6
May 1958 to May 1959	7.2
June 1959 through August 1959	[1]

[1] No record of sediment obtained.

Capacity.—Original, 970 acre-ft, December 1956; 921.2 acre-ft, May 28, 1959.

Maximums.—Inflow volume, 1,120 acre-ft or 20.4 acre-ft per sq mi, July 24–28, 1957. Inflow rate, about 750 cfs or 13.6 cfs per sq mi, July 25, 1957.

Remarks.—Records fair. Reservoir is equipped with an 18-inch ungated drop outlet pipe and an 8-inch gated outlet pipe. Sill of the 18-inch pipe is at elevation 34.93 ft. Invert of the 8-inch pipe is at elevation 29.0 ft. Reservoir capacity at 29.0 ft, 4.0 acre-ft, May 29, 1958.

Date of flow	Gage height (feet)			Spill (acre-ft)	Inflow	
	Before inflow	After inflow	Inflow stored (acre-ft)		Total (acre-ft)	Acre-ft per sq mi
1956						
Aug. 1		29.84	21.0	0	21.0	
Aug. 3	29.81	30.07	7.1	0	7.1	
Aug. 20	29.73	29.83	2.6	0	2.6	
Total			30.7	0	30.7	0.6
1957						
Apr. 29		29.70	18.0	0	18.0	
July 18		29.92	23.0	0	23.0	
July 20	29.89	29.95	1.2	0	1.2	
July 22	29.93	30.18	7.2	0	7.2	
July 25–28	30.17	39.55	803.5	223.4	1126.9	
July 28–Aug. 3	39.55	37.10	[1] −365.0	541.0	176.0	
Aug. 4–5	37.10	36.89	[1] −18.1	74.2	56.1	
Aug. 5–6	36.89	37.46	77.0	103.4	180.4	
Aug. 6–17	37.46	35.18	[1] −76.7	76.7	0	
Aug. 17–Sept. 2	35.18	35.28	[1] −45.0	48.0	23.0	
Oct. 11–12	34.29	34.99	63.0	10.0	73.0	
Total			488.1	767.0	1684.8	30.6
1958						
Aug. 21		34.29	319.0	0	319.0	
Sept. 3–4	34.05	34.83	81.0	0	81.0	
Sept. 6–8	34.83	35.16	25.0	23.0	48.0	
Total			425.0	23.0	448.0	8.2
1959						
June 3–19	30.97	32.21	18.0	67.0	85.0	
Aug. 1		31.88	100.0	0	100.0	
Aug. 6–7	31.86	33.86	180.0	0	180.0	
Aug. 13–15	33.77	35.05	120.0	20.0	140.0	
Aug. 18–20	34.91	35.79	65.0	46.0	111.0	
Aug. 21–23	35.50	35.73	4.0	26.8	30.8	
Aug. 24–26	35.52	35.57	[1] −67.0	79.8	12.8	
Total			420.0	239.6	659.6	12.0

[1] Withdrawal from storage.

RIO SALADO BASIN

VICTORINO WASH, NEW MEXICO

The Victorino Reservoir is located about 30 miles south of the Acoma Indian Pueblo in the headwater area of Victorino Wash, a tributary of Rio Salado. The drainage basin is typical of the high-plateau country that is located west of the Rio Grande, between the Rio San Jose on the north and Rio Salado on the south.

TOPOGRAPHY

The drainage basin of the reservoir has a broad, flat interior valley that on three sides grades abruptly into cliffs and steep sandstone slopes leading to narrow mesas along the divide. Elevations range from 7,000 feet at the reservoir to about 8,000 feet at the divide.

GEOLOGY

The flat central part of the basin is underlain by the Mancos shale, which has been eroded to a surface of low relief. The steep outer slopes and the small mesas along the divide are underlain by the resistant sandstone beds of the Mesa Verde group. Outcrops of Tertiary volcanic rock, which are resistant to erosion, are scattered throughout the upper reaches of the basin. Alluvial deposits occur in lower parts of the valley.

VEGETATION

Short grasses, mainly galleta and blue grama mixed with desert shrubs and scattered cholla cactus predominate in the central part of the basin, and scattered stands of pinyon and juniper grow on the higher areas underlain by sandstone. The density of the cover is less than 5 percent on the valley floors and the steep outer slopes, but it increases to about 15 percent on the sand mesas.

EROSION

Severe sheet erosion and minor gullying occurs on the steep outer slopes, but much of the sediment from these sources is deposited along the valley sides and does not reach the reservoir. The lower valley is trenched by a deep gully, and bank cutting and headcutting probably account for the high rate of sediment yield measured in and just above the reservoir.

PRECIPITATION

The precipitation station nearest Victorino Wash is located about 30 miles north at Laguna; but because of the similarity in position with respect to storm paths and topographic characteristics, it is believed that precipitation in the two areas is similar. Precipitation data for Laguna have already been presented.

RUNOFF

As in other parts of southwestern New Mexico, runoff in Victorino Wash occurs primarily as the result of high-intensity summer storms. None was recorded during the winter period. The mean annual runoff and sediment yield during the period of record are given in table 4; storm runoff and annual sediment yield are given in the following table.

Storm runoff and sediment yield measured in Victorino Wash Reservoir, New Mexico

Location.—Lat 34°37′, long 107°36′, in sec. 32, T. 5 N., R. 7 W., Victorino Wash near Acoma, Valencia County, N. Mex.

Drainage area.—10.1 sq mi.

Records available.—June 1954 to October 1958.

Gage.—Water-stage recorder. Datum of gage is approximately 5,500 ft above mean sea level.

Runoff and discharge determinations.—Contents of reservoir and volume of inflow and pipe outflow computed from a stage-capacity curve of the reservoir.

Sediment yield.—Computed from deposition in reservoir as shown by successive surveys.

Period of record	*Total sediment yield (acre-ft)*
June 1954 to May 1955	2.7
May 1955 to October 1955	7.0
October 1955 to October 1956	.0
October 1956 to December 1957	2.9
December 1957 to October 1958	.0

Capacity.—At spillway (gage height, 17.5 ft): 128.5 acre-ft, June 1954; 115.9 acre-ft, September 1958.

Maximum.—Inflow volume, more than 190 acre-ft, Aug. 20, 1955. Maximum inflow rate occurred on same date.

Remarks.—Records good, except that those for periods with no gage-height record are poor. Reservoir has an ungated 24-inch outlet pipe (gage height of sill, 4.25 ft). Of the 10.1 sq mi drainage area, runoff from 4.3 sq mi is controlled by an upstream reservoir equipped with a 21-inch outlet pipe; reservoir breached on Aug. 20, 1955, repaired same year, and measurements continued until 1958 when station was discontinued, because additional structures in drainage basin made the records worthless.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1953						
Date of storm unknown		[1] 7.5	16.0	0	16.0	1.6
1954						
Aug. 6		6.63	6.4	5.9	12.3	
Aug. 8	4.82	5.39	1.1	0.3	1.4	
Aug. 11	4.72	4.95	0.4	0	0.4	
Sept. 11	3.70	6.68	5.9	2.8	8.7	
Sept. 12	4.81	9.15	15.8	8.4	24.2	
Sept. 24	4.50	12.95	45.2	14.7	59.9	
Oct. 5	4.55	6.23	3.5	1.0	4.5	
Total			78.3	33.1	111.4	11.0
1955						
July 24		8.67	12.6	14.8	27.4	
July 25		7.96	7.9	13.1	21.0	
July 27	5.31	8.30	9.3	14.7	24.0	
Aug. 7	5.23	8.23	8.9	18.2	27.1	
Aug. 15	5.60	7.81	6.7	12.0	18.7	
Aug. 20	[2] 5.5	19.9	0	+190.0	+190	
Total			45.4	262.8	308.2	
1956						
Aug. 20		10.66	15.4	4.6	20.0	2.0
1957 [3]						
1958						
Oct. 5		11.85	15.7	15.4	31.1	3.1

[1] Estimate based on high-water mark.
[2] Estimate based on high-water mark, recorder stopped.
[3] No runoff record obtained.

MISCELLANEOUS AREAS IN THE MIDDLE RIO GRANDE BASIN

Measurements of sediment deposition are being made in seven small reservoirs on washes tributary to the Rio Grande to obtain sample rates of sediment yield in the area west of the Rio Grande below the mouth of the Rio Puerco. The topography and geology in five of the reservoir basins are similar in that each is located on the extensive gravel terraces along the west side of this part of the Middle Rio Grande Valley. Two of the reservoir basins are underlain by older sedimentary rocks, but the topography is similar in most respects to that of the other basins. On the basis of records from nearby U.S. Weather Bureau stations, precipitation in each of the basins is approximately the same—the mean annual rainfall ranging from 8.5 to 9.5 inches, of which about 75 percent falls in the summer period. Because of these similarities, the measurements are believed to be fairly representative of the mean annual sediment yield for most areas of grazing land in this part of the Rio Grande Valley. No records of runoff were obtained at either of the reservoirs, but the sediment yield from each of the basins was determined by periodic surveys and is shown in tables that follow the brief descriptions of the basins. The mean annual sediment yield and other details concerning the basins are given in table 4. The precipitation characteristics of the areas, as indicated by data from nearby Weather Bureau stations, are also given.

LADRON PEAK RESERVOIRS

The Ladron Peak Reservoirs 1 and 2 are located on the southwest side of Ladron Peak about 12 miles west and slightly south of the mouth of the Rio Puerco. The basins do not drain the flanks of the mountain but occupy only the pediment slopes along the southwest side. Both basins have a subdued topography with slight relief and poorly developed drainage channels. Each of the basins is underlain by rocks of the Magdalena group of Pennsylvanian age and include limestone, shale, and minor amounts of sandstone. The rocks are covered by a thin mantle of residual soils in the upper parts of the basin and with alluvium in the lower parts. Vegetation is sparse consisting mainly of scattered clumps of grama and desert shrubs that have a density of about 5 percent. Because there are no well defined channels, it is obvious that most of the sediment is produced by sheet erosion. Precipitation in the area is probably about equivalent to that measured at Los Lunas, as summarized in a later table.

The reservoirs were surveyed seven times during the period May 1951 to October 1959. The following table shows the sediment yield from the drainage basin as measured by deposition in the reservoirs.

Date of Survey [1]	Deposition since previous survey (acre-ft)	
	Reservoir 1	Reservoir 2
June 1954	0.61	0
May 1955	[2] +.06	0
October 1955	[2] +.02	0
October 1958	0.9	0
October 1959	0	0

[1] Original survey, May 1951.
[2] Increase in reservoir capacity due to drying and compaction of sediments.

HOT SPRINGS WASH RESERVOIRS 1 AND 2

The Hot Springs Wash Reservoirs 1 and 2 are located on unnamed tributaries of Hot Springs Wash about 5 miles northwest of Truth or Consequences, N. Mex. Both basins drain a flat terrace that has a maximum slope of less than 2 percent. In basin 1 a broad uncut swale, with no defined channel, slopes gently to the reservoir. In basin 2 the surface has been strongly dissected, and well-defined channels with steep side slopes lead to the reservoir. The terraces are underlain by unconsolidated deposits of gravel, sand, and silt. Vegetation is poor, consisting predominately of creosotebush and scattered clumps of grama. Both surface evidence and the measurement of sediment yield indicate that erosion in basin 1 is slight. The dissection in basin 2 has caused an increase in sheet erosion on flat areas adjacent to the channels in addition to degradation in the channel. The precipitation at Elephant Butte Dam, about 6 miles east, is believed to be representative of conditions at the two basins.

The following tabulation shows the sediment yield from the basin as measured by five reservoir surveys.

Date of Survey [1]	Deposition since previous survey (acre-ft)	
	Reservoir 1	Reservoir 2
April 1955	0	1.03
October 1955	.06	1.35
November 1957	0	([2])
October 1959	.03	

[1] Original survey, May 1951.
[2] Spillway breached; measurements discontinued.

NORDSTROM WASH RESERVOIRS 1, 2, AND 3

The Nordstrom Wash Reservoirs are located on three contiguous tributaries of Nordstrom Wash, which enters the Rio Grande a short distance below Caballo Dam. The basins drain a part of the slope

TABLE 4.—*Summary of storm runoff and sediment yield data for the Rio Grande basin*

[Discharge over spillway: L, large; M, medium; S, small; N, none]

Reservoir	No. on fig. 35	Location			Period of record	Drainage basin data				Reservoir capacity			Sediment yield for period of record			Runoff for period of sediment record			Ratio runoff to sediment	Discharge over spillway
										Original				Average annual			Average annual			
		Sec.	T.	R.		Area (sq mi)	Max relief (ft)	Length (ft)	Relief ratio	Acre-ft	Acre-ft per sq mi	Most recent survey (acre-ft)	Total (acre-ft)	Acre-ft	Acre-ft per sq mi	Total (acre-ft)	Acre-ft	Acre-ft per sq mi		
Jemez River basin, New Mexico																				
Zia [1]	22	16	15N	2E	1954-59	2.4	500	19,500	0.026	59.9	24.9	42.7	17.2	2.9	1.20	125.0	20.8	8.7	7.2	M
RIO PUERCO BASIN																				
San Luis Wash, New Mexico																				
[Area 23 on fig. 1]																				
San Luis 1	----	4	17N	2W	1953-59	1.06	-------	-------	-------	16.3	15.4	11.7	4.6	0.66	0.62	180.0	25.7	24.2	39.0	S
2 [2]	----	5	17N	2W	---do---	.92	-------	-------	-------	13.0	14.1	8.1	4.9	.70	.76	198.7	28.4	30.8	40.7	N
3	----	6	17N	2W	---do---	.67	-------	-------	-------	22.6	33.8	19.7	2.8	.41	.62	185.8	26.5	39.5	64.0	S
Cornfield Wash, New Mexico																				
[Area 24 on fig. 35. Location of study areas shown on fig. 42]																				
Cornfield Wash 5 [3]	----	23	19N	3W	1951-59	1.04	195	5,600	0.035	9.2	8.9	[4] 2.9	6.9	0.77	0.74	181.0	20.1	19.3	26.2	L
17	----	22	19N	3W	1955-60	.56	130	4,410	.029	18.3	31.0	17.4	.9	.15	.26	67.0	11.2	22.9	74.2	S
6	----	34	19N	3W	1951-59	[5] 3.20	220	15,100	.015	44.9	14.0	6.2	38.7	4.30	[6] 1.52	[7] 628.9	69.9	[6] 24.2	18.1	L
16	----	33	19N	3W	1955-59	.55	-------	-------	-------	28.9	52.5	25.7	3.2	.40	.73	139.5	23.3	42.3	43.5	N
7	----	33	19N	3W	1951-59	[5] 1.20	220	9,100	.024	15.0	12.5	5.4	9.6	1.06	[6] 1.30	[7] 232.0	25.8	[6] 33.5	24.3	L
4	----	35	19N	3W	---do---	1.18	200	8,865	.023	22.1	15.7	17.3	4.8	.53	.45	172.0	19.1	16.2	35.8	M
3	----	2	18N	3W	---do---	.25	110	3,040	.036	5.9	23.6	[4] 2.4	3.8	.42	1.68	81.0	9.0	36.0	21.3	L
9	----	33	19N	3W	---do---	.09	100	2,100	.048	4.6	51.1	3.1	1.5	.17	1.89	48.4	5.4	60.0	32.2	S
13	----	10	18N	3W	---do---	.33	170	3,966	.043	7.4	22.4	.0	7.4	.82	2.46	132.1	14.6	43.8	18.8	L
2	----	9	18N	3W	---do---	.87	160	6,050	.026	54.1	62.2	[4] 45.1	9.5	1.06	1.21	166.8	18.5	21.3	17.6	N
20	----	16	18N	3W	1957-59	.26	-------	-------	-------	28.1	108.0	26.2	1.9	.63	2.42	17.1	5.7	21.9	9.0	N

12		17	18N	3W	1951–59	[5] 7.07				323.6	44.1	[4] 123.8	201.2	22.4	[6] 3.10	[7] 2,054.6	210.7	[6] 23.4	10.2	M
15		29	19N	3W	1953–59	1.04				17.9	17.2	17.9	0			18.8	2.7	2.6		N
10		32	19N	3W	1951–59	[5] 3.05				48.6	15.9	[4] 36.9	11.9	1.3	[6] .54	453.3	50.4	[6] 22.0	38.1	S
21		5	18N	3W	1957–59	.03				8.2	274.0	8.2	0			1.8	.6	20.0		N
18		6	18N	3W	do	.02				4.4	220.0	4.4	0			1.4	.5	25.0		N
19		6	18N	3W	do	.18				13.8	76.6	13.4	.4	.1	.74	16.8	5.6	31.1	42.0	N
11		18	18N	3W	1951–59	[5] 3.03				166.8	55.2	88.5	78.3	8.7	[6] 2.98	1,021.9	113.5	[6] 37.4	13.0	N
1		19	18N	3W	do	.29	170	3,700	.046	24.0	82.7	11.9	16.4	1.8	6.20	153.6	17.1	59.0	9.4	S

Rio Colorado basin, New Mexico

Rio Colorado [8]	25	29	8N	5W	1957–58	55.0				910.0	16.5	861.2	48.8	24.4	0.44	2,132.8	1,066.4	19.4	43.7	S

Rio Salado basin, New Mexico

Victorino Wash [9]	26	32	5N	7W	1954–58	10.1	1,000	22,900	0.044	128.5	12.7	115.9	12.6	2.5	0.25	469.7	93.9	9.3	37.3	M
Ladron Peak 1	27	13	2N	3W	1951–59	.79				10.7	13.6	12.1	1.5	.21	.28					N
2	27	33	3N	3W	do	.51				31.2	61.3	31.2	0	0	0					N

Hot Springs Wash basin, New Mexico

[Area 28 on fig. 35]

Hot Springs Wash 1		14	13S	5W	1951–59	1.02				5.1	5.0	5.0	0.1	0.01	.01					S
2		11	13S	5W	1951–55	.98				11.4	11.6	9.0	2.4	.48	.49					L

Nordstrom Wash basin, New Mexico

[Area 29 on fig. 35]

Nordstrom Wash 1		27	16S	5W	1951–59	1.00				28.6	28.6	24.6	4.0	0.44	0.44					N
2		27	16S	5W	do	.17				8.5	50.0	4.3	4.2	.47	2.77					N
3		27	16S	5W	do	.58				25.9	44.8	21.4	4.5	.50	.86					N

[1] 8-inch outlet pipe.
[2] 10-inch outlet pipe.
[3] For details on outlet pipes Cornfield Wash reservoirs, see Kennon and Peterson, 1960 table 2.
[4] Adjusted for increase in reservoir capacity due to compaction and drying of sediment.
[5] Drainage area reduced by construction of upstream reservoir.
[6] Adjusted for change in drainage area.
[7] Does not include discharge from upstream reservoir.
[8] 18-inch outlet pipe.
[9] 24-inch outlet pipe.

leading from the high terrace west of the valley to the Rio Grande flood plain. In outline, the basins are long and narrow with a steeply sloping divide on each side and a gently sloping central floor. Unconsolidated deposits of silt, sand, and gravel, which are part of the Rio Grande terrace deposits, underlie the area. The soils are sandy and highly permeable. Vegetation is sparse and consists predominately of creosotebush and minor amounts of grass. Despite the steep slopes along the sides of the basins and the poor cover, there is little evidence of serious erosion. The main drainage channels are not trenched and there are no rills or gullies on the valley side slopes. Sheet erosion is the dominant type and doubtless is responsible for the moderate rate of sediment yield from the basins. Precipitation in the basins should be about the same as that at the U.S. Weather Bureau station at Caballo Dam, about 4 miles northeast. The precipitation data for this and other stations are summarized below.

The following tabulation shows the sediment yield from the basins as measured in five surveys of reservoirs conducted between 1951 and 1959. The mean annual sediment yield is shown in table 4.

Date of survey [1]	Deposition since previous survey (acre-ft)		
	Reservoir 1	Reservoir 2	Reservoir 3
April 1955	3.24	2.02	2.09
October 1955	.31	1.57	1.55
November 1955	0	.22	.05
October 1959	.46	.43	.81

[1] Original survey, May 1951.

Precipitation data considered to be representative of the three areas are shown in the following tables.

Mean precipitation at miscellaneous areas in the middle Rio Grande basin

Ladron Peak Reservoirs, Los Lunas, 1906–40, 1950–59

	Inches
Annual	9.07
April to October	6.02
November to March	3.05
Maximum month (July)	1.15

Hot Springs Wash Reservoirs, Elephant Butte, 1909–59

	Inches
Annual	9.02
April to October	7.00
November to March	2.02
Maximum month (August)	2.02

Nordstrom Wash Reservoirs, Caballo Reservoir, 1939–59

	Inches
Annual	8. 22
April to October	6. 63
November to March	1. 59
Maximum month (September)	1. 74

Frequency of 1-day precipitation events of selected magnitude from May through October

	1-day precipitation greater than—			
	0.5 in.	1.0 in.	1.5 in.	2.0 in.
Los Lunas:				
Percent of years in which at least one event occurred, 1906–40, 1950–59	90. 0	52. 0	14. 0	2. 0
Average number of events per year during—				
1903–59	2. 9	. 8	. 2	0
1951–59	1. 9	. 7	0	0
Elephant Butte:				
Percent of years in which at least one event occurred, 1917–59	95. 3	67. 5	11. 1	2. 3
Average number of events per year during—				
1917–59	3. 5	1. 1	. 1	0
1951–59	3. 0	. 9	0	0
Caballo Reservoir:				
Percent of years in which at least one event occurred, 1939–59	95. 2	71. 4	23. 8	9. 5
Average number of events per year during—				
1939–59	3. 0	1. 2	0. 3	0. 1
1947–59	3. 2	1. 3	. 2	. 0

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