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CHANNEL GAIN AND LOSS INVESTIGATIONS

TEXAS STREAMS

1918 - 1958

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United States Department of the Interior

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INTRODUCTION

Of the water that reaches a stream channel, part is discharged by evaporation and transpiration, and by seepage into the ground along the stream channel where the water table is lower than the surface of the stream. The part lost by seepage may return later to the same channel at a point downstream; it may flow through underground channels to be discharged in distant springs or even into another river channel; it may become a part of ground water which will appear, perhaps years later, in wells that furnish water for domestic or industrial use, for irrigation, or for other uses.

The determination of available water in Texas streams cannot be made entirely from runoff records at the regular streamflow stations maintained on streams throughout the State. Special investigations must be made to locate, identify, and determine gains or reductions in streamflow. Investigations have been made on many Texas streams to determine flow conditions during periods of base flow, to identify interchange of surface water and ground water, to determine losses of water in irrigation systems, and to determine the change in the pattern of flow and amount of water released from a reservoir as it is conveyed in a stream channel to a point downstream. Such investigations are of basic importance in consideration of problems that involve supply and use of water for almost any purpose.

This publication combines in one volume the results of all special investigations that have been made by the Texas Board of Water Engineers and the U. S. Geological Survey from 1918 through 1958 to determine quantitative gains and losses of stream flow through long reaches of natural stream channels and canals in Texas; and it also includes results of an investigation on the Rio Grande made in 1928 by the U. S. Geological Survey in cooperation with the International Boundary and Water Commission. This bulletin compiles two types of studies; low-flow investigations, many of which have been published in Geological Survey water-supply papers in Parts 7 and 8 of the annual series, "Surface Water Supply of the United States"; and delivery-of-water investigations, which in most cases have been published as open-file reports with very limited distribution. The first of these special investigations was made in 1918. Since that date nearly 150 investigations of channel gains and losses have been made.

LOW-FLOW INVESTIGATIONS

Purpose and Scope

The low-flow investigations were made to show gains and losses of flow in a selected reach of stream during a period of base flow; that is, when the total flow of the stream was contributed by springs or seeps from aquifers with no

direct runoff from recent storms. The aquifers that contribute to streamflow may be alluvial beds in the stream channel, other deposits of sand and gravel in the watershed, areas of cavernous rock even outside the watershed, or any other geologic formations that are capable of transmitting water. Water enters these aquifers by percolation from rainfall on the outcrop area, by seepage on flood plains during periods of over-bank flow, or by seepage into permeable streambeds at elevations higher than that of the area under investigation. The quantity of water that may enter an aquifer depends on various geologic and hydraulic factors. Permeability of the formation and hydraulic gradient are two of the factors that affect the quantity of water transmitted by aquifers.

Base streamflow will disappear into a permeable streambed where the water level is below stream level; the water may reappear downstream or may flow through the bed of the stream into a ground-water reservoir which transmits the water away from the stream. This process effects a substantial interchange of surface water and ground water in many areas of Texas. A good example of such interchange is found along the south edge of the Edwards Plateau in west-central Texas. In this region most of the streams obtain their base flow from springs that flow from porous limestone aquifers. The water flows in channels cut into the Glen Rose limestone, which may add significantly to the base flow, and then plows into the Edwards limestone through cracks and fissures in the streambed along the Balcones fault zone; the line along which the Edwards has been dropped several hundred feet by faulting. The water flows underground in the Edwards limestone many miles to the east, where much of it emerges as spring flow and sustains substantial base flow in streams all the way to the Gulf of Mexico. Comal Springs, San Marcos Springs, and San Antonio Springs all flow from the Edwards limestone, which is recharged largely from streams in the upper Nueces River basin within the limits of the Edwards Plateau.

Description of Investigations

The low-flow investigations have ranged from a reconnaissance type study, with a few discharge measurements on the main stream, to comprehensive types of studies with many measurements of main-stream flow, tributary inflow, and diversions. Recent, more comprehensive investigations have been made as follows: streamflow measurements were made with a Price current meter at sites on the main stream, the sites being selected on basis of stream mileage, on changes in geology, or on changes in pattern of flow as determined from previous investigations; tributary inflow and diversions were measured by current meter or were estimated; particular attention was paid to bank seepage and to springs, additional measurements being made to determine the exact point where natural gains or losses occurred; and notes were made of channel conditions, streambed composition, and vegetation in the streambed, on the banks, and in the stream valley.

The first low-flow or seepage investigations were made along the Colorado River, along tributaries of the Colorado River above Austin, and along the Pecos River during a very dry period in the summer of 1918. A second series of investigations in the Colorado River basin was made in 1925, another drought year. The investigations along the Colorado River in 1918 covered 593 miles, from the town of Robert Lee to the river's mouth. The numerous seepage investigations in the Pecos River basin were made for the purpose of determining conveyance losses in irrigation canals.

Since December 1954 a number of low-flow investigations have been made along the upper reaches of all large streams from the Guadalupe to the Nueces Rivers that recharge the Edwards limestone in the Balcones fault zone. One such inves-

tigation made along the Guadalupe River in 1955 included chemical analysis of water samples and water temperatures which helped solve a complex problem of surface and ground water interchange.

An intensive investigation of the low-flow characteristics of the Pedernales River was made during a drought period in January 1956. The field investigation was made and the report was prepared by a party of three: an engineer from the Texas Board of Water Engineers, who interviewed landowners to determine point of and the amount of diversions for irrigation and other uses; and a geologist and an engineer from the U. S. Geological Survey, who made streamflow measurements and flow analyses on the basis of geology and other stream characteristics.

During the period from 1918 to 1958, 138 separate low-flow investigations were made, most of them in the basins of the Colorado, Guadalupe, and Nueces Rivers and the Rio Grande. The data in the early investigations are especially valuable, having been obtained before major river developments took place, flows generally represented natural conditions; although even in 1918, there were large diversions for rice irrigation from the lower Colorado River. Certainly, the series of hydroelectric plants and storage reservoirs completed on the Colorado River in recent years have so altered the pattern of low flow as to make future low-flow investigations meaningless insofar as natural river conditions are concerned.

DELIVERY-OF-WATER INVESTIGATIONS

Purpose and Scope

Delivery-of-water investigations have been made during periods when water was being released from a reservoir and allowed to flow down the natural stream channel to a point of diversion or use. These investigations provide information on time of travel of released water, losses encountered in conveying water downstream, peak-flow reductions, and changes in rate of flow of released water as it progressed downstream--information essential to enable the water user to compute the rate of release which will effect maximum recovery of released water at the point of diversion or use.

Generally, these investigations have been made when reservoir water was being released to meet water demands during drought periods. At such times channel reaches through which the released water was conveyed were usually dry or nearly dry; consequently bank storage, prior to the release, was at a minimum. In such water deliveries water was lost in varying amounts through evapotranspiration and bank storage, and seepage losses or recharge to ground-water reservoirs occurred only where geology favored such loss.

The first delivery-of-water investigation was made during the 1918 drought and recorded the movement of a special release of stored water from Lake Austin down the Colorado River to irrigators in the vicinity of Bay City. The second investigation, made in 1934, recorded the movement of water released from Brownwood Reservoir down Pecan Bayou and thence down the Colorado River to Wharton. The other investigations involved the diversion of Red River water to Lake Dallas in the Trinity River basin in 1954; and delivery of water from reservoirs in the Brazos River basin, namely, Possum Kingdom, Whitney, and Belton Reservoirs, to Richmond in 1948, 1954, and 1956. These investigations are the forerunners of similar ones that will be required as other reservoirs are provided.

Description of Investigations

Data collected at regular stream-gaging stations in the reach of river being investigated provided the basic information for studying the movement of released water. For some of the investigations, special visits and additional discharge measurements were made at the stream-gaging stations during the release period. When necessary, temporary recording gages were installed and records of stage and discharge at other points were obtained to supplement the regular gaging-station records. Where major pumping plants diverted water in the reach under study, inspections and discharge measurements were made to assure an accurate record of the diversions. In some of the investigations, discharge measurements of ungaged tributary streams were made to provide information for identifying and defining base streamflow.

PRESENTATION OF DATA

The investigations included in this report are presented in two sections: (1) low-flow investigations and (2) delivery-of-water investigations. The investigations in each section are arranged geographically according to basin from east to west across the State and in downstream order of tributaries or diversions within the basin.

The data presented for each low-flow investigation include a tabulation of measurements, text and any substantiating information available. The table of measurements gives the following information: river basin, name of the stream investigated, a precise description of the location of the reach under investigation, period of the investigation, date of each flow determination, river miles below the starting point, a short description of the location of the determination, stream discharge in cubic feet per second (cfs) at each point, and water temperature if available. Data for the recent, more comprehensive investigations may include field notes concerning conditions that affect the flow, description of streambed composition at a measuring section, or references to important changes in geology.

The information presented for each delivery-of-water investigation includes a discussion of the purpose and scope, a summary of results, and a presentation of results in the form of discharge hydrographs and time-of-travel curves.

The basic data and original field notes for all the investigations in this report are available for examination in the files of the Surface Water Branch District office of the U. S. Geological Survey in Austin, Texas.

Low-flow Investigations

Tierra Blanca Creek — Aug. 31, Sept. 28, 1941

Reach: From Buffalo Lake (Umbarger Reservoir) near Umbarger to a point about 18 miles downstream, near Canyon, Tex.

A series of discharge measurements was made on Aug. 31 and Sept. 28, 1941 on Tierra Blanca Creek, Tex., between Buffalo Lake (Umbarger Reservoir) and a point 17.9 miles downstream in the vicinity of Canyon. The measurements represent natural conditions and were made during a constant discharge release from Buffalo Lake. No diversions were found in the reach and no inflow was found from tributaries.

On Aug. 31 total flow of the creek is released water from Buffalo Lake. This discharge varied from 2.0 to 0.97 cfs from Aug. 24-29 but was increased from 0.97 to 4.4 cfs at 1:40 p.m. Aug. 29. A constant release of 4.4 cfs was held from Aug. 29-31. Field inspection revealed that flow had stabilized from dam to a point 10.9 miles downstream but below this point flow was fluctuating due to fluctuating releases prior to Aug. 29. Estimate of discharge at mile 17.9 indicated that at least the minimum release (0.97 cfs) was lost by seepage, evaporation or by storage in several small reservoirs in the reach. The investigation was not continued because rainfall occurring a few days later did not permit the flow to stabilize.

On Sept. 28 the above investigation was continued. According to records of the Soil Conservation Service, 3.19 cfs were being released from Buffalo Lake on Sept. 28 and the released discharge had ranged from 3.08 to 3.27 cfs for the period Sept. 24-27. Field inspection indicated that the stage was constant throughout the reach on Sept. 28 and that a total loss of 2.6 cfs was found in the 17.9 miles of channel investigated.

Date 1941	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Aug. 31	Tierra Blanca Creek	600 ft below dam at Buffalo Lake	0		4.54			
31	Tierra Blanca Creek	NE ¼ of sec. 87, Block B-5, 2½ mi SE of Umbarger	2.0		4.54			
31	Tierra Blanca Creek	SW ¼ of sec. 72, Block B-5, 3½ mi SE of Umbarger	3.8		4.34			
31	Tierra Blanca Creek	NE ¼ of sec. 72, Block B-5, 4½ mi S of Umbarger	5.0		3.98			
31	Tierra Blanca Creek	SE ¼ of sec. 58, Block B-5, 300 ft below new Gordon-Cummings Dam and 5½ mi S of Umbarger	6.6		3.78			
31	Tierra Blanca Creek	SE ¼ of sec. 37, Block B-5, 2 mi SW of Canyon	9.2		3.75			
31	Tierra Blanca Creek	NW ¼ of sec. 62, Block B-5, ½ mi S of Canyon	10.9		2.92			

Date 1941	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From Buffalo Lake (Umbarger Reservoir) near Umbarger to a point about 18 miles downstream, continued							
Aug. 31	Seepage investigation discontinued at this point due to unstabilized conditions.							
31	Tierra Blanca Creek	SW ¼ of sec. 12, Block B-6, 1 mi SE of Canyon, just below McSpaddens Dam	17.9		0.01			Estimate.
	Investigation continued on Sept. 28							
Sept. 28	Tierra Blanca Creek	600 ft below dam at Buffalo Lake	0		*3.19			*Computed by wier formula.
28	Tierra Blanca Creek	SE ¼ of sec. 37, Block B-5, 2 mi SW of Canyon	9.2		2.57			
28	Tierra Blanca Creek	NW ¼ of sec. 62, Block B-5, ½ mi S of Canyon	10.9		2.09			
28	Tierra Blanca Creek	NW ¼ of sec. 63, Block B-5, 3/4 mi S of Canyon	12.6		1.55			
28	Tierra Blanca Creek	SW ¼ of sec. 64, Block B-5, 1 mi S of Canyon at Highway 87	15.8		1.51			
28	Tierra Blanca Creek	SW ¼ of sec. 12, Block B-6, 1 mi SE of Canyon just below McSpaddens Dam	17.9		.59			

LOW-FLOW INVESTIGATIONS - NECHES RIVER BASIN

Bowles Creek October 28, 1942

Reach: From a point 1.8 miles west of Old London to mouth of Horsepen Branch near Carlisle, Tex.

A series of discharge measurements on Bowles Creek (tributary to Striker Creek) and tributaries, in Rusk and Smith Counties, Tex., was made between county-road bridge on West Fork Bowles Creek 1.8 miles west of Old London, Rusk County, and a point just upstream from Horsepen Branch, 2.6 miles northwest of Carlisle, Rusk County. The measurements were made during a period of constant stage of the creek, in order to determine seepage. All tributaries and diversions were measured. The seepage investigation was made in connection with a study of oil-field waste.

Date 1942	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Oct. 28	W.Fk.Bowles Cr	At county road crossing ½ mi above mouth	0		1.4			
28	E.Fk.Bowles Cr	At county road crossing ½ mi above W. Fork	.5			1.0		
28	Bowles Cr	Just below confluence of E.and W. Fork	.5		2.8			
28	Bowles Cr	.7 mi above Allen Branch	1.3		2.7			
28	Allen Branch	.6 mi above mouth 2.1 mi SW Old London	2.0			1.1		
28	Bowles Cr	Just above Wright Branch	3.7		3.3			
28	Wright Branch	Just above mouth .8 mi SE of Wright City	3.7			1.3		
28	Henson Cr	Just above mouth 2.1 mi south of Wright City	5.2			.5		
28	Bowles Cr	.2 mi above Denton Creek	5.6		8.2			
28	Denton Cr	Just above mouth 2.7 mi NW of Carlisle	5.8			.6		
28	Bowles Cr	Just above Horsepen Branch	6.5		8.9			
28	Horsepen Branch	Just above mouth 2.4 mi NW of Carlisle	6.6			1.3		

LOW-FLOW INVESTIGATIONS - TRINITY RIVER BASIN

Trinity River November 1-8, 1952

Reach: From Riverside to Liberty, Tex.

A seepage investigation was made on Trinity River and its tributaries between the gaging station at Riverside, Tex., and a point 8.7 miles upstream from the gaging station at Liberty, Tex. This investigation was made to determine the seepage gains or losses in the 133.5 river mile reach from Riverside to head of tide water above Liberty.

During the investigation the rate of flow at any point was practically constant throughout the reach. The gage-height records at Riverside and Romayor show slight variations in stage, which are of small percentage and well within the accuracy range of the discharge measurements when translated into discharge.

For complete report on this investigation see U. S. Geological Survey Open File Release No. 44, November 1952, Austin, Texas (SW).

Date 1952	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Nov. 7	Trinity River	At State Highway 45 at Riverside-gaging station	0		165			
6	Unnamed Creek	2.3 mi SW of Embryfield	6.0			0.5		
4	White Rock Creek	1.3 mi NW of Sebastapol	12.6			0		
4	Sulphur Creek	1.0 mi SE of Sebastapol	15.2			.1		
4	Mill Creek	1.4 mi SE of Sebastapol	15.5			.3		
6	Palmetto Creek	2.0 mi above mouth	22.0			0		
7	Trinity River	3.2 mi above Highway 190 near Onalaska	25.9		168			
4	Kickapoo Creek	At Kickapoo	26.9			0		
6	McGhee Creek	At mouth 7.0 mi N of Cold Springs	34.6			.2		
6	Wolf Creek	5.0 mi N of Cold Springs	39.7			.3		
6	Bird Creek	3.5 mi N of Cold Springs	40.5			.3		
6	Mills Creek	2.0 mi NW of Camilla	47.5			2.38		
6	Hoffman Creek	3.7 mi NW of Shepherd	61.8			1.29		
6	Long King Creek	.8 mi W of Goodrich	65.0			4.93		
7	Trinity River	.5 mi below Highway 59 near Urbana	65.7		183			
6	Copeland Creek	3.8 mi SE of Goodrich	68.3			3.83		
6	Drews Mill Creek	5.0 mi SE of Goodrich	69.3			2.13		
6	Menard Creek	4.0 mi N of Romayor	80.5			12.8		

Date 1952	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Riverside to Liberty, Tex., continued							
Nov. 6	Big Creek	3.0 mi NE of Shepherd	84.2			3.78		
6	Trinity River	At Romayor - gaging station	88.2		209			
1	Trinity River	8.7 mi above Liberty - temporary gage	133.5		229			
2	Trinity River	8.7 mi above Liberty - temporary gage	133.5		228			
8	Trinity River	8.7 mi above Liberty - temporary gage	133.5		235			

LOW-FLOW INVESTIGATIONS - BRAZOS RIVER BASIN

Leon River March 13-14, 1951

Reach: Just below Olden Lake Dam 3.7 mi southeast of Eastland to bridge on U. S. Highway 67 near Hasse, Tex.

A series of discharge measurements was made March 13, 14, 1951, on the Leon River and its tributaries, Texas, from a point just below Olden Lake Dam near Eastland, to the crossing of U. S. Highway 67 near Hasse, 45½ miles downstream, to determine the seepage gains or losses in the reach. Records of two gaging stations in the reach indicated a constant river stage for several days prior to and during the investigation. All tributaries were investigated and those having flow were measured.

As indicated in the following table, the flow of the Leon River at river mile 6.6 was 0.21 cfs, while at river mile 12.0 the streambed was dry. The streambed through this section is composed of apparently fairly deep sand. The water reappeared a short distance above river mile 15.4, consisting of a succession of shallow pools with approximately 0.01 cfs flowing between pools. About 3/4 mile below river mile 15.4, this small flow disappeared. At river mile 19.8 the streambed was dry, while at river mile 23.6 a flow of 0.32 cfs was measured, and at river mile 32.6 the flow was 0.21 cfs. From this point on downstream the flow in the river gradually increased to 4.69 cfs at river mile 45.5.

Date 1951	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Mar. 13	Leon River	Lat 32° 22', long 98°46', 300 ft below Olden Lake Dam, 3.7 mi SE of Eastland	0	56	0.46			Water sample obtained.
13	Leon River	Near Eastland (recording gage)	5.2	52	.20			150 ft below gage.
13	Leon River	Lat 32°22', long 98°42', 7.0 mi south of Ranger	6.6	52	.21			100 ft below bridge. Water sample obtained.
13	Colony Creek	Lat 32°23', long 98°40', 5.7 mi south of Ranger	9.0	54		0.01		Estimate - sample obtained.
13	Leon River	Lat 32°19', long 98°39', 7.0 mi NW of Desdemona	12.0		0			
13	Natches (Nash) Creek	Lat 32°18', long 98°40', 5.6 mi north of Gorman	14.8			0		Sand bed - sand wet.
13	Leon River	Lat 32°18', long 98°38', 5.4 mi NW of Desdemona	15.4		0			Estimate .01 cfs about ¼ mi below bridge.
13	Rough Branch Creek	Lat 32°18', long 98°37', 4.4 mi NE of Desdemona	16.0			.02		Estimate - water sample obtained.
13	Leon River	Lat 32°15', long 98°36', 3.0 mi SW of Desdemona	19.8		0			No flow in Ellison Spring Branch.
14	Leon River	Lat 32°10', long 98°32', 4.0 mi north of DeLeon	23.6	43	.32			300 ft above bridge. Water sample obtained.
14	Leon River	Lat 32°06', long 98°30', 2.0 mi east of DeLeon	32.6	48	.21			100 ft below bridge. Water sample obtained.

Date 1951	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	Just below Olden Lake Dam 3.7 mi southeast of Eastland to bridge on U.S. Highway 67 near Hasse, Tex., continued							
Mar. 14	Armstrong Creek	Lat 32°06', long 98°29', 3.3 mi east of DeLeon	34.2	45		1.21		100 ft below bridge. Water sample obtained.
14	Leon River	Lat 32°03', long 98°29', 4.8 mi SE of DeLeon	35.2	49	1.73			300 ft above bridge.
14	Sabana River	Lat 32°04', long 98°32', 3.8 mi south of DeLeon	39.8	52		1.36		500 ft below bridge and below tributaries - sample obtained.
14	Leon River	Lat 31°59', long 98°28', 9.0 mi SE of DeLeon	41.0	51	3.38			100 ft below bridge.
14	Rush Creek	Lat 32°01', long 98°33', 7.3 mi SW of DeLeon	42.8	63		.81		50 ft above bridge. Water sample obtained.
14	Duncan Creek	Lat 31°58', long 98°33', 5.5 mi NE of Comanche	42.8	56		.56		50 ft below bridge. Water sample obtained.
14	Leon River	Near Hasse (recording gage)	45.5	55	4.69			2,000 ft below gage. Water sample obtained.

LOW-FLOW INVESTIGATIONS - BRAZOS RIVER BASIN

Sulphur Creek June 30, Aug. 10, 1942

Reach: Just south of Hancock Park in Lampasas, Lampasas County to a point 3.67 miles downstream and 1.5 miles downstream from Burleson Creek near Lampasas, Tex.

A series of discharge measurements was made on June 30, 1942, and another one on Aug. 10, 1942 on Sulphur Creek (tributary of Lampasas River) and tributaries, between a point in Lampasas and a point 1.5 miles downstream from Burleson Creek. The investigations were made during a constant stage and determinations represent natural conditions. Distances along the creek were measured on topographic maps prepared by the State Reclamation Department.

Date 1942	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
June 30	Sulphur Creek	Lat 31°03'01", long 98°11'06", just south of Hancock Park, at low-water crossing on Lampasas-Llano road	0		15.6			50 ft below crossing.
30	Sulphur Creek	Lat 31°03'21", long 98°11'13", about 100 ft upstream from city pump	.53		18.3			City pump in operation.
30	Municipal pump station	On left bank about 0.4 mi upstream from U. S. Hwy. 281	.55				1.1	Computed flow. City pumping about 500 gpm.
30	Sulphur Creek	Lat 31°03'17", long 98°11'01", about 100 ft upstream from main Hancock Spring	.77		17.9			
30	Sulphur Creek	Lat 31°03'18", long 98°10'57", about 100 ft downstream from main Hancock Spring	.87		21.0			100 ft above bridge.
30	Swimming pool spring	Lat 31°03'17", long 98°10'55", just upstream from U. S. Hwy. 281	.90			1.2		30 ft below pool.
30	Sulphur Creek	Lat 31°03'21", long 98°10'52", about 150 ft downstream from U. S. Hwy. 281	.95		25.5			Water turbulent - gravel bed.
30	Hannah Spring	Lat 31°04'06", long 98°10'34", about 200 ft upstream from Santa Fe Railroad on Hackberry Street	2.17			1.3		100 ft below spring basin.
30	Sulphur Creek	At lower crossing of Santa Fe Railroad and 1.5 miles downstream from Burleson Creek	3.67		32.2			200 ft above bridge.

Date 1942	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	Just south of Hancock Park in Lampasas, Lampasas County to a point 3.67 miles downstream and 1.5 miles downstream from Burleson Creek near Lampasas, Tex., continued							
Aug. 10	Sulphur Creek	Lat 31°03'01", long 98°11'06", just south of Hancock Park, at low-water crossing on Lampasas-Llano road	0		5.0			50 ft below crossing.
10	Sulphur Creek	Lat 31°03'21", long 98°11'13", about 100 ft upstream from city pump	.53		6.8			City pump in operation.
10	Municipal pump station	On left bank about 0.4 mi upstream from U. S. Hwy. 281	.55				1.1	Computed flow. City pumping about 500 gpm.
10	Sulphur Creek	Lat 31°03'17", long 98°11'01", about 100 ft upstream from main Hancock Spring	.77		9.2			
10	Sulphur Creek	Lat 31°03'18", long 98°10'57", about 100 ft downstream from main Hancock Spring	.87		12.4			100 ft above highway bridge.
10	Swimming pool spring	Lat 31°03'17", long 98°10'55", just upstream from U.S. Hwy. 281	.90			1.0		30 ft below pool.
10	Sulphur Creek	Lat 31°03'21", long 98°10'52", about 150 ft downstream from U. S. Hwy. 281	.95		15.3			Water turbulent.
10	Hannah Spring	Lat 31°04'06", long 98°10'34", about 200 ft upstream from Santa Fe Railroad on Hackberry Street	2.17			1.5		100 ft below spring basin.
10	Sulphur Creek	At lower crossing of Santa Fe Railroad and 1.5 mi downstream from Burleson Creek	3.67		18.1			200 ft above bridge.

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

Colorado River — August 7-14, 1918

Reach: Colorado River, from Robert Lee to mouth near Matagorda, Tex.

An investigation of gains and losses from seepage in the Colorado River from a point at Robert Lee to the mouth was made in August 1918. The discharge was measured at various intervals along the main stream, at the mouth of each tributary, and at the point of each diversion. Gages at Bronte, Ballinger, Chadwick, Marble Falls, and Columbus are read twice daily, and at Austin a continuous recorder is maintained. Although data were insufficient to warrant a correction of discharge for time interval, these gages showed the stream to be at a practically constant stage, with no floods to interfere with the investigation. Few corrections for time intervals were necessary.

These data represent natural conditions as they were found above Columbus, but below that point the flow was practically all diverted for rice irrigation. It is therefore difficult to draw definite conclusions from the measurements made below Columbus. During the investigation the reservoir, formed by the Austin Dam, was empty, and the natural flow of the river was passing through the dam. An extremely low stage existed throughout the course of the river.

Above the mouth of San Saba River the river was dry with the exception of 0.2 cfs at the mouth of Pecan Bayou. The course of the river from Chadwick to Austin is through rough and rugged country, with most of the distance through canyons and gorges, with a few stretches of valleys. Between the Chadwick and Marble Falls gaging stations there was a slight gain. From Marble Falls to Austin dam the flow increased from 3 to 21 cfs. Between the Austin dam and Austin gaging station there was a gain of 4.1 cfs, and from the Austin gage to Platts Ferry, a distance of 11 miles, the gain was 27.4 cfs. From Platts Ferry to Columbus the flow increased from 51 to 144 cfs, or a gain of 93 cfs in 125 miles. As previously stated, the flow below Columbus was practically all diverted. Lack of sufficient data for time interval correction makes records below this point of little value. The sectional gain of 32 cfs between Austin dam and Platts Ferry, a distance of 14 miles, is due in all probability to fissure streams or springs located in the Balcones fault zone, which tend to raise the level of the water table and increase the seepage into the river.

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	Colorado River,	from Robert Lee to mouth near Matagorda						
Aug. 7	Colorado River	At Robert Lee	0		0			No water in river for last two weeks.
7	Liveoak Creek	At mouth	12			0		
7	Colorado River	Near Bronte (gaging station)	14		0			
7	Kickapoo Creek	At mouth	15			0		
7	Colorado River	At Maverick-Miles highway bridge	20		0			No pumps in vicinity.
7	Oak Creek	At mouth	21			0		
7	Mule Creek	At mouth	22			0		
7	Valley Creek	At mouth	36			0		
7	Colorado River	At Ballinger (gaging station)	42		0			
7	Elm Creek	At mouth	43			0		
7	Colorado River	At mouth of Concho River	61		0			
7	Concho River	At mouth	61			0		
7	Elm Creek	At mouth	70			0		
7	Mustang Creek	At mouth	74			0		
7	Colorado River	At Stacy	80		0			
7	Salt Creek	At mouth	87			0		
7	Colorado River	At Waldrip	96		0			
7	Buhl Creek	At mouth	99			0		
7	Colorado River	At Whan	110		0			
8	Home Creek	At mouth	118			0		
8	Colorado River	At Milburn	126		0			No pumping in vicinity.
8	Clear Creek	At mouth	131			0		
8	Colorado River	At Brownwood-Richland Springs crossing	134		0			No pumping.
8	Buffalo Creek	At mouth	148			0		
8	Rough Creek	At mouth	149			0		
7	J. W. Perkins ditch	1/4 mi above Regency	150				2.0	Earthen ditch.
7	S. M. Jones ditch	1 mi below Regency	151				1.6	Semi-circular flume.
7	Cottonwood Creek	At mouth	154			0		
7	Spring Creek	At mouth	157			0		
7	King Creek	At mouth	163			0		
7	Pecan Bayou	At mouth	164			0		
7	Colorado River	Below Pecan Bayou	164		0.2			Wilson pump running.
8	Oglesby-Dawson ditch	6 mi below Pecan Bayou	170				1.4	Earth canal.

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	Colorado River, from Robert Lee to mouth near Matagorda, continued							
Aug. 8	Horse Creek	At mouth	172			0		
8	E. H. Hopgood ditch	At Warrens crossing	174				0.4	
8	Prescott Creek	At mouth	174			0		
8	Bull Creek	At mouth	176			0		
8	Yarbrough ditch	11 mi northwest of San Saba	176				2.0	Semi-circular flume.
8	Nabors Creek	At mouth	180			0		
8	Edmondson ditch	1-1/2 mi above San Saba River	188				.8	Semi-circular flume.
8	Bennett ditch	1 mi above San Saba River	189				1.0	Semi-circular flume.
8	San Saba River	2 mi above mouth	190			2.9		
8	Colorado River	1/4 mi below San Saba River	190		5.2			
9	Colorado River	Near Chadwick (gaging station)	193		4.0			Constant stage.
9	Elliott Creek	At mouth	194			0		
9	Red Bluff Creek	At mouth	196			0		
9	Antelope Creek	At mouth	198			0		
9	Rough Creek	At mouth	204			.1		
9	Brazil ditch	3-1/2 mi above Bend	205				1.4	Earth canal.
9	McCourry ditch	1-1/2 mi above Bend	206				2.6	Semi-circular flume.
9	Colorado River	At Bend	208		0			
9	Cherokee Creek	At mouth	210			0		
9	Colorado River	At Tow	232		3.5			
10	Colorado River	Near Bluffton	241		3.5			At mouth of L. H. Creek.
10	Morgan Creek	At mouth	241			0		
10	Colorado River	At Bluffton-Kingsland road	248		2.6			
10	Spring Creek	At mouth	252			0		
10	Llano River	At mouth	263			.2		
10	Colorado River	Below Llano River near Kingsland	263		3.7			
10	Colorado River	1 mi above Sandy Creek	268		3.6			
10	Sandy Creek	At mouth	269			0		
10	Pecan Creek	At mouth	272			0		
10	Colorado River	3-1/2 mi above Marble Falls	276		3.0			
10	Sparerib Creek	At mouth	280			0		
10	Flatrock Creek	At mouth	281			0		
10	Little Cypress	At mouth	295			0		
9	Colorado River	Just above Pedernales River	304		9.0			
9	Pedernales River	At mouth	304			0		
9	Cow Creek	At mouth	305			0		
9	Colorado River	At Cat Hollow Ford	310		9.3			

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	Colorado River,	from Robert Lee to mouth near Matagorda, continued						
Aug. 9	Bee Creek	At mouth	312			0		
9	Colorado River	At Lohmans Ford	314		7.6			
9	Williams pump	Just above Sandy Creek near Cedar Park	322				0.2	
9	Sandy Creek	At mouth	322			.1		
9	Colorado River	At Watsons Ford	323		6.6			1,000 ft below Sandy Creek.
10	Colorado River	At Cameron Ford	336		8.0			Large silt deposits.
10	Santa Monica Springs	1 mi below Cameron Ford	337			0		Silt over springs.
10	Bull Creek	At mouth	344			0		
10	Morman Springs	1/2 mi above Austin Dam	347			1.0		
10	Colorado River	Just below Austin Dam	348		20.5			
10	Colorado River	1/4 mi below Deep Eddy	349		24.2			First rapids below Deep Eddy.
10	Barton Creek	At mouth	350			14.3		
10	Austin City pump	At Austin	350½				12.0	Two pumps running.
10	Colorado River	At Austin (gaging station)	351		26.9			Constant stage.
10	Walker pump	5 mi below Austin	356				3.2	
10	Colorado River	At Platts Ferry below Austin	367		51.1			
10	Averys pump	1/2 mi below Platts Ferry	362½				1.1	
10	Shepard pump	3 mi above Onion Creek	363				1.3	
10	Colorado River	1/4 mi above Onion Creek	369		48.4			
10	Colorado River	1/4 mi above Utleys Ferry	383		63.5			
10	Big Sandy Creek	At mouth	395			0		
10	Piney Creek	At mouth	400			0		
10	Colorado River	At Bastrop	403		83.7			
11	Walnut Creek	At mouth	415			0		
11	Colorado River	At Smithville	426		101			
11	Pin Oak Creek	At mouth	437			0		
11	Colorado River	2 mi north of West Point	438		102			200 ft above S.A.P. bridge.
11	Colorado River	At LaGrange	453		123			
11	Buckners Creek	5 mi below LaGrange	458			0		
11	Williams Creek	10 mi below LaGrange	463			0		
11	Colorado River	2-1/2 mi south of Ellinger	470		132			
12	Columbine Creek	1 mi above Columbus	486			0		
12	Colorado River	At Columbus	487		144			Constant stage.
12	Lakeside pump	Near Eagle Lake	510				71.6	
12	Colorado River	1 mi below Lakeside pump	511		99.6			
12	Bunges pump	5 mi below Lakeside pump	515				5.0	

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	Colorado River,	from Robert Lee to mouth near Matagorda, continued						
Aug. 12	Garwood pump	At Garwood	520				70.6	
12	Colorado River	Below Garwood pump	520		30.2			900 ft below pump.
13	Colorado River	At Glen Flora about 8 mi above Wharton	541		80.2			300 ft above highway bridge.
13	Pierce estate pump	3 mi above Wharton	544				73.5	One pump operating.
13	Colorado River	At Wharton	547		21.5			
14	Southern Irrigation pump	8 mi below Wharton	555				99.3	At flume 1 mi below pump.
14	Jones Creek	At mouth	561			0		
14	Henry Miatt pump	8 mi below Jones Creek	569				6.1	
14	Carlson pump	1 mi above Blue Creek	571				1.3	
14	Colorado River	At Bay City	575		0			Upper end of raft.
14	Colorado River	4 mi above Matagorda	593		.8			

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

Colorado River April 7-24, 1925

Reach: From Robert Lee to stream-gaging station at Austin, Tex.

An investigation of gains and losses from seepage in the Colorado River from a point at Robert Lee to the gaging station at Austin was made in April 1925. The discharge was measured at various intervals along the main stream, at the mouth of each tributary, and at the point of each diversion. Gages at Robert Lee, Ballinger, Milburn, and Marble Falls are read twice daily, and at Tow and Austin continuous recorders are maintained. Data was insufficient to warrant a correction of discharge for time interval; however, these gages showed the river to be fairly constant, with the exception of a small rise on the night of April 22, causing a small increase in discharge at the Cox Ford site. These data represent natural conditions of the river throughout the reach investigated. During the investigation the reservoir, formed by the Austin Dam, was empty, and the natural flow of the river was passing through the dam. An extremely low stage existed throughout the course of the river.

Above the mouth of the Concho River the Colorado flow was very low, and the flow began to increase appreciably below this point. An increase from 5.7 to 17.5 cfs was noted from the Concho to the Milburn gaging station. The flow from Milburn to the San Saba River was fairly constant at about 20 cfs; however, the San Saba River contributed 67 cfs, the first major source of water. The flow from this point increased gradually downstream to a maximum of 118 cfs at the gaging station near Tow, and then decreased to 76 cfs 12 mi above the Llano River. The Llano River contributed 69 cfs to increase the main flow to 196 cfs at a point 1 mile below the mouth of Llano River; however, the flow then decreased to 172 cfs at the Marble Falls gaging station. Small gains and losses then occurred in the reach from this point to Austin; the main contributer at Austin being Barton Springs, which were flowing about 23 cfs, to increase the flow at the Austin gaging station to 255 cfs.

No data was available with which to describe the geology of the river section reaches.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Robert Lee	to Austin gaging station						
Apr. 7	Colorado River	At Robert Lee	0		0			
7	Colorado River	Near Robert Lee (Gaging station)	9		0			
7	Cow Creek	At mouth	9			0		
7	Colorado River	Near Bronte (former gaging station)	16		.1			
7	Colorado River	At Maverick-Miles Highway bridge	30		0			
7	Valley Creek	At mouth	44			0		
8	Colorado River	At Ballinger (Gaging station)	50		.2			Seepage in gravel.
8	Elm Creek	At mouth	51			0		
9	Colorado River	7 mi below Ballinger	57		.5			Estimate.
9	Colorado River	9 mi below Ballinger	59		.5			Estimate.
9	Mustang Creek	At mouth	60			0		
9	Colorado River	At Nichols Crossing	63		1.6			
8	Concho River	At mouth	69			.2		Estimate.
8	Colorado River	1,000 ft below Concho River	69		5.7			
9	Colorado River	Traps Crossing - 3 mi below Concho River	72		8.2			
8	Colorado River	Above Chriswell Springs - 5 mi below Concho River	75		10.7			
8	Colorado River	¼ mi below Chriswell Springs	76		10.3			
10	Colorado River	4 mi below Stacy	84		10.1			
10	Colorado River	8 mi below Stacy	96		11.3			
10	Colorado River	At Waldrip	104		13.2			
10	Colorado River	5 mi south of Whan	118		12.8			
11	Colorado River	At Milburn gaging station	134		17.5			
11	Bollinger pump	2¼ mi north of Bowser	142				0	
11	Colorado River	2 mi north of Bowser	144		16.6			
11	McMullen and Prewitt pump	3/4 mi below Ballinger	146				0	
13	Dwyer pump	At Regency	159				0	
13	Colorado River	¼ mi below Regency	159		15.6			
13	S. M. Jones pump	1 mi below Regency	160				0	
13	Cottonwood Creek	At mouth - 3 mi below Regency	163			0		
14	Pecan Bayou	At mouth - 12 mi below Regency	173			0		
14	Colorado River	1 mi below Pecan Bayou	174		18.0			
13	Colorado River	Goldthwaite-San Saba Highway	185		22.2			

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Robert Lee	to Austin gaging station, continued						
Apr. 13	Renfro pump	1 mi below Goldthwaite-San Saba Highway	186				0	
13	Taylor and Beaumont pump	3 mi below Goldthwaite-San Saba Highway	188				0	
13	Miller pump	5 mi below Goldthwaite-San Saba Highway	190				0	
13	Mausby pump	7 mi below Goldthwaite-San Saba Highway	192				0	
13	Crawford pump	10 mi below Goldthwaite-San Saba Highway	195				0	
14	Colorado River	5 mi above San Saba River	195		23.4			
15	Colorado River	2 mi above San Saba River	198		19.9			
15	Edmonson pump	1 mi above San Saba River	199				0	
15	San Saba River	½ mi above mouth	200			67.2		
15	Colorado River	At Chadwick - 2 mi below San Saba River	202		87.0			
16	Rough Creek	At mouth - 4 mi above Bend	214			1.57		
16	McCurry pump	1½ mi above Bend	216				2.0	
16	Colorado River	At Bend	218		95.0			
16	Cherokee Creek	2 mi below Bend	220				0.3	
16	Lewis and Fry pump	Just below Cherokee Creek	220				0	
16	Cagle pump	Just below Cherokee Creek	220				0	
16	Frazier pump	Just below Cherokee Creek	220				0	
16	Sulphur Springs	6 mi below Bend	224			0		
16	Gorman Creek	11 mi below Bend	229			0		
17	Falls Creek	At mouth - 3 mi above Tow	240			2.4		
17	Colorado River	At gaging station near Tow	243		102			
16	Colorado River	At gaging station near Tow	243		118			
16	Tanners pump	1 mi below gage near Tow	244				0	
16	Tow Creek	At mouth - 1 mi below Tow	244			0.2		Flow from spring ½ mi upstream.
16	Cowan Creek	At mouth - 2 mi below Tow	245			.1		
16	Beaver Creek	At mouth - 3 mi below Tow	246			.3		
16	Morgan Creek	At mouth - ¼ mi above Bluffton	251			.1		
17	Colorado River	At Llano-Burnet Highway	251		107			
17	S. W. Graphite pump	¼ mi below Llano-Burnet Highway	252				0.8	

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Robert Lee	to Austin gaging station, continued						
Apr. 17	Lion Creek	1 mi below Llano-Burnet Highway	252			0		
17	Campground Creek	5 mi below Llano-Burnet Highway	256			0		
17	Redrock Creek	7 mi below Llano-Burnet Highway	258			0		
17	Colorado River	12 mi above Llano River	262		76.3			
17	Clear Creek	12 mi above Llano River	262			0		
17	Spring Creek	11 mi above Llano River	263			0		
17	Peter Creek	Hoover Valley	265			0		
17	Powdermill Creek	5 mi above Llano River	269			0		
17	Llano River	At mouth - Kingsland	274			69.0		
18	Colorado River	1 mi below Llano River	275		196			No change in stage - overnight.
18	Sandy Creek	At mouth - 6 mi below Llano River	280			0		
18	Colorado River	1,000 ft below Sandy Creek	280		179			
20	Pecan Creek	At mouth - 8 mi above Marble Falls	282			.2		
20	Slickrock Creek	At mouth - 6 mi above Marble Falls	284			0		
20	Colorado River	4 mi above Marble Falls	285		163			
20	Tiger Creek	At mouth - 2 mi above Marble Falls	288			0		
20	Meeks pump	5/8 mi above Marble Falls	289				0	
20	Phelps pump	1/2 mi above Dam at Marble Falls	290				0	Pumps intermittently.
20	Stamford pump	3/8 mi above Dam at Marble Falls	290				0	Pumps intermittently.
20	Wagner pump	1/4 mi above Dam at Marble Falls	290				0	Pumps intermittently.
20	Sparerib Creek	At mouth - at Marble Falls	290			0		All flow is in sand beds.
20	City pump	At Marble Falls City pump at Falls	290				.3	Pumping 200,000 gallons per day.
20	Colorado River	At gaging station at Marble Falls	290		172			
21	Flatrock Creek	At mouth - near Marble Falls	291			0		
21	Hamilton Creek	At mouth - 5 mi below Marble Falls	295			.2		
21	Sycamore Creek	At mouth - 5 mi below Marble Falls	295			0		
21	Doublehorn Creek	At mouth - 8 mi below Marble Falls	298			.5		
21	Postoak Branch	At mouth - 13 mi below Marble Falls	303			0		
21	Spanish Oak Creek	At mouth - 14 mi below Marble Falls	304			0		
21	Little Cypress Creek	At mouth - 9 mi above Pedernales River	307			.2		
22	Colorado River	100 ft above mouth of Pedernales River	316		226			

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Robert Lee	to Austin gaging station, continued						
Apr. 22	Pedernales River	1 mi above mouth - above backwater	316			3.2		Backwater extends 1 mi.
21	Cow Creek	At mouth - 1 mi below Pedernales River	317			.1		
22	Cedar Knob Springs	4 mi below Pedernales River	320			.1		
22	Colorado River	At Cox Ford - 6 mi below Pedernales River	322		202			
23	Colorado River	At Cox Ford - 6 mi below Pedernales River	322		216			Small rise on river.
22	Bee Creek	At mouth - 8 mi below Pedernales River	324			.2		
23	Colorado River	At Lohmans Ford - 9 mi below Pedernales River	325		228			Small rise on river.
23	Sandy Creek	At mouth - ½ mi above Watson Ford	334			.1		
23	Colorado River	At Watson Ford - 18 mi below Pedernales River	334		238			
23	Cypress Creek	At mouth - 1 mi below Watson Ford	335			.2		Water comes from springs.
23	Bull Creek	Near Austin - 8 mi above Austin gage	357			0		
24	Barton Creek	At Austin	364			23.2		
24	City pump	At City Water Works	364				10.8	Pumping 7,000,000 gals. per day.
24	Shoal Creek	At mouth - at Austin	364			3.5		Estimate.
24	Lone Star Ice Company	At Austin	364				.1	Pumping 200 gals. per min.
25	Colorado River	At gaging station at Austin	365		255			Constant stage.

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

South Concho River June 18, 1953

Reach: South Concho River, from a point about 2 miles above stream-gaging station at Christoval, Tex. to a point 12 miles downstream.

A series of discharge measurements was made on June 18, 1953, on South Concho River from a point about 2.0 miles upstream from gaging station at Christoval, Tex., to a point 12 miles downstream and above backwater from Lake Nasworthy. These measurements were made to determine seepage gains or losses in the reach. The gaging stations on South Concho River at Christoval and on South Concho Irrigation Company's Canal at Christoval indicated that there had been no appreciable change in stage for several days prior to the investigation. Just prior to the investigation the reach was inspected by airplane and no inflow from tributaries or diversions other than South Concho Irrigation Company's Canal were observed.

Date 1953	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
June 18	South Concho R	2.1 mi south of Christoval	0	79	4.98			
18	South Concho Irrig. Co. Canal	At Christoval - gaging station	1.9				0.34	Computed by weir formula.
18	South Concho R	At Christoval - gaging station	2.0	82	3.12			Gravel bed.
18	South Concho R	1.9 mi north of Christoval	4.8	83	3.39			Rock bed.
18	South Concho R	5.9 mi, north of Christoval	9.0	83	1.92			Gravel bed.
18	South Concho R	10 mi south of San Angelo	12.0		0			

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

Concho River — March 1918

Reaches: South Concho River, from Christoval to confluence with North Concho River at San Angelo, Tex.
Middle Concho River, from San Angelo-Mertzon road crossing to the mouth
Spring Creek, from a point just above Seven Springs to the mouth
North Concho River, from Sterling City to confluence with South Concho River
Concho River, from confluence of North and South Concho Rivers to mouth

Seepage investigation on Concho River, including Spring Creek and North and South Concho Rivers, was made March 27 and 28, 1918. With the exception of the Middle Concho, numerous pumping plants are situated along each of the above streams and during the investigation there was a large amount of irrigating. This is the only factor that would affect results. Data were insufficient to warrant a correction of discharge for time interval, but in all the streams there was a constant stage previous to and at the time of the investigation so that correction for time interval was in most cases not necessary.

In Spring Creek there was a gain of 10 cfs in a distance of 27 miles. Above Spring Creek the Middle Concho was dry, but from the mouth of Spring Creek to the confluence with South Concho River there was a gain of 2 cfs in 2 miles. The North Concho from Sterling City to Water Valley showed a gain of 1.0 cfs, but from Water Valley to the mouth there was a loss of 2.0 cfs. In the South Concho from Christoval to the confluence with the North Concho there was a gain of 12 cfs in 20 miles. In the main Concho there was a gain of 5 cfs, but throughout the lower half of the river's course the measurements show there was a seepage loss. From the gaging station near San Angelo to the Paint Rock gage there are 10 dams and reservoirs which affect the accuracy of a seepage investigation. Interpretations of the measurements on the main Concho are therefore somewhat doubtful.

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	South Concho River, from Christoval to confluence with North Concho River							
Mar. 27	Christoval Canal	At Christoval	0				9.7	
27	South Concho R	300 ft below Christoval Canal	0		3.4			
27	Pecan Creek	At mouth	9			0		
28	South Concho R	Just above Middle Concho R	11.8		6.0			
28	Middle Concho R	At mouth	12			3.9		
28	South Concho R	1/2 mi below Middle Concho R	12.5		20.5			
28	Hank pump	At Metcalfe Lake 1/2 mi above diversion	15				2.7	Computed from pump capacity.
28	Metcalfe Canal	3-1/2 mi below Middle Concho R	15.5				12.0	At headgate.
28	South Concho R	Just below Metcalfe diversion dam	15.5		0			
28	South Concho R	At Christoval road crossing	16.5		.4			

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	South Concho River, from Christoval to confluence with North Concho River, continued							
Mar. 28	Lovelace pump	1/4 mi below Christoval road crossing	16.8				.9	
28	San Angelo L&P pump	1/2 mi above mouth of So. Concho	19.3				1.2	Computed from pump capacity.
28	South Concho R	Just below San Angelo L&P Co. dam	19.3		1.0			Estimate.
28	South Concho R	At mouth	19.8		3.8			Springs contribute flow.
	Check data on South Concho River in April 1918							
Apr. 27	South Concho R	Just above Middle Concho R	11.8		2.0			
27	Middle Concho R	At mouth	12			1.8		
27	South Concho R	3/4 mi below Middle Concho R	12.8		6.0			
27	Metcalfe Canal	3-1/2 mi below Middle Concho R	15.5				5.2	
	Middle Concho River, from San Angelo-Mertzon road crossing to the mouth							
Mar. 27	Middle Concho R	At San Angelo-Mertzon road crossing	0		0			
28	Middle Concho R	At mouth	22		3.9			
	Spring Creek, from a point just above Seven Springs to the mouth							
Mar. 27	Spring Creek	Just above Seven Springs	0		1.9			
27	Spring Creek	Just below Seven Springs	0		9.9			
27	Mertzon Canal	At Mertzon	3				9.3	
27	Spring Creek	100 ft below Mertzon Canal	3		0			
27	Return flow from Mertzon Canal	1500 ft below Mertzon Canal	3.4			.2		Estimate.
27	Spring Creek	1500 ft below Mertzon Canal	3.4		.2			Estimate.
27	Spring Creek	1/4 mi north of Sherwood	7		.5			Estimate - no pumping above.
27	Spring Creek	At Sherwood - Tankersly road crossing	11		1.6			No flow in Lopez Creek.
27	Hager pump	1-1/2 mi south of Tankersly	16				.8	Estimate.
27	Spring Creek	Just below Hager pump	16		1.9			
27	Spring Creek	Just above Dove Creek	20		2.1			
27	Dove Creek	At mouth	20			4.2		
27	Mottel Canal	2 mi above mouth of Spring Creek	25				5.9	
27	Spring Creek	Just below Mottel Canal	25		.8			Estimate.
27	Spring Creek	At mouth	27		.8			Estimate.

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	North Concho River, from Sterling City to confluence with South Concho River							
Mar. 27	North Concho R	At Sterling City	0		0.6			
27	Sterling Creek	3 mi below Sterling City - at mouth	3.0			0.5		Estimate.
27	North Concho R	300 ft below Sterling Creek	3.0		1.0			Estimate.
27	North Concho R	At Broome - 9 mi below Sterling City	9.0		0			
27	North Concho R	At Water Valley	20.0		1.3			Estimate.
27	Two pumps	1 mi below Water Valley	21.0				0	Not pumping.
27	North Concho R	At Carlsbad	27.0		2.0			Estimate.
27	North Concho R	3 mi below Carlsbad	30.0		0			
27	North Concho R	At mouth	48.0		0			
	Concho River, from confluence of North and South Concho Rivers to mouth							
Mar. 27	Concho R	At confluence of N and S Concho R	0		3.8			Measurement - good.
27	Concho R	At gaging station 1/4 mi below confluence	.2		5.1			Measurement - good.
28	Newton pump	Northeast of San Angelo	8.8				2.2	Computed from pump capacity.
28	Red Bank Creek	At mouth	9.2			0		
28	Pumping plant	Southwest of Miles	12.8				2.0	Computed from pump capacity.
28	Crownest Creek	At mouth	14			0		
28	Pumping plant	4-1/2 mi southwest of Miles	16				2.0	Computed from pump capacity.
28	Concho R	South of Miles	17		0			
28	Pumping plant	South of Miles	17.1				2.2	Computed from pump capacity.
28	Concho R	4 mi south of Miles	18		1.5			Estimated.
28	Lipan Creek	At mouth	26.5			0		
28	Kickapoo Creek	At mouth	31.5			0		
28	Concho R	At gaging station 2 mi west of Paint Rock	32		.7			Estimated.
28	Concho R	At mouth	51.5		0			

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

Concho River — February 28 to March 20, 1925

Reaches: South Concho River, from a point just below main springs, 5 miles above Christoval, Tex. to the mouth.
Middle Concho River, from Kiowa Creek to mouth.
Spring Creek, from Seven Springs above Mertzon to mouth.
Dove Creek, from a point about 9 miles above Knickerbocker to mouth.
North Concho River, from a point above Sterling City to confluence with South Concho River.
Concho River, from confluence of North and South Concho Rivers to mouth.

The purpose of this investigation was to determine gains and losses of flow in the river reaches listed above in the Concho River watershed. The area covered is the same as that investigated in 1918; however, the river miles distance at some of the sites are revised in this report. During this investigation the stream flow was practically constant and time interval was neglected.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	South Concho River, from a point just below main springs, 5 miles above Christoval, Tex. to the mouth							
Mar. 12	South Concho R	At Main Springs - 5 mi above Christoval	0		10.7			No flow above springs.
12	Mill Spring	1 mi above Christoval	4			2.4		
12	Christoval Canal	At Christoval - 5 mi below Main Springs	5				8.0	
12	South Concho R	At Christoval - below Christoval Dam	5		21.6			
13	Return flow from Christoval Dam	4 mi below Christoval	9.1			1.8		
13	Pecan Creek	At mouth - just above Broome Dam	14.4			0		
13	Diversion at Broome Dam	500 ft below Pecan Creek	14.4				19.6	
13	South Concho R	Just below Broome Dam	14.4		8.4			
13	Return flow from Broome Dam	2 mi below Pecan Creek	16.4			7.1		
13	Return flow from Broome Dam	2.3 mi below Pecan Creek	16.7			5.4		
14	South Concho R	At new City Dam - 4 mi above mouth	20.8		19.6			
16	South Concho R	At new City Dam - 4 mi above mouth	20.8		22.3			Less diversions upstream.
16	South Concho R	At mouth	24.8		19.4			

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	Middle Concho River, from Kiowa Creek to mouth							
Mar. 10	Middle Concho R	Mouth of Kiowa Creek	0		0.1			Kiowa Creek dry.
10	Middle Concho R	Mouth of Liveoak Draw	6.8		0			Liveoak Creek dry.
10	Middle Concho R	7.8 mi below Kiowa Creek	7.8		0			
10	Middle Concho R	8.5 mi below Kiowa Creek	8.5		.3			Estimate.
10	Middle Concho R	11.6 mi below Kiowa Creek	11.6		0			
10	Middle Concho R	13.1 mi below Kiowa Creek	13.1		.9			
10	Middle Concho R	Near Arden - 2 mi above San Angelo-Mertzon road crossing	23.7		1.0			No flow in Dry Creek.
11	West Rocky Cr	At mouth	26.8			0.7		
11	Middle Concho R	Just above East Rocky Creek	29.7		1.2			
11	Middle Concho R	At Baucum Dam	36.5		.1			No diversions.
11	Middle Concho R	At 12 Mile Bridge	38.2		0			No diversions.
11	Middle Concho R	½ mi above Spring Creek	45.2		2.1			Gravel bed - seepage.
11	Middle Concho R	Just below Spring Creek	45.7		7.3			
11	Middle Concho R	At mouth	47.7		0			Gates at Dam ½ mi upstream had just been closed.
	Spring Creek, from Seven Springs above Mertzon to mouth							
Mar. 6	Spring Creek	Just above Seven Springs	0		.7			Estimate.
6	Spring Creek	Just below Seven Springs	.1		12.2			
6	Mertzon Canal	At Mertzon	3				7.8	
6	Spring Creek	At Mertzon - below Mertzon Canal	3		5.4			
6	Middle Ditch Diversion	1½ mi below Mertzon	4.5				2.7	
7	Spring Creek	3.7 mi below Mertzon	6.7		7.5			At Lee's Dam.
7	Spring Creek	At Sherwood-Tankersley crossing	10.6		8.0			
7	Spring Creek	2.2 mi above Tankersley	14.3		4.4			
7	Spring Creek	1.2 mi above Russell Dam	16.5		4.8			
7	Spring Creek	Just below Russell Dam	17.7		0			Gates at Dam closed.
9	Spring Creek	.1 mi above Dove Creek	18.7		.8			
9	Elliott Pump	.2 mi below Dove Creek	19.0				3.1	
9	White Pump	.8 mi below Dove Creek	19.6				1.9	
9	Mottel Canal	1 mi below Dove Creek - at Dam	19.8				6.2	Old Lackey Dam.
9	Spring Creek	Just below Mottel Dam	19.9		.2			
9	Spring Creek	3.9 mi below Dove Creek	22.7		2.4			
9	Spring Creek	At mouth	26.5		4.6			
11	Spring Creek	500 ft above mouth	26.5		4.2			Check measurement.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	Dove Creek, from a point about 9 miles above Knickerbocker to mouth.							
Mar. 4	Dove Creek	Just below spring source	0		13.0			
4	Diversion Canal	Just above Stillson Dam	.9				11.7	
4	Dove Creek	Just below Stillson Dam	1.1		.7			
4	Diversion Canal	Just above San Jose Dam	3.9				4.1	
4	Dove Creek	½ mi below San Jose Dam	4.4		8.6			
5	Dove Creek	½ mi below San Jose Dam	4.4		7.6			
5	Diversion Canal	Just above Baze Dam	8.5				4.5	
5	Dove Creek	At Knickerbocker	8.7		8.9			
5	Dove Creek	Just above mouth	11.8		8.4			
	North Concho River, from a point above Sterling City to confluence with South Concho River							
Feb. 28	North Concho R	2 mi above McIntyres Dam	0		0			
28	North Concho R	At McIntyres Dam	2		.2			Estimate.
28	McIntyres Pump	1½ mi below Dam	3.5				0	Not pumping.
28	North Concho R	At McIntyres Pump	3.5		1.2			
28	North Concho R	½ mi above Sterling City	11.6		1.4			
28	North Concho R	At Sterling City - below Santa Fe Pump	12.1		1.2			Pump in operation.
28	North Concho R	8.4 mi above Water Valley	23.5		1.0			
Mar. 2	North Concho R	5.0 mi above Water Valley	26.9		1.9			
2	North Concho R	.6 mi above Water Valley	31.3		3.2			
3	North Concho R	Near Carlsbad - gaging station	37.0		3.9			Constant stage.
3	North Concho R	8.8 mi above San Angelo	45.6		3.1			Gravel beds.
17	North Concho R	*At San Angelo - gaging station	54.4		*2.5			Constant stage.
17	North Concho R	½ mi above mouth	55.3		2.3			
	*Discharge Mar. 3 = 2.5 cfs							
	Concho River, from confluence of North and South Concho Rivers to mouth							
Mar. 17	Concho River	At gaging station near San Angelo	0		22.3			
17	Boyd Pump	1 mi below confluence	1.0				1.5	
17	Kaisers Pump	7.2 mi below confluence	7.2				3.1	
17	McDonald Pump	7.4 mi below confluence	7.4				1.0	
17	Concho River	8.0 mi below confluence	8.0		16.4			
18	Hart Pump	13 mi below confluence	13				1.2	
18	Lackey Pump	13 mi below confluence	13				2.1	
18	Concho River	14 mi below confluence - at Mullins crossing	14		10.0			

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	Concho River, from confluence of North and South Concho Rivers to mouth, continued							
Mar. 18	Richard Pump	.4 mi below Mullins crossing	14.4				1.0	
18	Ollie May Pump	1.0 mi below Mullins crossing	15.0				2.2	
18	Davis No. 1 Pump	1.5 mi below Mullins crossing	15.5				2.2	
18	Davis No. 2 Pump	1.6 mi below Mullins crossing	15.6				1.8	
18	Rackett Pump	1.6 mi below Mullins crossing	15.6				1.6	
18	Concho River	2.0 mi below Mullins crossing at Rackett Dam	16.0		1.5			Estimate.
18	Concho River	3 mi below Mullins crossing south of Miles	17.0		4.4			
19	Concho River	3 mi below Mullins crossing south of Miles	17.0		11.1			
19	Allen No. 1 Pump	17.1 mi below confluence	17.1				1.9	
19	Kenedy Pump	17.1 mi below confluence	17.1				1.8	
19	Balcom Pump	17.6 mi below confluence	17.6				1.0	
19	Allen No. 2 Pump	17.6 mi below confluence	17.6				1.5	
19	Reed Pump	17.8 mi below confluence	17.8				3.4	
19	Concho River	18.0 mi below confluence	18.0		1.5			Estimate.
19	Concho River	18.5 mi below confluence	18.5		0			
19	Concho River	20.4 mi below confluence	20.4		0			
19	Concho River	25 mi below confluence at Rowena-Merata crossing	25.7		0			
20	Lipan Creek	28.4 mi below confluence	28.4			0		
20	Concho River	34.0 mi below confluence at Simm Dam	34.0		.2			Estimate.
20	Concho River	At gaging station near Paint Rock	37.0		.7			Estimate - constant stage.
20	Concho River	At mouth	54.5		1.6			Estimate.

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

North Concho River May 25-26, 1918

Reach: From a point 13 miles above Sterling City to confluence with South Concho River at San Angelo, Tex.

During the investigation the river was at a constant stage and discharge represents the natural conditions.

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
May 25	North Concho R	At McIntyres Dam - 13 mi above Sterling City	0		0.2			Estimate - 300 ft below dam.
25	North Concho R	0.75 mi below McIntyres Dam	0.75		1.2			
25	McIntyres ditch	Near pumping plant	1.0				2.3	8" pump - 25' lift.
25	North Concho R	11 mi above Sterling City	3.0		.3			
25	North Concho R	0.5 mi above Slaton Dam	4.0		.1			
25	Slaton ditch	Near pumping plant	4.0				.2	
25	North Concho R	Below Slaton Dam	4.5		.2			Estimate. Seepage under dam.
25	North Concho R	1 mi above Byers Dam	6.5		.0			
25	Byers ditch	At flume	7.0				1.8	West pump only.
25	North Concho R	Below Byers Dam	7.5		.1			Estimate. Seepage under dam.
25	James Dailey ditch		9.0				.0	Not pumping.
25	North Concho R	Below James Dailey pump	9.0		.3			Measurement, fair.
25	H. K. Ray ditch	At flume	9.2				.4	
25	Allen ditch		9.5				.3	
25	A. C. Pierson ditch		9.5				.0	Not pumping.
25	North Concho R	Below Allen and Pierson pumps	9.5		.2			Estimate.
25	Ray and Johnson pumps		11.0				.0	Not pumping.
25	North Concho R	Just above Johnson pump	11.0		.2			Estimate.
25	Henry Bode pump		13.0				.0	Not pumping.
25	North Concho R	At Henry Bode pump	13.0		.1			Estimate.
25	North Concho R	At Sterling City	14.0		.0			
25	North Concho R	6 mi below Sterling City	20.0		.0			
25	North Concho R	9 mi below Sterling City	23.0		.0			
25	North Concho R	10 mi below Sterling City	24.0		.3			Estimate.
25	North Concho R	18 mi below Sterling City	32.0		.0			
25	North Concho R	25 mi below Sterling City	39.0		.0			
25	North Concho R	1.5 mi above Water Valley	44.0		.9			Measurement rated, good.

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From a point 13	miles above Sterling City to confluence	with South Concho River at					San Angelo, continued
May 26	North Concho R	At Water Valley	45.0		1.8			
26	North Concho R	0.5 mi below Water Valley	45.5		2.7			
26	Trodden and Nell pumps	1.5 mi below Water Valley	46.5				0.0	Not pumping.
26	North Concho R	Road crossing - 7½ mi below Water Valley	51.5		1.7			
26	Carlsbad Sanitarium	At Carlsbad	56				.1	
26	North Concho R	At Carlsbad	56		1.5			Below Sanitarium Dam
26	North Concho R	0.5 mi below Carlsbad	56.5		1.5			Below 2nd pump.
26	North Concho R	4.5 mi below Carlsbad	60.5		1.3			
26	North Concho R	9 mi below Carlsbad	65		.0			
26	North Concho R	11 mi above San Angelo	66		.2			Estimate.
26	North Concho R	6 mi above San Angelo	71		.1			Estimate.
26	North Concho R	At San Angelo gaging station	77		.2			
26	North Concho R	At mouth	78		.2			Estimate.

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

San Saba River March 29-31, 1918

Reach: From Fort McKavett Springs near Fort McKavett, Tex. to mouth.

The low-flow investigation on San Saba River was carried on from March 29 to 31. From McKavett Springs to the Rector Dam and Canal at San Saba, natural conditions were found. Owing to lack of sufficient data, results below the Rector Dam are doubtful.

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Mar. 29	San Saba River	1 mi below Fort McKavett Springs	0		8.6			
29	Rocky Creek	At mouth	10			0.5		Estimate.
29	Clear Creek	At mouth	13			11.9		
29	San Saba River	.8 mi below Clear Creek	13.8		26.7			
29	Ellis pump	1 mi below Clear Creek	14				5.2	
29	Russell pump	2½ mi above Menard	18.5				2.6	
29	Las Moras Creek	At mouth	20.5			.8		Estimate.
29	San Saba River	At Menard - gaging station	21		21.7			
30	Kitchen Canal	5 mi below Menard	26				4.4	
30	McWilliams Canal	10 mi below Menard	31				2.4	
30	San Saba River	At Hext-Brady crossing	41		30.9			
30	San Saba River	At Brady-Camp San Saba crossing	56		28.0			
30	San Saba River	Just above mouth of Brady Creek	76		34.9			
30	Brady Creek	At mouth	76			1.7		
30	San Saba River	At Dorans Ranch 5 mi below Brady Creek	81		34.0			
30	Sloans Springs	At mouth 7 mi below Brady Creek	83			4.7		
30	Jobs Creek	At mouth	87			0		
30	Wallace Creek	At mouth	90			0		
30	Harkey pump	½ mi above railroad bridge west of San Saba	91				3.4	
30	Gunter pump	½ mi below railroad bridge west of San Saba	92				2.2	
30	Richland Creek	At mouth	92.1			0		
30	Young Pierce pump	1 mi above gaging station near San Saba	94				1.1	

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	From Fort McKavett Springs near Fort McKavett, Tex. to mouth, continued.							
Mar. 30	San Saba River	Near San Saba - gaging station	95		33.0			
30	Rector Canal	½ mi above Mill Creek	97.5				2.5	
31	San Saba River	Just below Rector Dam	97.6		32.5			
30	Mill Creek	At mouth	98			22.9		Computed from differences.
30	San Saba River	3/4 mi below Mill Creek	98.8		55.4			
30	Becker pump	1 mi below Mill Creek	99				1.8	
31	San Saba River	At mouth	105		23.0			

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

San Saba River — July 27-29, 1933

Reach: From a point just above Fort McKavett, Tex. to Brady Creek.

During the investigations the river was at a constant stage, and measurements represent natural conditions.

Date 1933	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
July 27	San Saba River	¼ mi above Fort McKavett	0		9.7			
27	Government Spring	At mouth near Fort McKavett	.5			2.0		
27	San Saba River	At first Fort McKavett-Menard crossing	1.0		14.2			
27	Mears Pump	4 mi below Fort McKavett	4.0				1.7	
27	McKnight Pump	6 mi below Fort McKavett	6.0				1.9	
27	San Saba River	8 mi below Fort McKavett	8.0		11.1			
27	Rocky Creek	At mouth	10.0			.2		Estimate.
27	Clear Creek	At mouth	13.0			14.1		
27	San Saba River	½ mi below Clear Creek	13.5		25.1			
27	San Saba River	Just above Noyes Canal	17.0		24.4			
28	Noyes Canal	At Menard	17.0				0	
28	Waddell Pump	Below Noyes Canal head gate	17.8				0	
28	Placker Pump	2 mi above Menard	19.0				2.1	
28	San Saba River	At Menard - gaging station	21.0		20.7			
28	San Saba River	At 5 mi crossing on Menard-Mason road	26.0		21.8			
28	Kitchen Canal	5½ mi below Menard	26.5				9.9	Pumping 27th and 28th.
28	San Saba River	At second Menard-Mason crossing	31.0		7.9			Pump upstream not pumping.
28	San Saba River	At Mathews Tract	35.0		5.3			No pumps operating.
28	San Saba River	At Brady-Hext crossing	41.0		2.2			
28	San Saba River	9 mi below Brady-Hext crossing	50.0		1.4			
28	Calf Creek	At mouth 10 mi below Brady-Hext road	51.0			0		
29	San Saba River	Near Camp San Saba	60.0		1.5			
29	San Saba River	¼ mi above Voca	64.0		2.1			
29	San Saba River	¼ mi above Lost Creek	69.0		2.0			
29	Lost Creek	At mouth	69.3			.2		Estimate.
29	San Saba River	At Campbell crossing 4 mi below Lost Creek	72.0		1.3			
29	Deer Creek	At mouth	73.0			0		
29	San Saba River	At Deer Creek	73.0		0			
29	Deep Creek	At mouth	78.5			0		River starts flowing 3 mi above Brady Creek.

Date 1933	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From a point just above Fort McKavett to Brady Creek, Continued							
July 29	San Saba River	Just above Brady Creek	80.0		18.3			
29	Brady Creek	Just above mouth	80.0			4.5		
29	San Saba River	Just below Brady Creek	80.1		22.8			Obtained by addition.

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

San Saba River February 20-21, 1940

Reach: From a point below Fort McKavett, Tex. to stream-gaging station at Menard, Tex.

A series of discharge measurements was made during the period February 20-21, 1940, on the San Saba River and its tributaries and diversions, Tex., between a point 1 mile northeast of Fort McKavett and the gaging station at Menard, 20.9 miles downstream, to determine the seepage gains or losses. The investigation was made during a period of constant stage of the river. All flowing tributaries were measured. Determination of gain or loss represent normal conditions except the apparent gain of 4.4 second-feet from above Noyes Canal to the Menard gaging station. The discharge of Noyes Canal at the gaging station on the Canal at Menard on this date was 22.7 second-feet, or 4.1 second-feet less than at the headgates. This loss of 4.1 second-feet from the Canal presumably returns to the river above the river gage at Menard and essentially accounts for this apparent gain of 4.4 second-feet.

Date 1940	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Feb. 20	San Saba River	At first McKavett-Menard crossing	1		23.8			Gravel beds.
20	San Saba River	At third McKavett-Menard crossing	6.7		20.8			Rock channel - no pumping.
20	Rocky Creek	At road crossing about 1 mi above mouth	10.0			1.3		Estimate.
20	Clear Creek	150 ft above mouth	12.5			18.2		
20	San Saba River	¼ mi below Clear Creek	12.7		44.9			Rock channel.
20	Dry Creek	600 ft above mouth	12.8			0		
21	San Saba River	At dam-site 6½ mi above Menard	15.4		44.7			Gravel and rock channel.
21	San Saba River	At 4-mi crossing ½ mi above Noyes Canal	17.0		42.9			Earth channel.
21	Noyes Canal	At headgate - 4 mi above Menard	17.9				26.8	
21	Coglin Creek	At mouth	18.1			1.2		
21	Las Moras Creek	At road crossing 1 mi above Menard	21.3			.2		Estimate.
21	Celery Creek	1,000 ft above mouth	21.7			1.4		Estimate.
21	San Saba River	At Menard- gaging station	21.9		23.3			Constant stage.

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

San Saba River November 17-18, 1921

Reach: From damsite near Dorans Ranch to gaging station near San Saba, Tex.

During the investigation the river was at a constant stage and discharges represent the natural conditions. No flow of consequence was found in tributaries not shown in the table of measurements.

Date 1921	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Nov. 17	San Saba River	At damsite at Dorans Ranch 20 mi above San Saba	0		25.0			
18	Fleming Spring	At Fleming Ranch near San Saba	1			3.0		Estimate.
18	Sloan Spring	At road crossing near San Saba	2			5.3		
18	Wallace Creek	At road crossing near San Saba	9			2.1		
18	Richland Creek	At mouth	11			0		
18	San Saba River	Near San Saba - gaging station	14		34.5			

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

Brady Creek March 29, 1918

Reach: From Brady, Tex. to mouth

During the investigation the creek was at a constant stage and discharges represent the natural conditions.

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Mar. 29	Brady Creek	At Brady	0		0			
29	Brady Creek	8 mi south of Rochelle	13		1.0			
29	Brady Creek	At mouth	28		1.7			

Llano River — March 31 to April 3, 1918

Reaches: South Llano River, from a point above Telegraph, Tex. to confluence with North Llano River.
Llano River, from Junction, Tex. to the mouth.

The low-flow investigation in the Llano River basin included the South Llano River and the Llano River from Junction to the mouth. From the mouth of Big Paint Creek to the confluence with the North Llano River there was practically no gain or loss in the South Llano River. On the Llano River in the reach from the gaging station near Junction to Beaver Creek there was a loss of 10 cfs; from Beaver Creek to Little Llano River there was a gain of 28 cfs; and a loss of 7 cfs from Little Llano River to the mouth, with a net gain of 11 cfs from the junction of North and South Llano Rivers to the mouth of the Llano River, a distance of 105 miles.

Data were insufficient to warrant a correction of discharge for time interval, but prior to and during the period of each investigation the stage was practically permanent so that a correction for time interval was generally not necessary.

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	South Llano River, from a point above Telegraph to confluence with North Llano							
Apr. 1	Big Paint Creek	At mouth about 3 mi. below 700 Springs	0			23.1		
1	South Llano R	½ mi below Paint Creek	.5		34.8			
1	Theo Hunger Pump	2 mi below Telegraph	4.0				1.9	
1	Llano Land & Irrigation Co. Pump	6 mi above Junction	13.0				7.0	
1	Cedar Creek	At mouth	18.5			1.0		Estimate.
1	South Llano R	At mouth just above North Llano R	19.0		29.2			
	Llano River, from Junction to the mouth							
Apr. 1	South Llano R	Just above North Llano River	0		29.2			
1	North Llano R	At mouth	0			1.8		
1	Llano River	3 mi below Junction - gaging station	3		42.6			
2	Neal Pump	3/4 mi above Johnson Fork	6.2				.5	Estimate.
2	Westervelt Pump	1/2 mi above Johnson Fork	6.5				.8	Estimate.
2	Johnson Fork	At mouth - 7 mi below Junction	7.0			7.5		

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	Llano River, from Junction to the mouth, continued							
Apr. 2	Llano River	Just below Johnson Fork	7.0		47.9			
2	J. W. White Pump	At Damtown	19.5				1.8	
2	Llano River	Due south of London - at Damtown	20		42.5			
2	Llano River	3 mi. SE of Streeter	35		40.2			
3	James River	At mouth	43			0.5		
3	Llano River	Just below James River	43		42.3			
3	Comanche Creek	At mouth	51			0		
3	Llano River	½ mi above Beaver Creek	54		37.4			
3	Beaver Creek	At mouth	54.5			.5		
3	Willow Creek	At mouth	55.5			0		
3	Llano River	At Castell	64		45.3			
3	Hickory Creek	At mouth	72.5			0		
3	Llano River	9 mi above Llano	73.5		50.8			
Mar. 31	Llano River	3/4 mi above Llano Dam	82		56.4			
31	Llano River	1/4 mi below Llano Dam (Temporary gage)	83		65.7			
Apr. 1	Little Llano R	At mouth	90.5			0		
1	Llano River	Just above Miller Creek near Lone Grove	92		65.7			
1	Miller Creek	At mouth	92			.1		
1	Honey Creek	At mouth	102			0		
1	Llano River	At mouth near Kingsland	106		58.8			

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

Llano River February 6-21, 1925

Reaches: North Llano River, from a point 10.2 miles above Roosevelt to Junction, Tex.
South Llano River, from a point just below confluence of West and South Forks to the mouth.
Johnson Fork Llano River, from headwater springs 8.3 miles above Segovia to mouth.
Llano River, from confluence of North and South Forks to the mouth.

During these investigations the rivers were at a constant stage and discharge represents the natural conditions.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	North Llano River, from a point 10.2 miles above Roosevelt to Junction, Tex.							
Feb. 7	North Llano R	At road crossing 10.2 mi above Roosevelt	0		0			
7	North Llano R	8.1 mi above Roosevelt	2.1		12.7			Rock channel.
8	North Llano R	At Roosevelt	10.2		15.5			
8	Menard Creek	At mouth 1.6 mi below Roosevelt	11.8			3.7		
8	North Llano R	1.9 mi below Roosevelt	12.1		19.0			
8	Copperas Creek	5.0 mi below Roosevelt at road crossing	15.2			2.8		
9	North Llano R	At Copperas School 5.8 mi below Roosevelt	16.0		22.0			
9	Bois D'Arc Creek	At mouth .7 mi below Copperas School	16.7			.2		Gravel channel.
9	North Llano R	Just below Bois D'Arc Creek	16.7		21.9			
9	North Llano R	At road crossing 10.8 mi below Roosevelt	21.0		21.9			Gravel channel.
9	North Llano R	At road crossing 6.8 mi above Junction	25.0		22.8			
10	Bear Creek	At mouth 5.6 mi above Junction	26.2			3.3		
10	North Llano R	Near Junction - gaging station	27.3		25.6			
14	North Llano R	At mouth near Junction	31.8		16.9			
	South Llano River, from a point just below confluence of West and South Forks to the mouth							
Feb. 10	South Llano R	Just below confluence of West and South Forks	0		.5			Estimate.
10	South Llano R	24.2 mi above Junction	1.7		2.0			Estimate.
11	Unnamed Spring	23.2 mi above Junction	2.7			8.9		

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	South Llano River, from a point just below confluence of West and South Forks to the mouth, continued							
Feb. 11	South Llano R	23.2 mi above Junction and 1.1 mi above 700 Springs	2.7		15.7			Rock channel.
11	South Llano R	.2 mi below 700 Springs	3.8		32.6			
12	South Llano R	Just above Paint Creek	6.7		32.7			No pumping above.
12	Big Paint Creek	At mouth 19.2 mi above Junction	6.7			36.5		
12	South Llano R	.3 mi below Big Paint Creek	7.0		67.8			
12	South Llano R	At Telegraph	8.6		66.4			
13	South Llano R	Just below Chalk Creek	16.4		72.3			
13	Cedar Creek	½ mi above mouth at Junction	25.4			2.2		
14	South Llano R	At mouth at Junction	25.9		74.8			
	Johnson Fork Llano River, from headwater springs 8.3 miles above Segovia to mouth							
Feb. 6	Johnson Fork Llano	At springs 8.3 mi above Segovia	0		1.9			800 ft below springs.
6	Johnson Fork Llano	7.4 mi above Segovia	.9		8.9			
6	Joy Branch	4.4 mi above Segovia	3.9			1.4		Estimate.
6	Johnson Fork Llano	Just below mouth of Joy Branch	4.0		13.8			Springs in channel above.
6	Johnson Fork Llano	At road crossing 3 mi above Segovia	5.3		14.6			
7	Johnson Fork Llano	At road crossing 1.6 mi above Segovia	6.7		14.8			Gravel bed.
7	Johnson Fork Llano	At road crossing 1.7 mi below Segovia	10.0		13.8			No diversions above.
7	Johnson Fork Llano	At road crossing 3.8 mi below Segovia	12.1		13.0			Gravel bed.
15	Johnson Fork Llano	.3 mi above mouth and 8.5 mi below Segovia	16.8		12.2			Water goes into gravel beds below this point.
	Llano River, from confluence of North and South Forks to the mouth							
Feb. 14	Llano River	At junction of North and South Forks	0		97.7			Gravel beds.
14	Llano River	1,000 ft below junction	.2		101			
14	Llano River	3 mi below junction - gaging station	3.0		101			
15	Johnson Fork	6.8 mi below junction	6.8			12.2		Seepage through gravel beds.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	Llano River, from confluence of North and South Forks to the mouth, continued							
Feb. 15	Llano River	6.8 mi below junction	6.8		111			
15	Llano River	At Yates-London road crossing	15.0		107			
16	Bluff Creek	Southeast of Streeter	35.5			0.7		
16	Llano River	1½ mi below Bluff Creek	37.0		114			Rock channel.
16	James River	Near mouth and 9 mi SE of Mason	43.6			3.8		
17	Llano River	0.4 mi below James River	44.0		114			
17	Llano River	3/4 mi above Beaver Creek	54.2		118			Gravel channel.
17	Beaver Creek	About 0.3 mi above mouth	55.0			.7		
18	Llano River	At Castell-Mason road crossing	64.9		118			Gravel channel.
18	Llano River	At Castell - gaging station	69.7		122			Gravel channel.
19	Llano River	About 8 mi above Llano	74.7		114			
19	Llano River	3/4 mi above Llano	82.3		119			
20	Llano River	Just below dam at Llano	83.0		118			Sand and rock channel.
20	Little Llano R	At mouth	90.0			1.1		Estimate.
20	Llano River	3 mi below Little Llano River	93.0		116			Sand channel.
20	Miller Creek	At mouth	93.2			.1		Estimate.
21	Llano River	At old Llano-Kingsland road crossing	94.2		121			Sand channel.
21	Llano River	At Llano-Kingsland road crossing	98.7		120			
21	Llano River	At Kingsland - just above mouth	105		122			Sand channel.

Llano River September 3, 4, 1952

Reach: From gaging station near Junction to gaging station at Llano, Tex.

A series of discharge measurements was made during the period September 3, 4, 1952, on the Llano River and its major tributaries beginning at the gaging station near Junction, Tex., and continuing downstream to the gaging station at Llano, Tex., to determine and locate the seepage gains or losses. The investigation was made during a period of relatively constant stage of the river, and no diversions were observed in this section of the river.

Date 1952	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Sept. 3	Llano River	Near Junction - gaging station	0		16.8			
3	Johnson Fork	At road crossing 3.3 mi east of Junction	4			2.03		
3	Llano River	At road crossing 2.3 mi SE of Teacup	10		15.8			
4	Llano River	At Ranch Road 385, 3.8 mi NE of Teacup	16		13.6			
3	Llano River	At road crossing 10 mi SW of Mason	35		5.67			
3	James River	10 mi S of Mason, ½ mi above mouth	38			0		
3	Llano River	At road crossing 8.5 mi S of Mason	39		2.57			
4	Llano River	At U. S. Highway 87 crossing .5 mi S of Hedwig	47		.73			
4	Llano River	At road crossing at Castell	59		.01			
4	Llano River	At road crossing 13.9 mi W of Llano	64		0			
4	Llano River	At road crossing 1.6 mi W of Llano	76		0			
4	Llano River	At Llano - gaging station	79		0			

LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

Pedernales River January 9-17, 1956

Reach: From a point 2 miles downstream from Harper, Gillespie County, to stream-gaging station near Johnson City, Blanco County, Tex.

Objective: For several years, a comprehensive hydrologic study of the interrelationships of surface and ground waters in various river basins in central and south Texas has been conducted by the U. S. Geological Survey, in cooperation with the State Board of Water Engineers. The objective of this investigation is to extend these studies into the Pedernales River basin and to evaluate the interchange of surface and ground waters in that basin.

This report shows the results of an intensive investigation of the low-flow characteristics of the Pedernales River during a drought period from a point near Harper, Gillespie County, to the U. S. Geological Survey-State Board of Water Engineers gaging station, 1.2 miles northeast of Johnson City, Blanco County.

SURFACE WATER INVESTIGATIONS

Conclusions: The Pedernales River system derives its low or base flow from the following:

1. Headwater springs issuing from the base of the Edwards limestone near Harper on the main stem and on most of the tributaries entering from the south.

2. Contributions from extensive areas of the Hensell sand member of Barnes (1948) enter the river principally from the north through tributaries and seepage to the large beds of alluvium along the river valley. Potentially, Barnes' Hensell sand member is the best aquifer in the Pedernales basin.

3. Springs and seeps originating in areas of faulting, jointing, and solution channeling in the Ordovician rocks (Palo Alto Creek to Blumenthal) and in the Pedernales dolomite member (at and below Stonewall).

4. Springs that issue from the Tanyard formation in the North Grape Creek area.

This series of measurements indicate that the Pedernales River system loses only small amounts of water here and there throughout the 70 miles investigated and that these losses are principally due to evaporation, transpiration, and to irrigation pumpage. No area was found where losses of consequence could be attributed to seepage into the groundwater reservoirs.

Summary: During this investigation the flow of the Pedernales River was wholly from ground-water sources and no flood water was encountered at any time. Prior to the investigation on Dec. 1, 1955, a small rise occurred with a maximum discharge of 16 cfs (cubic feet per second) at the gaging station at Johnson City. The discharge had dropped to 5.3 cfs by December 11 and averaged about 5 cfs for the remainder of the month. During the first half of January 1956 the flow at Johnson City dropped from 4.8 to 3.3 cfs with a 1.0 cfs decline in flow during the period of this investigation. From January 9 to 16 the weather was dry with cold nights and warm sunny days. On January 17 the weather changed to cloudy with north winds and intermittent drizzle, and during the night of January 17-18 rain and

sleet fell, amounting to more than an inch of precipitation over most of the watershed. A small amount of surface runoff resulted which caused the river discharge to rise from 3.3 to 11.0 cfs at Johnson City. The investigation was discontinued at this time due to the presence of an indeterminate amount of surface runoff in addition to a probable increase in base flow of the river.

At the time of this investigation, the farthest upstream flow of the Pedernales River system issued from springs near the base of the Edwards limestone. On the main stem of the river these springs are located a short distance downstream from Harper, Gillespie County, and were flowing at a rate of 0.3 cfs. The Edwards limestone, which caps the major drainage divides of the upper reaches of the Pedernales, contains many joints, fissures, and solution channels. Much of the rain which falls on the Edwards outcrop penetrates to the water table and eventually appears as surface flow through springs and seeps.

The flood plain of the Pedernales River contains large deposits of alluvium (gravel, sand and silt) which can absorb and store considerable water. The initial flow from the springs near Harper and the inflow from Scott Branch, about 0.15 cfs, is soon lost in the alluvial deposits as it progresses downstream, completely disappearing about 13 miles below Harper.

The Cap Mountain limestone member of the Riley formation crops out in the river channel at a point about 2 miles above Morris Ranch, and about 4 miles below the point where the initial flow disappeared. This outcrop forms a heavy rock ledge across the channel which acts as a dam across the beds of alluvium. No water was flowing over the rock outcrop at this point indicating that the alluvium beds were not full of water at this time. Numerous wells take water from the gravels, and transpiration losses occur through the trees and other vegetation that grows on the alluvium terraces.

All the tributaries entering from the south probably have headwater springs issuing near the base of the Edwards limestone, but Scott Branch was the only one having flow at its mouth. Wolf Creek has spring flow on both branches above State Highway 16 but was dry at its mouth. The combined flow in Wolf Creek amounted to 0.46 cfs (206 gallons per minute) and was all lost to pumping, evaporation, and transpiration before reaching the Pedernales. Four irrigation pumps were located on Wolf Creek with a combined capacity of about 1,600 gallons per minute with two of them pumping a total estimated 1,000 gallons per minute. These two pumps were taking water from a single large natural pool although one of the pump owners has four small dams on the creek. Wolf Creek was selected for complete investigation as an example of a typical tributary. The scope of the study did not include investigating all tributaries to source.

A short distance below the outcrop of the Cap Mountain limestone member the river starts to flow on the surface again.

From Morris Ranch to Palo Alto Creek the river flows through the southern edge of a large area of the Hensell sand member of Barnes (1948). This is the basal member of the Shingle Hills formation (Barnes, 1948), which forms the best and most extensive aquifer in the area, capturing a relatively high percentage of the rain which falls upon its surface. The peach orchards and peanuts cultivated in Gillespie County are grown on the pink and red Hensell sand member of Barnes (1948).

At the county road crossing south of Morris Ranch a flow of 0.1 cfs was found and 1 mile downstream it had increased to 0.4 cfs (180 gallons per minute). About 0.1 mile above State Highway 16, at the foot of a 3/4-mile long pool, only 0.1 cfs was found flowing. On the south bank and about 500 feet upstream from the foot of the pool, an irrigation pump

was pumping an estimated 500 gallons per minute from the river. According to a local resident, this pool has never pumped dry and is reputed to have underground recharge. Very likely it is directly connected to the large beds of alluvium along the river valley and the reservoir is much more extensive than appears on the surface. Throughout this reach the gravel beds along the flood plain are large, with a number of gravel pits which invariably fill with water to river level when excavated below that elevation.

The flow gradually increases as it progresses downstream, to 0.6 cfs one mile above Live Oak Creek which was flowing 0.56 cfs at its mouth. About 1,000 feet below Live Oak Creek 1.10 cfs was measured in the river. Bear Creek, which enters from the south about 3.5 miles upstream from Live Oak Creek, was dry at its mouth but several small seeps were found along the north bank between Bear and Live Oak Creeks.

River flow measurements indicate very little fluctuation in discharge from Live Oak to Palo Alto Creeks with only small inflow from tributaries. Muesebach Creek was dry at its mouth and Barons Creek was flowing 0.05 cfs where it entered the river. Barons Creek has some flow through the town of Fredericksburg and had an estimated flow of 0.2 cfs at U. S. Highway 290. An irrigation pump was taking an estimated 400 gallons per minute from a pool behind a temporary dirt dam on Barons Creek about 3/4 mile below U. S. Highway 290. Another irrigation pump (4" intake) was located on the north bank of the river just upstream from Muesebach Creek. It pumps from a large gravel pit, but was not operating when observed. The pit is located about 200 feet from the river bank and its water surface appeared to be the same as that in the river. A 4-foot rock dam has been built across the river a few feet upstream from Palo Alto Creek. This dam forms a large pool on which are located two irrigation pumps. A 6" pump on the north bank was pumping an estimated 500 gallons per minute to irrigate a large field of winter grain. A 4" pump on the south bank was not pumping but had a pipe line to a surface storage pond (capacity about 10 acre-feet) from which a very large field (100 acres more or less) had been irrigated. A 2" electric pump was pumping (estimated 100 gallons per minute) from a shallow well into the surface tank. The well probably takes water from the large beds of river alluvium. Palo Alto Creek was contributing 0.02 cfs to the river. This was the total surface flow but very probably much more water is carried by underflow below the surface of the wide sand creek bed.

From Palo Alto Creek to Blumenthal the heavy beds of gravel in the river channel give way to Ordovician rocks from which rise a series of springs and seeps along faults and joints. The river discharge measured 1.36 cfs 1.6 miles above Palo Alto Creek, 1.98 cfs 0.5 mile below Palo Alto Creek, and 3.14 cfs 1.5 miles below Palo Alto Creek and near Blumenthal. Numerous seeps and small springs were observed along the channel below Palo Alto Creek and along the fault line just above Blumenthal.

From Blumenthal to Stonewall the river again crosses the alluvium beds associated with the Hensell sand member of Barnes (1948) and shows little variation in discharge through this reach. South Grape Creek had no surface flow at its mouth although there was a small flow just above the bridge on U. S. Highway 290. Some water may have been entering the river through the sand below the surface of the creek bed.

At Stonewall, where the Pedernales dolomite member of the Wilberns formation appears in the river channel, river flow increases to 3.95 cfs. This increase is associated with an area of intensive jointing and solution channeling in the dolomite which yields water to wells and springs in the Pedernales area. About 1.2 miles below Stonewall the river discharge decreased to 3.09 cfs, but it increased to 3.49 at a point 3.4 miles below Stonewall. About 3/4 mile below Stonewall the river crosses an area of faulted rock which may take some water from the river. Also, measuring conditions in this area are not good, and some of the apparent gain and loss may be due to inaccuracy of flow measurements.

A 3-mile stretch below Stonewall is the most heavily pumped area encountered along the Pedernales River. Four pumps, with an estimated total capacity of 2,000 gallons per minute, were located and 2 other pump sites were found where the pumps had been removed. Two pumps on the north bank were pumping from a small lake (formed by a concrete dam about 5 feet high). One was irrigating winter grain and the other was pumping into a small concrete-lined earthen tank about 500 feet from the river. Another pump (about 2") was pumping into this same tank from a shallow well about 300 feet from the river. The well had an open concrete-walled sump about 25 feet deep with the electric motor and pump at the bottom of this sump. The other two pumps take water from a second small lake (formed by a concrete dam about 4 feet high) about 1/2 mile below the 5-foot dam. The two pump sites, where the pumps had been removed, are located upstream from both of the small lakes.

From Stonewall to McDougals crossing the stream flows directly upon rock surfaces of the Riley and Wilberns formations and on the Oatman Creek granite of Stenzel (1932), in places partially disappearing into solution channels and sinks but reappearing and maintaining its quantity of flow downstream. About 3/4 mile above McDougals crossing (FM 1320) a flow of 3.37 cfs was measured. Fault-line springs and seeps were contributing minor amounts of water in the vicinity of McDougals crossing. From Stonewall to Johnson City, a distance of about 21 miles, the streambed falls about 380 feet, or an average of about 18 feet to the mile. Within this reach, the fall approaches 25 feet to the mile between Hye and North Grape Creek, a distance of about 10 miles.

Below McDougals crossing the streambed is of rock and some small losses probably occur in the zone of fracturing above and below the mouth of Rocky Creek. River-flow measurements indicate minor losses. A flow of 2.97 cfs was measured half a mile below Rocky Creek. This flow decreased to 2.65 cfs and 2.62 cfs at points 3 miles and 1 mile, respectively, above North Grape Creek. Rocky Creek contributed 0.05 cfs at its mouth.

The surface flow of North Grape Creek amounted to 0.53 cfs. Probably the total contribution of the creek is somewhat greater because of flow through the deep beds of sand at the mouth of the creek. North Grape Creek contributes the only inflow of consequence from Stonewall to Johnson City and derives its flow from headwater springs which issue from joints and solution channels in the Tanyard formation. River flow was measured at 3.66 cfs about 700 feet below North Grape Creek.

The discharge measurement below North Grape Creek was made late in the afternoon of January 17. Rain began a few hours after that measurement was completed. This rain caused sufficient surface runoff to make further measurements useless; therefore, the investigation was discontinued. The river flow of 3.3 cfs, as indicated at the gaging station near Johnson City, was determined from the continuous recorder record and is not the result of an actual discharge measurement.

Method of Investigation: The field work was done by a party of three, an engineer from the State Board of Water Engineers and a geologist and an engineer from the U. S. Geological Survey, during the period Jan. 9-17, 1956. The geologic maps of Gillespie and part of Blanco Counties, prepared by the Bureau of Economic Geology, University of Texas, were used as a guide to locating tributaries, road crossing, geologic formations, etc.

Measurements of streamflow were made at approximately 2-mile intervals on the main stream, and inflow from all tributaries was measured. Measurement sites were selected on impermeable material wherever possible to prevent underflow bypassing the measuring section. Unfortunately, such sites are scarce and, therefore, many measurements necessarily were made on gravel beds. The river was observed at many points where measurements were not made in order for the geologist to observe and study the geology. Geologic features were considered in the selection of measuring sites as well as

channel conditions and the 2-mile interval. The scope of the study precluded investigating all tributaries upstream to their sources. Therefore, Wolf Creek was selected as a typical tributary to be completely studied.

Wherever pumps or pump sites were observed, the size of the pump was determined and a few pump owners were interviewed by the engineer from the State Board of Water Engineers. The pumps were mostly portable, being either trailer or tractor mounted. A few sites were found where the pumps had been removed for the winter. All irrigation systems observed were of the sprinkler type using aluminum pipe to transport the water, and some were operating to irrigate winter grain crops. Pumps and pump sites are shown in tables, but it is certain that there are others that were not observed. Therefore, those shown do not represent the total number pumping during the irrigation season.

In order to illustrate that variations in base flow were negligible during the period of study, a discharge hydrograph for the Johnson City gaging station is included as figure 1.

Streamflow measurements in this investigation range in accuracy from good (probably less than 5% in error) to poor (possible error may exceed 8%). This accuracy rating is estimated from the physical conditions of the measuring section. The better sections are on gravel or sand and the poorer ones on rock. In tables where rock is indicated in the measuring section, probably all the flow is represented, but where gravel is shown there is a possibility of an indeterminate amount of flow below the surface of the gravel deposit. Measurements were made on rock wherever possible, but rock channels do not ordinarily lend themselves to good or even fair (probable error less than 8%) measuring conditions and are particularly poor for measurement of small discharges.

GEOLOGY

General Setting: The Pedernales River system has been developed on a marginal portion of the Edwards Plateau where much of the original plateau surface has been removed by erosion. Along the main river channel are outcrops of rocks ranging in age from Precambrian to Recent. These rocks grade from coarse, poorly indurated sands and gravel through silt and clay to dense limestones and crystalline dolomites. The upper reaches of the channel are characterized by poorly indurated sand, gravel, silt, and clay of Cretaceous age. Denser rocks of Paleozoic age crop out at Morris Ranch, near Palo Alto Creek, and form most of the streambed from Stonewall to Johnson City. Alluvium is noticeably concentrated along portions of the stream where Cretaceous rocks crop out, whereas the streambed is generally scoured to bedrock where the channel cuts rocks of Paleozoic age.

Formations and their Water-Bearing Properties

Precambrian rocks: Rocks of Precambrian age are represented in the Pedernales area by the Oatman Creek granite of Stenzel (1932). According to Barnes (1952d), Stenzel's Oatman Creek granite consists of medium to coarsely crystalline pink to red aplogranite. The formation is relatively impermeable except, of course, where it might be fractured or weathered.

Cambrian rocks: The Cambrian rocks of the Pedernales River area have been divided into two formations, the Riley formation and the Wilberns formation. The lower or Riley formation has been divided into three members, in ascending order the Hickory sandstone member, the Cap Mountain limestone member, and the Lion Mountain sandstone member. The Hickory sandstone member consists of massive, crossbedded coarse-grained sandstone which grades upward into fine sandstone and shale. Cementation is generally poor. The Hickory does not crop out in the area, however, is relatively permeable

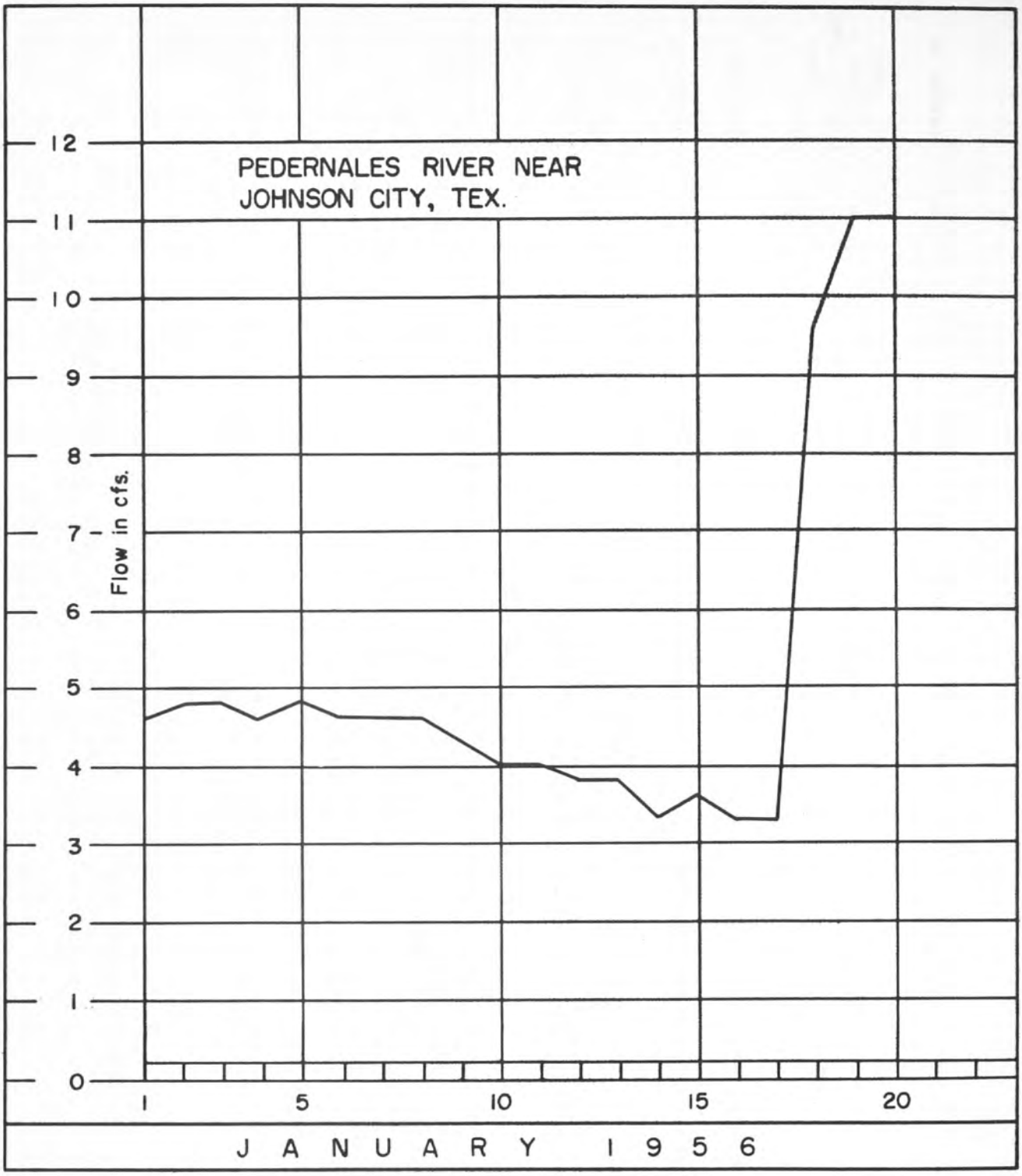

FIGURE 1.- DISCHARGE HYDROGRAPH, PEDERNALES RIVER NEAR JOHNSON CITY, TEX.

and yields water to wells in many places in the Pedernales River area and elsewhere in central Texas. The Cap Mountain limestone member consists of tightly cemented sandstones which grade upward into massive, solution-jointed limestones. Persistent silty zones are present near the top of the member. Water is obtained locally from joints and solution channels in this member. The Lion Mountain sandstone member of the Riley formation consists of highly glauconitic grey to brown sandstone. Its water-bearing properties are not known.

The Wilberns formation lies disconformably upon older rocks and is divided into five members. The basal or Welge sandstone member consists of poorly indurated light-brown nonglauconitic sand which during wet seasons becomes saturated. The Welge grades upward into the Morgan Creek limestone member which consists of relatively impermeable coarse to fine-grained greenish-gray limestone. The Point Peak shale member overlies the Morgan Creek member and consists of thin-bedded argillaceous limestone, fissile shale, and massive stromatolitic bioherms. It is relatively impermeable. The San Saba limestone member overlies the Point Peak and consists of thick-bedded hard limestone which grades laterally into the top member of the Wilberns formation, the Pedernales dolomite member. The Pedernales consists of coarse to fine-grained dolomite and contains stromatolitic bioherms. The upper surface of the Pedernales member is in disconformable contact with overlying beds, and is noticeably jointed by solution and fracturing. The member yields water to wells and springs in the Pedernales area.

Ordovician rocks: Ordovician rocks in the area consist largely of limestones and dolomites which have been divided into the Tanyard formation below and the Gorman formation above (Cloud and Barnes, 1946). Springs in the North Grape Creek area issue from joints and solution channels in the Tanyard formation.

Cretaceous rocks: The Cretaceous rocks of the Pedernales area are represented by the Shingle Hills formation of Barnes (1948) and the Fredericksburg group. Barnes has divided his Shingle Hills formation into a sandy member, the Hensell, and an upper sequence of thin-bedded limestones, dolomites, and clays, the Glen Rose member. The coarse materials of Barne's basal Hensell form the best and most extensive aquifer in the area, capturing a relatively high percentage of the rain which falls upon its surface. The Glen Rose member of Barnes is relatively impermeable.

The Fredericksburg group in the Pedernales area includes the Walnut clay, Comanche Peak limestone, and Edwards limestone, in ascending order. The Walnut clay grades upward into the Comanche Peak limestone, which is highly argillaceous and fossiliferous. Neither formation may be considered an aquifer. The Edwards limestone caps the major drainage divides of the upper reaches of the Pedernales area and consists of hard limestone, dolomite, and chert. The limestone contains many joints, fissures, and solution channels, and much of the rain that falls on the outcrop of the Edwards penetrates to the water table and is transmitted just above the contact between the Edwards and Comanche Peak.

Alluvium: Deposits of alluvium of Recent age occur in many places along the Pedernales River. The alluvium consists largely of thin disconnected beds of gravel, sand and silt. The material in most places is coarser near the bottom.

Conclusions: Two distinct types of lithology are responsible for the storage, transmission, and discharge of water of the Pedernales River system. The coarse sands and gravels of the Cretaceous readily absorb rainfall, and transmit it to discharge points in wells and springs. Because of their extensive outcrop area the sands of Cretaceous age form the best aquifer in the Pedernales basin. Limestones of the Fredericksburg group and those of Paleozoic age may collect and transmit water wherever fracturing and solution channeling have created zones of permeability. The sandstones of Paleozoic age may serve as aquifers, but because of greater induration and limited surface outcrop, they are less prolific than the sands of Cretaceous age.

Date 1956	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From a point 2 miles downstream from Harper, Gillespie County, to stream-gaging station near Johnson City, Blanco County, Tex.							
Jan. 9	Pedernales R	2 mi downstream from Harper	0		0			Rock streambed.
9	Pedernales R	0.5 mi downstream from Head Spring	0.5		.3			Est. Rock streambed.
9	Pedernales R	100 ft below Pecan Creek	2.3		.3			Est. Gravel streambed.
9	Pedernales R	At county crossing	4.0		.3			Est. Rock streambed.
9	Pedernales R	Just above Scott Branch	5.7		.25			Est. Gravel streambed.
9	Scott Branch	At mouth	5.7			0.15		Est. Gravel streambed.
9	Flag Creek	At mouth	7.3			0		Gravel streambed.
9	Pedernales R	1.0 mi below Flag Creek	8.3		0			Gravel streambed.
9	Pedernales R	At county crossing	9.2		.2			Est. Rock streambed.
9	Pedernales R	0.5 mi above ranch crossing	11.4		.1			Est. Gravel streambed.
10	Pedernales R	1.5 mi above White Oak Creek	13.3		0			Est. Gravel streambed.
10	Pedernales R	500 ft above White Oak Creek	14.7		0			Rock streambed.
10	White Oak Cr	At mouth	14.8			0		Gravel streambed.
10	Pedernales R	At county crossing - natural rock	16.5		0			Rock streambed.
10	Pedernales R	At county crossing	18.0		.05			Est. Gravel streambed.
10	Spring Creek	At mouth	19.2			0		Est. Gravel streambed.
10	Pump site	On right bank	19.2				-	Pump removed.
10	Pedernales R	At county crossing	19.5		.1			Est. Gravel streambed.
10	Pedernales R	1.0 mi above State Highway 16	20.6		.4			Est. Gravel streambed.
10	5" pump	On right bank	21.3				1.0	Est. Irrigating winter grain.
10	Pedernales R	0.1 mi above State Highway 16	21.4		.1			Est. Gravel streambed.
16	Wolf Creek	12.1 mi above mouth	-		0			Rock streambed.
16	Spring Area	10.6 to 12.1 mi above mouth of Wolf Creek	-			-		Could not measure flow.
16	3" pump	On right bank; 11.0 mi above mouth of Wolf Creek	-				-	Not pumping.
16	Wolf Creek	9.8 mi above mouth	-	50°	.37			Rock streambed.
16	Tributary	From right; 9.0 mi above mouth of Wolf Creek	-			.1		Est. Rock streambed.
16	Wolf Creek	8.3 mi above mouth	-	50°	.46			Gravel streambed.
16	6" & 5" pump	4.3 mi above mouth of Wolf Creek	-				2	Est. From large pool.
16	Wolf Creek	3.6 mi above mouth	-		.1			Est. Rock streambed.
16	4" pump	On right bank; 1.9 mi above mouth of Wolf Creek	-				-	Not pumping.
16	Wolf Creek	At mouth	21.5		0			Gravel streambed.

Date 1956	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Jan. 10	Pedernales R	0.3 mi above Bear Creek	23.5		0.2			Est. Gravel streambed.
10	Bear Creek	At mouth	23.8			0		Est. Gravel streambed.
10	Tributary	From left bank	25.0			.02		Est. Sand streambed.
10	Pedernales R	2.0 mi above Live Oak Creek	25.1		.3			Est. Gravel streambed.
10	Tributary	From left bank	25.2			.01		Est. Sand streambed.
10	Pedernales R	1.0 mi above Live Oak Creek	26.0		.6			Gravel streambed.
10	Live Oak Creek	At mouth	27.0	52°		.56		Sand streambed.
10	Pedernales R	500 ft below Live Oak Creek	27.1	53°	1.10			Gravel streambed.
10	Pump site	--	27.8				-	Pump removed.
10	Pedernales R	0.4 mi above U.S. Highway 87	28.8	51°	1.24			Sand and gravel streambed.
11	Pedernales R	0.2 mi above Muesebach Creek	31.0		1.0			Est. Gravel streambed.
11	4" pump	0.2 mi above Muesebach Creek; on left bank	31.0				-	Not pumping.
11	Muesebach Cr	At mouth	31.2			0		Gravel streambed.
11	4" pump	On Barons Creek; 1 mi above mouth	-				1	Est. From pool behind temporary dirt dam.
11	Barons Creek	At mouth	32.0			.05		Est. Sand streambed.
11	Pedernales R	0.3 mi below Barons Creek	32.3	45°	.96			Gravel streambed.
11	Pedernales R	200 ft above U.S. Highway 290	34.4	52°	.90			Gravel streambed.
11	Pedernales R	--	36.6	52°	1.31			Gravel streambed.
11	Pedernales R	2 mi north of Rocky Hill School	38.4	50°	1.36			Rock streambed.
12	4" pump	On right bank; 0.5 mi above Palo Alto Creek	38.9				-	Not pumping.
12	6" pump	On left bank; 0.3 mi above Palo Alto Creek	39.1				1	Est. From pool behind 4 ft dam.
12	Palo Alto Cr	At mouth	39.4			.02		Est. Sand streambed.
12	Pedernales R	0.6 mi below Palo Alto Creek	40.0	50°	1.98			Rock streambed.
12	Pedernales R	150 ft above county crossing	41.5	54°	3.14			Sand over rock streambed.
12	South Grape Cr	At mouth	43.2			0		Sand streambed.
12	Pedernales R	1.4 mi below South Grape Creek	44.6	48°	3.09			Sand and gravel streambed.
12	Cave Creek	At mouth	45.4			0		Sand streambed.
12	Pump site	0.2 mi below Cave Creek	45.6				-	Pump removed.
12	Pedernales R	0.2 mi above Three Mile Creek	46.7	50°	2.82			Gravel streambed.
12	Three Mile Cr	At mouth	46.9			0		Sand streambed.
12	Pedernales R	2,000 ft below concrete crossing	48.8	51°	3.95			Rock streambed.
13	Pump site	0.6 mi below Stonewall; on right bank.	49.2				-	Pump removed.
13	Pump site	1.0 mi below Stonewall; on right bank	49.6				-	Pump removed.

Date 1956	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
Jan. 13	Pedernales R	1,000 ft below concrete crossing	50.0	43°	3.09			Gravel streambed.
16	5" pump	In shallow pit; on left bank	50.5				1	Pumping into concrete-lined earth tank.
14	6" pump	On left bank	50.9				1	Pumping from small lake with 5 ft channel dam.
13	6" pump	On left bank	51.1				-	Not pumping.
13	6" pump	On left bank	51.7				-	Not pumping. Takes water from small reservoir with 4 ft channel dam.
13	Pedernales R	60 ft below concrete bridge	52.2	54°	3.49			Gravel streambed.
13	Iron Rock Cr	At mouth	54.9			0		Rock streambed.
13	Pedernales R	0.7 mi above F.M. 1320	56.5	53°	3.37			Rock streambed.
17	Pedernales R	0.7 mi above F.M. 1320	56.5	44°	3.34			Rock streambed.
17	Rocky Creek	At mouth	57.6			.05		Est. Rock streambed.
17	Pedernales R	0.5 mi below Rocky Creek	58.2	44°	2.97			Rock streambed.
17	Pedernales R	--	59.8	46°	2.65			Rock streambed.
17	Pedernales R	About 1.0 mi above North Grape Creek	62.0	44°	2.62			Rock streambed.
17	North Grape Cr	At mouth	63.1	46°		.53		Sand streambed.
17	Pedernales R	700 ft below North Grape Creek	63.3	45°	3.66			Sand streambed.
17	Pedernales R	At gaging station near Johnson City	70.0		3.3			Not measured. From continuous recorder record.

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LOW-FLOW INVESTIGATIONS - COLORADO RIVER BASIN

Onion Creek April 23-24, 1958

Reach: From FM Road 12 in Hays County to State Highway 71 in Travis County, Tex.

Problem: To determine gains and losses in streamflow in the section of Onion Creek from Farm Road 12, two miles south of Dripping Springs, Hays County, to State Highway 71, five miles east of Austin, Travis County, Texas; with particular attention paid to losses into the Edwards limestone.

Results: Data obtained in this set of stream-flow measurements are as follows:

1. The flow gradually increased from 10 cfs to about 57 cfs in the first 14 miles of channel investigated. This reach is on the Glen Rose limestone with the streambed composed mainly of smooth rock. Flow was found in each of the tributaries inspected.

2. About 10 cfs was lost in the 10 mile (approximate) reach that is on the Edwards limestone. This reach extends from about mile 16 to the fault line and the falls at mile 26, about 3 miles upstream from Buda.

3. Below Buda the flow increased 31 cfs, from 50 to 81 cfs, in 26 miles; of the increased flow, about three cfs can be attributed to measurable tributary inflow. The remainder of this increase in flow probably comes from the alluvium in the creek valley.

Discussion: Current-meter measurements were made at seven points on the main stream through the 59 mile reach; four of these measurements were made to determine losses into the Edwards limestone. Tributary inflows were estimated only at points accessible to highways and county roads. The channel was investigated only at such points as indicated by discharge measurements or field estimates. No attempt was made to pace the measurements with the rate of change in flow as the investigation progressed downstream. The flow was probably decreasing 2% to 5% per day, as in comparable streams crossing the Balcones fault zone; no check was made of this condition. All measurements and estimates were of base flow, there having been no recent surface runoff. Stream-flow measurements at mile 14 and 25.6 were made as near the contacts of the Edwards limestone as practicable. The pickup in flow found at mile 20 probably comes from the short stretch of Glen Rose limestone downstream from mile 14, a pickup in flow being unlikely after the stream crosses onto the Edwards limestone. The three cfs loss indicated between mile 25.6 and mile 29 is probably absorbed at or near the downstream contact of the Edwards limestone, a fault line and falls about 600 ft below the measuring section. Although several small lakes with channel dams were found, no irrigation equipment was seen; nevertheless, it is likely that a considerable quantity of water is used for irrigation during the growing season.

Date 1958	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From FM Road 12	in Hays County to State Highway 71	in Travis		County			
Apr. 23	Onion Creek	At FM 12	0		10			Estimate. Gravel and rock streambed.
23	South Onion Cr	At FM 12, 1.4 mi above mouth	1.4			7		Estimate. Broken rock streambed.
23	Tributary	From right; 3.8 mi above mouth	3.7			3		Estimate. Rock streambed.
23	Onion Creek	At abandoned county concrete crossing	10.0	71°	53.0			Gravel streambed.
23	Tributary	From right; at mouth	10.3			.1		Estimate. Rock streambed.
23	Tributary	From right; 0.6 mi above mouth	12.9			2		Estimate. Rock streambed.
23	Onion Creek	400 ft below lower crossing of FM 150	14.0	73°	57.3			Smooth rock streambed.
23	Tributary	From right; 1.8 mi above mouth	18.8			0		Gravel streambed.
23	Onion Creek	At abandoned crossing on Kuykendal ranch	20.0	78°	60.2			Rough rock.
23	Onion Creek	At abandoned crossing 600 ft above falls	25.6	81°	53.5			Rough rock.
23	Onion Creek	At Buda; 100 ft above FM 967	29.0	82°	50.5			Rock and gravel streambed.
24	Bear Creek	At mouth	34.5			1		Estimated. Rock streambed.
24	Rinard Creek	1.0 mi above mouth	39.2			.3		Estimate. Rock streambed.
24	Slaughter Cr	1.7 mi above mouth	40.0			.2		Estimate. Rock streambed.
24	Onion Creek	200 ft below county crossing at Bluff Springs	41.1	75°	65.6			Gravel streambed.
24	Boggy Creek	1.0 mi above mouth	41.9			.4		Estimate. Rock streambed.
24	Marble Creek	0.9 mi above mouth	45.5			.1		Estimate. Gravel streambed.
24	Williamson Cr	2.8 mi above mouth	47.1			.8		Estimate. White rock streambed.
24	Cotton Mouth Cr	4.4 mi above mouth	50.1			0		Gravel streambed.
24	Onion Creek	600 ft above State Highway 71	55.1	74°	81.4			Gravel streambed.
24	Onion Creek	At mouth	59.2		-			Backwater from Colorado River.

LOW-FLOW INVESTIGATIONS - LAVACA RIVER BASIN

Lavaca River — Nov. 4, 1947; Aug. 5, 6, 1948

Reach: From Dr. Lee pumping plant to Koop Brother's pump near Edna, Tex.

A series of discharge measurements was made Nov. 4, 1947, and Aug. 5, 1948, on Lavaca River between Dr. R. E. Lee's pump, about 3½ miles northwest of Edna, and Koop Brother's pump, about 6½ miles southeast of Edna. Discharge measurements were made of Lavaca River at upper and lower ends of river reach, and at three intervening points. In addition, the quantity of water being diverted from river by each of three pumps was measured. These were all of the known diversions from this reach of the river at the time the investigation was made. There was no inflow into the reach. The investigations were made during periods of constant stage of river as indicated at gaging station near Edna which is within the reach. The determination of gain or loss represent normal conditions.

Measurements in November were made when no pumps were operating and none had been operated during the preceding week. Measurements in August were made while all pumps were operating at a constant rate of speed and had been for several days preceding the measurements.

Date 1947	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
Nov. 4	Lavaca R	Just above Dr. Lee pump near Edna	0		15.6			
4	Dr.Lee's pump	3½ mi NW of Edna	0				0	
4	Lavaca R	At U.S.Hwy 59 - gaging station	3.0		17.6			
4	Lavaca R	Just above Babb's pump 3 mi SW Edna	4.1		17.4			
4	Babb's pump	3 mi SW of Edna	4.1				0	
4	Lavaca R	Just below old county bridge 4 mi SW	6.5		19.4			
4	Lavaca R	Just above Koop Bro's. pump 6½ mi S Edna	9.5		21.3			
4	Koop Bro's. pump	6½ mi S of Edna	9.5				0	

Date 1948	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Dr. Lee pumping plant to Koop Brother's pump near Edna, Tex., continued							
Aug. 5	Lavaca R	Just above Dr. Lee pump	0		17.7			
5	Dr. Lee pump	3½ mi NW of Edna	0				6.48	
5	Lavaca R	At U.S.Hwy. 59 - gaging station	3.0		12.7			
5	Lavaca R	Just above Babb pump	4.1		13.1			
5	Babb pump	3 mi SW of Edna	4.1				10.5	
5	Lavaca R	Just below old county bridge 4 mi SW	6.5		4.34			
6	Lavaca R	Just above Koop Bro's. pump	9.5		5.20			
5	Koop Bro's. pump	6½ mi S of Edna	9.5				6.49	

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Guadalupe River — January 16-19, 1928

Reach: From Comfort to New Braunfels, Tex.

During the investigation the river was at a constant stage and measurements represent the natural conditions.

Date 1928	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
Jan. 16	Guadalupe River	2 mi above Comfort - Gaging station	0		52.0			
16	Cypress Creek	¼ mi above mouth at Comfort	3.0			1.5		
16	Holliday Creek	600 ft above mouth near Comfort	4.8			.3		
16	Guadalupe River	At Railroad bridge below Comfort	6.4		58.6			
16	Guadalupe River	At Highway crossing at Waring	12.2		58.7			
17	Joshua Creek	2 mi above mouth near Waring	16.0			1.6		
17	Sister Creek	½ mi above mouth near Sisterdale	19.7			.4		
17	Guadalupe River	Just below Sister Creek near Sisterdale	19.7		65.4			
17	Wasp Creek	At mouth 6 mi below Sisterdale	29.5			.2		
17	Sabino Creek	At mouth 8 mi NE of Boerne	31.2			.5		
17	Guadalupe River	Just below Sabino Creek at Ammans crossing	31.2		70.9			
17	Guadalupe River	At Schillers crossing 4 mi N of Bergheim	45.6		68.3			
18	Currys Creek	½ mi above mouth	55.8			2.6		
18	Guadalupe River	At Specks crossing 2.5 mi SW of Spring Branch	57.5		71.9			
18	Spring Branch	1½ mi above mouth near Spring Branch	59.0			1.5		
18	Guadalupe River	Near Spring Branch - Gaging station	61.7		73.5			
18	Big Spring	At Cranes Mill	78.5			3.9		
18	Guadalupe River	At road crossing at Cranes Mill	78.5		72.3			
18	Guadalupe River	At road crossing 2 mi NE of Sattler	92.7		88.9			
19	Jacobs Creek	At mouth 2 mi below Sattler	95.9			0		
19	Guadalupe River	4 mi below Sattler	97.4		83.2			
19	Isaacs Creek	At mouth 5½ mi above New Braunfels	103.5			0		
19	Guadalupe River	¼ mi above Elm Creek 5 mi above New Braunfels	103.9		81.6			

Date 1928	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Comfort to	New Braunfels, Tex. - Continued						
Jan. 19	Elm Creek	At mouth near New Braunfels	104.3			0		
19	Guadalupe River	1 mi above Comal River - Gaging station	108.7		77.7			

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Guadalupe River February 18-22, 1929

Reach: From Comfort to New Braunfels, Tex.

During the investigation the river was at a constant stage and discharge measurements represent the natural conditions.

Date 1929	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Feb. 18	Guadalupe River	2 mi above Comfort - gaging station	0		41.1			
18	Cypress Creek	¼ mi above mouth at Comfort	3.0			0.2		
18	Holliday Creek	600 ft above mouth near Comfort	4.8			0		
18	Guadalupe River	At Railroad bridge below Comfort	6.4		42.5			
18	Guadalupe River	At Highway crossing at Waring	12.2		36.4			
19	Joshua Creek	2 mi above mouth near Waring	16.0			.7		
19	Sister Creek	½ mi above mouth near Sisterdale	19.7			.2		
19	Guadalupe River	Just below Sister Creek near Sisterdale	19.7		45.2			
19	Wasp Creek	At mouth 6 mi below Sisterdale	29.5			0		
19	Guadalupe River	Just above Sabino Creek at Ammans crossing	31.2		40.7			
19	Sabino Creek	At mouth 8 mi NE of Boerne	31.2			.3		
19	Guadalupe River	At crossing 4 mi above Oberley crossing	34.2		38.2			
19	Guadalupe River	At Schillers crossing 4 mi N of Bergheim	45.6		43.0			
20	Curry Creek	½ mi above mouth	55.8			1.0		
20	Guadalupe River	At Specks crossing 2.5 mi SW of Spring Branch	57.5		47.7			
20	Spring Branch	1½ mi above mouth near Spring Branch	59.0			.9		
20	Guadalupe River	Near Spring Branch - Gaging station	61.7		47.4			
21	Guadalupe River	In Demijohn Bend E of Spring Branch	73.3		34.3			
21	Big Springs	At Cranes Mill	78.5			2.9		
21	Guadalupe River	Below Big Spring at Cranes Mill	78.5		39.2			
21	Guadalupe River	5 mi NW of Sattlers Store	86.2		48.8			
22	Guadalupe River	2 mi NE of Sattlers Store	94.0		48.2			
22	Jacobs Creek	At mouth 2 mi below Sattlers	95.9			.1		
22	Guadalupe River	4 mi below Sattlers	97.4		53.1			

Date 1929	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Comfort to	New Braunfels, Tex. - Continued						
Feb. 22	Isaacs Creek	At mouth 5½ mi above New Braunfels	103.5			0		
22	Godes Canal	At Highway bridge ½ mi above Elm Creek	103.9				9.3	Gates closed prior to measurement
22	Guadalupe River	Just below Godes Canal	104.1		53.0			Includes flow of Canal
22	Elm Creek	At mouth	104.3			0		
22	Guadalupe River	Above Comal River - Gaging station	108.7		49.0			Average discharge for day

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Guadalupe River January to May 1955

Reach: From county road crossing above U. S. Highway 281 near Spring Branch to New Braunfels, Tex.

Conclusions and Summary: A casual study of the discharge tables might lead to the belief that substantial amounts of water are lost in the reach of the Guadalupe River under study. Also, an algebraic summation of the actual gains and losses, as indicated by discharge measurements of the river and measurements of inflow from springs, would show a considerable loss. However, as explained later, the actual losses to the ground-water reservoir are small. Ben M. Petitt, Jr., and W. O. George, geologists of the Ground Water Branch of the U. S. Geological Survey, in their report on San Antonio area have this to say:

"The Guadalupe River, in contrast to most of the other streams crossing the Balcones fault zone, apparently does not lose significant quantities of water to the Edwards limestone . . . Investigations to determine seepage losses have failed to disclose losses greater than those that might be expected from evapotranspiration. However, there are minor losses and gains in various reaches of the river . . .

. . . Between Spring Branch and New Braunfels . . . stream losses and gains are insignificant."

These losses and gains are evident in the variation in discharge shown in the tables. The largest loss and gain occurred between sites 6 and 13 in the vicinity of Demijohn Bend. This bend is located at the end of a high ridge of rock that holds the river to a northeasterly course for several miles before it turns sharply in a southerly direction to meander down the opposite side of the rocky ridge. The river distance from the site of measurement 6 to Wolle Springs is 15 miles, and the drop in elevation is about 85 feet. This gives an average fall of about 6 feet to the mile. The airline distance is 3.5 miles, which gives an average fall of 24 feet to the mile. It is reasonable to assume that, with such a steep slope, water would find its way through this short stretch of cavernous limestone rock. The Wolle Springs have a history of flowing muddy or murky water prior to an upriver rise. This condition was observed by Pat H. Holland of the U. S. Geological Survey and R. L. Lowry, consulting engineer, on May 10-11, 1955. Cranes Mill Spring is also reported to flow muddy or murky water prior to upriver rise or during periods of heavy local or upriver rain.

The average temperature of the river water from measurement sites 6 to 11 was about 50°, while the average temperature of Wolle Springs was 56°. The temperature of river water responds readily to changes in air temperature, and water flowing underground will eventually assume the temperature of the surrounding formation. The springs measured in this study increase in temperature in a downstream order: Wolle Springs, 56°, Cranes Mill Spring, 65°, and Sorrel Creek Spring, 70.5°. This indicates that Wolle Springs are near the source of water supply and that Sorrel Creek Spring is the farthest away. Comal Springs, located at New Braunfels about 28 miles downstream from Sorrel Creek, have a mean temperature of about 74°.

The chemical analyses of 39 samples taken in January 1955, 32 from the river and 7 from springs, indicate that all the water was very similar in chemical content. (See table of chemical analyses.)

Table of chemical analyses gives in downstream order the analyses of samples collected in the Guadalupe River low-flow investigation during the period Jan. 24-31, 1955. Water from Spring Branch Creek was somewhat higher in bicarbonate and distinctly lower in chloride than the run of the river water. Water from the Sorrel Creek Spring was higher in hardness and bicarbonate and lower in chloride than the river water. Water from the various Wolle Springs and Cranes Mill Springs was very similar to the river water. The analyses suggest that gains in streamflow in some stretches of the Guadalupe River probably represent recoveries of water lost in other reaches upstream and not new water from distant sources.

The series of low-flow measurements started on Jan. 17, 1955, on the Guadalupe River was interrupted by rain and a subsequent increase in flow.

During the period January 24-31, discharge measurements were made at 32 locations in the 57 mile reach from a point 2-1/2 miles upstream from Spring Branch Creek to the gaging station at New Braunfels. All tributary flow of consequence was measured, including springs when measurable. Water samples were collected and water temperatures determined at all measuring sites and at all springs, whether measured or not. Physiography of river channel was obtained at all measuring sites and springs.

After a study was made of the January 24-31 series of measurements, thirteen points for re-measurement were selected. From February 28 to March 2 these thirteen re-measurements were made. Water temperatures were determined at each point but no water samples were collected.

Additional series of eight selected measurements were made on March 14-15, 29-30, April 12-13, 26-27, and May 10-11. Rainfall early in May caused small rises on the river and prevented further low-flow studies during that month.

Site No.	Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
						Main Stream	Tributary	Diversion	
	JAN.	From county road crossing above U. S. Highway 281		near	Spring	Branch	to New	Braunfels, Tex.	
1	17	Guadalupe River	At county road crossing above U. S. Highway 281	0	54°	36.4			Small gravel streambed.
2	17	Guadalupe River	500 ft above Spring Branch Creek	2.4	54°	34.1			Large gravel streambed.
2-A	17	Spring Branch Creek	At mouth	2.5	52°		1.0		Estimate. Rock and clay streambed
3	17	Guadalupe River	About 1 mi above U. S. Highway 281	3.3	57°	34.5			Small gravel streambed.
4	17	Guadalupe River	About 1 mi below U. S. Highway 281	4.7	55°	29.8			Small gravel streambed.
5	17	Guadalupe River	At gaging station near Spring Branch	5.7		32			From rating curve.
9	17	Guadalupe River	At Wunderlich ranch	15.1		0			Local information.
		The investigation was interrupted by rain.							
	Jan.								
1	24	Guadalupe River	At county road crossing above U. S. Highway 281	0	46°	51.5			Streambed of small gravel.
2	24	Guadalupe River	500 ft above Spring Branch Creek	2.4	48°	49.0			Streambed of large gravel.
2-A	24	Spring Branch Creek	At mouth	2.5	52°		1.0		Estimate. Rock and clay streambed
3	24	Guadalupe River	About 1 mi above U. S. Highway 281	3.3	49°	46.1			Streambed of small gravel.
4	24	Guadalupe River	About 1 mi below U. S. Highway 281	4.7	48°	44.5			Streambed of small gravel.
5	24	Guadalupe River	At gaging station near Spring Branch	5.7		49			From rating curve.
6	24	Guadalupe River	1.5 mi below gaging station	7.0	50°	44.3			Streambed of boulders and gravel.
7	25	Guadalupe River	At Smithson Valley county road	10.0	46°	28.0			Streambed of medium gravel.
8	25	Guadalupe River	2.5 mi below county road	12.5	54°	22.0			Streambed of small gravel.
9	25	Guadalupe River	At Wunderlich ranch	15.1	49°	13.2			Streambed of small gravel.
10	25	Guadalupe River	100 ft below Rebecca Creek	16.4	49°	11.4			Streambed of small gravel.
11	26	Guadalupe River	At lower end of Demijohn Bend	18.0	48°	9.2			Streambed of small gravel.
12	26	Guadalupe River	At Ben Wolle's upper pasture	20.5	50°	11.1			Streambed of medium gravel.
12-A	26	Wolle Spring 1	At Ben Wolle's upper pasture	21.0	56°		2.0		Estimate.
12-B	26	Wolle Spring 2	At Ben Wolle's upper pasture	21.2	55°		3.0		Estimate.
12-C	26	Wolle Spring 3	At Ben Wolle's lower pasture	22.0	56°		6.9		Between outlet and river.
12-D	26	Wolle Spring 4-5	At Ben Wolle's lower pasture	22.0	57°		10.0		Estimate.
13	26	Guadalupe River	At lower end of Wolle ranch	22.3	54°	27.1			Streambed of medium gravel.

Site No.	Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
						Main Stream	Tributary	Diversion	
	Jan.								
14	27	Guadalupe River	800 ft above Cranes Mill Spring	24.5	53°	24.9			Boulders and gravel.
14-A	27	Cranes Mill Spring	--	24.6	65°		8.1		Difference of measurements 14 and 15.
15	27	Guadalupe River	400 ft below Cranes Mill Spring	24.7	53°	33.0			Streambed of smooth rock.
16	27	Guadalupe River	2.5 mi below Cranes Mill Spring	27.2	57°	31.9			Streambed of rough rock.
17	27	Guadalupe River	1.5 mi above Tom Creek	29.0	55°	35.8			Gravel over rock.
17-A	27	Sorrel Creek Spring	--	29.4	70.5°		-		Not measurable.
18	27	Guadalupe River	200 ft above Tom Creek	30.4	55°	39.1			Streambed of smooth rock.
19	28	Guadalupe River	2 mi below Tom Creek	32.3	50°	41.9			Streambed of rough rock.
20	28	Guadalupe River	2.5 mi below Tom Creek	32.9	54°	37.8			Streambed of smooth rock.
21	28	Guadalupe River	Krause ranch - 2 mi above Canyon dam site	34.3	56°	41.8			Streambed of smooth rock.
22	28	Guadalupe River	3/4 mi below Canyon dam site	37.3	55°	40.8			Streambed of smooth rock.
23	29	Guadalupe River	1.5 mi below Canyon dam site	38.1	50°	37.9			Gravel over rock.
24	29	Guadalupe River	500 ft above Sattler Creek	39.9	53°	40.8			Rock streambed.
25	29	Guadalupe River	1 mi above 1st crossing below Sattler	41.7	51°	38.1			Rock streambed.
26	29	Guadalupe River	2 mi below Sattler	42.8	54°	35.4			Streambed of rough rock.
27	29	Guadalupe River	About 3 mi below Sattler	43.7	53°	43.0			Measurement poor - gravel.
28	30	Guadalupe River	About 7 mi above Hueco Springs	45.5	50°	41.6			Streambed of smooth rock.
29	30	Guadalupe River	About 4.5 mi above Hueco Springs	48.0	50°	40.7			Streambed of small gravel.
30	30	Guadalupe River	About 1.0 mi above Hueco Springs	51.5	50°	35.7			Gravel and rock.
30-A	30	Hueco Springs	--	52.6	-		0		
31	30	Guadalupe River	3/4 mi below Hueco Springs	53.3	52°	39.4			Fairly uniform rock streambed.
32	31	Guadalupe River	3/4 mi above Gruene	55.1	53°	35.9			Uniform rock streambed.
33	31	Guadalupe River	3/4 mi above gaging station at New Braunfels	57.0	55°	38.8			Streambed of gravel.
	Feb.								
1	28	Guadalupe River	At county road above U. S. Highway 281	0	60°	33.1			Streambed of small gravel.
5	28	Guadalupe River	At gaging station near Spring Branch	5.7	63°	31.5			Streambed of uniform rock.
11	28	Guadalupe River	At lower end of Demijohn Bend	18.0	64°	6.96			Streambed of small gravel.
14	28	Guadalupe River	800 ft above Cranes Mill Spring	24.5	65°	22.2			Boulders and gravel.
14-A	28	Cranes Mill Spring	--	24.6			5.3		Difference of meas. 14 and 15.
15	28	Guadalupe River	400 ft below Cranes Mill Spring	24.7	66°	27.5			Streambed of smooth rock.

Site No.	Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
						Main Stream	Tributary	Diversion	
	Mar.								
17	1	Guadalupe River	1.5 mi above Tom Creek	29.0	66°	30.4			Gravel over rock.
19	1	Guadalupe River	2.0 mi below Tom Creek	32.3	68°	38.2			Streambed of rough rock.
22	1	Guadalupe River	3/4 mi below Canyon dam site	37.3	68°	36.0			Streambed of smooth rock.
26	1	Guadalupe River	2 mi below Sattler	42.8	71°	37.0			Streambed of rough rock.
27	1	Guadalupe River	About 3 mi below Sattler	43.7	69°	35.2			On gravel - measurement poor.
29	1	Guadalupe River	About 4.5 mi above Hueco Springs	48.0	69°	39.3			Streambed of small gravel.
30	1	Guadalupe River	About 1.0 mi above Hueco Springs	51.5	72°	38.5			Gravel and rock.
30-A	1	Hueco Springs	--	52.6			0		
33	2	Guadalupe River	3/4 mi above gaging station at New Braunfels	57.0	67°	37.4			Streambed of gravel.
	Mar.								
1	14	Guadalupe River	At county road above U. S. Highway 281	0	69°	28.4			Small gravel.
5	14	Guadalupe River	At gaging station near Spring Branch	5.7	70°	25.7			Uniform rock.
11	14	Guadalupe River	At lower end of Demijohn Bend	18.0	72°	3.54			Small gravel.
15	14	Guadalupe River	400 ft below Cranes Mill Spring	24.7	71°	27.2			Smooth rock. Spring flowing.
19	14	Guadalupe River	2 mi below Tom Creek	32.3	74°	35.7			Rough rock.
29	14	Guadalupe River	About 4.5 mi above Hueco Springs	48.0	74°	38.7			Small gravel.
30	15	Guadalupe River	About 1.0 mi above Hueco Springs	51.5	71°	35.5			Gravel and rock.
30-A	15	Hueco Springs	--	52.6			0		
33	15	Guadalupe River	3/4 mi above gaging station at New Braunfels	57.0	71°	39.4			Gravel.
	Mar.								
0	29	Guadalupe River	300 ft below Bergheim-Kendalia road	-10.3	55°	28.4			Gravel.
1	29	Guadalupe River	At county road above U. S. Highway 281	0	55°	31.0			Small gravel.
5	29	Guadalupe River	At gaging station near Spring Branch	5.7	60°	27.6			Gravel over rock.
11	29	Guadalupe River	At lower end of Demijohn Bend	18.0	60°	1.0			Estimate. 300 ft upstream all flow is below gravel. 300-500 ft downstream springs trickle from bluff on right.
15	29	Guadalupe River	400 ft below Cranes Mill Spring	24.7	60°	19.6			Smooth rock. Spring flowing.
19	30	Guadalupe River	2 mi below Tom Creek	32.3	57°	27.0			Rock and gravel.
29	30	Guadalupe River	About 4.5 mi above Hueco Springs	48.0	56°	26.9			Small gravel.

Site No.	Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
						Main Stream	Tributary	Diversion	
	Mar.								
30	30	Guadalupe River	About 1.0 mi above Hueco Springs	51.5	62°	24.8			Gravel and rock.
30-A	30	Hueco Springs	--	52.6			0		
33	30	Guadalupe River	3/4 mi above gaging station at New Braunfels	57.0	59°	27.0			Gravel.
	Apr.								
1	12	Guadalupe River	At county road above U. S. Highway 281	0	71°	23.4			Gravel.
5	12	Guadalupe River	At gaging station near Spring Branch	5.7	74°	19.9			Gravel over rock.
11	12	Guadalupe River	At lower end of Demijohn Bend	18.0	76°	0.2			Estimate. Gravel.
15	12	Guadalupe River	400 ft below Cranes Mill Spring	24.7	75°	15.5			Smooth rock. Spring flowing.
19	12	Guadalupe River	2 mi below Tom Creek	32.3	80°	22.3			Rock and gravel.
29	12	Guadalupe River	About 4.5 mi above Hueco Springs	48.0	74°	22.6			Gravel.
30	13	Guadalupe River	About 1.0 mi above Hueco Springs	51.5	68°	22.2			Gravel and rock.
30-A	13	Hueco Springs	--	52.6			0		
33	13	Guadalupe River	3/4 mi above gaging station at New Braunfels	57.0	70°	23.1			Gravel.
	Apr.								
1	26	Guadalupe River	At county road above U. S. Highway 281	0	75°	10.1			Gravel.
5	26	Guadalupe River	At gaging station near Spring Branch	5.7	81°	8.20			Gravel over rock.
11	26	Guadalupe River	At lower end of Demijohn Bend	18.0		0.0			
15	26	Guadalupe River	400 ft below Cranes Mill Spring	24.7	78°	6.29			Smooth rock. Spring flowing.
19	26	Guadalupe River	2 mi below Tom Creek	32.3	78°	12.2			Rock and gravel.
29	26	Guadalupe River	About 4.5 mi above Hueco Springs	48.0	78°	12.8			Gravel.
30	27	Guadalupe River	About 1.0 mi above Hueco Springs	51.5	73°	12.0			Gravel and rock.
30-A	27	Hueco Springs	--	52.6			0		
33	27	Guadalupe River	3/4 mi above gaging station at New Braunfels	57.0	75°	10.9			Gravel.
	May								
5	9	Guadalupe River	At gaging station near Spring Branch	5.7		500			A peak of about 500 cfs.occurred at 1:00 a.m.
5	10	Guadalupe River	At gaging station near Spring Branch	5.7	75°	119			Rock streambed. Water mmddy.
7	10	Guadalupe River	At Smithson Valley county road	10.0		75			Estimate. Water murky.
11	10	Guadalupe River	At lower end of Demijohn Bend	18.0		35-50			Estimate. Water clear.
12-C	10	Wolle Spring 3	Ben Wolle's lower pasture	22.0			Trickle		Water muddy. River clear.
12-D	10	Wolle Spring 4-5	Ben Wolle's lower pasture	22.0			6		Estimate. Water muddy. River clear.

Site No.	Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
						Main Stream	Tributary	Diversion	
30-A	May 10	Hueco Springs	--	52.6			0		
33	10	Guadalupe River	3/4 mi above gaging station at New Braunfels	57.0	79°	6.96			Gravel. Water clear. Rise has not reached this point.
6-A	May 11	Guadalupe River	At cave about 2-1/2 mi below gaging station	8.2		-			Cave opening above water. Could not estimate flow. Water very muddy.
7	11	Guadalupe River	At Smithson Valley county road	10.0		60			Estimate. Water murky.
12-A	11	Wolle Spring 1	Ben Wolle's upper pasture	21.0			0.5		Estimate. Water clear from spring and in river.
12-D	11	Wolle Spring 5	Ben Wolle's lower pasture	22.0			4		Estimate. Water muddy. River clear. Springs 3 and 4 dry.
14-A	11	Cranes Mill Spring		24.6			6-8		
15	11	Guadalupe River	400 ft below Cranes Mill Spring	24.7		75			Estimate. Water clear.

Chemical Analyses, Guadalupe River, January 24-31, 1955

Site No.	Date 1955 Jan.	Stream	Location	Disch. (cfs)	Bicarbonate (ppm)	Chloride (ppm)	Hardness as $CaCO_3$ (ppm)	Specific conductance (micromhos at 25° C)	pH
1	24	Guadalupe River	At county road crossing above U. S. Highway 281	51.5	268	24	240	516	8.2
2	24	Guadalupe River	500 ft above Spring Branch Creek	49.0	271	24	246	516	8.0
2-A	24	Spring Branch Creek	At mouth	1.0	285	15	244	489	8.1
3	24	Guadalupe River	About 1 mi above U. S. Highway 281	46.1	272	25	247	516	8.1
4	24	Guadalupe River	About 1 mi below U. S. Highway 281	44.5	276	25	251	526	8.1
5	24	Guadalupe River	At gaging station near Spring Branch	-	278	26	252	527	8.2
6	24	Guadalupe River	1.5 mi below gaging station	44.3	278	26	252	532	8.2
7	25	Guadalupe River	At Smithson Valley county road	28.0	279	26	251	528	8.2
8	25	Guadalupe River	2.5 mi below county road	22.0	274	26	245	517	8.1
9	25	Guadalupe River	At Wunderlich ranch	13.2	275	26	248	525	8.0
10	25	Guadalupe River	100 ft below Rebecca Creek	11.4	274	26	248	517	8.2
11	26	Guadalupe River	At lower end of Demijohn Bend	9.2	274	26	256	525	8.1
12	26	Guadalupe River	At Ben Wolle's upper pasture	11.1	274	26	252	528	8.0
12-A	26	Wolle Spring 1	At Ben Wolle's upper pasture	2.0	272	26	244	511	8.1
12-B	26	Wolle Spring 2	At Ben Wolle's upper pasture	3.0	271	26	246	526	7.9
12-C	26	Wolle Spring 3	At Ben Wolle's lower pasture	6.9	278	26	252	535	7.8
12-D	26	Wolle Spring 4-5	At Ben Wolle's lower pasture	-	277	26	252	535	7.8
13	26	Guadalupe River	At lower end of Wolle ranch	27.1	275	26	254	532	8.0
14	27	Guadalupe River	800 ft above Cranes Mill Spring	24.9	274	26	250	528	8.1

Chemical Analyses, Guadalupe River, January 24-31, 1955

Site No.	Date 1955 Jan.	Stream	Location	Disch. (cfs)	Bicarbonate (ppm)	Chloride (ppm)	Hardness as $CaCO_3$ (ppm)	Specific conductance (micromhos at 25° C)	pH
14-A	27	Cranes Mill Spring	-	8.1	292	23	268	559	7.6
16	27	Guadalupe River	2.5 mi below Cranes Mill Spring	31.9	277	24	254	531	7.9
17	27	Guadalupe River	1.5 mi above Tom Creek	35.8	280	24	258	529	8.1
17-A	27	Sorrel Creek Spring	-	-	333	14	290	673	7.5
18	27	Guadalupe River	200 ft above Tom Creek	39.1	279	24	254	526	8.0
19	28	Guadalupe River	2 mi below Tom Creek	41.9	282	24	260	527	8.0
20	28	Guadalupe River	2.5 mi below Tom Creek	37.8	280	24	254	525	8.0
21	28	Guadalupe River	Krause ranch - 2 mi above Canyon dam site	41.8	276	24	248	520	8.0
22	28	Guadalupe River	3/4 mi below Canyon dam site	40.8	267	24	240	513	8.0
23	29	Guadalupe River	1.5 mi below Canyon dam site	37.9	267	24	240	513	8.1
24	29	Guadalupe River	500 ft above Sattler Creek	40.8	269	24	246	513	8.1
25	29	Guadalupe River	1 mi above 1st crossing below Sattler	38.1	265	25	242	510	8.1
26	29	Guadalupe River	2 mi below Sattler	35.4	265	25	240	512	8.1
27	29	Guadalupe River	About 3 mi below Sattler	43.0	262	24	236	507	8.1
28	30	Guadalupe River	About 7 mi above Hueco Springs	41.6	262	24	238	498	8.1
29	30	Guadalupe River	About 4.5 mi above Hueco Springs	40.7	260	24	238	501	8.1
30	30	Guadalupe River	About 1.0 mi above Hueco Springs	35.7	253	24	230	492	8.1
31	30	Guadalupe River	3/4 mi below Hueco Springs	39.4	253	24	230	491	8.1
32	31	Guadalupe River	3/4 mi above Gruene	35.9	252	23	230	494	8.1
33	31	Guadalupe River	3/4 mi above gaging station at New Braunfels	38.8	259	23	232	495	8.1

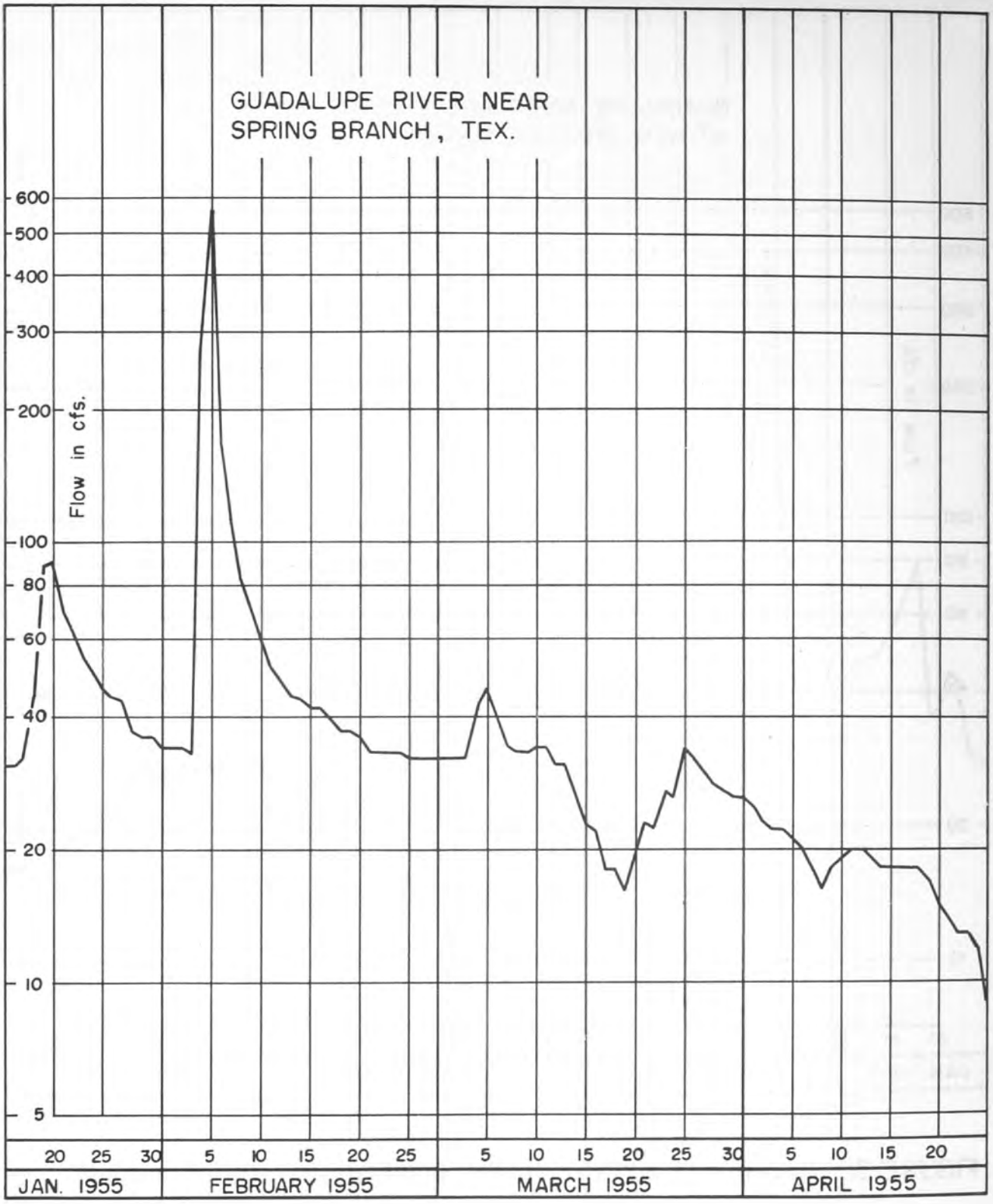

FIGURE 2.- DISCHARGE HYDROGRAPH, GUADALUPE RIVER NEAR SPRING BRANCH, TEX.

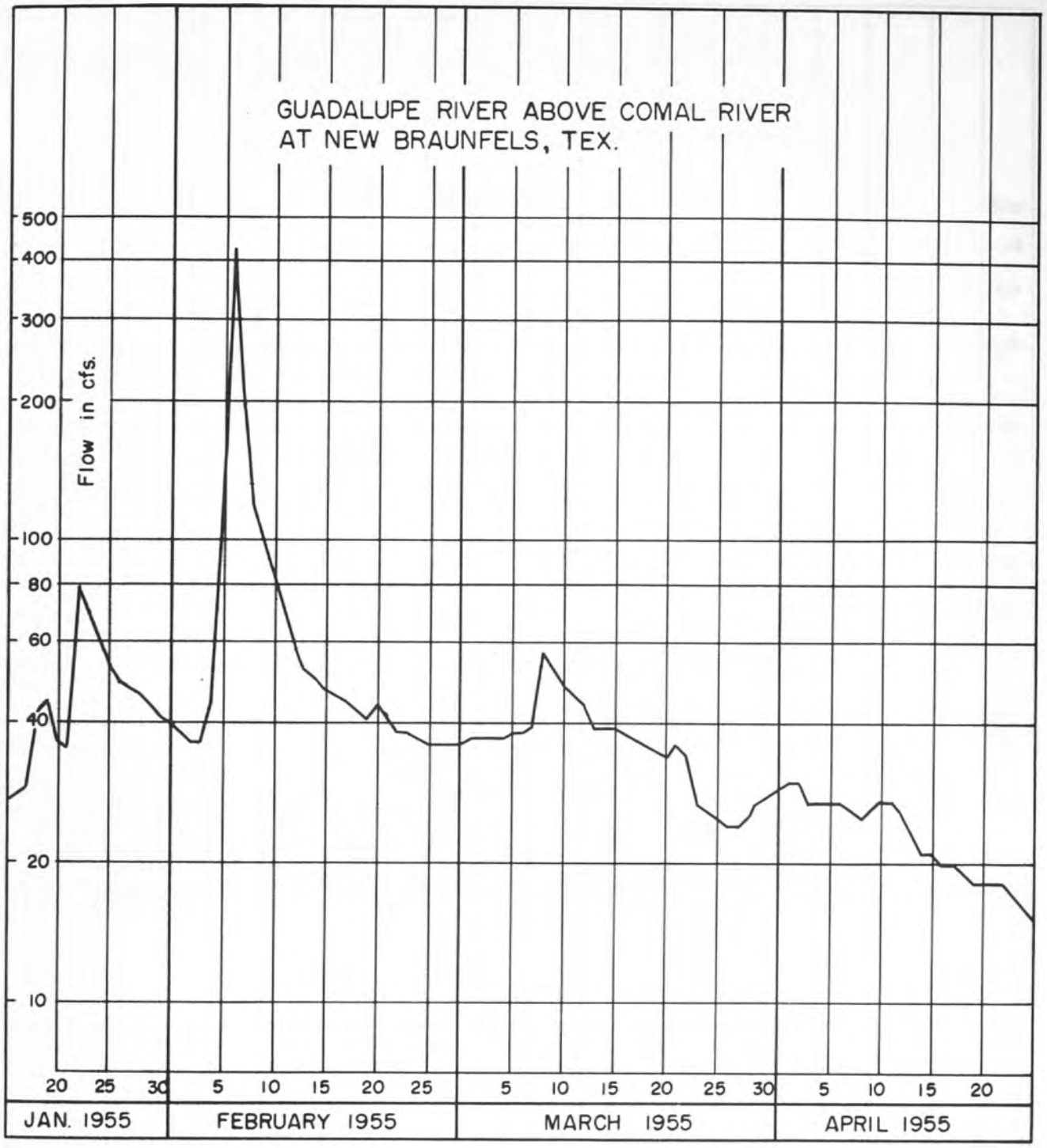

FIGURE 3.- DISCHARGE HYDROGRAPH, GUADALUPE RIVER ABOVE COMAL RIVER AT NEW BRAUNFELS, TEX.

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

San Marcos Springs March 2 to June 1, 1955

Location: San Marcos Springs are located at San Marcos, Hays County, Tex.

Conclusions and Summary: Discharge measurements and daily discharge record of San Marcos Springs show that the springs respond readily to rainfall and decrease in flow more slowly than other large springs in this region. Several showers fell in the vicinity of San Marcos from May 16 to 19 which caused small rises on the San Marcos River. The spring discharge increased from 78 to 106 cfs during this period and decreased only 12 cfs by July 21. During this same time, Comal Springs increased from 80 to 110 cfs and decreased to 68 cfs by June 30. (See hydrograph of daily discharges.)

Available quality-of-water data indicate that the immediate sources of water for Comal and San Marcos Springs are different. The analyses suggest that the Blanco River might be a source of part or all of the flow of San Marcos Springs. It does not appear from that data that the flow of Comal Springs is derived from the usual flow of the Guadalupe River.

During the period March 2 to June 1, 1955, weekly discharge measurements were made of the flow of San Marcos Springs at San Marcos, Tex. On April 6 a temporary recording gage was installed on the San Marcos River about 1-1/2 miles downstream from the springs. This gage was operated until June 1 and daily discharges were computed for the period. Weekly water samples were obtained from the springs during the investigation period.

A discharge hydrograph for the period of daily record was prepared and extended to fill out the period of investigation on basis of weekly discharge measurements; and as a basis for comparison a discharge hydrograph for Comal River at New Braunfels was plotted.

The fluctuations of flow of the San Marcos Springs is partially due to the operation of the dam at the springs area. The springs flow from the base of a rock cliff into a small lake that covers several acres. The lake contains a rank growth of water plants which are cut from time to time with a power mower. These cuttings float to the dam and lodge on the spillway and gate openings. The operator allows this debris to collect until the rise in lake level becomes objectionable at which time the debris is cleared away. As soon as it is removed the excess storage starts draining and results in a small rise on the river below the dam. This is the cause of the small sharp peaks.

Concurrently with the low-flow investigations in the Guadalupe and Blanco Rivers, a series of water samples were collected from the San Marcos Springs in Hays County, and the Comal Springs in Comal County. Results of the analyses are given in the tables.

The determination of nitrate was added to the tests run on the spring samples because nitrate concentrations have been observed to vary considerably in various springs along the Balcones fault zone and because sudden changes in nitrate might indicate inflow of local surface runoff.

Analyses of the weekly samples collected from San Marcos Springs between March 9 and June 1, 1955, showed that the chemical composition of the spring water changed very little during the period of sampling. The spring water had the same chloride concentration as the Blanco River at mile 38.6 of the Jan. 24-28, 1955 low-flow investigation; just above the reach where the Blanco River flow disappeared underground. The San Marcos Springs water was harder and higher in

bicarbonate and conductivity and lower in pH than the Blanco River water. If, after disappearing underground, the water of the Blanco River were to become charged with carbon dioxide, it would attack the limestone through which it flowed and its bicarbonate, hardness, and conductivity would increase. The analyses suggest that the Blanco River could be a source of part or all of the San Marcos Springs water.

Analyses of five samples collected from the Comal Springs from March 23 to May 10, 1955, showed that the chemical composition of the Comal Springs water was nearly constant and the water was consistently less concentrated than the San Marcos Springs water. The Comal Springs water had about the same bicarbonate content and hardness and about half the chloride concentration that was found in the Guadalupe River water. Hence, it did not appear that water flowing from Comal Springs came from the usual flow of the Guadalupe River.

Analyses of water samples collected from Comal Springs over a period of many years are given in table of chemical analyses. Examination of the table shows considerable variation in the concentration of some constituents. Apparent changes from time to time in the hardness and concentrations of calcium and bicarbonate may be as much due to differences in length of time between collection and analysis as to changes in the quality of the spring water. The rather large fluctuations in the amount of sodium reported may not represent real changes in quality of water. Sodium was computed generally by difference and not determined; hence, the sodium variation may be due in part to the difference in cation-anion balance. The nearly constant chloride and sulfate concentrations suggest that the quality of water in the Springs changed little from year to year.

Three complete analyses of samples collected from San Marcos Springs between 1937 and 1955 are given in table of chemical analyses. They suggest that the water of San Marcos Springs is much more variable in chemical content than water from Comal Springs. Unfortunately, not enough samples of water from San Marcos Springs have been analyzed in the past to make certain that this is the case.

Chemical Analyses, San Marcos Springs

Date of Collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Specific conductance (micromhos at 25°)	pH
	in parts per million														
Oct. 4, 1937			90	15	17		268	22	51			335	284		
May 16, 1947	11	0.05	90	20	7.1	5.4	334	19	22	0.8	3.0	349	306	602	7.2
Mar. 9, 1955							331		15		5.2		284	559	7.3
Mar. 16, 1955							312		16		5.5		284	556	7.3
Mar. 23, 1955	13		82	21	5.2	0.5	309	17	16	1.0	4.6	334	291	556	7.4
Mar. 30, 1955							311		16		4.5		280	562	7.4
Apr. 6, 1955							310		16		6.6		280	556	7.4
Apr. 13, 1955							311		16		6.0		282	571	7.4
Apr. 20, 1955							314		16		5.4		278	556	7.5
Apr. 27, 1955							314		16		5.1		284	562	7.5
May 4, 1955							313		16		5.8		284	561	7.3
May 11, 1955							307		16		5.8		280	563	7.2
May 18, 1955							310		16		5.9		278	559	7.2
May 25, 1955							308		16		5.8		278	562	7.2
June 1, 1955							308		16		5.9		280	560	7.1

Chemical Analyses, Comal Springs

Date of Collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Specific conductance (micromhos at 25°)	pH
	in parts per million														
May 25, 1934							268	30	12				264		
Oct. 27, 1936			56	19	15		244	26	17			253	219		
Apr. 10, 1938			75	17	3.3		266	23	13	0.0	5.0	267	257		
June 24, 1941			63	17	18		272	23	12		3.7	271	227		
Aug. 13, 1941							272	23	11						
Sept. 16, 1941	12	0.01	73	17	4.8		264	24	12	0.1	4.4	280	252		
Apr. 2, 1942	11	0.01	70	17	11		274	22	12	0.1	4.0	288	244		
Jan. 10, 1944			78	17	5.5		280	23	13		5.5	280	264		
Jan. 22, 1944	11	0.02	74	16	6.2	3.0	270	23	12	0.4	5.5	287	250		7.6
Mar. 23, 1944							270	24	12						
Oct. 9, 1945			76	18	2.8		274	20	14		5.6	292	264		
Feb. 1, 1947			80	20	2.1		286	28	14		4.0	289	282	506	7.4
Aug. 7, 1951	13	0.21	74	17	7.2	0.4	274	22	12	0.0	4.5	292	254	507	7.5
Mar. 23, 1955							275		14				258	501	7.4
Mar. 30, 1955							277		12		4.7		258	496	7.5
Apr. 13, 1955							278		14		4.5		256	507	7.5
Apr. 27, 1955							277		13		4.8		252	504	7.3
May 10, 1955							270		13		4.5		248	506	7.3

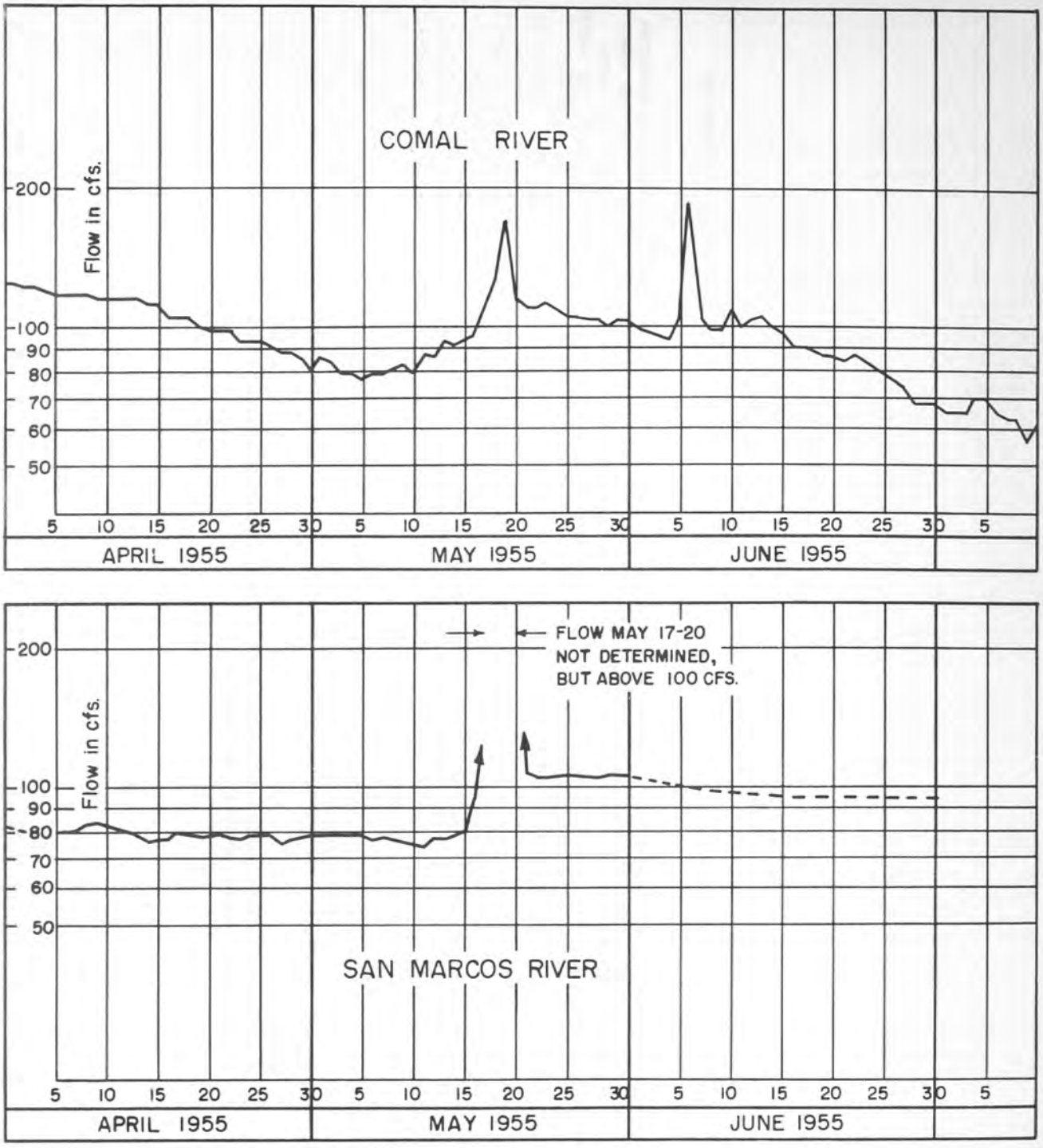

FIGURE 4.-DISCHARGE HYDROGRAPHS, COMAL RIVER AT NEW BRAUNFELS, TEX., AND SAN MARCOS RIVER AT SAN MARCOS, TEX.

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Blanco River — January 24-28, 1955; March 15-16, 1955

Reach: From a point 9.6 miles upstream from Little Blanco River to U. S. Highway 81 about 3 miles northeast of San Marcos, Tex.

Conclusions and Summary: A study of the two series of measurements on the Blanco River (table of discharge measurements) shows that the two principal sources of ground water that make up the base flow of the river are the springs about 11 miles above Wimberley, and spring-fed Cypress Creek. The base flow of Cypress Creek comes from Jacobs Well, a large spring a few miles above Wimberley. There was little or no loss of water from the Blanco River until it reached the mouth of Halifax Creek, where it disappeared completely in the outcrop of the Edwards limestone. Measurements indicate that flow was practically constant during the investigation.

The table of chemical analyses gives in downstream order the analyses of samples collected in the Blanco River low-flow investigation during the period Jan. 24-28, 1955. Results of these analyses, when considered by groups, clearly show changes due to aeration and loss of carbon dioxide. Thus the analyses of samples collected from mile 4.7-14.3, 16.3-25.3, and 27.6-38.6 showed decreases in bicarbonate, hardness, and specific conductance from point to point downstream, although the chloride concentrations increased slightly. Precipitation of calcium carbonate apparently occurred slowly downstream and no admixture of new water was indicated.

During the period Jan. 24-28, 1955, discharge measurements were made at 30 locations in a 49.6 mile reach of the Blanco River, from a point 9.6 miles upstream from Little Blanco River to U. S. Highway 81 about 3 miles northeast of San Marcos, Tex. All tributary flow was measured and water samples and water temperatures obtained at each measuring section.

On March 15-16 further discharge measurements were made at the critical points in the reach. Water temperatures were obtained but no additional water samples were taken.

Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From a point 9.6 miles upstream from Little Blanco River to U. S. Highway 81 about 3 miles northeast of San Marcos, Tex.							
Jan. 24	Blanco River	At east crossing of Chimney Valley road	0		0			
24	Blanco River	--	4.8		0			
24	Blanco River	--	8.1		0			
24	Blanco River	--	9.0		0			
24	Blanco River	--	9.5		0			
24	Little Blanco River	At mouth	9.6			0.1		
24	Blanco River	700 ft below Little Blanco	9.7		0			
25	Blanco River	3 mi below Little Blanco	12.5		0			
25	Blanco River	1,000 ft above crossing on Burnet ranch	13.6		0			
25	Blanco River	30 ft above crossing on Burnet ranch	13.7	67°	2.68			Gravel.
25	Blanco River	1,000 ft below crossing on Burnet ranch	13.9		.36			
25	Blanco River	2,000 ft below crossing on Burnet ranch	14.1		.02			
25	Blanco River	300 ft below 2-story rock house	14.3		.11			
25	Blanco River	1/2 mi below rock house	14.9		0			
25	Blanco River	At concrete crossing on Fishers store road	16.3	58°	7.50			Gravel.
26	Blanco River	On G. W. Haschke ranch	18.2	50°	7.25			Gravel.
26	Blanco River	0.7 mi above hunting lodge at pool	20.4	51°	7.30			Gravel.
26	Blanco River	400 ft below gravel road crossing	23.2	52°	7.13			Gravel.
26	Blanco River	On J. S. Leach ranch opposite Samson house	25.3	53°	7.84			Gravel.
26	Cypress Creek	3/4 mi above mouth at State Highway 12	26.9	54°		2.55		Gravel.
27	Blanco River	At gaging station at Wimberley	27.6	49°	10.5			Gravel.
27	Blanco River	700 ft above concrete bridge crossing	30.1	55°	11.0			Rock channel.
27	Blanco River	20 ft above concrete bridge crossing	32.7	55°	11.1			Gravel channel.
27	Blanco River	1/2 mi below creek on left bank	34.9	60°	10.6			Rock channel.
28	Blanco River	1.0 mi above Halifax Creek	38.6	47°	10.6			Gravel channel.

Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Jan. 28	Halifax Creek	At mouth	39.5			0		
28	Blanco River	400 ft below draw on left bank	39.9	55°	1.36			Rock channel.
28	Blanco River	1/2 mi below previous measurement	40.4	48°	0.14			Rock channel.
28	Blanco River	1/2 mi below previous measurement	40.9		0			Rock channel.
28	Blanco River	--	41.9		0			
28	Blanco River	--	45.9		0			
28	Blanco River	--	47.6		0			
28	Blanco River	At U. S. Highway 81 crossing	49.6		0			
Mar. 15	Blanco River	At Fishers store road crossing	16.3	70°	7.70			Gravel on rock.
15	Cypress Creek	3/4 mi above mouth at State Highway 12	26.9	69°		2.60		Gravel.
15	Blanco River	At gaging station at Wimberley	27.6	73°	10.1			Gravel.
16	Blanco River	1.0 mi above Halifax Creek	38.6	68°	10.4			Rock.
16	Blanco River	About 1 mi below Halifax Creek	40.4		.3			Rock.
16	Blanco River	100 ft below previous measurement	40.4		0			Rock. End of flow.
16	Blanco River	At U. S. Highway 81	49.6		0			

Chemical Analyses, Blanco River, January 24-28, 1955

Date 1955 Jan.	Stream	Location	Disch. (cfs)	Bicarbonate (ppm)	Chloride (ppm)	Hardness as $CaCO_3$ (ppm)	Specific conductance (micromhos at 25° C)	pH
24	Little Blanco River	About 3 miles above mouth	0.2	344	13	296	549	8.0
24	Little Blanco River	At mouth	.1	291	13	262	523	7.8
25	Blanco River	30 ft above crossing on Burnet ranch	2.68	314	14	310	615	7.7
25	Blanco River	1,000 ft below crossing on Burnet ranch	.36	298	15	302	584	8.0
25	Blanco River	300 ft below 2-story rock house	.11	244	15	253	499	8.1
25	Blanco River	At concrete crossing on Fishers store road	7.50	302	14	296	572	8.0
26	Blanco River	On G. W. Haschke ranch	7.25	283	15	280	545	8.1
26	Blanco River	0.7 mi above hunting lodge at pool	7.30	260	15	274	509	8.1
26	Blanco River	400 ft below gravel road crossing	7.13	238	15	250	479	8.1
26	Blanco River	On J. S. Leach ranch opposite Samson house	7.84	236	15	245	479	8.2
26	Cypress Creek	3/4 mi above mouth at State Highway 12	2.55	282	14	247	488	8.1
26	Cypress Creek	At bridge below Jacob's Well	2.39	326	14	294	563	8.0
27	Blanco River	At gaging station at Wimberley	10.5	241	14	247	476	8.2
27	Blanco River	700 ft above concrete bridge crossing	11.0	225	16	231	450	8.2
27	Blanco River	20 ft above concrete bridge crossing	11.1	222	14	222	445	8.2
27	Blanco River	1/2 mi below creek on left bank	10.6	216	16	216	436	8.2
28	Blanco River	1.0 mi above Halifax Creek	10.6	217	16	219	440	8.2
28	Blanco River	400 ft below draw on left bank	1.36	205	16	212	420	8.2
28	Blanco River	1/2 mi below previous measurement	0.14	203	14	204	420	8.2

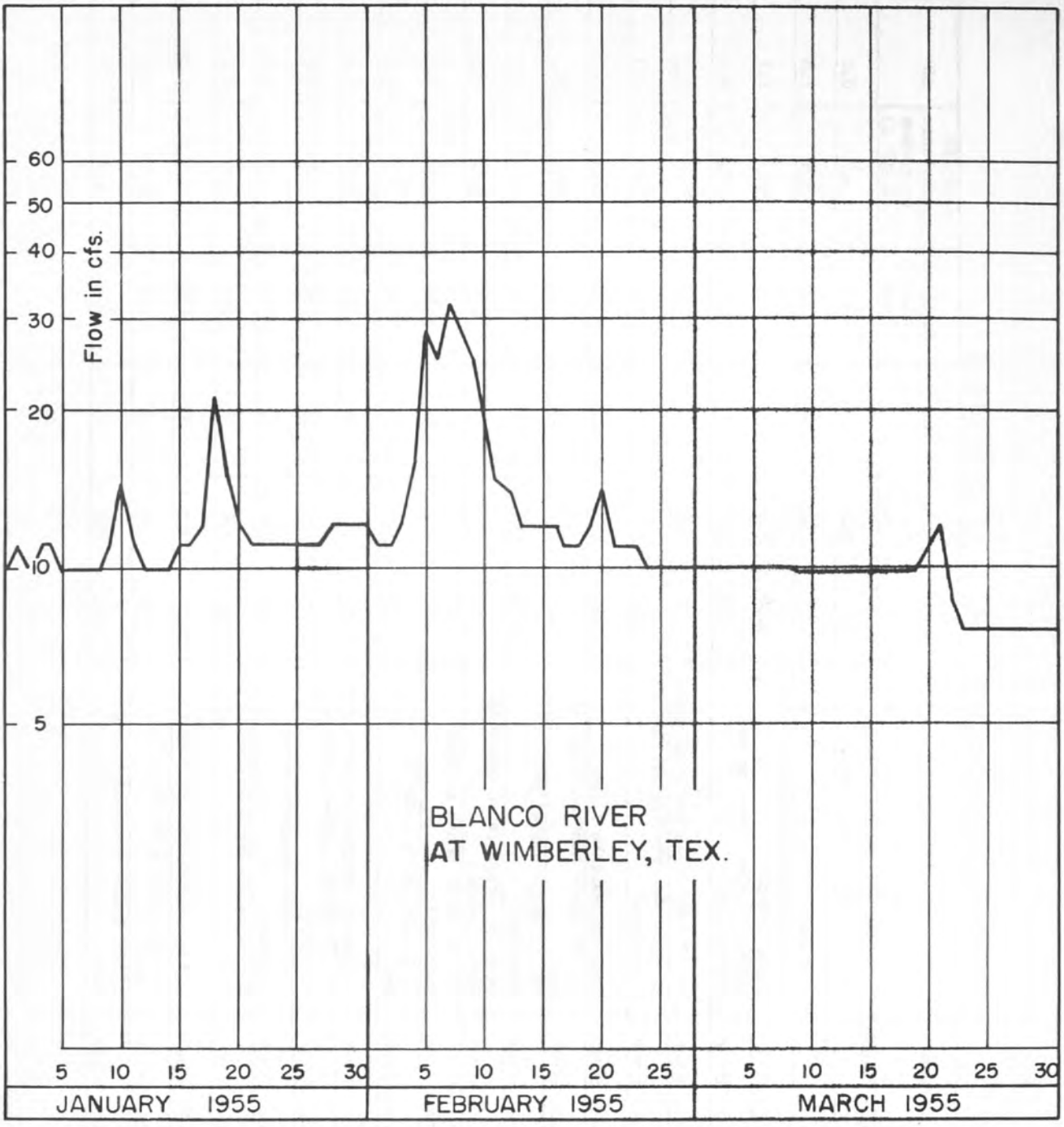

FIGURE 5.- DISCHARGE HYDROGRAPH, BLANCO RIVER AT WIMBERLEY, TEX.

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Blanco River June-July 1924

Reach: From a point at San Marcos-Wimberly crossing to International-Great Northern Railroad bridge near Kyle, Tex.

During these investigations the river was at a constant stage, and the measurements represent the natural conditions. There was no surface inflow or diversion.

Date 1924	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
June 12	Blanco River	At road crossing at Wimberly	0		202			Rock channel
12	Blanco River	At Falls about 1 mi above Halifax Creek	11.4		231			
12	Blanco River	At I.& G.N. Railroad bridge SW of Kyle	19.4		216			
July 16	Blanco River	At road crossing at Wimberly	0		64.7			
16	Blanco River	At Nance Ranch below Wimberly	3.7		63.2			
15	Blanco River	At Falls about 1 mi above Halifax Creek	11.4		67.7			
15	Blanco River	At I.& G.N. Railroad bridge SW of Kyle	19.4		51.9			
July 22	Blanco River	At Falls about 1 mi above Halifax Creek	11.4		58.4			
22	Blanco River	3/4 mi below Halifax Creek	13.4		53.8			
22	Blanco River	3/4 mi below Old Mill near Kyle	15.6		45.3			

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Blanco River July 10-11, 1957

Reach: From Cypress Creek at Wimberley to gaging station near Kyle, Tex.

Problem: To determine gains and losses in streamflow in the reach of Blanco River from the gaging station at Wimberley to the gaging station near Kyle, Hays County, Tex.

Results: The streamflow increased from 62.4 cfs at gaging station at Wimberley to 69.0 cfs at a point 5.2 miles downstream. Of the 62.4 cfs discharge at Wimberley gaging station, 12.1 cfs came from Cypress Creek which enters the Blanco River about one-fourth mile above the gaging station. At a point 11.1 miles downstream from the Wimberley station and 1 mile upstream from Halifax Creek, the Blanco River streamflow had dropped to 64.1 cfs; Halifax Creek was not flowing. From this measuring section one mile upstream from Halifax Creek to the gaging station near Kyle, a distance of 5.1 miles, the discharge dropped to 48.5 cfs.

Discussion: Current-meter measurements were started at Cypress Creek at 10:30 a.m. July 10 and completed at the Kyle gaging station at 4:30 p.m. July 11. Each measurement was made at a good section, either on rock or rock covered by gravel. No attempt was made to pace the measurements with the rate of change in streamflow and no time interval corrections were made. The rate of change in discharge was determined at each gaging station and was found to be fairly uniform throughout the reach. At the Wimberley station the discharge dropped 10.4 cfs in 4 days (4.2% per day) and at the Kyle station 7.5 cfs in 4 days (3.9% per day).

In the reach investigated, the Blanco River streambed is principally rock with small falls, steep rock riffles and some gravel deposits on the rock. There are many large pools, with shallow flows between: the resulting water surface exposure is large in proportion to the amount of streamflow involved, and evaporation and transpiration losses are high during the summer months when water temperatures range from 90° to 100° Fahrenheit. The gain and loss above Halifax Creek can be considered normal for the season. The loss below a point one mile above Halifax Creek, 15.6 cfs in 5 miles, is excessive for normal evaporation and transpiration losses; this water apparently is lost in a series of large pools where it seeps into the cracks and crevices in the porous streambed.

Date 1957	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	From Cypress Creek at Wimberley to gaging station near Kyle, Tex.							
July 10	Cypress Creek	At FM 12 crossing	0	79°		12.1		Rock.
10	Blanco River	At gaging station at Wimberley	0.5	89°	62.4			Rock and gravel.
14	Blanco River	At gaging station at Wimberley	0.5	-	52.0			Not measured. Determined from recorder record.
10	Blanco River	Above concrete bridge	3.1	95°	67.4			Rock.
10	Blanco River	Just above concrete crossing	5.7	93°	69.0			Gravel.
11	Blanco River	Morton ranch	7.9	97°	68.9			Rock and gravel.
11	Blanco River	1.0 mi above Halifax Creek	11.6	89°	64.1			Rock.
11	Halifax Creek	At mouth	12.5			0		Rock.
11	Blanco River	0.5 mi below Halifax Creek	12.9	87°	57.4			Rock and gravel.
11	Blanco River	At gaging station near Kyle	16.7	90°	48.5			Rock and gravel.
15	Blanco River	At gaging station near Kyle	16.7	-	41.0			Not measured. Determined from recorder record.

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

San Antonio River — July 17, 1957

Reach: From Hildebrand Ave. to mouth of San Pedro Creek in San Antonio, Tex.

Problem: To determine gains and losses in streamflow in the section of San Antonio River within the city of San Antonio from Hildebrand Ave. just above the spring area in Brackenridge Park to the mouth of San Pedro Creek. (See accompanying sketch.)

Results: The flow increased from zero just above the spring area in Brackenridge Park to about 9 cfs at the stream-gaging station at South Alamo Street. Data are insufficient to determine gains or losses from South Alamo Street to the mouth of San Pedro Creek. San Pedro Creek was contributing 3.53 cfs at a point about 1,200 ft above its mouth. No point of diversion or loss was located.

Discussion: Current-meter measurements were made at points of critical interest or wherever significant amount of flow was found. Ponded conditions caused by small dams prevented current-meter measurements of the flow between 7th Street and South Alamo Street. Flow conditions were probably stable or near stable above the Pioneer Flour Mill.

The unregulated instantaneous flow at South Alamo Street is difficult to determine when Pioneer Flour Mill is in operation. This mill is located about 1,000 feet upstream from the South Alamo Street stream-gaging station and regulates the flow by operation of gates on a small channel reservoir. As a result, the measured discharge (12 cfs) does not represent the natural condition. Flow of about 9 cfs was estimated at this point on basis of mean discharge for the month (9.7 cfs) as determined at the gaging station. The effect of regulation extends downstream, and current-meter measurements below South Alamo Street likewise do not represent the natural condition.

The flow measured in the 8 mile reach above South Alamo Street comes partly from wells in Brackenridge Park and partly from water emptied into the river from industrial wells; it is impossible to recognize or identify the many small contributions that come into the river in this highly developed reach.

Date 1957	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
July 17	San Antonio R	200 ft above Hildebrand Ave.	0		0			
17	Pump	In channel under Hildebrand Ave.	0			0.8		Estimate.
17	Zoo well	Combined flow from canal	.8			1.5		Estimate.
17	San Antonio R	In Brackenridge Park 125 ft below dam	.9	82°	3.81			Gravel channel.
17	San Antonio R	In Brackenridge Park 300 ft above mill race	2.0	84°	4.27			40 ft above foot bridge.
17	Mill race	In Brackenridge Park 100 ft above mouth	2.1			.02		No flow at upper end.

Date 1957	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
July 17	San Antonio R	At Josephine St.	2.3	84°	5.73			Claybed.
17	Storm sewers	25 ft below Josephine St.	2.3			.05		From left bank - estimate.
17	San Antonio R	150 ft below Jones St.	3.0	84°	6.09			Gravel channel.
17	San Antonio R	At 7th St.	3.7	85°	6.62			
Ponded conditions prevented measuring discharge between 7th St. and S. Alamo St. Part of increased flow at S. Alamo St. is released water from Pioneer Flour Mill reservoir.								
17	San Antonio R	At gaging station at S. Alamo St.	5.8	86°	12.0			Gravel channel.
17	San Antonio R	75 ft above Simpson St.	6.7	87°	12.0			Flow regulated by flour mill.
17	San Antonio R	500 ft below service company plant	7.2	89°	14.2			Flow regulated by flour mill.
17	San Antonio R	200 ft above San Pedro Creek	8.0	90°	14.5			Flow regulated by flour mill.
17	San Pedro Creek	1/4 mi above mouth	8.1	93°		3.53		600 ft below Mitchell St.

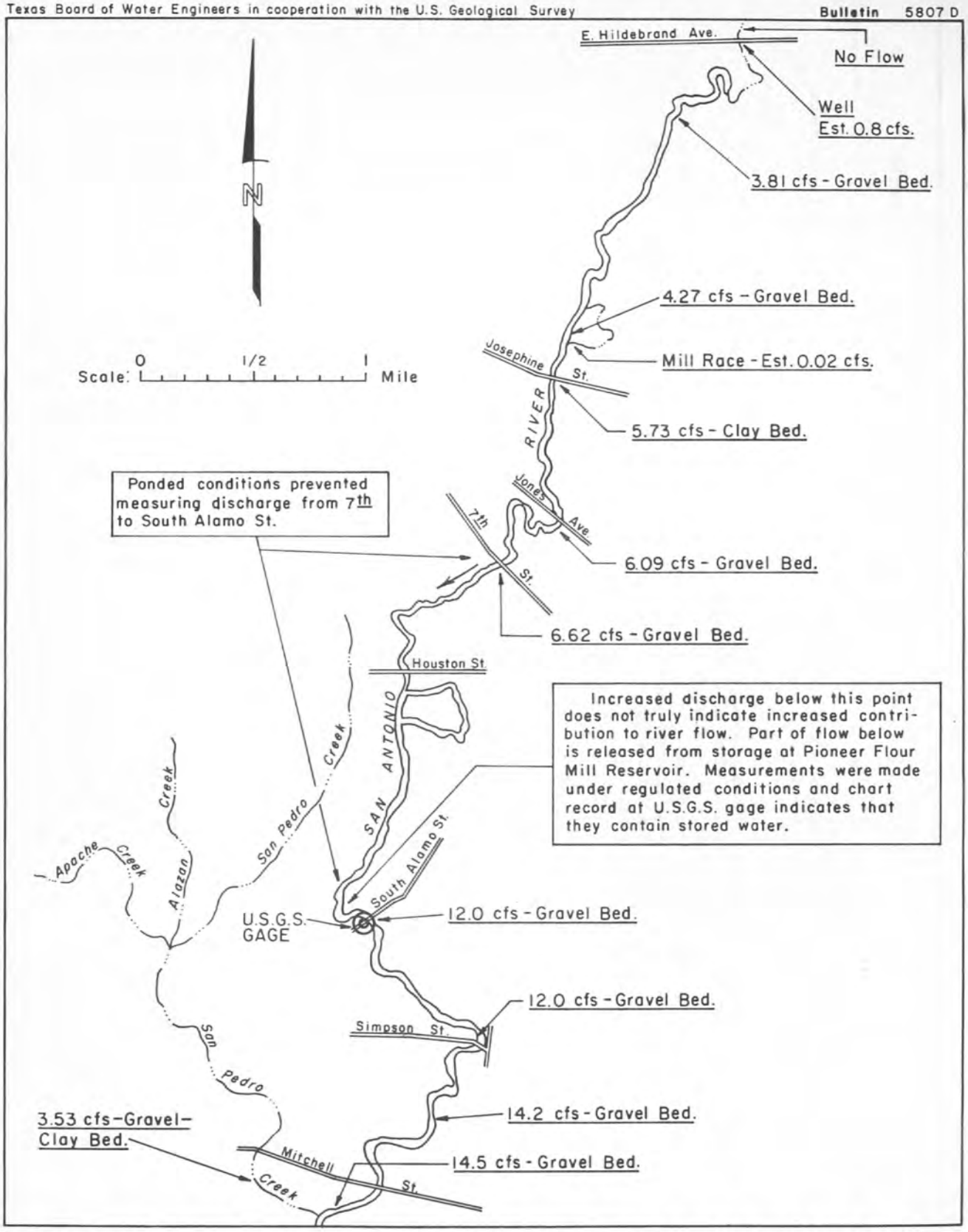

FIGURE 6 - LOW FLOW IN INVESTIGATION OF THE SAN ANTONIO RIVER AT SAN ANTONIO, TEXAS

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Medina River — June 3-5, 1925

Reach: From a point 5 miles above Lima to 4 miles below Pipe Creek, Tex.

During these measurements the river was at a constant stage.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
June 3	Medina River	5.3 mi NW of Lima	0		1.0			
3	Medina River	3.5 mi NW of Lima	2.0		3.4			
3	Onion Creek	3.5 mi NW of Lima	2.1			1.0		
3	Medina River	1.4 mi NW of Lima	4.5		6.4			
3	Brewington Creek	.8 mi NW of Lima	6.3			.2		
3	Medina River	3.4 mi SE of Lima	11.1		4.6			
3	Chalk Creek	4.9 mi SE of Lima	12.8			.2		
3	Medina River	5.0 mi SE of Lima	12.9		3.6			
3	Medina River	1.0 mi NW of Medina	16.1		8.4			
3	S Prong Medina	At Medina	17.7			1.5		
3	Medina River	3.3 mi SE of Medina	22.8		10.5			
4	Medina River	3.3 mi SE of Medina	22.8		10.1			
4	Weinans Creek	3.5 mi NW of Bandera	25.6			.2		
4	Medina River	4.7 mi NW of Bandera	25.9		12.0			
4	Medina River	At Bandera	34.2		10.9			
4	Myrtle Creek	1.4 mi NE of Bandera	36.2			.1		
4	Medina River	4.1 mi SE of Bandera	38.6		10.5			
5	Cold Springs	3.0 mi SW of Pipe Creek	41.7			5.0		
5	Medina River	3.0 mi SW of Pipe Creek - gaging station	41.7		13.4			
5	Medina River	4.2 mi SW of Pipe Creek	43.8		11.4			

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Medina River — January 3-7, February 17-18, September 6-7, 1955

Reaches: From a point 8.3 miles above Medina to a point 1.5 miles below Bandera - Medina county line, Tex.
From Bandera to Turks Head Mountain in Medina Lake, Tex.
From Wallace Creek, 5.8 miles above Medina to Turks Head Mountain in Medina Lake, Tex.

Problem: To determine gains and losses in streamflow in the section of Medina River from Bandera to Medina Lake, Tex.

Results: Data obtained in the three sets of measurement indicate that two sections of the channel lose small amounts of base flow. The upper losing section is about 8 miles long and extends from Bandera to the spring area 1.6 miles above the stream-gaging station near Pipe Creek; in February 1955 this reach absorbed about 9 cfs of flow. The second losing reach, extent not known, is located in the vicinity of the fault that crosses the river 4.5 miles below the gaging station near Pipe Creek; in February and in September 1955, this reach absorbed about 3.5 cfs of flow. The only source of inflow of consequence is Cold Spring, which enters the river about 1.6 miles upstream from the stream-gaging station near Pipe Creek, at the site of a former stream-gaging station (1923-34). Although the scope of these investigations did not include any portion of the stream above Bandera, a few estimates were made in the 28 mile reach above that point. The estimates indicate that probably most of the base flow developed by this stream comes from the watershed above Bandera; and that some water may be absorbed in the channel between Medina and Bandera.

Discussion: Current-meter measurements were made at all points where there were appreciable amounts of flow; many small flows were estimated. The channel was investigated throughout the reach and the discharge measurements were made as rapidly and as thoroughly as possible. No attempt was made to pace the measurements with the rate of change in flow as the investigation progressed downstream. The rate of change in flow was determined at the Pipe Creek stream-gaging station. Flow was practically constant during the January and February periods; and was decreasing during the September investigation, recorder record showing a decrease in flow from 5.01 to 3.80 cfs between September 7 and 11. No lakes with channel dams were found and no irrigation equipment was seen; however, it is likely that a considerable quantity of water is used to irrigate small acreages in the river valley above Bandera.

Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From a point 8.3 miles above Medina to a point 1.5 miles below Bandera - Medina county line							
Jan. 3	Medina River	0.5 mi below Rocky Creek	0		0			Gravel channel.
3	Medina River	Just below Wallace Creek	2.5		0			Gravel channel.
3	Medina River	At Medina	8.3		1.5			Estimate. Gravel channel.
3	Medina River	State Highway 16, above Indian Cr	22.5		.15			Estimate. Gravel channel.
3	Medina River	FM 689, at Bandera	27.8		.01			Estimate. Gravel channel.
3	Bandera Creek	At mouth	29.5			0		Rock streambed.
3	Medina River	Just below Bandera Creek	29.5		0			Rock streambed.
4	Medina River	3 mi below Bandera Creek	32.4		0			Rock streambed.
4	Medina River	Just above Privilege Creek	33.9		0			Gravel channel.
4	Privilege Creek	At mouth	33.9			0		Gravel channel.
4	Artesian well	Left bank, just below creek	33.9			.01		Estimate.
4	Medina River	--	35.7		0			Channel of gravel and boulders.
4	Medina River	--	36.6		0			Channel of gravel and boulders.
4	Big Spring	1,500 ft above Cold Spring	36.9			.2		Estimate. On left bank in edge of river.
4	Seep Spring	1,000 ft above Cold Spring	37.0			.1		Estimate. Beginning of rock streambed. Flow at top of rock on right bank.
4	Artesian well	Right bank	37.1			.01		Estimate. 50 ft from river.
4	Cold Spring	At site of discontinued gaging station on Medina River	37.2			.35		Estimate. On right bank.
4	Medina River	Just below discontinued gaging station	37.3	68°	.9			Gravel over rock.
4	Medina River	At gaging station near Pipe Cr	39.0	61°	1.0			Rock streambed.
6	Medina River	At gaging station near Pipe Cr	39.0		.9			Not measured. From continuous recorder record.
5	Red Bluff Cr	At mouth	39.8			0		Rock.
5	Medina River	Just below Red Bluff Creek	39.8		1.0			Estimate. Rock streambed.
6	Medina River	0.5 mi above tributary from left	43.0		.7			Estimate. Gravel channel.
6	Tributary	From left	43.5			0		Estimate. Gravel channel.
6	Medina River	100 ft below tributary	43.5		0			Flow disappears in bar of large loose gravel.
6	Medina River	--	44.1		0			Rock streambed.
7	Medina River	--	44.8		0			Gravel channel.
7	Medina River	0.5 mi below Bandera-Medina county line	46.1		0			Gravel channel.
7	Medina River	--	47.1		0			Road crossing on natural rock streambed.

Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Bandera to Turks Head Mountain in Medina Lake							
Feb. 17	Medina River	FM 689, at Bandera	27.8	62°	10.4			Gravel over rock channel.
17	Privilege Cr	At mouth	33.9			0		Gravel channel.
17	Medina River	500 ft below Privilege Creek	34.0	65°	4.06			Gravel over rock channel.
18	Medina River	Above springs	36.6		1.0			Estimate. Channel of gravel and boulders.
18	Big Spring	1,500 ft above Cold Spring	36.9			.2		Estimate. On left bank in edge of river.
18	Seep Spring	1,000 ft above Cold Spring	37.0			.1		Estimate. Beginning of rock streambed. Flow at top of rock on right bank.
18	Artesian well	Right bank	37.1			0.05		Estimate. 50 ft from river.
18	Cold Spring	At site of discontinued gaging station on Medina River	37.2			9.0		Estimate. On right bank.
18	Medina River	At gaging station near Pipe Creek	39.0	63°	10.1			Rock streambed.
23	Medina River	At gaging station near Pipe Creek	39.0		10			Not measured. From continuous recorder record.
18	Medina River	0.5 mi below Bandera-Medina county line	46.1	65°	6.52			Gravel channel.
18	Cypress Creek	At mouth, from right bank	48.2			0		Gravel channel.
18	Medina River	At Turks Head Mountain	48.2		6.13			Gravel channel.
	From Wallace Creek, 5.8 miles above Medina to Turks Head Mountain in Medina Lake							
Sept. 6	Wallace Creek	At mouth	2.5			0		Gravel channel.
6	Medina River	Just below Wallace Creek	2.5		.3			Estimate. Gravel channel.
6	Medina River	At Medina	8.3		5.0			Estimate. Gravel channel.
6	Medina River	State Highway 16, above Indian Creek	22.5		3.0			Estimate. Gravel channel.
6	Medina River	FM 689, at Bandera	27.8	78°	2.80			Gravel over rock channel.
6	Medina River	100 ft above Bandera Creek	29.4	80°	2.56			Gravel.
6	Bandera Creek	At mouth	29.5			0		Rock channel.
6	Medina River	--	31.1		1.0			Broken rock channel.
6	Medina River	--	31.2		.4			Broken rock and gravel channel.
6	Medina River	3 mi below Bandera Creek	32.4		.1			Estimate. Rock streambed.
7	Medina River	Just above Privilege Creek	33.9		0			Gravel channel.
7	Privilege Creek	At mouth	33.9			0		Gravel channel.
7	Artesian well	Left bank, just below creek	33.9			.01		Estimate.
7	Medina River	--	35.7		0			Streambed of gravel and boulders.

Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
From Wallace Creek, 5.8 miles above Medina to Turks Head Mountain in Medina Lake, continued								
Sept. 7	Artesian well	--	35.7			.01		Estimate. In overflow channel.
7	Medina River	--	36.6		0			Streambed of gravel and boulders.
7	Big Spring	1,500 ft above Cold Spring	36.9			.1		Estimate. On left bank in edge of river.
7	Seep Spring	1,000 ft above Cold Spring	37.0			.02		Estimate. Beginning of rock streambed. Flow at top of rock on right bank.
7	Artesian well	Right bank	37.1			.02		Estimate. 50 ft from river.
7	Cold Spring	At site of discontinued gaging station on Medina River	37.2	72°		5.0		Estimate. On right bank.
7	Medina River	200 ft below discontinued gaging station	37.3	74°	5.60			Rock and gravel streambed.
7	Medina River	At gaging station near Pipe Creek	39.0	75°	5.01			Rock streambed.
11	Medina River	At gaging station near Pipe Creek	39.0		3.8			Not measured. From continuous recorder record.
7	Red Bluff Creek	At mouth	39.8			.2		Estimate. Rock streambed.
7	Medina River	0.5 mi above tributary from left	43.0	79°	3.63			Gravel channel.
7	Medina River	0.5 mi below Bandera-Medina county line	46.1	77°	1.44			Gravel channel.
7	Cypress Creek	At mouth, from right bank	48.2			0		Gravel channel.
7	Medina River	At Turks Head Mountain	48.2	78°	.82			Gravel channel.

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Medina River — December 9, 1924

Reach: From Main Dam to Riomedina Crossing near Riomedina, Tex.

During these measurements the river was at a constant stage.

Date 1924	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Dec. 9	Medina River	At road crossing ½ mi below Dam	0		20.6			
9	Medina River	Just below Diversion Dam	3.3		22.1			No flow in Medina Canal
9	Medina River	At Haby's crossing	4.1		24.4			
9	Medina River	At Yellow Bank School	8.1		25.9			
9	Medina River	At Riomedina crossing	10.9		27.2			

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Medina River — July 1929 to December 1930

Reach: From Medina Dam to Losoya, Tex.

Staff gages, each having a range of about 3 feet, were installed at the stations listed below. From 11 to 15 discharge measurements were made at each station. On several occasions the stage rose above the gages; at those times and at times of apparent local run-off from rains daily discharge was not determined. Records good for stations near Cassin and below Von Ormy; fair for other stations.

Near Mico, Tex.--On left bank 600 feet above Stegall Bridge, 2,000 feet below Medina Dam, and 1 mile southwest of Mico post office, Medina County. Gates in dam closed Oct. 6-20, 23-30, Nov. 1-4, 8-20, 25-30, Dec. 1, 2, 7-14, 22-31. One discharge measurement made Mar. 20, 1931, while gates were closed, used as basis for estimating discharge for these periods. Period of record, Jan. 1 to Dec. 31, 1930.

Near Riomedina, Tex.--On right bank 2,000 feet below diversion dam and 6 miles west of north of Riomedina, Medina County. Period of record, Nov. 11, 1929, to Dec. 31, 1930.

Above Castroville, Tex.--Since Oct. 1, 1929, on right bank just above Draugel's road crossing and 2 miles north of Castroville, Medina County. Prior to Oct. 1, 1929, on right bank about half a mile below dam at Castroville and below return water of power plant. Period of record, July 9, 1929, to Sept. 30, 1930.

Below Von Ormy, Tex.--On left bank 50 feet below San Antonio-Somerset highway bridge and 2½ miles below International-Great Northern Railroad bridge at Von Ormy, Bexar County. Period of record, July 9, 1929, to Dec. 31, 1930.

Near Cassin, Tex.--On right bank about 500 feet northwest of J. N. Arnold's house and 1¼ miles above San Antonio, Uvalde & Gulf Railway bridge at Cassin, Bexar County. Period of record, July 10, 1929, to Dec. 31, 1930.

At Losoya, Tex.--On right bank just below bridge over Medina River on old San Antonio-Corpus Christi road, one-fourth mile from Losoya, Bexar County, and 3½ miles below Mitchell Lake. Period of record, Oct. 1, 1929, to Dec. 31, 1930.

Daily discharge records for the above temporary gaging stations are published in Water Supply Paper 703, pages 89-93.

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Medina River — May 26-28, 1925

Reach: From Medina Valley Irrigation Company diversion dam to Losoya, Tex., near mouth.

During these measurements the river was at a constant stage. The diversion dam is 63.8 miles below initial measurement of low-flow investigation above the dam made June 3-5, 1925.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
May 26	Medina River	Just below diversion dam	0		15.5			
26	Medina River	At Haby's Crossing	.8		19.6			
26	Medina River	At Yellow Bank School Crossing	4.8		22.0			
26	Medina River	At Riomedina Crossing	7.6		24.8			
26	Windmills	From 3 to 5 mi SW of Riomedina	10.2 12.1				0.5	
26	Medina River	Just below dam at Castroville	17.2		17.2			
27	Medina River	Just below dam at Castroville	17.2		18.0			
27	Medina River	3 mi below Castroville	19.5		20.7			
27	H.J.Rice Irrigation Canal	Near LaCoste	23.3				.8	
27	John Biebert Canal	Near Idylwild School	26.2				1.2	
27	Medina River	½ mi N of Idylwild School	26.3		14.6			
27	Medina River	At Canyon Road 5¼ mi NW of Von Ormy	31.8		9.2			
28	Medina River	At Canyon Road 5¼ mi NW of Von Ormy	31.8		8.8			
28	Medina River	At Highway No. 2 about 1½ mi NW of Von Ormy	37.1		10.2			
28	Medina River	1-3/4 mi SE of Von Ormy	41.8		11.7			
28	Medina River	4 mi SE of Von Ormy	45.2		9.2			
28	Medina River	3½ mi SW of Earle	47.3		11.0			
28	Leon Creek	At mouth near Earle	51.1			1.4		
28	Medina River	At Highway No. 9 near Earle	51.3		10.0			
28	Seepage from Mitchell Lake		53.4			3.5		
28	Medina River	At Losoya near mouth	55.1		14.7			

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Cibolo Creek — January 17-19, 28-30, 1958

Reach: From a point 7.5 miles above Boerne, Kendall County, to stream-gaging station at Selma, Bexar County.

Problem: To determine gains and losses in streamflow in Cibolo Creek above the stream-gaging station near Selma, Bexar County.

Results: During this investigation Cibolo Creek developed a maximum base flow of 129 cfs, most of which originates in Kendall County. All of this flow is lost into holes and fissures in that section of channel from a point 2 miles below Boerne to a point above Selma, a distance of about 42 miles.

Related geology: References to geology in this report are based on findings of W. O. George in WSP 1138 "Geology and Ground Water Resources of Comal County, Texas". For convenience of reference, George (1952, p. 17) arbitrarily divided the Glen Rose limestone into two parts which were referred to as upper and lower members of the Glen Rose limestone. The formation in Kendall and Comal counties ranges from 650 to 1,200 feet thick and the division between upper and lower members is made at the top of a well-known fossiliferous zone called the "Salenia texana" zone which occurs somewhat below the middle of the formation. The contact of the upper and lower members of the Glen Rose limestone is shown on a map by George (1952, plate 2). The results of discharge measurements made in this investigation have been referenced to the map by George (1952, plate 2); references indicate that the heavy losing sections in lower Kendall County and upper Comal County are on the lower member of the Glen Rose limestone. This bears out the following statements made by George (1952, p. 58, 59): "Between the mouth of Balcones Creek and the Bulverde gaging station the bed of the creek is in the lower member of the Glen Rose limestone and the losses in this part of the stream appear to be large. Between the Bulverde station and the Bracken station, the bed of Cibolo Creek is in the upper member of the Glen Rose limestone and the losses in this area are relatively small. Between the Bracken gaging station and the bridge at Bracken the bed of the creek is in the Edwards limestone which is honeycombed and broken by many small faults. Here the losses are believed to be large in proportion to the amount of water that reaches this stretch of the stream. Most of the rainfall in the upper reaches of the Cibolo, however, is intercepted by infiltration into the Glen Rose limestone before it reaches the Edwards limestone at Bracken gaging station. It is believed that most of the water entering caverns in the lower member of the Glen Rose limestone in this area passes laterally through underground channels into the Edwards limestone."

Discussion: Current-meter measurements were made at points of critical interest; field estimates were made where flows were small or unimportant. No attempt was made to pace the measurements with the rate of change in flow as the investigation progressed downstream. The channel was investigated throughout the reach and the measurements were made as rapidly and as thoroughly as possible. Measurements from mile 27 to Selma gaging station, mile 56, were made during the period Jan. 17-19. The information obtained introduced questions which could be answered only by investigation of the upstream portion of the reach. This further investigation was made during the period Jan. 28-30 and check measurements at mile 28.7 and 35 were obtained in order to relate change in flow conditions during the intervening period. The rate of change in flow in the upper part of the reach is indicated by two measurements at mile 5.4. The discharge at this point dropped 2.7 cfs (7%) in 2 days. At the Bulverde gaging station the flow dropped 12 cfs (39%) from Jan. 30 to Feb. 1 and flow had ceased on Feb. 9.

The crevice at the mouth of Balcones Creek described by George (1952, p. 56) was observed and was found to be taking considerable water. It is near the head of backwater from a small channel dam and at present has a three-foot concrete wall around it. The water was flowing over the top of the wall and gave the appearance of a "Glory Hole" type spillway. The amount of water entering this crevice was estimated as between 2 and 4 cfs. Another hole in the rock was found in the center of the channel about 100 feet above the gage near Selma. There was no flow at this point during this investigation but the hole, which is large enough to admit a small man, leads to a sizable cavern a few feet below the surface. During times of flow a pool is formed at this point and a vortex appears over the hole. George (1952, p. 58) makes the following statement about this section of channel: "Between the bridge at Bracken and the Selma gaging station about one mile below the crossing, the creek bed is in the Austin chalk and the losses in this stretch are probably small."

Several channel dams were located, each with small storage capacity; no diversion was apparent. No portable irrigation pumps were located but a number of small acreages were noted that probably are irrigated during the growing season.

Date 1958	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Jan. 28	Tributary	At mouth	0	55°		3.0		Estimate.
28	Cibolo Creek	75 ft below upper Cibolo road	0	55°	11.8			Rock streambed - gravel banks.
28	Ranger Creek	At mouth	5.4	58°		4.0		Estimate.
28	Cibolo Creek	175 ft below Ranger Creek road	5.4	58°	37.7			Rock streambed.
30	Cibolo Creek	175 ft below Ranger Creek road	5.4	52°	35.0			Second measurement made to indicate flow fluctuation.
28	Frederic Creek	0.5 mi above mouth	7.5	61°		30.1		Gravel and clay streambed.
28	Menger Creek	0.5 mi above mouth	9.6	62°		13.1		Gravel streambed.
28	Cibolo Creek	300 ft below Menger Creek	9.6	62°	98.7			Broken rock streambed. Grove of large cypress trees.
29	Cibolo Creek	Near Cascade cavern	12.5	56°	89.0			Smooth rock streambed.
29	Cibolo Creek	500 ft above Balcones Creek	14.6	57°	80.0			Gravel streambed.
28	Balcones Creek	At upper Balcones road - 8 mi above mouth	14.7	59°		6.06		Gravel and clay streambed.
29	Balcones Creek	900 ft above mouth	14.7	56°		28.6		Rock streambed.
30	Postoak Creek	3.5 mi above mouth	16.0			10		Estimate - rock streambed.
30	Postoak Creek	At mouth	16.0			1.5		Estimate - gravel and rock.
30	Cibolo Creek	On George Ranch - 1/2 mi below crossing	21.5	55°	72.3			Streambed of large gravel. Very rough.
30	Cibolo Creek	Schaeffer ranch - 500 ft below crossing	23.6	56°	68.0			Rough, broken rock streambed.

Date 1958	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Jan. 17	Cibolo Creek	1/4 mi above Blanco road	27.0	49°	38.8			Gravel on rock streambed.
17	Cibolo Creek	50 ft below Specht's crossing	28.7	50°	32.1			Gravel on rock streambed.
30	Cibolo Creek	50 ft below Specht's crossing	28.7	59°	47.1			Gravel on rock streambed.
17	Cibolo Creek	2-1.2 mi above U. S. Highway 281	30.5	51°	29.3			Clay streambed.
30	Indian Creek	3 mi above mouth	32.2			0		Rock streambed.
17	Cibolo Creek	At gaging station near Bulverde	35.0	52°	20.4			Rock streambed.
30	Cibolo Creek	At gaging station near Bulverde	35.0	59°	27.5			Rock streambed.
17	Cibolo Creek	2 mi below gaging station - 50 ft above private water crossing	37.0	53°	20.0			
18	Cibolo Creek	2 mi above Dripping Springs Creek	37.7	52°	17.4			Gravel and silt streambed.
18	Dripping Springs Creek	2 mi above mouth	39.7			.1		Estimated.
18	Cibolo Creek	200 ft upstream from county road	42.6	50°	10.0			Rock and gravel streambed.
18	Cibolo Creek		44.0	57°	15.2			Gravel on rock streambed.
18	Clear Fork Cibolo Creek	At mouth	49.3					Not inspected.
18	Cibolo Creek	At discontinued gaging station near Bracken	49.5	54°	17.5			Gravel streambed.
19	Cibolo Creek	At N. J. Marback ranch 1/2 mi downstream from Yellow Bluff	51.6	52°	5.26			Gravel streambed.
19	Cibolo Creek	3/4 mi below Yellow Bluff	51.9		0			
19	Cibolo Creek	Gaging station at Selma	56.0		0			

LOW-FLOW INVESTIGATIONS - GUADALUPE RIVER BASIN

Cibolo Creek September 12, 13, 1949

Reach: From Schertz to gaging station near Falls City, Tex.

The investigation was made during a constant stage and determinations of gain or loss represent normal conditions. All tributaries were measured and there was no diversion in the reach.

Date 1949	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Sept. 12	Cibolo Creek	At farm road 78 at Schertz	0		0			
12	Cibolo Creek	.4 mi above Highway 90 near Zuehl	10		1.56			
12	Santa Clara Creek	Near mouth and 2½ mi east of Zuehl	18			0		
12	Martinez Creek	2 mi above mouth and 2½ mi south of Zuehl	22			0		
12	Cibolo Creek	¼ mi below county road at Lavernia	29		1.79			
12	Blue Creek	½ mi above mouth and 2 mi east of Lavernia	30.6			.05		
12	Cibolo Creek	3¼ mi above Sutherland Springs	33.6		3.95			
12	Cibolo Creek	1.0 mi above Sutherland Springs	36.0		10.8			
13	Cibolo Creek	.2 mi below Sutherland Springs	38.0		11.6			
13	Cibolo Creek	Near Falls City - gaging station	62.0		14.0			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Nueces River — March and August 1924

Reach: From Odley Creek 14 mi above Barksdale to La Pryor crossing 4.7 mi below S.A.U.& G. Railroad bridge, Tex.

Seepage measurements were made on the Nueces River from mouth of Odley Creek to La Pryor crossing during March and August 1924. There were no unusual conditions during this investigation, and the measurements represent the natural conditions.

Date 1924	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Mar. 10	Nueces River	At O.S.T. crossing	59.1		0.1			Estimate
10	Nueces River	At Tom Nunn crossing	61.1		25.3			
11	Nueces River	At Tom Nunn Hill damsite	62.7		26.9			
17	Nueces River	Just below Odley Creek near Vance	0		1.0			
17	Nueces River	Just above unnamed spring 1½ mi below Odley Creek	1.5		.9			
17	Unnamed Spring	1½ mi below Odley Creek	1.5			11.2		
17	Nueces River	Near Vance	8.3		55.1			
18	Nueces River	At Barksdale 500 ft below highway crossing	14.2		39.2			
22	Nueces River	At Barksdale 500 ft below highway crossing	14.2		70.4			
22	Nueces River	At Camp Wood below Camp Wood Creek	18.1		126			
22	Nueces River	300 ft above Montell Creek at Montell	29.4		78.7			Large underground flow.
22	Montell Creek	At mouth	29.5			.2		Estimate.
22	Nueces River	At reservoir site above Laguna	37.2		142			
23	Nueces River	At gaging station at Laguna	40.2		149			
24	Nueces River	At Chalk Bluff	45.3		115			
24	Nueces River	At Riverview 3 mi below Chalk Bluff	49.3		123			
24	West Nueces River	At mouth	51.8			0		
24	Nueces River	Just below West Nueces R	51.8		64.7			
24	Nueces River	At Southern Pacific Railroad crossing	56.3		34.6			

Date 1924	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Mar. 25	Nueces River	At O.S.T. crossing 2½ mi below Southern Pacific Railroad	59.1		1.2			Estimate.
25	Nueces River	At Tom Nunn crossing	61.1		22.8			
25	Nueces River	At Tom Nunn Hill damsite	62.7		23.7			
25	Nueces River	At old Eagle Pass crossing (concrete slab)	66.6		37.6			
26	Nueces River	At S.A.U.& G. Railroad bridge	69.6		29.2			
26	Nueces River	At La Pryor road crossing	74.4		32.2			
Aug. 11	Nueces River	Near Vance	8.3		0			
12	Nueces River	At Barksdale	14.2		0			
12	Nueces River	At Camp Wood	18.1		20.0			
12	Nueces River	At Montell	29.4		0			
12	Montell Creek	At mouth	29.4			0		
13	Nueces River	At reservoir site above Laguna	37.2		24.0			
13	Nueces River	At gaging station at Laguna	40.2		17.1			
13	Nueces River	At Chalk Bluff	45.3		0			
13	Nueces River	At mouth of West Nueces R	51.8		0			
13	Nueces River	At Southern Pacific Railroad crossing	56.3		0			
13	Nueces River	At O.S.T. crossing	59.1		0			
18	Nueces River	At Tom Nunn crossing	61.1		27.0			
18	Nueces River	At La Pryor road crossing	74.4		21.0			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Nueces River — December 13-15, 1954; February 16, September 19-20, 1955; July 8-10, 1957

Reaches: From Barksdale, Edwards County to gaging station at Laguna, Uvalde County.
From Real-Uvalde County line to gaging station at Laguna, Uvalde County.

Problem: To determine gains and losses in streamflow in the section of Nueces River channel that is on the Glen Rose limestone between Barksdale and the gaging station at Laguna.

Results: Data obtained in the four sets of measurements made indicate that no material losses occurred in the 25 miles of channel investigated. Large contributions from springs and tributaries were found in the 8-mile reach from Barksdale to the Edwards, Real, Uvalde County line. Below the county line no inflow of consequence was found from any source. Throughout the reach the stream channel is composed of loose gravel of unknown depth which overlies the smooth rocks of the Glen Rose limestone.

Discussion: Current-meter measurements were made at all points of critical interest; many small flows were estimated. No attempt was made to pace the discharge measurements with the rate of change in flow as the investigation progressed downstream. The channel was investigated throughout the reach and the measurements were made as rapidly and as thoroughly as possible. The rate of change in flow was determined at the Laguna gaging station. Flow conditions were practically constant during the 1954-55 investigations but were dropping 2% per day during the July 1957 period, the recorder record showing a decrease in flow from 84 to 65 cfs from July 6 to 14.

All of the main stream measuring sections are on porous gravel except at mile 23.3 and discharge shown represents surface flow only. Section at mile 23.3 is on smooth rock but material amounts of water could have been flowing through the extensive gravel deposit to the right of the measuring section. The 1957 measurements indicate that as much as 50 cfs of surface flow had disappeared below the gravel at the upper Montell crossing (at mile 14.1). Very likely there was underflow through the gravels at all of the measuring sites including that at the Laguna gaging station.

The so-called "Spring Creeks" that flow along the edges of the wide gravel channel in the Montell area are probably flowing river water. Apparently, the gravel deposits are higher in the center of the channel having been built up by bed load gravel moving downstream during floods. The flood channel widens at the upper Montell crossing and velocities sufficient to move gravel do not extend into the wooded bays along the banks. Hence the surface of the gravel beds slope from the center toward the edges and have their lowest elevation near each bank. Water flowing laterally through the gravels appears in the "Spring Creek" channels. During the 1954-55 investigations there was no surface flow in the vicinity of the upper Montell crossing. At a short distance below the crossing the flow appears in the "Spring Creeks". No doubt the Montell settlement and the much earlier Indian Mission were located here because of the bountiful "spring flow" along the conglomerate bluff on the right bank. There is also evidence of ancient Indian camp grounds in the liveoak motts along this bluff.

No channel dams are in the reach investigated but several irrigation pumps were found. These pumps, trailer or skid mounted, are used in irrigating small acreages of alfalfa and other feed crops. During drought years this pumpage can deplete the surface flow to near zero.

Date 1954	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Barksdale,	Edwards County to gaging station at Laguna, Uvalde County						
Dec. 14	Nueces River	Barksdale - 100 ft below highway	0	58°	9.11			Porous gravel streambed.
13	Spring	On right bank	0.6			0.5		Estimated. Not from river gravels.
13	Spring	On right bank	1.5			1.5		Estimated. Not from river gravels-not measurable.
13	Spring	On left bank	1.7			5-10		Boiling spring in flowing river channel.
13	8" pump	On left bank	1.9				0	Not pumping.
13	Nueces River	About 2 mi below Barksdale	1.9	61°	14.8			Porous gravel streambed.
13	Camp Wood Creek	At mouth	3.1			0		Porous gravel streambed.
13	Pulliam Creek	At mouth	3.2			1.0		Estimated. Very porous gravel streambed.
13	Unnamed Spring Branch	Near mouth	3.5			1.0		Estimated. Flow from large spring 0.5 mi from river-Camp Wood City supply.
13	Nueces River	Camp Wood - Gravel water crossing	3.7	63°	27.3			Wide gravel streambed.
13	Tributary	From right	4.2			1.0		Estimated. Gravel streambed.
13	Tributary	From right	5.6			0		Gravel streambed.
13	4" pump	On left bank	5.9				0	Not pumping.
13	Nueces River	About 3 mi below Camp Wood	6.4	63°	26.4			Wide porous gravel streambed.
13	Tributary	From left	7.4			0		Gravel streambed.
13	4" pump	On right bank	7.5				0	Not pumping.
13	Pump site	On left bank	7.9				0	Pump removed.
14	Nueces River	500 ft below county line	8.4	54°	26.4			Porous gravel streambed.
14	Tributary	From right	10.7			0		Gravel streambed.
14	Nueces River	About 4 mi below county line	12.3	57°	22.1			Wide porous gravel streambed.
14	3" pump	On right bank	12.3				0	Not pumping.
14	Nueces River	0.7 mi above gravel crossing	13.8	64°	15.7			Wide porous gravel streambed.
14	Tributary	From left	13.8			0		Gravel streambed.
14	Nueces River	0.4 mi above gravel crossing	14.1		0			Last of water disappears in gravel at this point.
	From mile 14-17	river channel is 1/2 to 3/4 mile wide and composed of porous deposits of large gravel.						
14	"Spring Creek"	Along left side of wide river channel	14.5		1.5			Estimated. So called "Spring Creek" which flows intermittently along left side of river channel.
14	"Spring Creek"	Along right side of wide river channel	15.2		1.0			Estimated. "Spring Creek" along right bank.
14	"Spring Creek"	Along right side of wide river channel	15.7		10.0			Estimated. "Spring Creek" along right bank.

Date	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
1954	From Barksdale,	Edwards County to gaging station at Laguna, Uvalde County -						Continued.
Dec. 14	"Spring Creek"	Along right side of wide river channel	16.2		0			Estimated. "Spring Creek" along right bank.
14	"Spring Creek"	Along left side of wide river channel	17.1		0.8			Estimated. "Spring Creek" along left bank.
	The above "Spring Creeks" (local name) flow river water in varying amounts along both banks - Main channel dry from mile 14.1 to 17.							
14	Montell Creek	At mouth	17.1			0		Gravel streambed.
14	Nueces River		17-20		0-15			Surface flow varies.
15	Nueces River		20.8	52°	10.9			Gravel streambed.
15	Tributary	From left	22.0			0		Gravel streambed.
15	Springs	From left bank	23.3			1.0		Estimated. Several springs and seeps along left bank. Springs 10-15 feet above water surface in river.
15	Nueces River	About 1.5 mi above Sycamore Creek	23.3	62°	19.3			Smooth rock streambed - large bar of loose gravel bar on right.
15	Sycamore Creek	At mouth	24.8			0		Gravel streambed.
15	Nueces River	At Laguna - Gaging station	25.2	62°	21.1			Measured on riffle of large, loose gravel.
19	Nueces River	At Laguna - Gaging station	25.2		22			Not measured. Determined from recording gage.
	From Real-Uvalde County line to gaging station at Laguna, Uvalde County							
1955								
Feb. 16	Nueces River	500 ft below county line	8.4	63°	31.1			Porous gravel streambed.
16	Nueces River	About 1 mi above Montell - at crossing	14.1		0			Wide porous gravel streambed.
16	Nueces River	200 ft below water crossing (gravel)	20.8		17.8			Gravel streambed.
16	Nueces River	At Laguna - Gaging station	25.2		29.5			Measured on riffle of large, loose gravel.
	From Barksdale,	Edwards County to gaging station at Laguna, Uvalde County						
Sept. 19	Nueces River	Barksdale - 50 ft below highway	0	82°	9.12			Porous gravel streambed.
19	Spring	On left bank	1.7			1-3		Estimated. Boiling spring in edge of flowing river channel.
19	8" pump	On left bank	1.9				0	Not pumping.
19	Nueces River	About 2 mi below Barksdale	1.9	81°	14.8			Porous gravel streambed.
19	Camp Wood Creek	At mouth	3.1			0		Wide gravel channel.

Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From Barksdale,	Edwards County to gaging station at Laguna, Uvalde County,						Continued
Sept.19	Pulliam Creek	In vicinity of mouth	3.2			0-5		Inspected for ½ mi above mouth flow varies. 4 mi above mouth creek flowing 15-25 cfs in wide gravel channel.
19	Unnamed spring	Near mouth	3.5			2.5		Estimated. Flow from large spring 0.5 mi from river - Camp Wood City supply.
19	Nueces River	Camp Wood - Gravel water crossing	3.7	81°	33.9			Wide gravel streambed.
19	Tributary	From right	4.2			0.1		Estimated. Gravel streambed.
19	8" pump	On right bank	4.7				2	Estimated.
19	Tributary	From right	5.6			0		Gravel streambed.
19	4" pump	On left bank	5.9				0	Not pumping.
19	Nueces River	About 3 mi below Camp Wood	6.4	83°	31.8			Wide porous gravel streambed.
19	Tributary	From left	7.4			0		Gravel streambed.
19	4" pump	On right	7.5				0	Not pumping.
19	Nueces River	500 ft below county line	8.4	84°	34.3			Porous gravel streambed.
19	Tributary	From right	10.7			0		Gravel streambed.
20	Nueces River	About 4 mi below county line	12.3	79°	27.3			Wide porous gravel streambed.
20	Nueces River	0.7 mi above gravel crossing	13.8	81°	19.3			Wide porous gravel streambed.
20	Tributary	From left	13.8			0		Gravel streambed.
20	Nueces River	0.4 mi above gravel crossing	14.1		0			Last of water disappears in gravel at this point.
	From mile 14-17	river channel is 1/2 to 3/4 mile wide and composed of porous deposits of large gravel.						
20	"Spring Creek"	Along left side of wide river channel	14.5		1.5			Estimated. So called "Spring Creek" which flows intermittently along left side of river channel.
20	"Spring Creek"	Along right side of wide river channel	15.2		3			Estimated. "Spring Creek" along right bank.
20	"Spring Creek"	Along right side of wide river channel	15.7		15			Estimated. "Spring Creek" along right bank.
20	"Spring Creek"	Along right side of wide river channel	16.2		"Spring Creek" enters main channel - Flow diminishing.			
20	"Spring Creek"	Along left side of wide river channel	17.1		1.5			Estimated. "Spring Creek" along left bank.
	The above "Spring Creeks" (local name) flow river water in varying amounts along both banks. Main channel dry from mile 14.0-16.2.							
20	Montell Creek	At mouth	17.1			0		Gravel streambed.
20	Nueces River	0.2 mi below Montell Creek	17.3		4			Estimated. Main channel.

Date	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
1955	From Barksdale,	Edwards County to gaging station	at Laguna,	Uvalde	County,		Continued	
Sept.20	Nueces River	0.5 mi below Montell Creek and below "Spring Creek" on left	17.6		20			Estimated. Main channel.
20	Nueces River		17-20		4-20			Surface flow varies.
20	Nueces River	200 ft below low crossing	20.8	82°	18.7			Gravel streambed.
20	Tributary	From left	22.0			0		Gravel streambed.
20	Nueces River	About 1.5 mi above Sycamore Creek	23.3	83°	27.6			Smooth rock streambed. Large bar of loose gravel on right.
20	Sycamore Creek	At mouth	24.8			0		Gravel streambed.
20	Nueces River	At Laguna - Gaging station	25.2	83°	30.0			Measured on riffle of large, loose gravel.
23	Nueces River	At Laguna - Gaging station	25.2		30			Not measured. Determined from recording gage.
1957								
July 8	8" pump	On left bank	-.5				1-2	Estimated. pumping - 40 ac.(est.) alfalfa.
8	Nueces River	Barksdale - 600 ft below highway	0	78°	29.7			Porous gravel streambed.
9	2 springs	On right bank	0.5-1.5					Not inspected.
	Large, high bar record flood of	of loose gravel deposited by Sept. 24, 1955	1-2					
9	Spring	On left bank	1.7			3.0		Estimated. This spring partly covered by gravel bar.
9	Nueces River	About 2 mi below Barksdale	1.8	78°	32.2			Probably only part of flow - tremendous loose gravel bar here.
9	8" pump	On left bank	1.9				1-2	Estimated pumping - 50 ac. (est.) alfalfa.
9	Camp Wood Creek		3.1			0		Wide gravel channel at mouth.
9	Pulliam Creek		3.2			5		Estimated at mouth - Porous gravel. 4 mi upstream creek flowing 15-20 cfs in wide gravel channel.
9	Unnamed Spring Branch	Near mouth	3.5			3		Estimated. Flow from large spring 0.5 mi from river - Camp Wood City supply.
9	Nueces River	Camp Wood - Gravel water crossing	3.7	78°	57.9			Wide gravel streambed.
9	8" pump	On left bank	3.9				1-2	Estimated. Pumping.
9	Tributary	From right	4.2					Not inspected.
9	8" pump	On right bank	4.7				1-2	Estimated. Pumping.
9	Tributary	From right	5.6			0		Gravel streambed.

Date 1957	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Barksdale,	Edwards County to gaging station	at Laguna,		Uvalde	County,	Continued	
July 9	6" pump	On left bank	6.3				1-2	Estimated. Pumping.
9	Nueces River	About 3 mi below Camp Wood	6.7	82°	65.6			Porous gravel streambed.
9	Tributary	From left	7.4			0		Gravel streambed.
9	Nueces River	0.6 mi below county line - 300 ft below concrete crossing	9.2	82°	69.7			Porous gravel streambed.
9	Tributary	From right	10.7			0		Gravel streambed.
9	Nueces River	About 3½ mi below county line	12.1	83°	66.1			Porous gravel streambed.
9	Nueces River	About 0.3 mi above upper Montell crossing	13.8	80°	51.0			Gravel streambed.
10	Nueces River	500 ft below upper Montell crossing	14.1		20.7			Porous gravel streambed.
	From mile 14-17	river channel is 1/2 to 3/4 mi wide and composed of deposit of large gravel.						
10	"Spring Creek"	Along left side of wide river channel	14.7		10			Estimated. So called "Spring Creek" which flow along left side of river channel.
10	"Spring Creek"	Along right side of wide river channel	15.5		20			Estimated.
10	"Spring Creek"	Along right side of wide river channel	16.5		30			Estimated. "Spring Creek" enters main channel here.
	The "Spring Creek" (local name) flow river water in varying amounts along both banks.							
10	"Spring Creek"	Along left side of wide river channel	16.9		5			Estimated
	Main channel flowing through this reach (mile 14-17).		Minimum surface flow probably 20 cfs.					
10	Montell Creek	At mouth	17.1					Gravel streambed.
10	"Spring Creek"	Along left bank	17.2					Impossible to measure. Flows into main channel here.
10	Nueces River	0.5 mi below lower Montell crossing	17.4		55.8			Porous gravel streambed.
10	Nueces River	¼ mi below low crossing	20.8		47.1			Porous gravel streambed.
10	Nueces River	About 2 mi above Laguna gage	23.3		62.6			Smooth rock streambed. Large bar of loose gravel on right.
10	Nueces River	At Laguna - Gaging station	25.2		72.9			Measured on riffle of large, loose gravel.
6	Nueces River	At Laguna - Gaging station	25.2		84			Discharge shown on July 6, 14,
14	Nueces River	At Laguna - Gaging station	25.2		65			not measured. Determined from recording gage record.

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Nueces River April 30-May 8, 1925

Reach: From gaging station at Laguna to Cinonia, Tex.

Discharge measurements were made to determine seepage gains or losses on the Nueces River from Laguna to Cinonia, Tex., in April and May 1925. During this series of measurements the river was at a constant stage.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Apr. 30	Nueces River	At gaging station at Laguna	0		35.3			
30	Nueces River	At Chalk Bluff	5.1		13.5			
30	Nueces River	At Cline (O.S.T.) crossing west of Uvalde	18.9		0			
30	Nueces River	At Tom Nunn crossing	20.9		4.3			
30	Nueces River	At Tom Nunn Hill	22.8		1.5			
May 1	Nueces River	At old Eagle Pass road crossing	26.8		9.0			
1	Nueces River	S.A.U.& G. Railroad crossing	29.8		2.8			
8	Nueces River	At Habey Ranch	31.6		0			
8	Nueces River	At mouth of Live Oak Creek	34.5		.5			
1	Nueces River	At Uvalde-La Pryor crossing	34.5		.5			
1	Nueces River	Due east of La Pryor	40.7		0			
1	Nueces River	At La Pryor Ranch house	43.2		0			
1	Nueces River	4 mi below La Pryor Ranch house	47.4		8.0			
2	Nueces River	2 mi above Cinonia at Old Ranch Ford	54.9		5.4			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Nueces River — May-August 1931

Reach: From gaging station at Laguna to Cinonia, Tex.

During the investigations the river was at a constant stage, and measurements represent natural conditions.

The discharge measurements of the Nueces River were made to determine seepage gain or loss from gaging station at Laguna, Tex., to former gaging station near Cinonia, Tex. in 1931.

Date 1931	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
May 16	Nueces River	At gaging station at Laguna	0		316			
16	Nueces River	At mouth of West Nueces R	13.0		259			
16	Nueces River	At S. P. Railway bridge	18.0		222			
16	Nueces River	At Uvalde-Del Rio road crossing	20.6		199			
16	Nueces River	At gaging station near Uvalde	22.7		219			From rating curve.
17	Nueces River	At Uvalde-Eagle Pass road crossing	28.2		229			
17	Nueces River	At S.A.U.& G. Railway bridge	31.6		227			
17	Nueces River	At old Uvalde-La Pryor road crossing	36.3		221			
17	Nueces River	At gas well 5 mi NE of La Pryor	39.6		219			
17	Nueces River	At La Pryor-Batesville road crossing	44.8		208			
17	Nueces River	At old gaging station site near Cinonia	56.5		240			
19	Nueces River	At gaging station at Laguna	0		275			
19	Nueces River	6.8 mi above West Nueces R	6.2		279			
19	Nueces River	2.6 mi above West Nueces R	10.4		274			
19	Nueces River	At gaging station near Uvalde	22.7		196			
June 4	Nueces River	At gaging station at Laguna	0		192			
4	Nueces River	2.6 mi above West Nueces R	10.4		187			
4	Nueces River	At mouth of West Nueces R	13.0		157			
4	Nueces River	At S. P. Railway bridge	18.0		116			
5	Nueces River	At Uvalde-Del Rio road crossing	20.6		84.6			
5	Nueces River	At gaging station near Uvalde	22.7		114			
5	Nueces River	At S.A.U.& G. Railway bridge	31.6		118			
5	Nueces River	At gas well 5 mi NE of La Pryor	39.6		111			

Date 1931	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
June 6	Nueces River	At La Pryor-Batesville road crossing	44.8		107			
6	Nueces River	3½ mi above Cinonia bridge	53.0		108			
15	Nueces River	At gaging station at Laguna	0		156			
15	Nueces River	2.6 mi above West Nueces R	10.4		140			
15	Nueces River	At mouth of West Nueces R	13.0		106			
15	Nueces River	At S. P. Railway bridge	18.0		69.7			
15	Nueces River	At Uvalde-Del Rio road crossing	20.6		46.6			
16	Nueces River	At gaging station near Uvalde	22.7		63.7			
16	Nueces River	At Uvalde-Eagle Pass road crossing	28.2		81.2			
16	Nueces River	At S.A.U.& G. Railway bridge	31.6		75.7			
16	Nueces River	At gas well 5 mi NE of La Pryor	39.6		65.1			
16	Nueces River	At La Pryor-Batesville road crossing	44.8		60.4			
17	Nueces River	3½ mi above Cinonia bridge	53.0		69.0			
17	Nueces River	At old gage site near Cinonia	56.5		82.4			
22	Nueces River	At gaging station at Laguna	0		138			
22	Nueces River	2.6 mi above West Nueces R	10.4		124			
22	Nueces River	At mouth of West Nueces R	13.0		84.1			
22	Nueces River	At S. P. Railway bridge	18.0		43.4			
22	Nueces River	At Uvalde-Del Rio road crossing	20.6		21.5			
23	Nueces River	At gaging station near Uvalde	22.7		40.2			
23	Nueces River	At Uvalde-Eagle Pass road crossing	28.2		57.2			
23	Nueces River	At S.A.U.& G. Railway bridge	31.6		50.1			
23	Nueces River	At gas well 5 mi NE of La Pryor	39.6		40.9			
23	Nueces River	At La Pryor-Batesville road crossing	44.8		33.2			
24	Nueces River	3½ mi above Cinonia bridge	53.0		45.3			
24	Nueces River	At old gage site near Cinonia	56.5		46.1			
July 2	Nueces River	At gaging station at Laguna	0		118			
2	Nueces River	2.6 mi above West Nueces R	10.4		101			
2	Nueces River	At mouth of West Nueces R	13.0		63.8			
2	Nueces River	At S. P. Railway bridge	18.0		27.5			
2	Nueces River	At Uvalde-Del Rio road crossing	20.6		6.3			

Date 1931	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
July 3	Nueces River	At gaging station near Uvalde	22.7		26.9			
3	Nueces River	At Uvalde-Eagle Pass road crossing	28.2		43.9			
3	Nueces River	At S.A.U.& G. Railway bridge	31.6		39.6			
3	Nueces River	At gas well 5 mi NE of La Pryor	39.6		29.6			
3	Nueces River	At La Pryor-Batesville road crossing	44.8		24.2			
4	Nueces River	3½ mi above Cinonia bridge	53.0		35.8			
4	Nueces River	¼ mi below Cinonia bridge	56.5		35.5			
July 9	Nueces River	At gaging station at Laguna	0		98.9			
9	Nueces River	2.6 mi above West Nueces R	10.4		69.4			
9	Nueces River	At mouth of West Nueces R	13.0		36.5			
9	Nueces River	At S. P. Railway bridge	18.0		4.6			
9	Nueces River	At Uvalde-Del Rio road crossing	20.6		1.5			Estimate.
9	Nueces River	At gaging station near Uvalde	22.7		21.6			
13	Nueces River	At gaging station near Uvalde	0		17.5			From rating curve.
13	Nueces River	At Uvalde-Eagle Pass road crossing	5.5		33.6			
13	Nueces River	At S.A.U.& G. Railway bridge	8.9		29.0			
13	Nueces River	At gas well 5 mi NE of La Pryor	16.9		17.9			
13	Nueces River	At La Pryor-Batesville road crossing	22.1		11.5			
13	Nueces River	3½ mi above Cinonia bridge	30.3		23.4			
13	Nueces River	¼ mi below Cinonia bridge	33.8		21.5			
16	Nueces River	At gaging station at Laguna	0		91.8			
16	Nueces River	6.8 mi above West Nueces R	6.2		79.9			
16	Nueces River	2.6 mi above West Nueces R	10.4		63.8			
16	Nueces River	At mouth of West Nueces R	13.0		25.1			
16	Nueces River	At Uvalde-Del Rio road crossing	20.6		0			
17	Nueces River	At gaging station near Uvalde	22.7		18.8			
Aug. 29	Nueces River	At gaging station at Laguna	0		119			
29	Nueces River	2.6 mi above West Nueces R	10.4		56.8			
29	Nueces River	At mouth of West Nueces R	13.0		40.2			
29	Nueces River	At S. P. Railway bridge	18.0		15.2			
30	Nueces River	At Uvalde-Del Rio road crossing	20.6		7.8			
30	Nueces River	At gaging station near Uvalde	22.7		26.9			

Date 1931	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Aug. 30	Nueces River	At Uvalde-Eagle Pass road crossing	28.2		36.3			
30	Nueces River	At S.A.U.& G. Railway bridge	31.6		38.8			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Nueces River — November 14-16, 1931; January 24-25, 1932

Reach: From gaging station at Laguna to gas well 5 mi NE of La Pryor, Tex.

During the investigations the river was at a constant stage, and measurements represent natural conditions.

Date	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
1931								
Nov. 14	Nueces River	At gaging station at Laguna	0		64.2			
14	Nueces River	6.8 mi above West Nueces R	6.2		43.0			
15	Nueces River	2.6 mi above West Nueces R	10.4		14.9			
15	Nueces River	At mouth of West Nueces R	13.0		0			
15	Nueces River	At S. P. Railway bridge	18.0		0			
15	Nueces River	At Uvalde-Del Rio road crossing	20.6		0			
15	Nueces River	At gaging station near Uvalde	22.7		9.0			
15	Nueces River	At Uvalde-Eagle Pass road crossing	28.2		16.8			
16	Nueces River	At S.A.U.& G. Railway bridge	31.6		12.7			
16	Nueces River	At gas well 5 mi NE of La Pryor	39.6		4.0			
1932								
Jan. 24	Nueces River	At gaging station at Laguna	0		64.0			
24	Nueces River	6.8 mi above West Nueces R	6.2		46.2			
24	Nueces River	2.6 mi above West Nueces R	10.4		22.9			
24	Nueces River	At mouth of West Nueces R	13.0		0			
24	Nueces River	At S. P. Railway bridge	18.0		0			
24	Nueces River	At Uvalde-Del Rio road crossing	20.6		0			
24	Nueces River	At gaging station near Uvalde	22.7		8.1			
25	Nueces River	At Uvalde-Eagle Pass road crossing	28.2		14.4			
25	Nueces River	At S.A.U.& G. Railway bridge	31.6		12.8			
25	Nueces River	At old Uvalde-La Pryor road crossing	36.3		8.3			
25	Nueces River	At gas well 5 mi NE of La Pryor	39.6		4.5			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Nueces River — November 1932
July 1933

Reach: From gaging station at Laguna to old gage site near Cinonia, Tex.

During the investigation the river was at a constant stage, and measurements represent natural conditions.

Date	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
1932								
Nov. 1	Nueces River	At gaging station at Laguna	0		244			
1	Nueces River	6.8 mi above West Nueces R	6.2		247			
1	Nueces River	2.6 mi above West Nueces R	10.4		298			
1	Nueces River	At mouth of West Nueces R	13.0		240			West Nueces dry.
2	Nueces River	At S. P. Railway bridge	18.0		218			
2	Nueces River	At Uvalde-Del Rio road crossing	20.6		218			
2	Nueces River	At gaging station near Uvalde	22.7		251			
2	Nueces River	At Uvalde-Eagle Pass road crossing	28.2		262			
3	Nueces River	At S.A.U.& G. Railway bridge	31.6		249			
3	Nueces River	At old Uvalde-La Pryor road crossing	36.3		256			
3	Nueces River	At gas well 5 mi NE of La Pryor	39.6		246			
4	Nueces River	At La Pryor-Batesville road crossing	44.8		244			Pumpage added to measurement.
4	Nueces River	3½ mi above Cinonia bridge	53.0		255			Pumpage added to measurement.
4	Nueces River	At old gage site near Cinonia	56.5		272			Pumpage added to measurement.
1933								
July 23	Nueces River	At gaging station at Laguna	0		23.1			
23	Nueces River	5.2 mi above West Nueces R	7.8		22.9			
23	Nueces River	2.6 mi above West Nueces R	10.4		0			
23	Nueces River	At mouth of West Nueces R	13.0		0			West Nueces dry.
23	Nueces River	At S. P. Railway bridge	18.0		0			
23	Nueces River	At Uvalde-Del Rio road crossing	20.6		0			
24	Nueces River	At gaging station near Uvalde	22.7		16.3			
24	Nueces River	At Uvalde-Eagle Pass road crossing	28.2		20.6			
24	Nueces River	At S.A.U.& G. Railway bridge	31.6		16.3			
24	Nueces River	At old Uvalde-La Pryor road crossing	36.3		11.3			

Date 1933	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
July 25	Nueces River	At gas well 5 mi NE of La Pryor	39.6		7.2			No pumps operating.
26	Nueces River	At La Pryor-Batesville road crossing	44.8		4.1			
25	Nueces River	3½ mi above Cinonia bridge	53.0		13.9			
25	Nueces River	At old gage site near Cinonia	56.5		14.4			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Nueces River June 14-30, 1939

Reach: From gaging station at Laguna to a point 3.8 mi SE of Cinonia, Tex.

A series of discharge measurements was made during the period June 14-30, 1939, on the Nueces River and tributaries, Tex., between the gaging station at Laguna and a point 3.8 miles southeast of Cinonia, to determine seepage gains or losses. The river distance was 61.4 miles. The investigation was made during a period of constant stage of the river, and the determinations of gain or loss represent natural conditions. All flowing tributaries were measured.

Date 1939	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
June 14	Nueces River	1,200 ft above gaging station at Laguna	-.2		26.6			
14	Nueces River	1,200 ft below gaging station at Laguna	+.2		25.7			
15	Nueces River	At 19 mi crossing on U. S. Highway 83-B	1.8		21.6			
15	Nueces River	1.8 mi below U. S. Highway 83-B	3.6		17.8			
15	Nueces River	5.4 mi above mouth of West Nueces R	6.6		5.6			
16	Nueces River	4.4 mi above mouth of West Nueces R	7.6		10.1			
16	Nueces River	3.8 mi above mouth of West Nueces R	8.2		0			
16	Nueces River	Just below mouth of West Nueces R	12.0		0			
16	Nueces River	At Texas and New Orleans Railway bridge	16.9		0			
17	Nueces River	At U. S. Highway 90 bridge	19.6		0			
17	Nueces River	1 mi below U. S. Highway 90 bridge	20.6		0			
17	Nueces River	At old gage site at Tom Nunn crossing	21.6		8.9			
17	Nueces River	1 mi below gage site at Tom Nunn crossing	22.6		10.0			
19	Unnamed spring	2 mi above present gaging station below Uvalde	24.6			0.3		Estimated.
19	Nueces River	Just below unnamed spring	24.6		7.3			
19	Unnamed spring	100 ft below previous measurement	24.6			.2		Estimated.
19	Nueces River	At gaging station 4 mi above Highway 83	26.6		11.8			

Date 1939	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
June 22	Nueces River	1 mi below gaging station	27.6		10.2			
20	Nueces River	At U. S. Highway 83 bridge	30.6		5.5			
20	Nueces River	1 mi below old Uvalde-La Pryor road crossing	35.7		5.3			
21	Nueces River	At gas well 5 mi NE of La Pryor	38.0		1.1			
21	Nueces River	At La Pryor-Batesville road crossing	43.2		0			
30	Nueces River	3.3 mi below La Pryor-Batesville road crossing	46.5		7.0			
29	Nueces River	3.6 mi above Mitt-Smith crossing	50.0		4.8			
29	Nueces River	At Mitt-Smith crossing 3½ mi NE of Cinonia	53.6		4.8			
29	Nueces River	3.3 mi below Mitt-Smith crossing	56.9		4.7			
30	Nueces River	On Thoren-Walker ranch 3.8 mi SE of Cinonia	61.4		3.4			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Nueces River — May, July, August, September 1940

Reach: From 0.4 mi above gaging station at Laguna to 4.8 mi SE of La Pryor, Tex.

A series of discharge measurements was made during each of the periods May 2, 3, July 9, 10, Aug. 28, 29, and Sept. 26, 27, on the Nueces River and Tributaries, Tex., between a point 0.4 mile upstream from gaging station at Laguna and a point 4.8 miles southeast of La Pryor. The river distance is 46.5 miles. The investigations were made during periods of constant stage of the river, and determinations of gain or loss represent normal conditions. All tributaries and diversions were measured. Tributaries not listed were not flowing.

Date 1940	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
May 2	Nueces River	0.4 mi above gaging station at Laguna	-0.4		72.4			
2	Nueces River	200 ft above Spring Branch	7.6		54.9			
2	Spring Branch	At mouth, 4.4 mi above West Nueces R	7.6			4.0		
2	Nueces River	3.2 mi above West Nueces R	8.8		18.4			
2	Nueces River	Just below West Nueces R	12.0		0			
2	Nueces River	At U. S. Highway 90 bridge	19.6		0			
2	Nueces River	At old gage site 7 mi SW of Uvalde	21.6		8.6			
2	Nueces River	1 mi below present gage 9 mi SW of Uvalde	27.6		15.0			
3	Nueces River	1,000 ft above U. S. Highway 83 bridge	30.4		9.3			
3	Nueces River	1 mi below old Uvalde-La Pryor road crossing	35.7		6.0			
3	Nueces River	1,300 ft above gas well, 5 mi NE of La Pryor	37.8		0			
3	Nueces River	500 ft above gas well, 5 mi NE of La Pryor	37.9		4.6			
3	Nueces River	.2 mi below Batesville-La Pryor road bridge	43.4		2.2			
3	Nueces River	3.3 mi below Batesville-La Pryor road bridge	46.5		12.6			

Date 1940	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
July 9	Nueces River	.4 mi above gaging station at Laguna	-0.4		74.6			
9	Nueces River	500 ft above Spring Branch	7.5		64.1			
9	Spring Branch	At mouth, 4.4 mi above West Nueces R	7.6			3.1		
9	Nueces River	3.2 mi above West Nueces R	8.8		21.2			
9	Nueces River	500 ft below West Nueces R	12.0		0			
9	Nueces River	At U. S. Highway 90 bridge	19.6		0			
9	Nueces River	At old gage site	21.6		10.8			
9	Nueces River	1 mi below present gage	27.6		18.4			
10	Nueces River	900 ft above U. S. Highway 83 bridge	30.4		11.3			
10	Nueces River	1 mi below old Uvalde-La Pryor road crossing	35.7		8.8			
10	Nueces River	.2 mi above gas well	37.8		0			
10	Nueces River	300 ft above gas well	37.9		5.2			
10	Nueces River	.2 mi below Batesville-La Pryor road bridge	43.4		1.4			
10	Nueces River	3.3 mi below Batesville-La Pryor road bridge	46.5		11.0			
Aug. 28	Nueces River	.4 mi above gaging station at Laguna	-0.4		56.7			
28	Nueces River	500 ft above Spring Branch	7.5		45.9			
28	Spring Branch	At mouth, 4.4 mi above West Nueces R	7.6			3.6		
28	Nueces River	3.2 mi above West Nueces R	8.8		5.4			
28	Nueces River	500 ft below West Nueces R	12.0		0			
28	Nueces River	At U. S. Highway 90	19.6		0			
28	Nueces River	At old gage site	21.6		8.2			
28	Nueces River	1 mi below present gage	27.6		13.7			
29	Nueces River	At U. S. Highway 83 bridge	30.6		6.8			
29	Nueces River	1 mi below Uvalde-La Pryor road crossing	35.7		5.3			
29	Nueces River	1,300 ft above gas well	37.8		0			
29	Nueces River	500 ft above gas well	37.9		.2			
29	Nueces River	.2 mi below Batesville-La Pryor road bridge	43.4		.3			
29	Nueces River	3.3 mi below Batesville-La Pryor road bridge	46.5		8.0			

Date 1940	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Sept. 26	Nueces River	.4 mi above gaging station	-0.4		37.5			
26	Nueces River	500 ft above Spring Branch	7.5		25.9			
26	Spring Branch	500 ft above mouth	7.6			3.2		
26	Nueces River	3.2 mi above West Nueces R	8.8		0			
26	Nueces River	500 ft below West Nueces R	12.0		0			
26	Nueces River	At U. S. Highway 90 bridge	19.6		0			
26	Nueces River	At old gage site	21.6		7.0			
26	Nueces River	1 mi below present gage	27.6		12.1			
27	Nueces River	At U. S. Highway 83 bridge	30.6		6.5			
27	C & M Produce Company Pump	.6 mi below old Uvalde-La Pryor road crossing	35.3				5.0	
27	Nueces River	1 mi below old Uvalde-La Pryor road crossing	35.7		.1			
27	Nueces River	500 ft above gas well	37.9		.1			
27	Nueces River	At Batesville-La Pryor road bridge	43.2		.1			
27	Nueces River	3.3 mi below Batesville-La Pryor road bridge	46.5		7.8			

LOW FLOW INVESTIGATIONS - NUECES RIVER BASIN

West Nueces River — Dec. 13-14, 1954; Sept. 11-12, 1955

Reach: From Black Water Hole to discontinued stream-gaging station near Brackettville

Problem: To determine gains and losses in streamflow in the West Nueces River above the site of the discontinued stream-gaging station near Brackettville. The reach is 48 miles long and extends 24 miles upstream from the Edwards-Kinney county line.

Results and Discussion: There was no base flow in this reach of the West Nueces River during these investigations. Tributary spring flow reaching the river is lost in the porous rock and immense gravel beds. The flow of Kickapoo Springs in Edwards County, 2-6 cfs, disappears a short distance below the mouth of Kickapoo Creek. Schwandner Springs, the only other source of inflow found, enters from the left at a point about 13 miles below the county line; however, the flow from this spring, 3-5 cfs, disappears in less than 4 miles into gravel beds downstream from the mouth of the creek in which the spring is located. Several so called lakes and water holes found in the reach have been scoured from the gravel and probably have underground springs that sustain them. At times water flows from some of these pools but it is usually lost in the gravel bed a short distance downstream. The surface flows found in this reach are probably a small part of the total flow below and into the gravel deposits.

Date 1954	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Dec. 14	West Nueces R	At Black Water Hole	0		0			
14	West Nueces R	1 mi below Five Mile Draw	4.8		0			
14	West Nueces R	1/2 mi above Two Mile Draw	7.8		0			
14	West Nueces R	1800 ft above Kickapoo Springs	10.5		0.5			Estimate
14	Kickapoo Springs	At mouth on Mayes ranch	10.6	68°		1.98		
14	West Nueces R	800 ft below Kickapoo Springs	10.7	62°	6.21			Large gravel
14	West Nueces R	1-1/2 mi below Bluff Creek	13.4		0			End of flow
14	West Nueces R	2-1/2 mi below Bluff Creek	14.5		0			
14	West Nueces R	1-1/2 mi below Four Mile Draw	16.7		0			
14	West Nueces R	1 mi below Cave Creek	24.3		0			
14	West Nueces R	At mouth of Griffen Creek	29.3		0			
14	West Nueces R	At Dutch Water Hole	32.6		0			
13	Silver Lake	At Schwandner ranch	37.5			0		
13	Schwandner Spr	At Schwandner ranch	37.6			2.97		
13	Water hole	Below Schwandner ranch	38.7		0	0		
13	West Nueces R	1/2 mi above Leona Draw	43.6		0			
13	West Nueces R	2 mi below Leona Draw	46.1		0			
13	West Nueces R	At discontinued stream-gaging station near Brackettville	47.7		0			

Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Sept. 11	West Nueces R	At Black Water Hole	0		0			
11	West Nueces R	1 mi below Five Mile Draw	4.8		0			
11	West Nueces R	1/2 mi above Two Mile Draw	7.8		0			At Thurman ranch
11	West Nueces R	1000 ft above Kickapoo Creek	10.5		0			Beginning of flow
11	Kickapoo Sprs	At mouth	10.7	74°		1.81		Flow of Kickapoo Creek
12	West Nueces R	600 ft below Kickapoo Creek	10.8	81°	2.35			Gravel channel
12	West Nueces R	2.3 mi above Four Mile Draw	13.4		0			
12	West Nueces R	1.2 mi above Four Mile Draw	14.5		0			
12	West Nueces R	1.4 mile below Four Mile Draw	16.7		0			At McNealy ranch
12	West Nueces R	1 mi below Cave Creek	24.3		0			At Brice ranch
12	West Nueces R	At mouth of Griffen Creek	29.3		0			On DeLong ranch
11	West Nueces R	At Dutch Water Hole	32.6		0			
11	West Nueces R	At Silver Lake on Schwandner ranch	37.5		0			
11	Schwandner Spr	At Schwandner ranch	37.6			5.14		
11	West Nueces R	2-1/2 mi below Schwandner ranch	40.1	84°	2.73			At concrete crossing
11	West Nueces R	2-1/2 mi above Leona Draw	41.6		0			
11	West Nueces R	1-1/2 mi above discontinued stream-gaging station	46.1		0			
11	West Nueces R	At discontinued stream-gaging station near Brackettville	47.7		0			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

West Nueces River — May 13, 1941

Reach: From a point 1,000 ft above stream-gaging station near Brackettville, Tex. to a point 0.8 mi above mouth, near Uvalde, Tex.

A series of discharge measurements was made on May 13, 1941, on the West Nueces River and tributaries, Tex., between a point 1,000 ft above gaging station near Brackettville and a point 37 mi downstream (0.8 mi upstream from mouth), to determine the seepage gains or losses. The river was falling about 0.5 cfs per day at gaging station. All flowing tributaries were measured.

Date 1941	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
May 13	West Nueces River	1,000 ft above gaging station near Brackettville	0		2.3			
13	West Nueces River	2.6 mi above Live Oak Creek	9.2		8.3			
13	Live Oak Creek	½ mi above mouth	11.8			4.8		
13	West Nueces River	1.6 mi below Live Oak Creek	13.4		21.1			
13	West Nueces River	.8 mi above mouth	37.0		0			
	River was falling about 0.5 cfs per day at gaging station.							

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Frio River June 26-28, 1925

Reach: From a point 11.8 mi above Leakey to a point 7.0 mi below Concan, Tex.

During this series of measurements the river was at a constant stage, and the measurements represent natural conditions.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
June 26	East Fork Frio River	Just above Big Spring Creek 11.8 mi above Leakey	0		1.71			
26	Big Spring Creek	At mouth 12 mi above Leakey	.05			8.86		
26	East Fork Frio River	200 ft below Big Spring Creek 11.7 mi above Leakey	.1		9.46			
26	East Fork Frio River	8.5 mi above Leakey	3.3		12.1			
26	Cypress Creek	At mouth 8.0 mi above Leakey	3.8			.96		
26	Grigsby-Horton Ditch	5.5 mi above Leakey	6.3				0.74	
26	Weston-Cox Ditch	3.1 mi above Leakey	8.7				.88	
26	East Fork Frio River	At concrete road crossing 3.0 mi above Leakey	8.8		8.91			
26	West Fork Frio River	At mouth 1.5 mi above Leakey	10.3			0		
26	Frio River	1.0 mi above Leakey	10.8		0			Flow 100 ft above and ½ mi below.
27	Frio River	¼ mi above Spring Branch at Leakey	11.8		4.53			
27	Spring Branch	½ mi above mouth at Leakey	11.8			13.9		
27	Frio River	½ mi below Leakey	12.3		25.0			
27	Frio River	3 mi below Leakey below road crossing	14.8		27.1			
27	Lombardy Ditch	At headgate of dam 4 mi below Leakey	15.8				11.1	Part of diversion re-enters river.
27	Lombardy Ditch	7 mi below Leakey	18.8			5.0		Estimate.
27	Frio River	At road crossing 11.5 mi below Leakey	23.3		26.4			
27	Frio River	At road crossing 15.0 mi below Leakey	26.8		39.5			

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
June 27	Frio River	At Concan - gaging station	31.3		40.5			
27	Frio River	1½ mi below Concan	32.3		32.5			
27	Frio River	23½ mi below Leakey	35.3		20.1			
27	Frio River	At road crossing 26 mi below Leakey	37.8		6.30			
28	Frio River	½ mi below road crossing 26.3 mi below Leakey	38.1		2.5			Estimate.
28	Frio River	.7 mi below road crossing 26.5 mi below Leakey	38.3		0			No flow below long deep pool.

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Frio River — May 17-23, 1954

Reach: From Wolf Ranch on East Fork 11 mi above Leakey to end of flow 3.7 mi below gage at Concan, Tex.

During the period May 17-23, 1954 a series of discharge measurements was made on the Frio River, Texas from Wolf Ranch, on the East Fork about 11 miles upstream from Leakey, to the end of flow about 3.7 miles downstream from gaging station at Concan. These measurements were made primarily for a ground water study of gains and losses in river flow and no attempt was made to measure all tributary inflow. The gaging station record at Concan indicated that the river maintained a constant flow during the investigation.

Date 1954	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
May 22	East Fork Frio River	On Wolf Ranch 3,300 ft above upper dam	0		2.25			
23	East Fork Frio River	On Perry Ranch 60 ft below small falls	4.1		2.77			
23	Big Spring Creek	On Perry Ranch 190 ft above small dam	4.2	75		4.58		
20	Irrigation Canal	2 mi N of Rio Frio Post Office	16.5				8.40	
19	Frio River	185 ft above Buffalo Creek	20.8		12.8			
18	Frio River	1,500 ft below Farm Road 1050	22.5		19.6			
18	Frio River	At Garner Park concession bldg.	24.6		18.3			
20	Frio River	2,000 ft below Cherry Creek	26.5		19.5			
17	Frio River	200 ft below concrete road crossing 4 mi above Concan	30.0		20.4			
17	Frio River	At gaging station at Concan	34.8		18.4			
17	Frio River	2,800 ft below Echols Dam	35.8		9.44			
17	Frio River	6,000 ft below Echols Dam	36.5		3.27			
17	Frio River	6,100 ft below Echols Dam	36.5		0			
18	Frio River	3,200 ft above gravel dam	37.4		2.71			
18	Frio River	1,500 ft below gravel dam	38.1		.72			
18	Frio River	3,300 ft below gravel dam	38.5		0			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Frio River

Jan. 4- 7, 1955
Feb. 14-15, 1955
Sept. 7-10, 1955
July 8- 9, 1957

Reach: From Prade ranch, 16 miles above Leakey to gaging station at Concan, Tex.

Problem: To determine gains or losses in streamflow in the reach of Frio River that is on the Glen Rose limestone upstream from the stream-gaging station at Concan.

Results: No material losses were found in the reach investigated which covers 39.5 miles of the main stream and 11.0 miles of its main tributary, East Frio River. The Frio River, East Frio River and most of the tributary streams above Leakey have headwater springs that issue from the Edwards and associated limestones. These headwater springs together with springs in a small area in the vicinity of the Real-Uvalde county line contribute the greater part of the streamflow found in this investigation. The springs and seeps in the county line areaprobably flow from the Glen Rose limestone.

Discussion: Current-meter measurements were made at points of critical interest; field estimates were made where flows were small or unimportant. No attempt was made to pace the discharge measurements with the rate of change in flow as the investigation progressed downstream. The channel was investigated throughout the reach, and the measurements were made as rapidly and as thoroughly as possible. The rate of change in flow was determined at the Concan stream-gaging station. Flow was not stable during the investigation, a condition normal for this stream: it is probably not possible to have stable base flow conditions in any of the streams that head in the Edwards plateau. Related conditions during the investigations are indicated by two determinations of discharge at the Concan stream-gaging station for each set of measurements.

"Spring Branch" that flows from the river gravels at Leakey is probably flowing river water that had disappeared in the gravels further upstream and should not be considered a tributary contribution.

Several channel dams were located, each with small storage capacity. The only diversion of consequence found was an irrigation canal that diverts from the left bank about 2 miles upstream from Rio Frio. No portable irrigation pumps were located but small acreages were noted that probably are irrigated during the growing season.

Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	From Prade ranch, 16 miles above Leakey to gaging station at Concan							
Jan. 4	Frio River	At Prade ranch	0		0.1			Estimated; rock channel.
4	Frio River	At first crossing below Prade ranch	.5		0			
4	Frio River	At second crossing below Prade ranch	.8		0			
4	Frio River	1-1/2 mi below Prade ranch; below dam	1.4		1.67			Rock channel.
4	Frio River	2.2 mi below Prade ranch	2.2		1.92			Rock channel.
4	W. Fork Frio R	3.2 mi above mouth	-			1.52		Rock channel.
4	W. Fork Frio R	At small dam near mouth	2.3			1.52		Estimate; same as upstream meas.
4	Frio River	0.6 mi below West Fork Frio R	3.0		3.82			Gravel channel.
4	Tributary	1.3 mi below West Fork Frio R	3.7			.1		Estimate.
4	Frio River	2.2 mi below West Fork Frio R	4.5		4.47			Rock and gravel channel.
4	Bluff Creek	At mouth	6.0			.1		Estimate.
4	Frio River	500 ft above Kent Creek	7.8		6.11			Rock channel.
4	Kent Creek	At mouth	7.9			1.13		
5	Frio River	2 mi below Kent Creek	9.9		5.09			Gravel channel.
5	Frio River	Just below Lewis ranch airfield	11.6		0			Wide gravel channel.
5	Frio River	1-1/2 mi above Leakey	14.5		0			Wide gravel channel.
5	Frio River	At mouth of East Frio River	16.1		0			Wide gravel channel.
5	East Frio River	Above upper dam on H. E. Butt ranch; 11.0 mi above Frio River	-			1.22		Rock channel; head springs 0.5 mi upstream.
5	East Frio River	100 ft above spring; 6.9 mi above Frio River	-			1.11		Rock channel.
5	Spring Branch	Near mouth	-	66°		4.80		Rock channel; spring at cave 0.7 mi upstream.
5	East Frio River	1.3 mi below Perry ranch	-	63°		5.30		Rock channel.
6	Tributary	From left; 1.6 mi below Perry ranch	-			.1		Estimate.
6	East Frio River	At road, above Cypress Creek; 5.2 mi above Frio River	-			6.63		Rock and gravel channel.
6	Cypress Creek	At mouth; 5.1 mi above Frio R	-			.89		Gravel channel.
6	East Frio River	At Harrison Stockade ranch; 2.6 mi above Frio River	-			2.61		Gravel channel.
6	East Frio River	2 mi above Frio River	-			0		Gravel channel.
6	East Frio River	Above bridge on Grady ranch; 1.0 mi above Frio River	-			0		Gravel channel.
6	East Frio River	200 ft below bridge on Grady ranch	-			1.94		Rock channel.
6	East Frio River	At mouth	16.1		0			Gravel channel.

Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	Frio River continued							
Jan. 6	Frio River	Road crossing at Leakey	17.0		0			Gravel channel.
6	Spring Branch	Road crossing at Leakey	17.1	65°	4.56			Gravel channel; probably flowing river water.
6	Frio River	At Ranch Road 1120; 2 mi below Leakey	19.7	62°	10.6			Gravel channel.
6	Irrigation Canal	2.7 mi above Rio Frio	21.6				3.89	Diverts from left bank at river.
6	Frio River	At road; 2 mi above Rio Frio	22.3		8.49			Gravel channel.
6	Frio River	Just above Cold Springs	26.5		8.34			Rock channel.
6	Cold Springs	At mouth	26.5	62°		0.5		On left bank.
7	Frio River	At Garner Park; 400 ft above concession building	29.5	54°	11.1			Gravel channel.
7	Frio River	2.6 mi above Concan	35.7		11.4			Rock channel.
7	Frio River	At gaging station at Concan	39.5	57°	9.62			Rock and gravel channel.
10	Frio River	At gaging station at Concan	39.5		13.0			Not measured. Mean daily discharge from recorder record.
	From Kent Creek, 8 miles above Leakey to gaging station at Concan							
Feb. 14	Frio River	500 ft above Kent Creek	7.8	62°	5.01			Rock channel; gravel banks.
14	Kent Creek	At mouth	7.9			.6		Estimate.
14	Frio River	At mouth of East Frio River	16.1		0			Wide gravel channel.
14	East Frio River	At road above Cypress Creek; 5.2 mi above Frio River	-	65°		5.95		Gravel channel.
14	Cypress Creek	At mouth; 5.1 mi above Frio R	-			1.0		Estimate; gravel channel.
14	East Frio River	Above bridge on Grady ranch; 1.0 mi above Frio River	-			0		Wide gravel channel.
14	East Frio River	200 ft below bridge on Grady ranch	-	66°		3.53		Rock channel.
14	East Frio River	At mouth	16.1		0			Wide gravel channel. No defined low water channel.
	Frio River continued							
15	Frio River	At Ranch Road 1120; 2 mi below Leakey	19.7	59°	14.1			Gravel channel.
15	Frio River	2.6 mi above Concan	35.7	58°	16.5			Rock channel; gravel banks.
15	Frio River	At gaging station at Concan	39.5	59°	17.2			Rock and gravel channel.
18	Frio River	At gaging station at Concan	39.5		18.0			Not measured. Mean daily discharge from recorder record.

Date 1955	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	From Prade ranch, 16 mi above Leakey to gaging station at Concan							
Sept. 8	Frio River	At hydraulic ram on Prade ranch	0		0.03			Rock channel.
8	Frio River	At first crossing below Prade ranch	.5		0			
8	Frio River	At second crossing below Prade ranch	.8		0			
8	Frio River	1-1/2 mi below Prade ranch; below dam	1.4	86°	1.95			Rock channel.
8	Frio River	2.2 mi below Prade ranch	2.2	89°	2.20			Rock channel.
8	W. Fork Frio R	3.2 mi above mouth	2.3	82°		1.53		Rock channel.
8	Frio River	0.6 mi below W. Fork Frio River	3.0	83°	2.94			Gravel channel.
8	Tributary	1.3 mi below W. Fork Frio River	3.7			0		
8	Frio River	2.2 mi below W. Fork Frio River	4.5	81°	3.33			Rock channel.
8	Bluff Creek	At mouth	6.0			.3		Estimate.
9	Frio River	500 ft above Kent Creek	7.8	76°	3.21			Rock channel.
9	Kent Creek	At mouth	7.9			.45		
9	Frio River	2 mi below Kent Creek	9.9	77°	2.11			Gravel channel.
9	Frio River	Just below Lewis ranch airfield	11.6		0			Wide gravel channel.
9	Owl Hollow	At mouth	11.6			0		
9	Frio River	3 mi below Lewis ranch	14.5		0			Wide gravel channel.
9	Frio River	At Highway 83	16.0		0			Wide gravel channel.
9	Frio River	At mouth of East Frio River	16.1		0			Wide gravel channel.
7	East Frio River	Above upper dam on H. E. Butt ranch; 11.0 mi above Frio River	-			0		Rock channel.
7	East Frio River	At upper dam on H. E. Butt ranch	-			.83		Rock channel.
7	East Frio River	Just above Spring Branch on Perry ranch 6.9 above Frio River	-	75°		2.55		Rock channel.
7	Spring Branch	150 ft above mouth	-	73°		4.0		Rock channel; spring 0.7 mi upstream.
7	East Frio River	1.3 mi below Perry ranch	-	83°		6.45		Rock channel.
7	Tributary	From left; 1.6 mi below Perry ranch	-			.02		Estimate.
7	East Frio River	Above Cypress Creek, at road 5.2 mi above Frio River	-	86°		5.57		Rock and gravel channel.
7	Cypress Creek	At mouth, 5.1 mi above Frio R	-	77°		.09		Gravel channel.
7	East Frio River	At Harrison Stockade ranch; 2.6 mi above Frio River	-	79°		.36		Gravel channel.
7	East Frio River	Above bridge on Grady ranch; 1.0 mi above Frio River	-			.0		Gravel channel.
7	East Frio River	200 ft below bridge on Grady ranch	-	71°		.76		Rock channel.
9	East Frio River	At mouth	16.1		0			Gravel channel.

Date	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
1955	Frio River continued							
Sept. 9	Frio River	Road crossing at Leakey	17.0		0			Gravel channel.
9	Spring Branch	Road crossing at Leakey	17.1	72°	1.86			Gravel channel. Probably flowing river water.
9	Frio River	At Ranch Road 1120, 2 mi below Leakey	19.7	81°	6.40			Gravel channel.
9	Irrigation Canal	2.7 mi above Rio Frio	21.6	78°			2.96	Diverts from left bank of river.
9	Frio River	At road, 2 mi above Rio Frio	22.3	82°	4.60			Rock channel.
9	Frio River	Just above Cold Springs	26.5	83°	6.44			Rock channel.
9	Cold Springs	At mouth	26.5	73°		0.6		On left bank.
10	Frio River	At Garner Park; 500 ft above concession building	29.5	78°	10.6			Gravel channel.
10	Frio River	2.6 mi above Concan	35.7	81°	8.37			Gravel channel.
10	Frio River	At gaging station at Concan	39.5	84°	8.49			Rock and gravel channel.
13	Frio River	At gaging station at Concan	39.5		8.2			Not measured. Mean daily discharge from recorder record.
1957	From a point 11.6 mi upstream from confluence with East Frio River to gaging station at Concan							
July 8	Frio River	2.2 mi below West Fork Frio R	4.5	90°	5.76			Smooth rock channel.
8	Frio River	500 ft above Kent Creek	7.8	88°	6.69			Smooth rock channel.
8	Kent Creek	At mouth	7.9			1.78		
8	Frio River	2.0 mi below Kent Creek	9.9	87°	4.52			Gravel channel.
8	Owl Hollow	At mouth	11.6			0		
8	Frio River	Just below Lewis ranch airfield	11.6		0			Wide gravel channel.
8	Frio River	1-1/2 mi above Leakey	14.5		0			Wide gravel channel.
8	Frio River	At mouth of East Frio River	16.1		0			Wide gravel channel.
9	East Frio River	At road above Cypress Creek; 5.2 mi above Frio River	-	79°		8.59		Gravel channel.
9	Cypress Creek	At mouth; 5.1 mi above Frio R	-			.94		Gravel channel.
9	East Frio River	Above bridge on Grady ranch; 1.0 mi above Frio River	-			.01		Estimate; gravel channel.
9	East Frio River	200 ft below bridge on Grady ranch	-	73°		3.20		Rock channel.
9	East Frio River	At mouth	16.1	74°	1.04			Gravel channel.
	Frio River continued							
9	Frio River	Road crossing at Leakey	17.0	80°	1.59			Gravel channel.
9	Spring Branch	Road crossing at Leakey	17.1	70°	10.8			Gravel channel. Probably flowing river water.
9	Frio River	At gaging station at Concan	39.5	88°	38.4			Rock and gravel channel.
12	Frio River	At gaging station at Concan	39.5		34.0			Not measured. Mean daily discharge from recorder record.

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Frio River July 1, 1931

Reach: From road crossing above Concan to road crossing below Concan, Tex.

Discharge measurements were made to determine seepage on the Frio River from Concan to Uvalde-Concan road crossing, Tex., July 1931. During the investigation the river was at a constant stage, and the measurements represent the natural conditions. No diversions from portion of river covered by measurements; no inflow from tributaries.

Date 1931	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
July 1	Frio River	At Concan-Leakey road crossing	0		112			
1	Frio River	At gaging station at Concan	1.0		114			
1	Frio River	1½ mi below gaging station	2.5		116			
1	Frio River	3½ mi below gaging station	4.5		107			
1	Frio River	¼ mi above Uvalde-Concan road crossing	6.0		86.3			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Frio River — November 5, 6 and December 20, 1932

Reach: From stream-gaging station at Concan, Tex. to U. S. Highway 90 crossing near Knippa, Tex.

Date 1932	Stream	Location	River Miles	Water Temp	Discharge in cfs: Main Stream	Tributary	Diversion	Remarks
Nov. 5	Frio River	At gaging station at Concan	0		233			
5	Frio River	1.2 mi below gaging station	1.2		226			
5	Frio River	3.0 mi below gaging station	3.0		253			
6	Frio River	¼ mi above Uvalde-Concan road crossing	5.0		220			
6	Frio River	At road crossing on Uvalde-Sabinal Highway	18.5		0			
Dec. 20	Frio River	At gaging station at Concan	0		124			
20	Frio River	1.2 mi below gaging station	1.2		108			
20	Frio River	3.0 mi below gaging station	3.0		123			
20	Frio River	¼ mi above Uvalde-Concan road crossing	5.0		98.8			
20	Frio River	At road crossing on Uvalde-Sabinal Highway, U. S. Highway 90	18.5		0			
	No diversion or inflow during investigation.							

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Dry Frio River

December 16, 1954
September 9, 1955
January 15-16, 1958

Reaches: From a point 2.0 miles above Real-Uvalde county line to a point 2.2 miles below stream-gaging station near Reagan Wells, Tex.
From a point 10.2 miles upstream from Real-Uvalde county line to a point 1.9 miles below stream-gaging station near Reagan Wells, Tex.
From a point 10.2 miles upstream from Real-Uvalde county line to stream-gaging station near Reagan Wells, Tex.

Problem: To determine gains and losses in the Dry Frio River in the reach that is on the Glen Rose limestone above the stream-gaging station near Reagan Wells, Tex.

Results: Data obtained in the three sets of measurements indicate that no material losses other than those normally attributed to evaporation and transpiration occurred in the 28 miles of channel investigated. A few points were found where the flow partially, and in one case wholly, disappeared into the river gravels; in every instance, the water soon returned to the surface with no apparent losses. The streamflow, principally from the Edwards and associated limestones gradually increased between the initial point and the gaging station.

Although the scope of these investigations did not include any portion of channel below the gaging station near Reagan Wells, observations were made at and below the point of contact of the Glen Rose and the Edwards limestone, this point being about two miles further downstream. In 1954 and 1955 all of the flow disappeared in the gravel deposits immediately after crossing the fault line that marks the upper contact of the Edwards limestone; in 1958 the Edwards absorbed the 28 cfs of flow within the first two miles of channel below the fault line.

Discussion: Current-meter measurements were made at all points of critical interest and at all points where appreciable amounts of flow were involved; many small flows were estimated. No attempt was made to pace the discharge measurements with the rate of change in flow as the investigation progressed downstream. The channel was investigated throughout the reach and the discharge measurements were made as rapidly and as thoroughly as possible. The rate of change in flow was determined at the Reagan Wells stream-gaging station. Flow was practically constant during the 1954 and the 1955 investigations, and was slowly decreasing during the January 1958 period, recorder record showing a decrease in flow from 28 to 27 cfs from January 16 to 20: it probably is not possible to have a constant rate of flow in this reach if any appreciable amount of flow is present, near constant flow being found only when rate approaches zero and very small flow remains. Whenever possible, measurements were made on rock streambed to eliminate possibility of underflow through the gravels; however, only two sections were found in which it was judged that total flow was measured; the large gravel deposits in this canyon store considerable water, and water probably percolates through the gravels at nearly all of the measuring sections. No channel dams were located on the main stream. Several portable irrigation pumps were found; used to irrigate small acreages of alfalfa and other feed crops. This use probably is small but may be significant during the growing season when natural losses are high and amounts of streamflow are small.

Unlike adjacent streams that head in the Edwards plateau this stream does not obtain significant amounts of base flow from the reach of channel that is on the Glen Rose limestone, which in this region covers only a small area along the floor of the generally deep, narrow canyon.

Date	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From a point 2.0 miles above Real-Uvalde county line to a point 2.2 miles below stream-gaging station near Reagan Wells, Tex.							
1954								
Dec. 16	Dry Frio River	At gravel ford	8.2		0.0			Gravel channel.
16	Dry Frio River	--	8.9		0.2			Estimate. On gravel.
16	Big Burn Creek	At mouth	11.1			0		Rock channel.
16	Dry Frio River	--	11.1		0			Gravel channel.
16	Dry Frio River	--	12.2		1.0			Estimate. On gravel.
16	Dry Frio River	--	13.1		0			Estimate. On gravel.
16	Dry Frio River	--	13.3		0.4			Estimate. On gravel.
16	Dry Frio River	--	13.9		0			Estimate. On gravel.
16	Dry Frio River	--	14.2		0.1			Estimate. On gravel.
16	Mine Creek	1,500 ft above mouth	14.7			0		Rock channel.
16	Dry Frio River	At natural rock ford to ranch	15.3		1.0			Estimate. Rock channel.
16	Dry Frio River	Just above tributary from right	16.4	49°	1.29			Gravel channel.
16	Honey Creek	At mouth	16.8			0		Rock streambed.
16	Dry Frio River	0.2 mi below gravel ford from ranch	18.7	55°	1.24			Rock streambed and gravel banks.
16	Spring	On right bank, 300 ft from river	20.9			.15		Estimate.
16	Tributary	From right	20.9			0		Gravel streambed.
16	Spring	On right bank	21.1			.1		Estimate.
16	Spring	On right bank	21.2			.1		Estimate.
16	Dry Frio River	20 ft below FM 1051	22.6	60°	1.17			Gravel channel.
16	Dry Frio River	400 ft below tributary	24.1	62°	1.83			Rock streambed.
16	Tributary	From left	25.9			0		Gravel channel.
16	Fusch Creek	Near mouth	25.9			.4		Estimate. Rock streambed with gravel banks.
16	Dry Frio River	400 ft above gaging station	26.1	64°	1.99			Smooth rock streambed.
20	Dry Frio River	400 ft above gaging station	26.1		2.0			Not measured. From automatic recorder record.
16	Dry Frio River	Below gravel ford	28.2		0			Gravel channel.
	From a point 10.2 miles upstream from Real-Uvalde county line to a point 1.9 miles below stream-gaging station near Reagan Wells, Tex.							
1955								
Sept. 9	Dry Frio River	300 ft above cedar hunting cabin	0		1.5			Estimate. Rock and gravel channel
9	Tributary	From right	0.1			0		Rock channel. 6-ft dam 50 ft above mouth. Lake full.
9	Trough Spring	On left bank	0.2			.5		Estimate. Flows from bluff 25-30 ft above river.

Date	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From a point 10.2 miles upstream from Real-Uvalde county line near Reagan Wells, Tex., continued				to a point 1.9 miles			below stream-gaging station
1955								
Sept. 9	Dry Frio River	50 ft below rock ford	0.8	74°	2.56			Rock streambed and gravel banks.
9	Dry Frio River	50 ft above rock ford	2.5	77°	2.24			Rock streambed and gravel banks.
9	Dry Frio River	--	6.2		0			Gravel.
9	Dry Frio River	--	7.4		.8			Estimate.
9	Dry Frio River	--	7.7		.2			Estimate.
9	Dry Frio River	At gravel ford	8.2		0			Gravel.
9	Dry Frio River	--	8.9		1.0			Estimate. On gravel.
9	Big Burn Creek	At mouth	11.1			0		Rock streambed.
9	Dry Frio River	--	11.1		0			Gravel.
9	Dry Frio River	--	12.2		1.0			Estimate. On gravel.
9	Dry Frio River	--	13.0		.2			Estimate. On gravel.
9	Dry Frio River	--	13.2		1.5			Estimate. On gravel.
9	Dry Frio River	--	13.5		.5			Estimate. On gravel.
9	Dry Frio River	--	13.7		0			Gravel.
9	Dry Frio River	--	14.5		1.0			Estimate. On gravel.
9	Dry Frio River	50 ft above natural rock ford to ranch	15.3	84°	2.82			Rock channel. Measured 100% of flow here.
9	Dry Frio River	0.2 mi below gravel ford from ranch	18.7	83°	1.68			Rock streambed and gravel banks.
9	Spring	On right bank	20.9			.15		Estimate.
9	Spring	On right bank	21.1			0		
9	Spring	On right bank	21.2			.03		Estimate.
9	Dry Frio River	400 ft below tributary	24.1	85°	.88			Rock streambed.
9	Dry Frio River	400 ft above gaging station	26.1	83°	1.24			Rock streambed.
13	Dry Frio River	400 ft above gaging station	26.1		1.2			From automatic recorder record.
9	Dry Frio River	At gravel ford	28.0		0			Gravel.
	From a point 10.2 miles upstream from Real-Uvalde county line near Reagan Wells, Tex.				to stream-gaging station			
1958								
Jan. 15	Dry Frio River	300 ft above cedar hunting cabin	0	43°	1.99			Rock and gravel channel.
15	Tributary	From right	0.1			.05		Estimate. Rock channel. Dam 50 ft above mouth.
15	Trough Spring	On left bank	0.2			1.00		Estimate. Flows from bluff 25-30 ft above river.
15	Dry Frio River	15 ft above rock ford	0.8	47°	3.95			Gravel channel.

Date 1958	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From a point 10.2 miles upstream from Real-Uvalde county line to stream-gaging station near Reagan Wells, Tex., continued							
Jan. 15	Tributary	From right	2.3			0.5		Estimate. Spring located 1/2 mi upstream from river. Flow disappears in gravel before entering river.
15	Dry Frio River	100 ft above rock ford	2.5	49°	3.44			Rock streambed with gravel banks.
15	Tributary	From right	2.6			.15		Estimate. Enters river over low rock falls.
15	Dry Frio River	50 ft below rock ford	4.8	51°	3.74			Rock streambed with gravel banks.
15	Tributary	From left	6.7			.0		Gravel channel.
15	Dry Frio River	At gravel crossing	6.7		0.0			Gravel channel. Natural gravel dam 300 ft (est.) long.
15	Dry Frio River	20 ft below gravel ford	7.7	56°	4.33			Gravel channel. Seepage from both banks.
15	Tributary	From right	8.3			.15		Estimate. Gravel channel.
15	Big Burn Creek	600 ft above mouth	11.1	59°		1.53		Rock streambed with gravel banks.
15	Dry Frio River	25 ft above tributary from left	12.0	59°	7.11			Rock channel.
15	Tributary	From left	12.0			.4		Estimate. Loose gravel streambed.
15	Tributary	From right	12.1			.0		Gravel. Probably flow below gravel.
15	Tributary	From left	13.0			.5		Loose gravel streambed.
15	Tributary	From right	13.4			.0		Estimate. Probably flow below gravel.
16	Mine Creek	1,500 ft above mouth	14.7	49°		1.78		Rock streambed.
16	Dry Frio River	50 ft above natural rock ford to ranch	15.3	51°	14.8			Rock channel. Measured 100% of flow here.
16	Tributary	From right	16.4			.2		Estimate. Loose gravel streambed.
16	Honey Creek	From right	16.8			.6		Estimate. Rock streambed. Small seeps from high alluvium banks.
16	Tributary	From left	18.3			.02		Estimate. Gravel streambed and high alluvium banks.
16	Dry Frio River	0.2 mi below gravel ford from ranch	18.7	55°	19.1			Rock streambed and gravel banks.
16	Spring	On right bank; 300 ft from river	20.9			.5		Estimate. This spring has had long use as domestic supply.
16	Tributary	From right; just below spring draw	20.9			.0		Gravel. May have underflow.
16	Dry Frio River	100 ft above rock ford to hunters cabin.	21.1	57°	20.3			Rock streambed and gravel banks.

Date 1958	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From a point 10.2 miles upstream from Real-Uvalde county line to stream-gaging station near Reagan Wells, Tex., continued							
Jan. 16	Spring	On right bank; just above hunters cabin	21.1			0.3		Estimate. Flows from crevice in bed of rock draw; 100 ft from river.
16	Spring	On right bank; 400 ft below hunters cabin	21.2			.3		Estimate. Similar to above spring; 25 ft from river.
16	Tributary	From right	24.0			.7		Estimate. Rock channel. Enters river over low falls.
16	Dry Frio River	400 ft below tributary	24.1	59°	22.0			Rock streambed with gravel bar on left.
16	Tributary	From left	25.9			.5		Estimate. Gravel; spring reported 1/2 mile upstream.
16	Fusch Creek	From left. Above crossing; 1,500 ft above mouth	25.9	59°		5.82		Rock streambed with gravel bank. Reported to have headwater springs
16	Dry Frio River	600 ft above gaging station	26.1	57°	28.0			Smooth rock channel.
20	Dry Frio River	At gaging station	26.1		27.0			Not measured; from automatic recorder record.

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Dry Frio River — June 28, 1925

Reach: From Clark's Ranch house to a point 9½ miles below Reagan Wells, Tex.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
June 28	Dry Frio River	At Clark Ranch house 6 mi above Reagan Wells	0		0.5			Estimate.
28	Dry Frio River	Near Hurd School 3.6 mi above Reagan Wells	2.4		1.65			
28	Mine Creek	At Hurd School 3.5 mi above Reagan Wells	2.5			0.5		Estimate.
28	Dry Frio River	½ mi below Reagan Wells	6.5		5.16			
28	Dry Frio River	4½ mi below Reagan Wells	10.5		6.74			
28	Dry Frio River	8 mi below Reagan Wells	14.0		9.66			
28	Dry Frio River	9½ mi below Reagan Wells	15.5		0			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Sabinal River — December 15-16, 1954; September 10-11, 1955

Reach: From a point 8 miles upstream from Vanderpool, Bandera County to gaging station "near Sabinal", located 12.4 miles downstream from Utopia, Tex.

Problem: To determine gains and losses in river flow in the section of Sabinal River channel that flows on the Glen Rose limestone formation above the gaging station "near Sabinal".

Results: No conclusions could be reached due to insufficient flow in the streams involved. The larger flows found in December 1954 over those found in September 1955 were probably the result of decreased evaporation and transpiration. The 1955 investigation was made prior to first frost and no doubt the December flows were comparable to the preceding year.

Accuracy of Results: Only a few actual current-meter measurements were possible but those made were rated "Good - 5%". A considerable number of estimates were made of small flows, which are important only as an indication of visible surface flow. Flow conditions were stable during these investigations and data represent natural conditions.

Date 1954	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Dec. 15	Sabinal River	8.2 mi upstream from Vanderpool	0		0			Pool of water.
15	Sabinal River	7.0 mi upstream from Vanderpool	1.2		.2			Estimate.
15	Sabinal River	At Frank Weed Ranch - 4 mi above Vanderpool	4.2	50°	.96			Rock streambed.
15	Unnamed tributary	3.9 mi upstream from Vanderpool	4.3			0		Gravel streambed.
15	Brushy Creek	1.5 mi upstream from Vanderpool	6.7			.15		Estimated. Rock streambed.
15	Sabinal River	At Vanderpool	8.2	61°	1.02			Gravel streambed.
15	Mill Creek	0.7 mi downstream from Vanderpool	8.9	52°		.88		Rock streambed.
16	Sabinal River	1.2 mi downstream from Vanderpool	9.4	44°	1.84			Rock streambed - gravel banks.
16	Sabinal River	2.1 mi downstream from Vanderpool	10.3		0			Gravel bar.
16	Sabinal River		11.6		.5			Estimated. Gravel bar.
16	Sabinal River		12.5		.75			Estimated. Gravel streambed.
16	Sabinal River		13.2		0			Gravel bar.
16	Sabinal River		14.4		.5			Estimated. Gravel streambed.
16	Sabinal River		14.8		0			Gravel bar
16	Sabinal River		15.7		0			Rock streambed.
16	Sabinal River	0.2 mi upstream from Canon Creek	17.9		0			Gravel streambed.
16	Canon Creek	300 ft above mouth at Utopia	18.1			.5		Estimated. Gravel streambed.

Date	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From a point 8 mi upstream from Vanderpool, Bandera County to gaging station "Near Sabinal", located 12.4 mi downstream from Utopia, Tex. - Continued.							
1954								
Dec. 16	Sabinal River	Crossing FM road 1050	19.0		0			Gravel streambed.
16	Sabinal River	0.2 mi upstream from Turkey Creek	24.5		.5			Estimated. Gravel streambed.
16	Turkey Creek	1,500 ft above mouth	24.7			0		Gravel streambed.
16	Sabinal River	0.8 mi downstream from Turkey Creek	25.5		0			Gravel streambed.
16	Sabinal River	0.4 mi above Onion Creek	28.8		.5			Estimated. Rock streambed and gravel banks.
16	Onion Creek	At mouth	29.2			0		Rock streambed.
16	Sabinal River	Near Sabinal - Gaging station	31.4		0			Gravel streambed.
1955								
Sept. 11	Sabinal River	8.2 mi upstream from Vanderpool	0		0			
11	Sabinal River	7.0 mi upstream from Vanderpool	1.2		0			
11	Sabinal River	At Frank Weed Ranch - 4 mi above Vanderpool	4.2	81°	.26			Rock streambed.
11	Unnamed tributary	3.9 mi upstream from Vanderpool	4.3			0		Gravel streambed.
11	Brushy Creek	1.5 mi upstream from Vanderpool	6.7			.02		Estimated. Rock streambed.
11	Sabinal River	At Vanderpool	8.2		.2			Rocky gravel streambed.
11	Mill Creek	0.7 mi downstream from Vanderpool	8.9			.25		Estimated. Rock streambed.
11	Sabinal River	1.2 mi downstream from Vanderpool	9.4		.4			Estimated. Rock streambed.
11	Sabinal River	2.1 mi downstream from Vanderpool	10.3		0			Gravel bar.
11	Sabinal River		11.6		.1			Estimated. Gravel bar.
11	Sabinal River		12.5		.15			Estimated. Gravel streambed.
11	Sabinal River		13.2		0			Gravel bar.
11	Sabinal River		14.4		.3			Estimated. Gravel streambed.
11	Sabinal River		14.8		.1			Estimated. Gravel bar.
11	Sabinal River		15.7		0			Rock streambed.
10	Sabinal River	0.2 mi upstream from Canon Creek	17.9		0			Gravel streambed.
10	Canon Creek	300 ft above mouth at Utopia	18.1			.81		Gravel streambed.
10	Sabinal River	Crossing FM road 1050	19.0		0			Gravel streambed.
10	Sabinal River	0.2 mi upstream from Turkey Creek	24.5		.3			Estimated. Gravel streambed.
10	Turkey Creek	1,500 ft above mouth	24.7			0		Gravel streambed.
10	Sabinal River	0.8 mi downstream from Turkey Creek	25.5		0			Gravel streambed.
10	Sabinal River	0.4 mi upstream from Onion Creek	28.8		.1			Estimated. Rock streambed and gravel banks.
10	Onion Creek	At mouth	29.2			0		Rock streambed.
10	Sabinal River	Near Sabinal - Gaging station	31.4		0			Gravel streambed.

LOW FLOW INVESTIGATIONS - NUECES RIVER BASIN

Sabinal River April 8-11, 1958

Reach: From a point 8 miles upstream from Vanderpool, Bandera County, to gaging station on Highway 90 at Sabinal, Uvalde County, Tex.

Problem: 1. To determine gains and losses in streamflow in the section of Sabinal River channel on the Glen Rose limestone above the stream-gaging station near Sabinal.

2. To determine the effectiveness of the two existing stream-gaging stations "near" and "at" Sabinal, in indicating losses of flow in the section of channel that crosses the Balcones fault zone above Sabinal.

Results: No material losses were found in the reach on the Glen Rose limestone. This section of channel, 31.4 miles long, contributed all of the flow measured at the upper gaging station, which is point of maximum flow found in this investigation. Sixty-one cfs (58%) of the 105 cfs maximum flow was lost between the two gaging stations, a distance of 17.6 miles. Only about 30 cfs was lost in the 5.4 miles of the losing reach which is on the Edwards limestone; the remainder of the lost water is absorbed into other formations that crop out downstream from the Edwards.

The data obtained in this investigation indicate that the two gaging stations are well located to determine total losses in the faulted zones of this river above Sabinal. The lower station might have been located 8-10 miles further upstream had a logical site been found; however, investigation of the channel in the area did not reveal another site suitable for a gaging station. A good record at all stages can be obtained at the Sabinal site.

Discussion: Current-meter measurements were made at all points of critical interest; many small flows were estimated. No attempt was made to pace the discharge measurements with the rate of change in flow as the investigation progressed downstream. The channel was investigated throughout the reach, and the measurements were made as rapidly and as thoroughly as possible. The rate of change in flow was computed at three points in the reach by two determinations of flow at each of these points. The flow was dropping 5.4% per day at Utopia (mile 17.9), 3.8% per day at the upper gaging station (mile 31.4) and 4.6% per day at lower gaging station (mile 49.0). It is probably not possible to have a constant rate of flow in this reach of the stream if any appreciable amount of flow is present. The sources of base flow respond quickly to rainfall and probably reach their maximum flow before surface runoff is completely gone. Immediately after surface or flood flow has ended the base flow begins to decline and rate of flow falls off rapidly. Near constant flow is found only when rate of flow approaches zero and very small flows remain.

Several small channel dams were found but none that stored an appreciable amount of water. No diversions were observed; no irrigation pumps were located, but it is likely that some water is used for irrigation during the growing season.

Date 1958	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
From a point 8 mi upstream from Vanderpool, Bandera County, to gaging station on Hwy 90 at Sabinal, Uvalde County, Tex.								
Apr. 8	Sabinal River	8.2 mi upstream from Vanderpool	0		0			Deep gravel in channel
8	Unnamed Trib.	8 mi upstream from Vanderpool	.2			0		Deep gravel in channel
8	Sabinal River	6.9 mi upstream from Vanderpool	1.3		.3			Est. - gravel streambed
8	Unnamed Trib.	5.4 mi upstream from Vanderpool	2.8			.5		Rock streambed
8	Sabinal River	At Frank Weed Ranch - 4 mi above Vanderpool	4.2	59°	3.04			Rock streambed
8	Unnamed Trib.	3.9 mi upstream from Vanderpool	4.3			.5		Est. - gravel streambed
8	Brushy Creek	1.5 mi upstream from Vanderpool	6.7			2.0		Est. - rock streambed
8	Unnamed Trib.	0.4 mi upstream from Vanderpool	7.8			.8		Est. - gravel streambed
8	Sabinal River	Vicinity of Vanderpool	8.2	Many springs and seeps along right bank for 1.5 mi above to 2 mi below Vanderpool				
8	Mill Creek	0.7 mi downstream from Vanderpool	8.9	63°		9.33		Gravel streambed - large cypress trees here.
8	Sabinal River	800 ft below low-water road crossing	9.5	62°	21.5			Smooth rock streambed. Springs and large seeps along right bank - cypress and pecan trees.
8	Sabinal River	300 ft below abandoned crossing	12.0	62°	21.3			Gravel streambed. Small springs flowing from low rock right bank. Large cypress trees.
8	Sabinal River	300 ft above creek from left	14.4	65°	21.4			Streambed composed of small boulder embedded in gray clay. Banks low - no cypress trees.
8	Unnamed Trib.	300 ft below above measurement	14.5			2.0		Est. - flow starts in conglomerate creek bed 1/4 mi above mouth.
8	Unnamed Trib.		14.6			0		No cut banks - shallow sloping banks - pecan & mesquite flats.
8	Sabinal River	500 ft above Canon Creek - at Utopia	17.9	66°	39.4			Gravel streambed - grove of large cypress trees - 2nd meas. made to show rate of change in flow.
11	Sabinal River	500 ft above Canon Creek - at Utopia	17.9	63°	33.6			Dropped 5.8 cfs in 65 hours.
8	Canon Creek	300 ft above mouth - at Utopia	18.1	65°		28.1		Gravel streambed - grove of large cypress trees. 2nd meas. made to show rate of change in flow.
11	Canon Creek	300 ft above mouth - at Utopia	18.1	64°		26.0		Dropped 2.1 cfs in 65 hours.
8	Sabinal River	Below Canon Creek	18.2		67.5			Not meas. Sum of above measurements.
11	Sabinal River	Below Canon Creek	18.2		59.6			Not. meas. Sum of above measurements made Apr. 11.

Date 1958	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Apr. 9	Sabinal River	Below Utopia - 100 ft above concrete slab crossing	21.6	64°	70.8			Solidified gravel streambed. Grove of large cypress trees. Smooth rock (Glen Rose) shows in streambed a short distance downstream.
9	Sabinal River	300 ft above Turkey Creek	24.6	66°	73.7			Gravel streambed - smooth rock shoal 300' upstream. A few cypress trees (dead) along right bank.
9	Turkey Creek	1500 ft above mouth - Sabine Grande Ranch	24.7	68°		14.3		Gravel streambed - banks of loam & sparsely wooded.
9	Sabinal River	1500 ft below Ranch Road 187 - 200 ft above Onion Creek	29.1	69°	96.9			Shallow gravel streambed over smooth rock - large cypress trees.
9	Onion Creek	400 ft above mouth	29.2	70°		6.0		Smooth rock streambed. Banks of loam - pecan trees & scattered cypress.
9	Sabinal River	Near Sabinal - gaging station	31.4	70°	105			Solidified gravel streambed.
11	Sabinal River	Near Sabinal - gaging station	31.4		98			Not measured. From recorder record. Flow dropped 7.0 cfs in 42 hours.
Gaging station at mile 31.4 is point of maximum flow. Stream leaves Glen Rose limestone formation and flows onto Edwards limestone about 1/4 mile below gaging station. Flow immediately starts to decrease. No tributary inflow below this point.								
9	Sabinal River	At abandoned highway crossing	33.2	69°	92.3			Very rough streambed, broken rock, gravel & boulders - water weeds & moss. No cypress trees.
10	Sabinal River	1.5 mi above Recharge Dam	35.4	69°	80.0			Streambed of solidified gravel and clay - water weeds and moss.
Downstream edge of Edwards limestone is located 1.4 miles downstream, at mile 36.8								
10	Sabinal River	300 ft above abandoned crossing	39.0	72°	50.2			Streambed of gravel - 100' downstream begins 1/4 mi long rock shoal. Rough & cracked.
10	Sabinal River	At upper edge of rock shoal	42.4	72°	47.0			Rock & gravel streambed
10	Sabinal River	200 ft below State Highway 127	45.8	71°	45.4			Gravel streambed
11	Sabinal River	At Sabinal - gaging station at U. S. Highway 90	49.0	69°	44.0			Rock streambed
13	Sabinal River	At Sabinal - gaging station at U. S. Highway 90	49.0		40.0			Not measured. Discharge determined from gage reading by observer. Dropped 4.0 cfs in 48 hours.

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Sabinal River January 10, 1934

Reach: From a point .8 mi below to 18.8 mi below Utopia, Tex.

Discharge measurements of Sabinal River from a point 0.8 mile below Utopia, Tex., to 18.8 miles below Utopia were made on January 10, 1934 to determine the seepage gains or losses. During the investigation the river was at a constant stage, and measurements represent natural conditions.

Date 1934	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Jan. 10	Sabinal River	.8 mi below Utopia	0		4.98			
10	Sabinal River	7.8 mi below Utopia	7.0		7.82			
10	Sabinal River	18.3 mi below Utopia	17.5		6.46			
10	Sabinal River	18.8 mi below Utopia	18.0		5.90			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Sabinal River May and August 1942

Reaches: From a point 1.0 miles south of Utopia to 6.0 miles north of Sabinal, Tex.
From Onion Creek to a point 6.0 miles north of Sabinal, Tex.

A series of discharge measurements were made during each of the periods May 8, 18, 1942, and August 5, 1942 on the Sabinal River and tributaries, Tex., in reaches 9.5 and 17.5 miles in length between points below Utopia and a point 6.0 miles north of Sabinal, Uvalde County. The investigations were made during periods of constant stage of the river except as noted, and the determinations of gain or loss represent normal conditions.

Date 1942	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From a point 1.0 mi south of Utopia to 6.0 mi north of Sabinal							
May 8	Sabinal River	1.0 mi S of Utopia	0		32.0			Rock channel.
8	Sabinal River	¼ mi above first road crossing below Utopia	3.0		36.3			Rock channel.
8	Onion Creek	At mouth 7½ mi below Utopia	8.0			0.7		Estimate.
8	Sabinal River	Just below Onion Creek	8.0		45.5			Gravel channel.
8	Sabinal River	Just below second road crossing above Sabinal	10.0		45.1			Rock channel.
9	Sabinal River	Just below second road crossing above Sabinal	10.0		42.3			Rock channel.
8	Sabinal River	At first road crossing above Sabinal	12.0		35.1			Rock channel.
9	Sabinal River	At first road crossing above Sabinal	12.0		33.2			Rock channel.
7	Sabinal River	At side road crossing 6 mi N of Sabinal	17.5		0			8 p.m.
8	Sabinal River	At side road crossing 6 mi N of Sabinal	17.5		1.5			Estimate 8 a.m.
8	Sabinal River	At side road crossing 6 mi N of Sabinal	17.5		7.2			8 p.m.
	From Onion Creek to a point 6.0 mi north of Sabinal							
May 18	Onion Creek	At mouth 7½ mi below Utopia	0			1.2		
18	Sabinal River	Just below Onion Creek	0		32.3			Gravel channel.
18	Sabinal River	At second road crossing above Sabinal	2.0		31.8			Rock channel.
18	Sabinal River	At first road crossing above Sabinal	4.0		23.0			Rock channel.

Date 1942	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Onion Creek to a point 6.0 mi north of Sabinal, continued							
May 18	Sabinal River	At side road crossing 6 mi N of Sabinal	9.5		0			
Aug. 5	Onion Creek	At mouth 7½ mi below Utopia	0			0.4		Estimate.
5	Sabinal River	Just below Onion Creek	0		6.55			Gravel channel.
5	Sabinal River	At second road crossing above Sabinal	2.0		3.03			Rock channel.
5	Sabinal River	At first road crossing above Sabinal	4.0		0			
5	Sabinal River	At side road crossing 6 mi N of Sabinal	9.5		0			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Hondo Creek April 5-7, 1958

Reach: From near the headwaters in Bandera County, 6 miles above Tarpley, to U. S. Highway 90 in Medina County, Tex.

Problem: To determine gains and losses in streamflow in Hondo Creek in the reach from near the headwaters in Bandera County to U. S. Highway 90 in Medina County.

Results: To simplify the description of this investigation the section of Hondo Creek covered is divided into three sub-reaches as follows:

Sub-reach 1: That portion lying above the stream-gaging station near Tarpley. This stretch, 12.2 miles long, is entirely on the Glen Rose limestone. It extends from a short distance above Pigeon Roost Creek to the gaging station near Tarpley.

Sub-reach 2: The central portion lying between the stream-gaging stations near Tarpley and Hondo. About 10.5 miles of the 11.9 mile reach is on the Edwards limestone.

Sub-reach 3: This reach extends 13.1 miles downstream from the stream-gaging station near Hondo to U. S. Highway 90, about 5 miles east of Hondo. In this interval the streambed crosses numerous geologic formations and faults.

Note: All references to geology (except those in Bandera County) were taken from Texas Board of Water Engineers Bulletin 5601, "Geology and Ground-Water Resources of Medina County, Texas." This bulletin was prepared in cooperation with the Geological Survey, United States Department of the Interior and was written by Charles L. R. Holt, Jr., Geologist, USGS.

Results, Sub-reach 1: No losses were found in this reach and the flow increased from 7.11 cfs to 58.8 cfs in 12.2 miles. This section of channel is on the Glen Rose limestone and contributes a major portion of the maximum of 58.8 cfs measured at its lower contact. A previous investigation found springs in the Edwards limestone at the head of this stream; therefore, it is presumed that a portion of the 7.11 cfs of initial flow measured is contributed by these springs. Williams Creek, which enters Hondo Creek about 1.0 mile below Tarpley, likewise has Edwards limestone springs at its source and was contributing 15.4 cfs at this time. There were many springs and seeps throughout the reach.

Results, Sub-reach 2: About one-fourth mile above the gaging station near Tarpley, Hondo Creek channel crosses the fault line separating the Glen Rose limestone from the Edwards limestone. Here the character of the channel changes and the flow begins to diminish. The smooth rock of the Glen Rose has given way to the gravel and alluvium on the Edwards. Of the 58.8 cfs at the upper contact of the Edwards limestone, 28.7 cfs (49%) is lost in the 11.9 miles between the gaging stations. Possibly a part of this loss was absorbed by the Buda limestone or the Austin chalk just above the lower gaging station. No contributions of any type were observed in sub-reach 2.

Results, Sub-reach 3: In the first 3.5 miles of this reach 16.5 cfs of a total of 30.1 cfs was lost into the formations that are crossed in this section. This loss averages 4.7 cfs per mile and it seems reasonable to assume that some water likewise is lost in the short section of these same formations extending above the gaging station into sub-reach 2, and that the losing section extends somewhat below the 3.5 miles mentioned above. Below mile 29 the losses appear to be about normal and can be attributed to evaporation and transpiration. The slight gain indicated in the section near the mouth of Verde Creek probably can be attributed to springs and seeps in the Leona formation. It is possible that the contribution from the Leona may increase below Highway 90 where the formation is more extensive.

Discussion: Chart records from the two stream-gaging stations indicate that the rate of flow throughout the reach investigated was slowly decreasing. The change was determined to be -0.5 cfs (0.8%) per day at the gage near Tarpley and -1.47 cfs (4.9%) per day at gage near Hondo. Check measurements are usually made at several points in the reach a few days after completion of an investigation, to indicate comparative flow conditions in the stream. A local rain shower on the immediate basin a few hours after this series of measurements was completed disturbed the rate of change in flow, and made check measurements impossible. The rates of change shown above were computed from gage-height charts for short periods just prior to the rain.

Measurements were started at 9:40 a.m. on April 5 at the mouth of Pigeon Roost Creek, which is about 1.0 mile above the crossing of F.M. 470. They were completed at 4:40 p.m. on April 7 at Highway 90 crossing 5 miles east of Hondo. The starting point was purposely selected far enough upstream to indicate contributions and losses in the Glen Rose limestone. Twenty current-meter measurements were made in the 37.2 miles of the stream investigated. Several estimates were made of springs and smaller tributaries.

The channel in sub-reach 1 is smooth rock, rather precipitous, with falls, rock riffles, deep erosion in places, and here and there a thin covering of gravel. There are numerous springs, and long stretches of channel with seepage of quantity from the alluvium and from cracks and crevices in the limestone. Several channel dams were located but no lakes of consequence. No irrigation or other diversion was found.

In sub-reach 2 the channel is rougher with large deposits of gravel, steep gravel and boulder riffles, and no smooth rock streambed. No springs or seeps were found and all tributaries were dry. The measuring sections are composed principally of large gravel that has a solidified appearance, with vegetation growing in the channel. The streambed on the riffles is extremely rough, and is composed of large gravel and boulders. There are no loose, porous gravel beds in this reach.

The first few miles of sub-reach 3 crosses several geologic formations and faults; rough, broken rock and large gravel beds are the rule in the streambed. In the lower section of the reach, the streambed, rather wide and flat, is principally of fine to medium-sized gravel, with much of it grown up in brush and weeds. Several small seeps were found in this lower section but no springs of consequence.

Date 1958	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
From near the headwaters in Bandera County, 6 miles above Tarpley, to U. S. Highway 90 in Medina County								
Apr. 5	Hondo Creek	100 ft above Pigeon Roost Creek	0		7.11			Smooth rock; seeps along left bank.
5	Pigeon Roost Cr	200 ft above mouth	0.1			2.76		Gravel over rock; seepage along left bank.
5	Spring	1000 ft below Pigeon Roost Creek	0.2			.5		Flowing from left bank.
5	Hondo Creek	3 mi above Tarpley	3.2	73°	12.6			Fine gravel and sand; large seeps from right bank.
5	Hondo Creek	500 ft above Williams Creek	6.1	69°	16.7			Smooth rock and cut down 8-10 ft into rock.
5	Williams Creek	4.7 mi above Hondo Creek	-	72°		5.04		Light gravel over rock, seepage along left bank.
5	2 Springs	3.2 mi above Hondo Creek left bank	-			1.0		Estimate.
5	Tributary to Williams Creek	3.1 mi above Hondo Creek from left	-			1.5		
5	Williams Creek	2.4 mi above Hondo Creek	-			9.14		Rock, partly rough.
5	Tributary to Williams Creek	1.5 mi above Hondo Creek from left	-			1.5		Rock.
5	Williams Creek	1600 ft above Hondo Creek	6.2	74°		15.4		Smooth rock. Bed cut down 10' into rock; strong seeps along left bank at top of rock.
5	Hondo Creek	At mouth of Williams Creek	6.2		32.1			Sum of Hondo and Williams Creek.
5	Tributary	From left - at mouth	6.4			0.2		Estimate; rock.
5	Tributary	From left - at mouth	6.5			3.0		Estimate; rock.
5	Tributary	From left - at mouth	7.2			.3		Estimate; rock.
6	Hondo Creek	50 ft above sharp bend to right	8.3	64°	41.8			Smooth rock. Seeps along left bank.
6	Tributary	From right, 1/4 mi above mouth	9.6	69°		5.66		Smooth rock. No seepage.
6	Hondo Creek	0.5 mi above Bandera Creek	10.0	72°	51.5			Gravel over rock. Small seeps along right bank.
6	Bandera Creek	600 ft above mouth	10.5	74°		3.45		Light gravel over rock. Small seeps along right bank.
6	Hondo Creek	At gaging station near Tarpley	12.2	74°	58.8			Large gravel.
8	Hondo Creek	At gaging station near Tarpley	12.2		57.8			Not measured; determined from recording gage record.
6	Hondo Creek	150 ft below concrete crossing	14.9	70°	49.1			Heavy gravel.
7	Tributary	From left	18.6			0		Gravel and boulders.
7	Hondo Creek	0.2 mile below tributary	18.8	68°	43.9			Gravel and boulders.
7	Hondo Creek	400 ft above Farm Road 462	21.4	65°	35.6			Firm gravel and boulders.

Date 1958	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Apr. 7	Hondo Creek	1000 ft below gaging station near Hondo	24.1	67°	30.1			Firm gravel.
8	Hondo Creek	1000 ft below gaging station near Hondo	24.1		28.2			Not measured; determined from recording gage record.
7	Hondo Creek	At abandoned ranch crossing	27.6	72°	13.6			Loose gravel.
7	Hondo Creek	0.5 mi below low concrete county crossing	31.1	73°	11.0			Broken and disturbed rock.
7	Hondo Creek	1/4 mi upstream from county road	34.7	72°	9.76			Loose gravel.
7	Verde Creek	0.2 mi above mouth	36.9			0.5		Estimate - loose gravel.
7	Hondo Creek	At U. S. Highway 90	37.2	72°	11.1			Medium firm gravel.

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Verde Creek January 14, 1958

Reach: From a point on Middle Verde Creek about 0.5 mile below Joe Short ranch house and 5.5 miles above East Verde Creek to County Road 4 miles west of Quihi, Medina County, Tex.

Problem: To determine the amount of flow in Verde Creek above and below the outcrop of the Edwards limestone in Medina County, Tex.

Results: Total measured streamflow at or just above the upper contact of the Edwards limestone formation was 58.4 cfs, distributed as follows: 48.0 cfs in Middle Verde Creek, mainstream of Verde Creek; 10.4 cfs in East Verde Creek; no flow in Turkey Roost Creek. An estimated 5 to 10 cfs was flowing in Verde Creek at the approximate lower edge of the Edwards limestone, which point is below East Verde and Turkey Roost Creeks. This remaining streamflow had disappeared about 3 miles further downstream; at a concrete crossing on a county road 5-1/2 miles west of Quihi and 0.5 miles above F.M. Road 689. A trickle (0.1 cfs) was found at F.M. 689 and at a county road 1.3 miles below F.M. 689. No springs, seeps, or tributary inflows were found other than that which was measured in East Verde Creek; no reservoirs or diversions were located.

Note: Data for references to geologic formations and fault lines were obtained from Texas Board of Water Engineers Bulletin 5601, Plate 1, "Geology and Ground-Water Resources of Medina County, Texas."

Discussion: Current-meter measurements were made on Middle Verde Creek at a point about 100 feet below a ranch crossing of natural rock about 1/2 mile below the Joe Short ranch house, and on East Verde Creek 400 feet below the lower crossing of the county road from Bandera to Hondo, about 2.2 miles southeast of the Joe Short ranch house. Turkey Roost Creek was inspected at a point about 2-1/2 miles southwest of the Joe Short ranch house and at several other points in the remaining 9 miles to its mouth. No flow was found and the creek, which throughout this reach is on the Edwards limestone, has a poorly defined channel with no definite low-water banks. No additional site suitable for a current-meter measurement was found on the main stream. An estimate of flow (10 cfs) was made at the concrete crossing 0.4 mile upstream from Turkey Roost Creek; and another estimate (5 cfs) at a point 5.2 miles further downstream. At this downstream point the streambed is composed of large gravel and 6-inch to 12-inch boulders on a series of steep rough rapids. The lower edge of the Edwards limestone is located about 2 miles upstream. The first point at which zero flow was observed was at a county concrete crossing 1.3 miles further downstream, about 1/2 mile upstream from the Haby Crossing Fault.

On January 17 a second current-meter measurement was made on East Verde Creek at the same site used on January 14. The second measurement was made to indicate the rate of change in streamflow during this period, there being no stream-gaging station on Verde Creek. The flow had fallen off 2.34 cfs in the three day interval, from 10.4 to 8.06 cfs, or 7.5% per day.

Date 1958	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	From a point on Verde Creek to	Middle Verde Creek about 0.5 mile below Joe Short ranch house and 5.5 miles above East County Road 4 miles west of Quihi, Medina County						
Jan. 14	Middle Verde Cr	1.3 mi below West Verde Creek	0	58°	48.0			Rock streambed.
14	East Verde Cr	3.8 mi above mouth	5.5	58°		10.4		Gravel streambed.
17	East Verde Cr	3.8 mi above mouth	5.5	53°		8.06		Gravel streambed. Second measurement made to indicate rate of change in streamflow.
14	Verde Cr	0.4 mi above Turkey Roost Creek	11.2		10			Estimate; very rough rock streambed.
14	Turkey Roost Cr	9.0 mi above mouth	-			0		Rough broken rock streambed; channel poorly defined.
14	Turkey Roost Cr	1.4 mi above mouth	11.2			0		Rough broken rock streambed; channel poorly defined.
14	Verde Cr	4.8 mi below Turkey Roost Creek	16.4		5			Estimate; very rough, steep riffles composed of large gravel and small boulders.
14	Verde Cr	At county road 1/2 mi above F.M. 689	17.7		0			Rock streambed.
14	Verde Cr	At F.M. 689	18.2		0.1			Estimate; loose gravel streambed.
14	Verde Cr	At county road, 4 mi west of Quihi	19.5		0.1			Estimate; gravel streambed.

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Seco Creek April 1-4, 1958

Reach: From near headwaters in Bandera County (3.2 miles above F. M. 470) to U. S. Highway 90 (1 mile west of D'Hanis), Medina County, Tex.

Problem: To determine gains and losses in streamflow in Seco Creek in the reach from near the headwaters in Bandera County to U. S. Highway 90 in Medina County.

Results: To simplify the description of this investigation the section of Seco Creek covered is divided into four sub-reaches as follows:

Sub-reach 1: That portion on the Glen Rose limestone above the upper contact of the Edwards limestone. This stretch is 16.4 miles long and extends 2.1 miles downstream from the gaging station near Utopia.

Sub-reach 2: The short middle portion about 2.8 miles long that is on the Edwards limestone.

Sub-reach 3: This reach 7.6 miles long extends from the lower contact of the Edwards limestone to the point of zero flow which is located about 7.1 miles downstream from the gaging station near D'Hanis.

Sub-reach 4: The 12.2 miles of channel from the point of zero flow to U. S. Highway 90.

Note: All references to geology in this report except those in Bandera County were taken from Texas Board of Water Engineers Bulletin 5601, "Geology and Ground-Water Resources of Medina County, Texas". This bulletin was prepared in cooperation with the Geological Survey, United States Department of the Interior and was written by Charles L. R. Holt, Jr., Geologist, USGS.

Results, Sub-reach 1: This reach, which is on the smooth rocks of the Glen Rose limestone, contributes most of the flow found in the section of Seco Creek investigated. A part of the initial flow (1.5 cfs) probably comes from springs in the Edwards limestone near the head of the creek. A few small springs and seeps were found a few miles above U. S. Highway 90. The flow increased from 1.5 cfs to about 33.5 cfs in the upper 13 miles of the reach; all tributaries were flowing and many springs and seeps were found. No losses were located in the upper 13 miles of the reach. The losing section begins about 1 mile above the gaging station near Utopia; about 5.3 cfs was lost from that point to the upper contact of the Edwards limestone 2.0 miles below the gage. There were no contributions in the losing section.

Results, Sub-reach 2: The losses in this reach, which flows on the Edwards limestone, could not be determined accurately but were small in comparison with losses in adjacent upstream and downstream reaches. The measurement at mile 16.4 (28.3 cfs) was made at the upper contact of the Edwards limestone. The lower contact is found in the small lake formed by the concrete dam at the Woodard ranch. This dam is built on the upper edge of a very rough rock outcrop which extends downstream below the mouth of Little Seco Creek. Two measurements were made as near the lower contact as possible, one above at mile 18.5 (27.3 cfs) and one below at mile 19.7 (25.4 cfs). Results of the measurements indicate a small loss to the Edwards, a minimum of 1.0 cfs and a maximum of 2.9 cfs. The formation that crops out below the Edwards and above mile 19.7 probably takes more water than the Edwards: losses from mile 19.7 to 21.8 (sub-reach 3) run 5.6 cfs per mile, whereas the Edwards absorbs only 1.0 cfs in 2.1 miles from mile 16.4 to 18.5. No tributary inflow or other contribution to flow was found in this reach.

Results, Sub-reach 3: The formations in this reach absorb 23.5 cfs of flow in 5.5 miles and the flow disappears completely at a point 7.1 miles below the gaging station near D'Hanis. No springs, seeps, or tributary inflow was found in this reach.

Results, Sub-reach 4: Gains or losses could not be defined in this reach due to lack of flow. Several pools were found in the creek a few miles above Highway 90. These are reputed to have springs as their source. A trickle of flow (0.2 cfs) was found on rock 3 miles above the highway; 0.01 cfs was estimated at the highway bridge. The pools and the two small flows above was all the water found in this reach.

Discussion: Current-meter measurements were made at all points of critical interest and a majority of them were made at good measuring sections. Field estimates were made where flows were small or unimportant. No attempt was made to pace the discharge measurements with the rate of change in flow as the investigation progressed downstream. Channel conditions were investigated throughout the reach and measurements were made as rapidly and as thoroughly as possible. The rate of change in flow was determined at three points in the reach by two determinations of flow at each point. The flow dropped 3.48 cfs in 96 hours (6.6% per day) at mile 3.5; 7.3 cfs in 96 hours (5.7% per day) at mile 11.8 (point of maximum flow); and 3.68 cfs in 97 hours (6.8% per day) at mile 21.8. It probably is not possible to have a constant rate of base flow in this stream except as the rate approaches zero and only very small flows are involved.

Measurements were started at 2:50 p.m. April 1, about 1 mile above the Smartt ranch house on West Fork of Seco Creek and about 3.2 miles upstream from Farm Road 470. They were completed at 5:30 p.m. on April 4 at U. S. Highway 90. The starting point was purposely selected far enough upstream to indicate gains or losses of flow in the Glen Rose limestone.

In sub-reach 1 the channel flows on the smooth rocks of the Glen Rose limestone, deeply eroded in places, with falls, steep rock riffles, and here and there a thin covering of gravel. A few springs were found and long stretches of channel where there was seepage of quantity from the banks. No dam nor lake was found except at Woodard ranch; no diversion.

In sub-reach 2 the channel becomes much rougher with broken rocks, boulders, and large deposits of coarse gravel. Measuring conditions in this type of channel are generally poor, and the one measurement made in the reach, at mile 18.5 is so rated. Woodard Cave is found on the right bank of the creek at mile 17.4. This is a vertical hole in the cavernous Edwards limestone about 30 feet in diameter and 200-300 feet deep, located in the flood plain of Seco creek. During extreme floods, a large amount of water flows into this cave. At the peak of the June 17,1958 flood an estimated 200 cfs was flowing into the Edwards limestone through this opening; a much larger quantity of water flowed into it during the flood in May 1935 when the peak stage was 6-7 feet higher than that of June 17, 1958.

The channel in sub-reaches 3 and 4 crosses several geologic formations and about 10 fault lines. Generally the streambed is composed of immense deposits of gravel with here and there shoals of rock. Further measurements should be made in this section when sufficient flow is found to carry through to U. S. Highway 90.

Reconnaissance of Nov. 7, 1958

The following observations were made by the hydrographer who made the above investigation.

Mile 19.7: Flow was determined to be 100 cfs at the recording gage near D'Hanis. Determination made by reference to recording gage and rating curve.

Mile 21.8: Flow estimated to be 60-70 cfs. Channel is composed of gravel.

Mile 22.3: Bartz Spring Creek enters from the left at this point. No flow was found in this creek with its very rough bed of broken rock, large and small boulders and gravel.

Mile 24.2: Flow estimated to be 40-50 cfs in a gravel channel with rock showing here and there.

Mile 24.9: Flow estimated to be 30 cfs in a tight gravel channel which has the appearance of conglomerate. One-fourth mile downstream from this point channel is composed of rock.

Mile 26.2: Flow estimated to be 30 cfs in a gravel channel. Rocky Creek which comes in from the left just upstream from this point was dry.

Mile 27.0: Last of flow disappears at this point. Channel is wide and composed of loose gravel. Last of flow tails out into gravel at lower end of a long pool. Velocity could be observed in the water flowing into the gravel.

Mile 28.2: No flow at FM 1796 crossing where channel is composed of gravel and small boulders.

Mile 32.8: No flow in streambed composed of loose gravel.

Mile 36.0: Estimated flow, 1.5 cfs on rock streambed. This flow is reported to come from springs and seeps in pools a short distance upstream.

Mile 39.0: Estimated flow, 1.5 cfs at U. S. Highway 90. Channel composed of gravel and clay.

Mile 49.0: Estimated flow, 1.5 cfs at Deer Creek road crossing which is about 10 miles below U. S. Highway 90. Channel composed of gravel and clay.

Mile 56.0: Estimated flow, 3.0 cfs at point about 17 miles downstream from U. S. Highway 90. Flow was estimated at a rock shoal in a narrow crooked channel.

Date 1958	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	From near headwaters in Bandera County (3.2 mi above FM 470) to U.S. Hwy 90 (1 mi west of D'Hanis) Medina County							
Apr. 1	West Seco Creek	Smartt ranch - 3.2 mi above FM 470	0	62°	1.50			Gravel. Seeps along both banks.
1	Tributary	From right; below above measurement	0	62°		0.57		Gravel. Seeps along both banks.
1	Spring	On right bank, 1/2 mi above Smartt house	.5			.02		Estimated. Did not go dry during drought.
1	Tributary	From left	.7			.1		Estimate.
1	West Seco Creek	300 ft above East Seco Creek	2.3	65°	3.90			Loose gravel and boulders.
1	East Seco Creek	600 ft above mouth	2.4	66°		3.55		Smooth rock.
2	Tributary	From left, 0.1 mi below FM 470	3.3			1.0		Estimate. Rock.
2	Tributary	From left	3.4	63°		1.80		Smooth rock. Creek enters Seco over 10 ft falls.
2	Seco Creek	1,500 ft below FM 470	3.5	63°	13.1			Smooth rock.
6	Seco Creek	1,500 ft below FM 470	3.5	57°	9.62			Smooth rock. Second measurement made to indicate rate of change of flow.
2	Tributary	From right	4.0			1.5		Estimate. Smooth rock. 25-30 ft fall at mouth.
2	Tributary	From left	4.5			1.0		Estimate. Smooth rock. 15-20 ft falls at mouth.
2	Seco Creek	--	5.5	65°	16.1			Smooth rock. Seeps along left bank.
2	Tributary	From right	6.5			.25		Estimate. Smooth rock.
2	Tributary	From right	7.2			.75		Estimate. Rock channel.
2	Seco Creek	--	7.6	68°	19.6			Smooth rock. Seeps along left bank.
2	Tributary	From right	8.2			.2		Estimate. Rock channel.
2	3 tributaries	From left	8.4	70°		5.11		Rock channel.
2	Seco Creek	At sharp bend to left	9.7	69°	25.8			Gravel. No seepage here.
2	Tributary	From left	10.4			3.0		Estimate. Smooth rock.
2	Tributary	From left	10.7			.8		Estimate. Smooth rock.
2	Tributary	From right	11.6			.2		Estimate. Broken rock.
2	Seco Creek	--	11.8	69°	32.1			Gravel over rock. Seepage along rock bluff on left.
6	Seco Creek	--	11.8	73°	24.8			Gravel over rock. Seepage along rock bluff on left. Second measurement made to indicate rate of change of flow.
2	Tributary	From left	13.2			1.5		Estimate. Rock.

Date 1958	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Apr. 2	Tributary	From right	14.0			0		First with zero flow. No tributary flow below this point.
3	Seco Creek	At gaging station near Utopia	14.4	68°	30.6			Smooth rock. No seepage.
3	Seco Creek	125 ft above north fence of Woodard ranch (Valdina farms)	16.4	72°	28.3			Rock. Some rough.
3	Seco Creek	0.5 mi above Woodard dam	18.5	78°	27.3			Gravel and boulders - rough.
3	Little Seco Cr	9 mi above mouth	-			.0		Gravel.
3	Little Seco Cr	7.1 mi above mouth	-			.1		Estimate. Rock - conglomarate bank.
3	Little Seco Cr	5.7 mi above mouth	-			1.5		Estimate. Rock.
3	Little Seco Cr	4.8 mi above mouth	-			1.5		Estimate. Rock.
	Rough rock falls and riffle. Flow starts disappearing in gravel just below the falls. Light loose gravel with smooth rock showing here and there.							
3	Little Seco Cr	4.6 mi above mouth	-			0		Gravel.
3	Little Seco Cr	3.4 mi above mouth	-			0		Gravel and small boulders.
3	Little Seco Cr	At mouth	19.5			0		Gravel and boulders.
	Seco Creek continued.							
3	Seco Creek	At gaging station near D'Hanis	19.7	82°	25.4			Gravel and small boulders.
3	Seco Creek	100 ft above private concrete bridge.	21.8	75°	13.6			Loose gravel, some large.
7	Seco Creek	100 ft above private concrete bridge.	21.8	71°	9.92			Loose gravel, some large. Second measurement made to indicate rate of change of flow.
4	Bartz Spring Cr	At mouth	22.2			0		Gravel and boulders.
4	Seco Creek	1.3 mi above Rocky Creek	24.6	70°	1.88			Heavy gravel.
4	Seco Creek	Just above Rocky Creek	25.9		1.5			Estimate. Large gravel.
4	Rocky Creek	At mouth	25.9			0		Gravel.
4	Seco Creek	Just below Rocky Creek	26.0		.1			Large bar of loose gravel.
4	Seco Creek	--	26.6		.05			Loose gravel.
4	Seco Creek	--	26.8		0			Wide bed of gravel and small boulders.
4	Seco Creek	Low crossing - FM 1796	28.2		0			Wide bed of gravel and small boulders.
4	Seco Creek	--	32.8		0			Bed of loose gravel.
	There are several large pools from mile 33.7 to 36.0 which are reported to be everlasting.							
4	Seco Creek	--	36.0		.2			Estimate. Rock channel.
4	Seco Creek	At U. S. Highway 90	39.0		.01			Gravel.

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Leona River April 25-28, 1925

Reach: From Uvalde-Friotown Highway bridge to old Woodward Ranch near Batesville, Tex.

Discharge measurements on Leona River from Highway bridge southeast of Uvalde to the old Woodward Ranch, were made in April 1925, to determine seepage gains or losses. The river was at a constant stage during this series of measurements.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Apr. 25	Leona River	At Uvalde-Friotown Highway crossing	0		3.78			
25	Leona Valley Irrigation Co.	Diversion No. 1	2.0				7.24	
25	Leona River	100 ft below Dam No. 1	2.1		1.96			
27	Leona River	At White place above Kincaid Dam	6.1		3.38			
27	Kincaid Canal	300 ft below Dam	8.1				7.66	
27	Leona River	Just below Kincaid Dam	8.1		0			All water diverted.
27	Leona River	3 mi below Kincaid Dam	11.0		12.0			
28	Leona River	At Hackberry crossing	17.0		8.01			
28	Batesville Canal	200 ft below Dam	20.1				4.77	
28	Leona River	Just below Batesville Dam	20.1		1.08			
28	Leona River	1½ mi below Batesville Dam	22.1		.4			Estimate.
28	Leona River	3 mi below Batesville Dam	23.3		.5			Estimate.
28	Leona River	At Ottenhouse Ranch	26.4		.3			Estimate.
28	Leona River	At old Woodward Ranch	33.5		0			Dry downstream.

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Leona River June 11-12, 1931

Reach: From Highway bridge 1.7 mi SE of Uvalde to Rogers Ranch 35 mi SE of Uvalde, Tex.

Discharge measurements of Leona River near Uvalde, Tex., were made on June 11, 12, 1931, to determine seepage gains or losses. During the investigation the river was at a constant stage, and the measurements represent the natural conditions. There were no diversions from the river or inflow from tributaries during this seepage investigation.

Date 1931	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
June 11	Leona River	At Highway bridge 1.7 mi SE of Uvalde	0		3.1			
11	Leona Valley Irrigation Co.	At headgate, Diversion No. 1	2.0				0	
11	Leona River	Just below Leona Valley Irrigation Dam	2.1		8.0			
11	Leona River	At White's place crossing above Kincaid Dam	6.6		16.4			
11	Kincaid Canal	At headgate	8.1				0	
11	Leona River	Just below Kincaid Dam	8.1		7.2			
11	Leona River	3 mi below Kincaid Dam	11.0		19.1			
12	Leona River	At Hackberry crossing	17.0		9.5			
12	Batesville Canal	At headgate	20.1				0	
12	Leona River	Just below Batesville Dam	20.1		6.9			
12	Leona River	1½ mi below Batesville	22.1		4.7			
12	Leona River	3 mi below Batesville	23.3		3.6			
12	Leona River	At Ottenhouse Ranch	26.4		2.2			
12	Leona River	At old Woodward Ranch	33.5		.5			
12	Leona River	At Rogers Ranch	37.5		0			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Leona River November 7, 1932

Reach: From Highway bridge 1.7 mi SE of Uvalde to Hackberry crossing near Batesville, Tex.

Discharge measurements of Leona River near Uvalde, Tex., were made on November 7, 1932, to determine seepage gains or losses. During the investigation the river was at a constant stage, and measurements represent natural conditions. There were no diversions from the river or inflow from tributaries during this investigation.

Date 1932	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Nov. 7	Leona River	At Highway bridge 1.7 mi SE of Uvalde	0		18.6			
7	Leona Valley Irrigation Co.	At headgate, Diversion No. 1	2.0				0	
7	Leona River	At S. L. Gilbert Ranch	5.5		40.8			
7	Kincaid Canal	At headgate	8.1				0	
7	Leona River	Just below Kincaid Canal	8.1		40.1			
7	Leona River	At Hackberry crossing	17.0		39.8			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Leona River June 21, 22, 1934

Reach: From Highway bridge 1.7 mi SE of Uvalde to Rogers Ranch near Batesville, Tex.

Discharge measurements of Leona River near Uvalde, Tex., were made on June 21, 22, 1934, to determine seepage gains or losses. During the investigation the river was at a constant stage, and measurements represent natural conditions. There was no inflow from tributaries during this seepage investigation.

Date 1934	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
June 21	Leona River	At Highway bridge 1.7 mi SE of Uvalde	0		6.8			
21	Lane-Taylor Canal	At headgate	2.0				0	Formerly Leona Valley Irrigation Company.
21	Leona River	Just below Lane-Taylor Dam	2.1		14.4			
21	Leona River	At crossing at White's Place	6.6		18.8			
21	Kincaid Canal	¼ mi below headgate	8.1				3.7	
21	Leona River	½ mi below Kincaid Dam	8.6		7.7			
22	Leona River	5 mi below Kincaid Dam	13.0		12.9			
22	Leona River	At Hackberry crossing	17.0		8.9			
22	Batesville Canal	At headgate	20.1				0	
22	Leona River	Just below Batesville Dam	20.1		5.3			
22	Leona River	3 mi below Batesville	23.3		2.4			
22	Leona River	At Ottenhouse Ranch	26.4		1.6			
22	Leona River	At Rogers Ranch	34.6		0			
	No inflow from tributaries during investigation							

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Leona River October 18-20, 1934

Reach: From Highway bridge 1.7 mi SE of Uvalde to Rogers Ranch near Batesville, Tex.

Discharge measurements of Leona River near Uvalde, Tex., were made on October 18-20, 1934, to determine seepage gains or losses. During the investigation the river was at a constant stage, and measurements represent natural conditions. There was no inflow from tributaries during this investigation.

Date 1934	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Oct. 18	Leona River	At Highway bridge 1.7 mi SE of Uvalde	0		1.4			
18	Lane Taylor Canal	At headgate	2.0				0	
18	Leona River	Just below Lane Taylor Dam	2.1		6.6			
19	Leona River	At S. L. Gilbert Ranch	5.8		11.4			
19	Kincaid Canal	500 ft below headgate	8.1				3.8	
19	Leona River	250 ft below Kincaid Dam	8.1		3.3			
19	Leona River	1 mi below Kincaid Dam	9.1		8.9			
19	Leona River	5 mi below Kincaid Dam	13.0		7.7			
19	Leona River	At Hackberry crossing	17.0		5.2			
19	Batesville Canal	At headgate	20.1				0	
19	Leona River	Just below Batesville Dam	20.1		3.6			
19	Leona River	3 mi below Batesville	23.3		2.6			
20	Leona River	At Ottenhouse Ranch	26.4		.8			
20	Leona River	At Rogers Ranch	34.6		0			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Leona River June and July 1939

Reaches: From Kincaid Dam 10 mi below Uvalde to Rogers Ranch near Batesville, Tex.
From Highway bridge 1.7 mi SE of Uvalde to a point 3 mi below Batesville, Tex.

A series of discharge measurements was made on June 8 and 10 on the Leona River and tributaries, Tex., between Kincaid Dam, about 10 miles below Uvalde, and Rogers Ranch, 36.3 miles below Uvalde. Another series of measurements was made during the period July 5-7 between a point 1.7 miles southeast of Uvalde and a point 23 miles downstream, near Batesville, to determine the seepage gains or losses. The investigations were made during periods of constant stage of the river; however a short flood, reaching a 4-foot stage, occurred about June 3. All flowing tributaries were measured.

Date 1939	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From Kincaid Dam 10 mi below Uvalde to Rogers Ranch near Batesville, Tex.							
June 10	Kincaid Canal	200 ft below headgate	0				3.8	
10	Leona River	½ mi below Kincaid Dam	.5		12.7			
10	Leona River	1 mi below Kincaid Dam	1.0		19.5			
10	Leona River	300 ft below Hackberry crossing	8.9		14.7			
8	Batesville Canal	700 ft below headgate	12.0				5.2	
8	Leona River	400 ft below Batesville Dam	12.0		9.5			
8	Batesville Drain	250 ft above entrance to river	13.7			4.3		Wasteway return from Batesville Canal.
8	Leona River	250 ft below Batesville drain	13.7		11.8			
8	Leona River	3 mi below Batesville Dam	15.2		11.4			
8	Leona River	At Ottenhouse Ranch	18.3		9.7			
8	Leona River	At Rogers Ranch	26.5		8.0			
	From Highway bridge 1.7 mi SE of Uvalde to a point 3 mi below Batesville							
July 5	Leona River	At Highway bridge 1.7 mi SE of Uvalde	0		7.1			
5	Van Ham pump	1,000 ft above Cooks Slough	1.5				.4	Estimate.
5	Leona River	At White's crossing - gaging station	4.8		13.6			
5	Kincaid Canal	300 ft below headgate	8.1				7.9	
5	Leona River	300 ft below Kincaid Dam	8.1		5.9			
6	Leona River	At T.P. Lee Lodge 1.0 mi below Kincaid Dam	9.1		11.8			
6	T.P.Lee Ranch pump	2 mi below Kincaid Dam	10.1				1.6	

Date 1939	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Highway bridge 1.7 mi SE of Uvalde to a point 3 mi below Batesville, continued							
July 6	Leona River	5 mi below Kincaid Dam	13.0		9.6			
6	Leona River	At Hackberry crossing	17.0		6.5			
6	Batesville Canal	½ mi below headgate	20.1				3.1	
6	Leona River	Just below Batesville Dam	20.1		.9			
6	Leona River	1 mi below Batesville Dam	21.0		.3			Estimate.
6	Leona River	2 mi below Batesville Dam	22.0		.1			Estimate.
6	Leona River	3 mi below Batesville Dam	23.0		0			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Leona River — February and August 1946

Reaches: From old Highway bridge 1.7 mi SE of Uvalde to a point .2 mi E of Zavalla-Frio County line, Tex.
From a point 2,500 ft below Kincaid Dam to Kincaid Camp 9.5 mi SE of Uvalde, Tex.
From Highway bridge 1.7 mi SE of Uvalde to a point on George West Ranch 7.1 mi SE of Batesville, Tex.

Three series of discharge measurements were made on Leona River and tributaries in February and August 1946. All of the measurements were made in the reach from the old Uvalde-Pearsall road, 1.7 miles southwest of Uvalde, Uvalde County and a point about 0.2 mile east of Zavalla-Frio County line.

The measurements were made in cooperation with the Ground Water Branch to establish a relation between flow of river with water table in the river valley. Investigations were made during a constant stage and determinations represent natural conditions. Distances along the river were measured on tracings from aerial photographs and U. S. Department of Agriculture Soil Survey Maps.

Date 1946	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From old Highway bridge 1.7 mi SE of Uvalde to a point .2 mi E of Zavalla-Frio County line							
Feb. 5	Leona River	At old Highway bridge 1.7 mi SE of Uvalde	0		0			
5	Leona River	At McKinney Ranch 3.1 mi SE of Uvalde	1.9		4.7			
5	Leona River	At gaging station 4.6 mi SE of Uvalde	3.8		4.7			
5	Leona River	On W. E. Lee Ranch 6.6 mi SE of Uvalde	6.3		9.8			
5	Kincaid Canal	At headgate	8.8				0	
5	Leona River	½ mi below Kincaid Dam	9.3		8.0			
5	Leona River	At Kincaid Camp 9½ mi SE of Uvalde	9.8		13.4			
5	Leona River	At Dockery Camp 9-3/4 mi SE of Uvalde	10.1		13.6			
5	Leona River	300 ft above Leona Lodge crossing	11.0		14.6			
6	Leona River	About .3 mi SE of Leona Lodge	11.3		14.1			
6	Leona River	About .4 mi SE of Leona Lodge	11.6		13.8			
6	Leona River	About .4 mi N of Uvalde-Zavalla County line	11.8		14.0			
6	Leona River	About .3 mi N of Uvalde-Zavalla County line	12.3		15.5			
6	Leona River	About .1 mi below Uvalde-Zavalla County line	12.9		12.2			

Date 1946	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From old Highway bridge 1.7 mi SE of Uvalde to a point .2 mi E of Zavalla-Frio County line, continued							
Feb. 6	Leona River	About .3 mi S of Uvalde-Zavalla County line	13.5		12.8			
6	Leona River	At Smith's crossing 7.2 mi NW of Batesville	15.9		12.3			
7	Leona River	6.2 mi NW of Batesville	17.2		12.8			
7	Leona River	1.4 mi above Hackberry crossing	19.3		10.8			
7	Leona River	At Hackberry crossing	20.8		10.0			
7	Leona River	Near Clay Sherer house	21.3		10.6			
7	Batesville Canal	.4 mi below headgate	23.1				4.4	
7	Leona River	300 ft below Batesville Dam	23.2		3.4			
7	Leona River	.9 mi NE of Batesville	24.5		3.7			
7	Leona River	At bridge 2 mi NE of Batesville	25.4		3.0			
7	Batesville Canal Waste	.7 mi SE of Batesville	26.2			2.6		
7	Leona River	Just below Canal Wasteway	26.2		5.4			
7	Leona River	At Leona Farms Mexican Camp	28.4		4.4			
8	Leona River	At O'Keefe Bros. cattle pen	30.4		3.9			
8	Leona River	3.8 mi SE of Batesville	31.5		3.5			
8	Leona River	Near Otterhouse Ranch house	34.0		2.3			
8	Leona River	On George West Ranch 7.1 mi SE of Batesville	36.3		2.4			
8	Leona River	On Carmichael Ranch 8.1 mi SE of Batesville	38.3		2.0			
8	Leona River	10.6 mi SE of Batesville	42.1		1.2			
8	Leona River	On Rogers Ranch 13.0 mi SE of Batesville	46.2		.5			
8	Leona River	.2 mi E of Zavalla-Uvalde County line	49.4		.2			
	From a point 2,500 ft below Kincaid Dam to Kincaid Camp 9.5 mi SE of Uvalde							
Feb. 19	Leona River	On W. E. Lee Ranch 5.2 mi SE of Uvalde	4.6		8.7			
19	Leona River	On W. E. Lee Ranch 5.8 mi SE of Uvalde	5.5		9.0			
19	Kincaid Canal	At Kincaid Dam	8.8		Not measured - pumping			
19	Leona River	2,500 ft below Kincaid Dam	9.3		3.4			
19	Leona River	2,700 ft below Kincaid Dam	9.4		5.6			

Date 1946	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From a point 2,500 ft below Kincaid Dam to Kincaid Camp 9.5 mi SE of Uvalde, continued							
Feb. 19	Leona River	3,000 ft below Kincaid Dam	9.5		8.2			
19	Leona River	At Kincaid Camp 9½ mi SE of Uvalde	9.8		9.4			
	From Highway bridge 1.7 mi SE of Uvalde to a point on George West Ranch 7.1 mi SE of Batesville							
Aug. 7	Leona River	At Highway bridge 1.7 mi SE of Uvalde	0		0			
7	Leona River	At McKinney Ranch 3.1 mi SE of Uvalde	1.9		.6			
7	Leona River	At gaging station 4.6 mi SE of Uvalde	3.8		.5			
7	Leona River	On W. E. Lee Ranch 5.2 mi SE of Uvalde	4.6		3.0			
7	Leona River	On W. E. Lee Ranch 5.8 mi SE of Uvalde	5.5		2.6			
7	Leona River	On W. E. Lee Ranch 6.6 mi SE of Uvalde	6.3		2.1			
8	Kincaid Canal	At Kincaid Dam	8.8				0.3	
7	Leona River	2,500 ft below Kincaid Dam	9.3		.4			
7	Leona River	2,700 ft below Kincaid Dam	9.4		1.4			
8	Leona River	At Kincaid Damp 9.5 mi SE of Uvalde	9.8		4.1			
8	Leona River	300 ft above crossing at Leona Lodge	11.0		4.4			
8	Leona River	.4 mi SE of Leona Lodge	11.6		4.3			
8	Leona River	.1 mi below Uvalde-Zavalla County line	12.9		3.3			
8	Leona River	At Smith's crossing 7.2 mi NW of Batesville	15.9		1.9			
8	Leona River	6.2 mi NW of Batesville	17.2		1.4			
9	Leona River	1.4 mi above Hackberry crossing	19.3		0			
9	Leona River	300 ft below Hackberry crossing	20.8		0			
9	Leona River	300 ft below Batesville Dam	23.2		0			
9	Leona River	At Batesville bridge	25.4		0			
9	Leona River	.7 mi SE of Batesville below wasteway	26.2		0			
9	Leona River	At O'Keefe Bros. cattle pen 3.1 mi SE of Batesville	30.4		0			
9	Leona River	On George West Ranch 7.1 mi SE of Batesville	36.3		0			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Leona River March 1, 1947

Reach: From Highway bridge 1.7 mi SE of Uvalde to Kincaid Camp 9.5 mi SE of Uvalde, Tex.

A series of five discharge measurements was made on Leona River and tributaries, Tex. The series was made in March between the old Uvalde-Pearsall road bridge, 1.7 miles southeast of Uvalde, Uvalde County, and Kincaid Camp, 9.5 miles southeast of Uvalde. Measurements were made to establish relation between flow of river and water table in the river valley. See report of Texas Board of Water Engineers (page 9), "Relationship of Ground Water to the Discharge of the Leona River in Uvalde and Zavala Counties, Tex." - April 1947.

Investigation was made during a constant stage and determinations represent natural conditions. Distances along river measured on tracings from aerial photographs and U. S. Department of Agriculture Soil-Survey Map.

Date 1947	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Mar. 1	Leona River	At Highway bridge 1.7 mi SE of Uvalde	0		3.49			
1	Leona River	At gaging station 4.6 mi SE of Uvalde	3.8		10.0			
1	Leona River	W. E. Lee Ranch 5.2 mi SE of Uvalde	4.6		17.0			
1	Leona River	2,500 ft below Kincaid Dam	9.3		12.9			
1	Leona River	At Kincaid Camp 9.5 mi SE of Uvalde	9.8		18.4			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Atascosa, Frio and Nueces Rivers — January and April 1951

Reach: From Campbellton to head of Lake Corpus Christi near Mathis, Tex.

During January and April 1951, three series of discharge measurements were made on the Atascosa, Frio and Nueces Rivers, Tex. The purpose was to determine seepage gains or losses along the river, and losses in transmission of water, from artesian wells near Campbellton to the head of Lake Corpus Christi near Mathis. The channels of the Atascosa, Frio and Nueces Rivers were used to transport the water. The Atascosa River is tributary to the Frio River and the Frio River is tributary to the Nueces River which flows into Lake Corpus Christi.

During the period January 23-26, 1951, prior to drilling of artesian well at Campbellton, a seepage investigation of a reconnaissance nature was made from a point near Poteet to the head of Lake Corpus Christi. At this time measurements were made only at those points on main stream and tributaries which were easily accessible.

During period April 19 to May 1, 1951, two series of measurements were made from Campbellton to head of Lake Corpus Christi. The first of these was made with one artesian well flowing into the river. All inflow and diversions were measured throughout the reach. The second was made of river and tributary flow after the artesian well was cut off. An additional measurement was made at miles 87.4, 96.4 and 103.8 as it was suspected that some well water was still present when the first ones were made (see table).

For complete report on transmission of well water from Campbellton to Lake Corpus Christi see U. S. Geological Survey Open File Release No. 42, October 1951, Austin, Texas (SW).

Date 1951	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Jan. 23	Atascosa River	3.0 mi SW of Poteet	0		0			
23	Atascosa River	1.3 mi south of Poteet	2.9	75	0.96			
23	Atascosa River	2.0 mi SE of Poteet	5.1	75	2.73			
23	Atascosa River	3.0 mi NW of Pleasanton	9.0	75	2.30			
23	Atascosa River	At Pleasanton	15.0	77	3.35			
23	Bonita Creek	South edge of Pleasanton	15.3			0.02		
23	Galvan Creek	2.0 mi NE of Pleasanton	17.0			0		
23	Atascosa River	At Coughran	21.0	77	3.82			Artesian wells flowing
24	Atascosa River	0.5 mi east of McCoy	35.1	65	3.84			
24	Unnamed Creek	4.0 mi NW of Campbellton	42.0	70		.20		
24	Borrego Creek	3.0 mi north of Campbellton	46.0	57		.06		
24	Atascosa River	At Campbellton	47.1	57	4.38			
24	Lapan Creek	1.5 mi SE of Campbellton	52.5	65		.10		

Date 1951	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Jan. 24	Matate Creek	3.0 mi SW of Campbellton		55		0.44		
24	La Parita Creek	5.0 mi SW of Campbellton	55.9	58		.39		
25	Atascosa River	At gaging station at Whitsett	59.7	45	4.80			
25	Olmos Creek	1.0 mi SE of Whitsett	61.0			0		
25	Merriman Hollow	2.0 mi SE of Whitsett				.05		
25	San Christoval Creek	5.0 mi SE of Whitsett				0		
25	Atascosa River	4.5 mi north of Three Rivers	71.4	49	4.32			
25	Frio River	1.0 mi above mouth of Atascosa R	73.9			0		
25	City Pump	At Three Rivers water intake	77.1				0.90	
25	Nueces River	4.0 mi above Three Rivers	80.3			0		
25	Nueces River	At gaging station near Three Rivers	80.5	68	3.48			
25	Sulphur Creek	At mouth near Oakville	87.3			.10		
25	Nueces River	1.5 mi SW of Oakville	87.4	60	4.34			
25	Nueces River	1.8 mi NW of George West	96.4	56	5.49			
26	Spring Creek	2.5 mi SW of George West	99.3			0		
26	Nueces River	.8 mi north of Mikeska	103.8	49	5.29			
Apr. 19	Atascosa River	At highway bridge at Campbellton-above well	47.1	70	3.36			
19	Atascosa River	At Campbellton - below well	47.6	97	5.65			
19	Unnamed Creek	Below Campbellton	47.9			.12		
19	Unnamed Creek	Above Lapan Creek	52.1			0		
19	Atascosa River	Above Lapan Creek	52.4	86	6.02			
19	Lapan Creek	At mouth	52.5	79		.30		
19	Atascosa River	Above La Parita Creek	55.8	83	5.36			
19	La Parita Creek	At mouth	55.9	73		.69		
19	Unnamed Creek	.2 mi below La Parita Creek	56.1			0		
19	Unnamed Creek	2 mi above Whitsett	57.9			.10		
19	Sulphur Well	1.6 mi above Whitsett	58.3			.01		
19	Atascosa River	At gaging station at Whitsett	59.7	78	6.30			
20	Olmos Creek	At mouth	61.0	76		.08		
20	Atascosa River	Below Olmos Creek	61.1	77	5.56			
20	Unnamed Creek	½ mi below Olmos Creek	61.3			0		
20	3 unnamed Creeks	Below Olmos Creek				0		
20	Atascosa River	At Falls above Three Rivers	69.0	80	5.61			
20	Atascosa River	At temporary recorder 2½ mi above Three Rivers	71.4	84	5.43			

Date 1951	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Apr. 20	Atascosa River	300 ft above mouth	73.9	80	4.88			
20	Frio River	At mouth of Atascosa R	73.9			0		
21	City Pump	At Three Rivers water intake	77.1				0.56	
20	Nueces River	At mouth of Frio River	80.3			0		
21	Nueces River	At gaging station near Three Rivers	80.5	76	4.30			
21	Sulphur Creek	At mouth near Oakville	87.3			.21		
21	Nueces River	500 ft below Sulphur Creek	87.4	78	4.78			
21	Nueces River	3 mi below Sulphur Creek	89.7		4.99			
21	Nueces River	Near George West	96.4	88	6.12			
21	Spring Creek	Below George West	99.3			.04		
21	Nueces River	At temporary recorder near Mikeska	103.8	82	4.06			
21	Nueces River	Near ruins of Old Fort Merrill below Mikeska	107.3	78	5.48			
27	Atascosa River	At Campbellton	47.6	82	1.94			
27	Unnamed Creek	Below Campbellton	47.9			.12		
27	Lapan Creek	At mouth	52.5	83		.33		
27	Atascosa River	Above La Parita Creek	55.8	83	1.86			
27	La Parita Creek	At mouth	55.9	80		.35		
27	Unnamed Creek	2 mi above Whitsett	57.9			.10		
27	Atascosa River	1.6 mi above Whitsett	58.3	81	1.87			
27	Sulphur Well	1.55 mi above Whitsett	58.3			.03		
27	Atascosa River	At gaging station at Whitsett	59.7	78	1.79			
28	Atascosa River	Above Olmos Creek	61.0	75	1.80			
28	Olmos Creek	At mouth	61.0			0		
28	Atascosa River	At Falls above Three Rivers	69.0	75	1.43			
28	Atascosa River	At temporary recorder 2½ mi above Three Rivers	71.4	75	1.52			
28	Frio River	At mouth at Atascosa R	73.9			0		
28	City Pump	At Three Rivers water intake	77.1				.56	
28	Nueces River	At mouth of Frio River	80.3			0		
28	Nueces River	At gaging station near Three Rivers	80.5		0.46			
28	Sulphur Creek	At mouth near Oakville	87.3			.08		
28	Nueces River	600 ft below Sulphur Creek	87.4	81	1.33			
30	Nueces River	600 ft below Sulphur Creek	87.4	90	0.85			
28	Nueces River	3 mi below Sulphur Creek	89.7	82	1.88			

Date 1951	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Apr. 28	Nueces River	Near George West	96.4	81	2.60			
30	Nueces River	Near George West	96.4	87	1.58			
28	Nueces River	At temporary recorder near Mikeska	103.8	82	3.10			
May 1	Nueces River	At temporary recorder near Mikeska	103.8	75	1.87			
1	Nueces River	Near Old Fort Merrill below Mikeska	105.9	76	2.17			

LOW-FLOW INVESTIGATIONS - NUECES RIVER BASIN

Nueces River April 20-22, 1948

Reach: From gaging station near Mathis to Corpus Christi Water Works at Calallen, Tex.

A series of discharge measurements was made Apr. 20-22, 1948, on the Nueces River and its tributaries, Tex., between the gaging station near Mathis and a point 25½ miles downstream, to determine the seepage gains or losses between the gaging station near Mathis and the city of Corpus Christi Water Works Plant at Calallen. The gates on Mathis Dam were not changed for several days preceding or during the investigation, thereby maintaining a constant stage of the river. All tributaries were investigated for inflow but none were found.

The last measurement made is 10 miles upstream from Corpus Christi Water Works Plant. Pool conditions prevented additional discharge measurements. There was no inflow between point of last measurement and water works.

Date 1948	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Apr. 20	Nueces River	At gaging station near Mathis	0		35.3			
20	Nueces River	4.1 mi SSW of Mathis	1.0		30.6			
20	Nueces River	4.1 mi south of Mathis	2.6		35.0			
20	Arroyo (no name)	At mouth 4 mi SSE of Mathis	4.5			0		
20	Arroyo Nombre de Dios	At mouth 4.3 mi SSE of Mathis	4.9			0		
20	Nueces River	4.4 mi SSE of Mathis	5.0		33.2			
20	Nueces River	3.7 mi NNW of San Patricio	7.0		33.0			
21	Nueces River	2.7 mi NNW of San Patricio	8.9		33.4			
21	Nueces River	2.2 mi NNW of San Patricio	10.9		35.8			
21	Javelin Creek	At mouth 2.4 mi WNW of San Patricio	11.7			0		
21	Sandy Hollow	At mouth 2.5 mi WNW of San Patricio	12.0			0		
21	Nueces River	2.3 mi WNW of San Patricio	13.4		34.0			
21	Nueces River	2.4 mi SW of San Patricio	15.7		35.9			
22	Nueces River	1.7 mi south of San Patricio	18.1		36.5			
22	Nueces River	2.5 mi SSE of San Patricio	19.9		38.0			
22	Dismero Slough	4.7 mi SSE of San Patricio	23.5			0		
22	Nueces River	4.7 mi SSE of San Patricio	23.6		35.6			
22	Nueces River	6.2 mi SE of San Patricio and 10 mi above Water Works Plant - no inflow between	25.5		34.6			

Pecos River May 28-30, 1918

Reach: From Angeles gaging station to Girvin, Tex.

From May 28 to 30, 1918, a study of losses and gains from seepage was made on Pecos River between the New Mexico-Texas State line and Girvin, Tex. Recording gages are maintained at Angeles (near State line), above Barstow, and near Grandfalls. Although data were insufficient to warrant a correction of discharge for time interval, the gages showed that the river was at a practically constant stage previous to and during the investigation so that few corrections for time interval were necessary. From Angeles gage to the Arno-Porterville highway bridge there was a gain of 25 cfs; from Arno-Porterville highway bridge to Barstow gage there was a loss of 30 cfs; and between Barstow and Girvin a gain of 48 cfs. Between the Arno-Porterville highway bridge and Barstow the river flows over a bed of deep sand, the seepage into which, in addition to the natural loss from evaporation might easily account for the loss of 30 cfs between these points.

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
May 28	Pecos River	Near Angeles - gaging station	0		81.7			
29	Pecos River	At Olds Ranch near Angeles	22		73.9			
29	Pecos River	Below the Falls near Riverton	43		86.8			
29	Pecos River	At road crossing near Arno	56		107			Porterville pump not running.
29	Farmers Independent Canal	At headgate 10 mi below Arno	75				12.5	
29	Biggs Canal	At diversion dam	84.8				.5	
29	Pecos River	Above Barstow - gaging station	85.0		64.5			
29	Barstow Canal	At headgate	86.5				64.4	
29	Pecos River	Below Barstow Canal	86.5		1.7			
29	Pecos River	Above Marguretta Flume	90		2.9			
29	Pecos River	Below Marguretta Flume	90		4.1			Leakage in flume.
29	Pecos River	At T.P. Railroad bridge	102		5.0			
29	Toyah Creek	At mouth below Pecos	112			0		
29	Pecos River	Just below Big Valley Dam	117		13.1			No pumping.
30	Pasaino Creek	At mouth	130			0		
30	Imperial Feeder Canal	At headgate 3 mi above Grandfalls	134				15.5	
30	Pecos River	Just below Imperial Canal	134		9.0			
29	Pecos River	Just below Grandfalls Dam	137		8.4			No pumping.
30	Second Imperial Division	At headgate	150				4.2	
30	Pecos River	Just below Second Imperial Div.	150		3.4			
30	Pecos River	Near Grandfalls - gaging station	154		4.6			

Date 1918	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
	From Angeles gaging station to Girvin, continued							
May 30	Zimmerman Canal	At headgates	160				2.5	
30	Pecos River	Just below Zimmerman Canal	160		0			
30	Pecos River	Near Buena Vista	180		16.0			
30	Comanche Creek	At mouth	183			0		
30	Pecos River	At highway crossing at Girvin	203		30.4			

Madera Canyon September 1932-August 1933

Reach: From a point 13.3 mi above to a point 3.5 mi above Toyahvale, Tex.

Date 1932	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Sept. 1	Madera Canyon	At gaging station	13.3		23.2			
1	Madera Canyon	Madera Springs road crossing	7.1		3.9			
1	Madera Canyon	8.2 mi below gage	5.1		0			
2	Madera Canyon	At gaging station	13.3		67.5			
2	Madera Canyon	Madera Springs road crossing	7.1		41.8			
2	Madera Canyon	8.2 mi below gage	5.1		2.2			
2	Madera Canyon	At Duncan-Kingston crossing	3.5		.5			
3	Madera Canyon	At gaging station	13.3		41.8			
3	Madera Canyon	Madera Springs road crossing	7.1		16.1			
3	Madera Canyon	8.2 mi below gage	5.1		8.3			
3	Madera Canyon	At Duncan-Kingston crossing	3.5		4.5			
12	Madera Canyon	At gaging station	13.3		28.7			
12	Madera Springs Creek	At mouth	11.3			0.5		
12	Madera Canyon	At Madera Springs road crossing	7.1		7.2			
12	Madera Canyon	8.2 mi below gage	5.1		2.5			
15	Madera Canyon	At gaging station	13.3		14.5			
15	Madera Canyon	At Madera Springs road crossing	7.1		.3			
15	Madera Canyon	8.2 mi below gage	5.1		.2			
21	Madera Canyon	At gaging station	13.3		5.2			
21	Madera Canyon	At rock outcrop	7.5		0			
21	Madera Canyon	At Madera Springs road crossing	7.1		.3			
21	Madera Canyon	.2 mi below Madera Springs road crossing	6.9		0			
21	Madera Canyon	8.2 mi below gage	5.1		.6			
24	Madera Canyon	At gaging station	13.3		6.7			
24	Side Canyon	At mouth	13.2			.3		
24	Madera Canyon	1.5 mi below gage	11.8		6.7			
24	Madera Canyon	2.5 mi below gage	10.8		1.0			
24	Madera Canyon	3.5 mi below gage	9.8		.2			

Date	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
1932	From a point 13.3 mi above to a point 3.5 mi above Toyahvale, continued							
Oct. 6	Madera Canyon	At gaging station	13.3		37.3			
6	Madera Springs Creek	At mouth	11.3			1.5		
6	Madera Canyon	2.6 mi below gage	10.7		22.6			
6	Madera Canyon	3.7 mi below gage	9.6		4.5			
6	Madera Canyon	At limestone outcrop	9.3		0			
1933								
Aug. 27	Madera Canyon	At gaging station	13.3		17.5			
27	Madera Canyon	At Madera Springs road crossing	7.1		11.4			
27	Madera Canyon	At Duncan-Kingston crossing	3.5		0			

Little Aguja Canyon August 17-October 6, 1932

Reach: From a point 15.5 mi above to 2.2 mi above Toyahvale, Tex.

Date 1932	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Aug. 17	Little Aguja Canyon	At temporary staff gage	15.5		1.3			
17	Little Aguja Canyon	2.8 mi below staff gage	12.7		1.0			
17	South Fork Little Aguja	.2 mi above mouth	11.5			0.4		
17	Little Aguja Canyon	5.5 mi below staff gage	10.0		.4			
17	Little Aguja Canyon	7.0 mi below staff gage	8.5		.6			
17	Little Aguja Canyon	8.5 mi below staff gage	7.0		.4			
17	Little Aguja Canyon	9.6 mi below staff gage	5.9		.2			
17	Little Aguja Canyon	300 ft above limestone bluff	4.3		.1			
17	Little Aguja Canyon	At upper end limestone bluff	4.3		0			
17	Little Aguja Canyon	At lower end limestone bluff	4.0		.2			
17	Little Aguja Canyon	At mouth	2.2		0			
Sept. 1	Little Aguja Canyon	3 mi below staff gage	12.5		12.1			
1	South Fork Little Aguja	.2 mi above mouth	11.5			6.4		
1	Little Aguja Canyon	At mouth	2.2		0			
13	Little Aguja Canyon	50 ft below South Fork	11.3		22.8			
13	Little Aguja Canyon	100 ft above limestone bluff	4.3		0			

Date 1932	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From a point 15.5 mi above to 2.2 mi above Toyahvale, continued							
Sept. 13	Little Aguja Canyon	50 ft above limestone bluff	4.3		0.1			
13	Little Aguja Canyon	.1 mi below limestone bluff	3.9		0			
14	Little Aguja Canyon	50 ft below South Fork	11.3		11.2			
14	Little Aguja Canyon	.5 mi below White bluff	8.2		0			
20	Little Aguja Canyon	60 ft below South Fork	11.3		4.1			
20	Little Aguja Canyon	150 ft above upper Duncan road	9.5		0			
20	Little Aguja Canyon	100 ft above White bluff	8.7		.6			
20	Little Aguja Canyon	600 ft below White bluff	8.6		0			
20	Little Aguja Canyon	At second White bluff	7.8		.6			
20	Little Aguja Canyon	.1 mi below second White bluff	7.7		0			
Oct. 6	Little Aguja Canyon	200 ft below South Fork	11.2		26.8			
6	Little Aguja Canyon	At lower Duncan road crossing	6.0		26.5			
6	Wet Weather Springs	At limestone bluff	4.3			0.2		
6	Little Aguja Canyon	50 ft below limestone bluff	3.9		2.2			
6	Little Aguja Canyon	4,000 ft above mouth	3.0		0			

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Big Aguja Canyon — September 1-October 6, 1932

Reach: From a point 11.8 mi above to 2.2 mi above Toyahvale, Tex.

Date 1932	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
Sept. 1	Big Aguja Canyon	At temporary staff gage	11.8		18.7			
1	Big Aguja Canyon	Above Seven Springs Creek	7.3		4.4			
1	Seven Springs Creek	At mouth	7.2			0.5		
1	Big Aguja Canyon	At mouth	2.2		0			
3	Big Aguja Canyon	At temporary staff gage	11.8		45.4			
3	Big Aguja Canyon	Above Seven Springs Creek	7.3		35.7			
3	Seven Springs Creek	At mouth	7.2			.4		
3	Big Aguja Canyon	At mouth	2.2		19.2			
13	Big Aguja Canyon	At temporary staff gage	11.8		8.6			
13	Walnut Canyon	At mouth	7.5			.2		
13	Big Aguja Canyon	Above Seven Springs Creek	7.3		5.6			
13	Seven Springs Creek	At mouth	7.2			4.8		
13	Big Aguja Canyon	At mouth	2.2		0			
Oct. 6	Big Aguja Canyon	At temporary staff gage	11.8		10.3			
6	Big Aguja Canyon	Above pipe line crossing	9.6		5.6			
6	Break in pipe line	At Canyon crossing	9.5			1.5		
6	Big Aguja Canyon	Below pipe line crossing	9.5		7.1			
6	Walnut Canyon	At mouth	7.5			.6		
6	Big Aguja Canyon	Above Seven Springs Creek	7.3		14.0			
6	Seven Springs Creek	At mouth	7.2			6.1		
6	Big Aguja Canyon	3 mi above mouth	5.2		0			
6	Big Aguja Canyon	½ mi above mouth	2.7		0			
6	Big Aguja Canyon	.4 mi above mouth	2.6		.1			
6	Big Aguja Canyon	At mouth	2.2		.1			

Reeves County Water Improvement District No. 1 near Balmorhea, Tex. July 27, 1922

Reach: From Main Canal headgate to a point near Barlow diversion near Balmorhea, Tex.

Date 1922	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
July 27	Main Canal	At headgates (San Solomon Springs)			34.0			
27	Giffin Springs	Just above confluence with Main Canal				4.65		
27	Bruces Diversion	At headgate below Giffin Springs					3.02	
27	Main Canal	Just below Bruces Diversion			36.1			
27	West Side Diversion	At headgates					7.83	
27	Westerman Diversion	At headgates					4.21	
27	Long Strip Diversion	At headgates					2.79	
27	Main Canal	Near Barlow Diversion			13.8			

Reeves County Water Improvement District No. 1 Canal System — September 25, 26, 1923

Reach: Canal system from headgates to last diversion, near Balmorhea, Tex.

Date 1923	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
Sept. 25	Main Canal	San Solomon Springs at outlet			35.0			
25	Giffin Springs	At outlet				1.75		
25	Main Canal	At Bruces and Stewarts			35.9			
25	Main Canal	At McGarry bridge			34.9			
25	Scherye Diversion						4.54	
26	West Side Delivery	At Koontz corner					12.2	
26	Main Canal	At Scherys and McGarry corner			18.5			
25	S.H.Sharp Delivery						4.72	
25	Grain field delivery						5.26	
25	Main Canal	At Knapp foot bridge			7.56			
25	J. F. Meir Delivery						4.14	
25	Main Canal	In front of Hotel			2.93			
26	West Side Delivery	On Byrd farm ½ mi below headgate					12.6	
26	Sharp Delivery	Bridge at Scherye corner					5.09	
26	Sharp Delivery	At corner of Sharp field					3.99	
26	Saragosa Spring Creek	Near old weir				4.04		

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Reeves County Water Improvement District No. 1 Canal System — April 26, 27, 1923

Reach: From Bruces corner to 6th diversion at Blakesley delivery near Balmorhea, Tex.

Date 1923	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
Apr. 26	Main Canal	400 ft south of Bruce corner			26.2			
26	1st diversion	C. C. Goss to Carpenter Place					3.05	
27	West Side Delivery	2nd diversion at County corner					6.97	
27	Main Canal	At Town delivery below 4th diversion			8.05			
27	Town delivery						0	
27	Main Canal	At Scherye corner			7.68			
27	Moore diversion	5th diversion					3.77	
27	Main Canal	Below Blakesley delivery			0			

Reeves County Water Improvement District No. 1 Canals near Balmorhea — October 27-November 18, 1931

Reach: Laterals of canal system, near Balmorhea, Tex.

Date 1931	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
Oct. 27	Carpenter takeout	At point of diversion	0		2.81			
27	Carpenter takeout	At point of delivery	1.0		2.73			
27	Reservoir takeout	At point of diversion	0		2.83			
27	Reservoir takeout	At confluence with creek	1.0		2.33			
27	Highway ditch	At point of diversion	0		9.32			
27	Mills ditch	At point of diversion	.8				5.91	
27	Highway ditch	Below Mills ditch takeout	.8		3.80			
27	Highway ditch	At point of delivery to Mayer farm	1.3		3.84			
28	Siphon ditch	At point of diversion	0		9.32			
28	Siphon ditch	At point of delivery to Fane Down farm	2.3		6.19			
Nov. 16	Moore canal	300 ft below dam	0		4.29			
16	Moore canal	At P.V.S. Railway crossing	.5		4.35			
16	Saragosa canal	1,000 ft below diversion dam	0		1.97			
16	Saragosa canal	At weir	.5		1.68			
18	Giffin Spring canal	At weir	0		3.80			
18	Giffin Spring canal	At siphon	.8		4.06			

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Reeves County Water Improvement District No. 1 Canal near Balmorhea — October 27, 28, 1931

Reach: Main canal from source to end, near Balmorhea, Tex.

Date 1931	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Oct. 27	Main canal	300 ft below San Solomon Spring	0		32.0			
27	Carpenter takeout	200 ft below weir	.8				2.81	
27	Giffin Spring	At source	1.4			1.34		
27	Reservoir takeout	At point of diversion	1.4				2.83	
27	Henry Jones takeout	At point of diversion	1.4				.40	
27	North canal takeout	At point of diversion	2.2				.27	
27	Gate leakage	Total leakage on Main Canal					.12	
27	Main canal	At Crenshaw garage	4.0		25.3			
27	Walker takeout	At point of diversion	6.0				.61	
27	Gate leakage	Total leakage on Main Canal					.10	
28	Main canal	At highway No. 3 crossing	7.0		21.4			
28	Highway takeout	At point of diversion	7.0				5.94	
28	Sol Mayer takeout	At point of diversion	8.0				5.20	
28	Saragosa canal	At weir inflow point	8.4			1.98		
28	Siphon ditch takeout	At weir	8.4				8.98	
28	Gate leakage	Total leakage on Main Canal					.60	
28	Main canal	150 ft below Siphon ditch takeout	8.4		1.42			
28	Gate leakage	Total leakage on Main Canal					.70	
28	Main canal	½ mi above end of system	11.4		.38			

Reeves County Water Improvement District No. 1 Canal near Balmorhea — January and March 1933

Reach: Main canal from source to end, near Balmorhea, Tex.

Date 1933	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
Jan. 11	Main canal	500 ft below Giffin canal	1.8		48.7			
11	North spill	At Knapps corner	3.1				26.3	
11	Main canal	At Balmorhea Hotel	4.7		19.9			
11	Gate leakage	Total of 2 leaks					.1	
11	West Sandia canal	At gage	5.6			1.8		
11	Main canal	At Brogado	6.0		22.2			
11	Lateral diversion	At point of diversion	6.6				.8	
11	Main canal	½ mi above highway crossing	7.1		20.2			
11	Gate leakage	Total of 3 leakr					.2	
11	Main canal	½ mi below highway crossing	8.1		21.0			
12	Siphon ditch	At weir 75 ft below msi n canal	9.6				1.8	
12	Main canal	Just below Siphon ditch	9.7		17.1			
12	Main canal	Near end of system	11.1		17.4			
Mar. 13	Main canal	500 ft below Giffin canal	1.8		11.3			
13	Main canal	At Wigley road crossing	2.8		11.4			
13	Gate leakage	At Knapps corner	3.1				.1	
13	Main canal	400 ft above Highway Garage	4.7		11.0			
13	West Sandia canal	50 ft above highway	5.6			1.3		
13	Main canal	1 mi below Grogado	6.3		11.9			
13	Main canal	At highway crossing	7.7		11.9			
13	Experiment Farm spill	At highway crossing	8.3			.6		
13	Main canal	Above Saragosa canal	9.6		12.5			
13	Main canal	½ mi below Siphon ditch	10.1		8.3			
13	Main canal	At Saragosa road crossing	11.1		8.8			
14	Main canal	500 ft below Giffin canal	1.8		8.2			
14	Gate leakage		3.0				.1	
14	Gate leakage		3.7				.1	
14	Main canal	400 ft above Highway Garage	4.7		7.8			

Reeves County Water Improvement District
No. 1 canal system near Balmorhea — February 6, 7, 1935

Reach: Middle Canal, Main Canal takeout to Balmorhea Reservoir, and Madera Canal, near Balmorhea, Tex.

During the investigation the stage remained constant.

Discharge measurements of laterals of Reeves County Water Improvement District No. 1 from San Solomon Springs to Balmorhea Reservoir, near Balmorhea, Tex., to determine seepage, on San Solomon Springs Middle Canal, Main Canal takeout to Balmorhea Reservoir, and Madera Canal, in February 1935.

Date 1935	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Feb. 6	Middle Canal	.5 mi below San Solomon Springs	.5		34.1			Total flow of springs.
7	Main Canal	Just below check gate 2½ mi above Balmorhea	1.4				2.2	Leakage thru gate.
7	Main Canal takeout to Balmorhea Reservoir	.2 mi below point of diversion	1.6		42.8			Combined flow of San Solomon and Phantom Lake Springs except leakage.
7	Main Canal takeout to Balmorhea Reservoir	.6 mi below point of diversion	2.0		44.0			
7	Madera Canal	Just above Main Canal takeout	2.2			0		
7	Madera Canal	½ mi below Main Canal takeout	2.7		42.0			
7	Madera Canal	300 ft above Balmorhea Reservoir	4.2		37.8			

Reeves County Water Improvement District
No. 1 canal system near Balmorhea — July-September 1940

Reach: All lateral canals of system, near Balmorhea, Tex.

A series of discharge measurements was made on each of several laterals in Reeves County Water Improvement District No. 1 in Toyah Creek Basin in the vicinity of Balmorhea, Tex., to determine seepage gains or losses. The investigations were made during periods of constant discharge and the determinations of gain or loss represent normal conditions. All diversions from each lateral were measured.

Date 1940	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
July 2	North lateral	At U. S. Highway290 road crossing	0		0.70			
2	North lateral	At NE corner of sec. 258	.9		.52			
2	North lateral	1 mi NW of Balmorhea	2.2		.50			
2	North lateral	At corner of sec. 39, 51, and 94	2.9		.49			
2	Delivery ditch	60 ft below the above location	2.9				0.1	Estimate.
2	North lateral	1 mi NE of Balmorhea	4.0		.16			
Aug. 28	North lateral	At U. S. Highway 290 road crossing	0		.52			
28	North lateral	At County road crossing NE edge of NW ¼ sec. 258	.4		.45			
28	North lateral	At NE corner of sec. 258	.9		.40			
28	North lateral	In SE ¼ sec. 259 near line between sec. 259 and 260	1.7		.32			
28	North lateral	Just below county road crossing at N corner sec. 260	2.5		.32			
28	Delivery ditch	10 ft below the above location	2.5				.02	Estimate.
28	North lateral	At corner of sec. 39, 51, and 94	2.9		.30			
28	Delivery ditch	4 ft below the above location	2.9				.03	Estimate.
28	North lateral	1 mi NE of Balmorhea	4.0		.21			
28	Humphrey-Mayer lateral	50 ft below headgate	0		3.36			
28	Humphrey-Mayer lateral	20 ft above drainage ditch	.5		2.95			
28	Humphrey-Mayer lateral	50 ft below drainage ditch	.5		3.57			Increase from drainage ditch.
28	Humphrey-Mayer lateral	20 ft above property line of Helms and Mayer	.7		3.48			

Date 1940	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Aug. 29	Back lateral	50 ft below property line of Pacy and Mott tracts	0		4.34			
29	Back lateral	1,000 ft below SW corner of SE ¼ sec. 117	1.1		4.57			
29	Back lateral	650 ft above SE corner of SW ¼ sec. 128	1.7		4.37			
29	Back lateral	650 ft below SE corner of SW ¼ sec. 128	2.2		4.34			
Sept. 6	Greasy Row lateral	50 ft below headgate	0		.60			
6	Delivery ditch	½ mi below headgate	.5				0.01	
6	Greasy Row lateral	½ mi below headgate	.5		.60			
6	Delivery ditch	1 mi below headgate	1.0				.01	
6	Greasy Row lateral	1½ mi below headgate	1.5		.56			
Aug. 29	Halbert corner lateral	Just below county road crossing	0		4.28			
29	Delivery ditch	30 ft above SW corner of SW ¼ sec. 129	.7				.03	
29	Halbert corner lateral	15 ft below SW corner of SW ¼ sec. 129	.7		4.32			
29	Halbert corner lateral	Near SW corner of NW ¼ sec. 129	1.2		3.82			
29	Delivery ditch	10 ft below the above location	1.2				.03	
29	Delivery ditch	At boundary between Pardoe and Hanaker Estate	1.4				.15	
29	Halbert corner lateral	Near SE corner of NW ¼ sec. 129	1.6		4.22			
29	Ikens Estate lateral	SW corner of SW ¼ sec. 116 Blk 13	0		5.50			
29	Ikens Estate lateral	Boundary between Benham and B. L. Co.	.2		4.54			

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Reeves County Water Improvement District No. 1 canal system — July, August 1932 and July 1933

Reach: Reservoir outlet canal from reservoir to main canal, near Balmorhea, Tex.

Date	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
1932								
July 22	Outlet canal	.1 mi below release gate	.1		52.2			
22	Gate leakage	.3 mi below release gate	.3				0.4	
22	Outlet canal	3.5 mi below release gate	3.5		48.0			
26	Outlet canal	.1 mi below release gate	.1		42.1			
26	Gate leakage	.3 mi below release gate	.3				.3	
26	Outlet canal	.7 mi below release gate	.7		40.9			
26	Outlet canal	1.7 mi below release gate	1.7		41.1			
26	Outlet canal	2.4 mi below release gate	2.4		39.8			
26	Outlet canal	50 ft above main canal	3.5		41.5			
Aug. 17	Outlet canal	.1 mi below release gate	.1		1.8			
17	Outlet canal	.4 mi below release gate	.4		2.1			
17	Outlet canal	2.6 mi below release gate	2.6		1.6			
1933								
July 20	Outlet canal	.2 mi below release gate	.2		14.2			
20	Outlet canal	.4 mi above main canal	3.1		11.6			
26	Outlet canal	.2 mi below release gate	.2		7.2			
26	Outlet canal	.6 mi above main canal	2.9		6.0			

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

West Sandia Creek October 17, 1932

Reach: From a point 4,000 ft above gage to the gaging station near Balmorhea, Tex.

Date 1932	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Oct. 17	West Sandia Creek	300 ft above springs	0		0.2			
17	West Sandia Creek	80 ft below springs	.07		.6			
17	Canal wasteway	500 ft below springs	.15			0.1		
17	West Sandia Creek	At gaging station	.76		2.2			

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Cherry Canyon September 15-October 7, 1932

Reach: From a point 1.5 mi above to 2.5 mi below gage near Toyahvale, Tex.

Date 1932	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Sept. 15	Cherry Canyon	10 mi above Highway 290 - gaging station	0		13.5			
15	Cherry Canyon	500 ft above Kingston line fence	2.0		0			
21	Cherry Canyon	1.5 mi above gaging station	-1.5		1.2			
21	Cherry Canyon	At gaging station	0		5.0			
Oct. 7	Cherry Canyon	At gaging station	0		31.2			
7	Cherry Canyon	2.5 mi below gaging station	2.5		0			

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Limpia Creek — October 1932-August 1933

Reach: From a point 12.3 mi above to 40.2 mi below Fort Davis, Tex.

Date 1932	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Oct. 8	Limpia Creek	.8 mi below Wild Rose Canyon	14.7		31.0			
8	Short Canyon	At mouth	15.8			1.8		
8	Limpia Creek	500 ft below old Limpia post office	18.2		46.0			
8	Limpia Creek	3 mi below old Limpia post office	21.2		41.8			
8	Horse Thief Canyon	At mouth	27.7			1.2		
8	Runey Canyon	At mouth	27.9			1.5		
8	Limpia Creek	At Jeff Ranch house	28.2		65.1			
8	Limpia Creek	9 mi below Jeff Ranch house	37.2		4.2			
8	Limpia Creek	12 mi below Jeff Ranch house	40.2		0			
18	Limpia Creek	12.3 mi above old Fort Davis lane	-12.3		.1			
18	Limpia Creek	12.0 mi above old Fort Davis lane	-12.0		0			
18	Limpia Creek	11.3 mi above old Fort Davis lane	-11.3		.2			
18	Limpia Creek	11.0 mi above old Fort Davis lane	-11.0		0			
18	Limpia Creek	10.3 mi above old Fort Davis lane	-10.3		.5			
18	Limpia Creek	9.8 mi above old Fort Davis lane	- 9.8		0			
18	Limpia Creek	9.7 mi above old Fort Davis lane	- 9.7		.1			
18	Limpia Creek	7.9 mi above old Fort Davis lane	- 7.9		.6			
18	Limpia Creek	6.0 mi above old Fort Davis lane	- 6.0		5.7			
18	Side Canyon	5.9 mi above old Fort Davis lane	- 5.9			.5		
18	Limpia Creek	3.7 mi above old Fort Davis lane	- 3.7		5.7			
18	Limpia Creek	1.3 mi above old Fort Davis lane	- 1.3		5.3			
18	Grayson Canal	At old Fort Davis lane	0				0.5	
18	Limpia Creek	At first Fort Davis-Toyahvale crossing	1.2		3.8			
19	Limpia Creek	At first Fort Davis-Toyahvale crossing	1.2		3.8			
19	Side Canyon	2.1 mi below old Fort Davis lane	2.1			.4		
19	Side Canyon	2.1 mi below old Fort Davis lane	2.1			.2		
19	Limpia Creek	4.2 mi below old Fort Davis lane	4.2		8.0			
19	Side Canyon	4.8 mi below old Fort Davis lane	4.8			.5		
19	Limpia Creek	7.2 mi below old Fort Davis land	7.2		8.8			

Date	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
1932	From a point 12.3 mi above to 40.2 mi below Fort Davis, continued							
Oct. 19	Limpia Creek	10.2 mi below old Fort Davis lane	10.2		8.4			
19	Frazier Canyon	At mouth	10.3			0.4		
19	Limpia Creek	At upper end of Wild Rose Canyon	11.7		9.4			
19	Limpia Creek	At lower end of Wild Rose Canyon	14.0		12.9			
19	Short Canyon	At mouth	15.8			.1		
19	Limpia Creek	At old Limpia post office	18.2		14.0			
Nov. 1	Limpia Creek	At old Limpia post office	18.2		8.2			
1	Limpia Creek	3 mi below old Limpia post office	21.2		5.4			
1	Limpia Creek	5.9 mi below old Limpia post office	24.1		4.6			
1	Limpia Creek	At Jeff Ranch house	28.2		6.2			
1	Limpia Creek	1 mi below Jeff Ranch house	29.2		0			
21	Limpia Creek	At upper end of Wild Rose Canyon	11.7		4.0			
21	Limpia Creek	At lower end of Wild Rose Canyon	14.0		6.1			
21	Limpia Creek	At old Limpia post office	18.2		4.7			
21	Limpia Creek	3 mi below old Limpia post office	21.2		2.0			
21	Limpia Creek	6 mi below old Limpia post office	24.2		1.1			
21	Limpia Creek	At Jeff Ranch house	28.2		2.4			
21	Limpia Creek	½ mi below Jeff Ranch house	28.7		0			
1933								
Aug. 3	Limpia Creek	75 ft below mouth of Short Canyon	15.8		12.6			
3	Limpia Creek	At old Limpia post office	18.2		4.0			
3	Limpia Creek	½ mi below old Limpia post office	18.7		0			

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Toyah Creek November 1932-July 1933

Reach: From a point 1.2 mi above to a point 8.8 mi below Toyahvale, Tex.

Date	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
1932								
Nov. 6	Toyah Creek	At Aloma settlement	1.0		13.6			
6	Project waste	.9 mi above Balmorhea	3.9			0.3		
6	Saragosa Springs Creek	150 ft above mouth	4.7			9.9		
6	Toyah Creek	500 ft below Balmorhea bridge	4.8		29.1			
6	Toyah Creek	500 ft below Moore Dam	5.8		30.7			
6	Toyah Creek	At Saragosa Dam	8.8		29.0			
1933								
Jan. 23	Toyah Creek	1.8 mi above Balmorhea bridge	3.0		0			
23	Saragosa Springs Creek	200 ft above mouth	4.7			8.2		
23	Toyah Creek	300 ft below Balmorhea bridge	4.8		12.5			
23	Toyah Creek	300 ft below Moore Dam	5.8		12.8			
23	Toyah Creek	At Saragosa Dam	8.8		10.5			
Mar. 14	Toyah Creek	At U. S. Highway 290 crossing	-1.2		2.5			
14	Toyah Creek	1.8 mi above Balmorhea bridge	3.0		0			
14	Saragosa Springs Creek	200 ft above mouth	4.7			6.7		
14	Toyah Creek	500 ft below Balmorhea bridge	4.8		9.4			
14	Moore Canal	150 ft below headgates	5.8				5.3	
14	Toyah Creek	500 ft below Moore Dam	5.8		4.8			
14	Saragosa Canal	50 ft below headgates	8.8				6.0	
14	Toyah Creek	50 ft below Saragosa Dam	8.8		.2			
May 16	Toyah Creek	1.8 mi above Balmorhea bridge	3.0		0			
16	Saragosa Springs Creek	50 ft above mouth	4.7			6.4		
16	Toyah Creek	500 ft below Balmorhea bridge	4.8		9.2			
16	Moore Canal	2,000 ft below headgates	5.8				7.3	
16	Toyah Creek	500 ft below Moore Dam	5.8		1.6			
16	Saragosa Canal	50 ft below headgates	8.8				4.0	
16	Toyah Creek	50 ft below Saragosa Dam	8.8		0			

Date 1933	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
	From a point 1.2 mi above to a point 8.8 mi below Toyahvale, continued							
July 11	Toyah Creek	1.8 mi below Balmorhea bridge	3.0		0			
11	Saragosa Springs Creek	200 ft above mouth	4.7			5.6		
11	Toyah Creek	500 ft below Balmorhea bridge	4.8		8.3			
11	Moore Canal	2,000 ft below headgates	5.8				7.0	
11	Toyah Creek	500 ft below Moore Dam	5.8		1.6			
11	Saragosa Canal	125 ft below headgates	8.8				3.5	
11	Toyah Creek	50 ft below Saragosa Dam	8.8		0			

Pecos County Water Improvement District No. 1 canal system at Fort Stockton — November-December 1939

Reach: High line, Seven-D, lateral No. 2, and lateral No. 3 Canals, near Fort Stockton, Tex.

A series of discharge measurements was made on each of several canals and laterals in Pecos County Water Improvement District No. 1 in Comanche Creek Basin in the vicinity of Fort Stockton, Tex., to determine seepage gains or losses. The investigations were made during periods of constant discharge and the determinations of gain or loss represent normal conditions. All diversions from each canal were measured.

Date 1939	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Nov. 24	High line Canal	1.2 mi below headgates	-		28.3			
24	Lateral No. 2	SW corner water tract 25, sec. 8	-				11.1	
24	High line Canal	2.8 mi below headgates	0		12.4			
24	Lateral No. 3	At Grandfalls-Fort Stockton Hwy.	1.1				5.3	
24	High line Canal	At Grandfalls-Fort Stockton Hwy.	1.1		6.8			
24	High line Canal	In water tract 7, sec. 2	3.6		6.7			
24	High line Canal	9.2 mi below headgates at end of concrete	6.4		6.3			
Dec. 14	High line Canal	At headgates	0		41.0			
14	Seven-D Canal	Just above Fort Stockton-Sheffield Hwy.	1.2				13.8	
14	High line Canal	2½ mi below headgates	2.5		27.6			
14	Seven-D Canal	At headgates	0		13.8			
14	Seven-D Canal	Just below siphon under Comanche Creek	.1		13.5			
14	Delivery ditch	In water tract 3, sec. 2	1.4				6.4	
14	Delivery ditch	In water tract 1, sec. 2	1.5		6.4			
14	Lateral No. 2	At headgates	0		12.1			
14	Minear delivery	¼ mi below headgates	.2				5.4	
14	Lateral No. 2	2,000 ft below headgates	.4		6.7			
14	Lateral No. 2	1 mi below headgates	1.0		6.7			
14	Delivery ditch	At Barker House in water tract 63, sec. 10	2.4		6.3			
14	Lateral No. 3	At headgate	0		6.2			
14	Lateral No. 3	At end of concrete sec.	1.8		6.2			

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Rio Grande February 7-20, 1925

Reach: From Lajitas to Del Rio, Tex.

During this series of measurements the river was at a constant stage and the measurements represent natural conditions.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
Feb. 7	Rio Grande	At Lajitas	0		1,060			
7	Terlingua Creek	At mouth	16.8			0		
8	Rio Grande	At Sublett, Tex., ½ mi below Grand Canyon of Santa Helena and mouth of Terlingua Creek	17.3		1,040			
9	Rio Grande	Near Mariscal damsite	60.5		1,040			
11	Rio Grande	At Boquillas, Coah.	79.5		1,090			
13	Rio Grande	At Stillwell crossing	94.0		1,120			
15	Rio Grande	At Reagan Canyon	118.9		1,220			
19	Rio Grande	At Langtry	219.8		1,440			
19	Pecos River	Near Comstock - gaging station	240.7			199		From daily records.
20	Devils River	Near Del Rio - gaging station	281.2			378		From daily records.
20	Rio Grande	Near Del Rio	293.1		2,420			

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Devils River January and October 1921

Reach: From a point about 30 mi above to mouth near Del Rio, Tex.

Date 1921	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
Jan. 26	Devils River	At Rubboard Ford	0		283			
26	Smiths Spring	8 mi below Rubboard Ford	8			25		Estimate.
28	Devils River	At Rough Canyon Damsite	20		393			
27	Devils River	At Del Rio-Comstock road crossing	25		417			
27	Devils River	½ mi below Southern Pacific Railroad bridge	27.2		448			Rock channel.
Oct. 6	Devils River	At Rough Canyon Damsite	20		292			
7	Devils River	At Del Rio-Comstock road crossing	25		290			
7	Devils River	At Southern Pacific Railroad bridge	26.8		342			
7	Devils River	At Abandoned gage site at Devils River	27.8		344			

Devils River August 8-13, 1925

Reach: From Beaver Lake to Del Rio-Comstock highway crossing, Val Verde County, Tex.

During this investigation the stream was at a constant stage and the measurements represent natural conditions.

Date 1925	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
Aug. 8	Devils River	Just below Beaver Lake	0		1.6			
8	Devils River	.2 mi below Beaver Lake	.2		0			
8	Juno Springs	At Juno	3.2			5.8		
8	Devils River	1.0 mi below Juno	4.2		0			
8	Devils River	Just above Pecan Springs Creek	13.7		0			
8	Devils River	Just below Pecan Springs Creek	13.8		42.2			
8	Devils River	At first crossing above Bakers Crossing	19.3		78.1			
8	Devils River	At Bakers Crossing - gaging station	22.3		119			
9	Devils River	1½ mi below Bakers Crossing	23.8		122			
9	Devils River	5½ mi below Bakers Crossing	26.6		132			
9	Devils River	7 mi below Bakers Crossing	32.5		148			
10	Devils River	3 mi above Dolan Creek	33.5		165			
10	Dolan Creek	At mouth	36.5			34.2		
10	Devils River	Just below Dolan Creek	36.5		243			Large increase from east side not measurable.
10	Dry Devils River	At mouth	45.4			0		
11	Devils River	½ mi below Dry Devils River	45.9		301			
12	Devils River	4½ mi above Sellers Ranch	56.3		303			
12	Swann-Shelton Springs	½ mi above Sellers Ranch	60.8			44.3		Part of inflow only - not possible to measure total.
13	Devils River	2½ mi below Sellers Ranch	63.3		492			Poor measurement - subject to error.
13	Devils River	At Del Rio-Comstock highway crossing	73.0		473			
13	Devils River	At Devils River - gaging station	76.0		512			Not measured - from recorder record.

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Devils River — February 14-20, 1928
February 7-11, 1928

Reaches: From Dolans Creek to Smith Ranch about 3 miles below Satan Creek near Comstock, Tex.
From Smith Ranch 3 miles below Satan Creek to a point ½ mile below Southern Pacific Railroad bridge near Del Rio, Tex.

During the investigations the river was at a constant stage, and the measurements represent the natural conditions.

Tributaries not listed were not flowing at the time these investigations were made.

Date 1928	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From Dolans Creek to Smith Ranch about 3 mi below Satan Creek							
Feb. 14	Devils River	Just above Dolans Creek	0		118			
15	Dolans Creek	At mouth	.1			17.5		
15	Devils River	Just below Dolans Creek	.1		147			
15	6 springs	On left bank 1.1 mi below Dolans Creek	1.2			2.0		Estimate.
15	Devils River	1.3 mi below Dolans Creek	1.4		149			
15	Spring	On left bank 1.4 mi below Dolans Creek	1.5			.02		Estimate.
15	4 springs	On left bank 1.8 mi below Dolans Creek	1.9			.1		Estimate.
15	Spring	On left bank 2.6 mi below Dolans Creek	2.7			.3		Estimate.
15	Spring	On left bank 2.6 mi below Dolans Creek	2.7			1.0		Estimate.
15	Spring	On left bank 2.6 mi below Dolans Creek	2.7			.1		Estimate.
15	Devils River	3.1 mi below Dolans Creek	3.2		164			
16	Devils River	1,000 ft above Indian Creek	3.8		167			
16	Spring	On left bank 1.5 mi above Dry Devils River	6.5			.1		Estimate.
16	Spring	On right bank 1.5 mi above Dry Devils River	6.5			.1		Estimate.
16	Devils River	1.5 mi above Dry Devils River	6.55		203			
17	Devils River	At mouth of Dry Devils River	8.1		189			
17	Devils River	1.0 mi below Dry Devils River	9.2		189			
18	Devils River	1.5 mi above Deadman Creek	10.8		180			
18	Devils River	1.5 mi below Deadman Creek	13.4		200			

Date 1928	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From Dolans Creek to Smith Ranch about 3 mi below Satan Creek, continued							
Feb. 19	Devils River	2-3/4 mi above Satans Creek	16.8		205			
20	Devils River	1.0 mi below Satans Creek	20.7		193			
20	4 springs	On left bank 1.5 mi below Satans Creek	21.3			1.0		Estimate.
20	Swann-Shelton Spring	On left bank 1.5 mi below Satans Creek	21.3			25.7		
20	Spring	On left bank 1.8 mi below Satans Creek	21.5			.5		Estimate.
20	Spring	On left bank 1.8 mi below Satans Creek	21.5			1.5		Estimate.
20	Little Satan Creek	At mouth	22.0			.5		Estimate.
20	Devils River	3/4 mi above Smith Ranch house	22.3		232			
	From Smith Ranch 3 mi below Satan Creek to a point ½ mi below Southern Pacific Railroad bridge							
7	Devils River	3/4 mi above Smith Ranch house	0		242			
7	Unnamed spring	On right bank across from Smith Ranch house	.5			2.69		
7	Unnamed spring	In river channel 600 ft below Smith Ranch house	.6			-		Not measured.
7	12 springs	On left bank just below Smith Ranch house	.6-1.2			1.0		Estimate.
7	Devils River	3/4 mi below Smith Ranch house	1.3		275			
7	5 springs	On right bank .8 mi below Smith Ranch	1.55			1.54		
7	Spring	On right bank 1.1 mi below Smith Ranch	1.70			.2		Estimate.
7	Spring	On right bank 400 ft above Sellers Ranch	1.85			.50		
7	6 springs	On right bank at Sellers Ranch house	2.00			1.0		Estimate.
7	Spring	On right bank ¼ mi below Sellers Ranch house	2.2			.4		Estimate.
8	Lester Spring	On left bank .6 mi below Sellers Ranch house	2.7			.2		Estimate.
8	Spring	On left bank 1.2 mi below Sellers Ranch house	3.45			2.71		
8	Spring	On left bank 1.25 mi below Sellers Ranch house	3.50			.54		
8	Devils River	1½ mi below Sellers Ranch house	3.90		292			

Date 1928	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Tributary	Diversion	Remarks
	From Smith Ranch 3 mi below Satan Creek to a point ½ mi below Southern Pacific Railroad bridge, continued							
Feb. 8	Spring	On left bank 2 mi above Dam #1	5.75			0.1		Estimate.
8	Devils River	1¼ mi above Dam #1	6.5		289			
9	Spring	On left bank 1.2 mi above Dam #1	6.55			.1		Estimate.
9	Spring	On left bank .9 mi above Dam #1	7.0			.53		
9	Spring	On left bank .6 mi above Dam #1	7.20			.8		Estimate.
9	Spring	On left bank .6 mi above Dam #1	7.20			.1		Estimate.
9	Spring	On right bank in Rough Canyon	7.25			1.0		Estimate.
9	5 springs	On left bank .5 mi above Dam #1	7.30			1.5		Estimate.
9	Spring	On left bank 1,000 ft above Dam #1	7.70			.08		
9	Devils River	At mouth of Bluff Creek 1,000 ft below Dam #1	8.00		301			
9	Spring	On left bank .3 mi below Dam #1	8.50			1.0		Estimate.
10	Devils River	1.0 mi below Dam #1	9.20		303			
10	Devils River	At Country Club ¼ mi below Damsite #9	11.8		301			
11	Devils River	At causeway 12 mi above Del Rio	14.0		315			
11	Spring	On right bank opposite gaging station	15.5			10.2		
11	Devils River	Just above Southern Pacific Railroad bridge	15.8		369			
11	Devils River	3,000 ft below Southern Pacific Railroad bridge	16.5		366			

In conjunction with the above investigations temporary gages were installed at five sites described below, each gage being a staff gage from 0 to 3.3 feet. From two to seven measurements were made at each station. On several occasions the stage rose above the gages. At those times daily discharge was not determined (see footnote to table of daily discharge). Records good for stations at Smith ranch and highway bridge; fair for the others.

At Gobbles ranch.-On right bank just below ranch house of M. H. Gobbles, 2½ miles below mouth of Dry Devils River, 25 miles northwest of Del Rio, Val Verde County, and 30 miles above mouth. Period of record: Mar. 22, 1928, to Apr. 27, 1929.

At Carruthers ranch.-On left bank near ranch house of J. W. Carruthers, 22 miles northwest of Del Rio, Val Verde County, and 27 miles above mouth. Period of record: Mar. 5, 1928, to Apr. 30, 1929.

At Smith ranch.-In front of Sam Smith ranch house, on left bank at Slaughter Bend crossing, 18 miles north of Del Rio, Val Verde County, and 18 miles above mouth. Period of record: Mar. 5, 1928, to Apr. 30, 1929.

At country club.-On right bank 500 feet above Devils River Country Club house, 6 miles above mouth, and 10 miles northwest of Del Rio, Val Verde County. Period of record: Mar. 12 to Sept. 21, 1928.

At highway bridge.-On right bank 800 feet above Comstock-Del Rio highway bridge, 5 miles above mouth, and 9 miles northwest of Del Rio, Val Verde County. Period of record: Jan. 1 to Sept. 21, 1928.

Daily discharge records for the above temporary gaging stations are published in Water Supply Paper 688, pages 112-118.

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Rio Grande February 9-March 3, 1926

Reach: From Del Rio to Eagle Pass, Tex.

During this series of measurements the river was at a constant stage, and the measurements represent the natural conditions.

Date 1926	Stream	Location	River Miles	Water Temp.	Discharge, in cfs			Remarks
					Main Stream	Tributary	Diversion	
Feb. 9	Rio Grande	Near Del Rio - gaging station	0		2,730			
Mar. 2	San Felipe Creek	At springs 5 mi above mouth	3			76		
3	Sycamore Creek	2 mi above mouth	12			1		
Feb. 10	Rio Grande	3/4 mi above Bedell-Moore pump	14		2,830			
Mar. 3	Pinto Creek	1 mi above mouth	21			6		
Feb. 11	Rio San Diego	1 mi above mouth	26			77		
Mar. 3	Las Moras Creek	1 mi above mouth	32.5			7		
Feb. 11	Rio San Rodrigo	At mouth	40			27		
12	Rio Grande	3 mi below Jiminez	43		3,060			
12	Rio Grande	At Eagle Pass - gaging station	57		3,040			

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Rio Grande February 12-22, 1926

Reach: From Eagle Pass to San Ygnacio, Tex.

During this series of measurements the river was at a constant stage, and the measurements represent the natural conditions.

Date 1926	Stream	Location	River Miles	Water Temp.	Discharge, in cfs: Main Stream	Discharge, in cfs: Tributary	Discharge, in cfs: Diversion	Remarks
Feb. 12	Rio Grande	At Eagle Pass - gaging station	0		3,040			
13	Rio Chico	At mouth	3			71		
13	Rio Grande	1 mi above Rio Santo Domingo	11		2,950			
13	Rio Santo Domingo	At mouth	12			10		Estimate.
14	Rio Grande	At Indio Ranch	19		2,980			
14	Rio Grande	2 mi above long islands and shoals	29		3,000			
15	Rio Grande	At lower end of shoals	41		2,970			
16	Rio Grande	½ mi below San Ambrosia Creek	55		2,870			
16	Rio Grande	At island 2 mi below San Lorenzo Creek	67		2,990			
17	Rio Grande	1 mi below Apache Ranch	77		2,880			
17	Rio Grande	1 mi below Palafox	89		2,970			
18	Rio Grande	At Minerva	99		2,900			
18	Irrigation Pumps	From mile 99 to 111	99-111				5	Estimate.
18	Rio Grande	3 mi SE of Isletas	111		2,910			
19	Rio Grande	2½ mi SE of San Isabel	116.5		2,790			
19	Irrigation Pumps	From mile 111 to Laredo	111-127				5	Estimate.
19	Rio Grande	1½ mi above Laredo - gaging station	127.5		2,760			
20	Irrigation Pumps	From Laredo to mile 139½	127.5-139				15	Estimate.
21	Rio Grande	½ mi below Santa Rosa Ranch	139.5		2,750			
21	Rio Grande	1 mi SE of Los Castros Ranch	146		2,790			
22	Rio Grande	¼ mi below La Perla Creek	157		2,760			
22	Rio Grande	At San Ygnacio	167		2,760			

LOW-FLOW INVESTIGATIONS - RIO GRANDE BASIN

Rio Grande January 12-April 25, 1928

Reach: From, Near Comal, Tex., half a mile below confluence with Rio San Rodrigo (Mexican tributary) to Laredo, Tex.

Temporary gaging stations were established on the Rio Grande at the following locations, a water-stage recorder being installed at each station. All stations were well rated by current-meter measurements from a boat for range of stage during period. Records excellent.

Near Comal Tex., half a mile below confluence with Rio San Rodrigo (Mexican tributary) and 16 miles northwest of Eagle Pass. Period of record, January 12 to March 18, 1928.

At Eagle Pass, Tex., a temporary gage was installed at the intake for the municipal water plant on January 10, 1928, and was moved 650 feet upstream to a permanent location on April 12, 1928.

At Rosita pumping plant, 9 miles below Eagle Pass. Period of record, February 1 to March 15, 1928.

At Indio ranch, 1 mile above "The Narrows" and 18 miles below Eagle Pass. Period of record, January 11 to April 13, 1928.

At Palafox, Tex. (upper), 1,000 feet above point where road approaches river's edge, 41 miles above Laredo, and 87 miles below Eagle Pass. Two ratings were developed for this station, 300 and 500 feet respectively below the gage, the lower rating giving 60 second-feet the greater discharge. Period of records, February 18 to April 25, 1928.

At Palafox, Tex. (lower). See Palafox upper. Period of record, February 18 to April 25, 1928.

At Darwin Ferry, Tex., 28 miles above Laredo and 100 miles below Eagle Pass. Period of record, April 2-25, 1928.

At Islitas, Tex., 20 miles above Laredo and 108 miles below Eagle Pass. Period of record, February 17 to April 25, 1928.

At Laredo, Tex., 128 miles below Eagle Pass. Period of record, February 21 to April 22, 1928.

The gain in discharge due to visible inflow and the loss due to diversions by a number of small pumping plants for that stretch of river under investigation were a negligible percentage of the total discharge and were considered to approximately balance each other.

Summary of Miscellaneous Discharges, Rio Grande, 1928

Period	Station	River Miles	Mean Discharge, in cfs
Jan. 13 to Mar. 18	Comal	0	2,855
Do	Eagle Pass	16	2,885
Do	Indio ranch	34	2,945
Feb. 2 to Mar. 14	Eagle Pass	0	2,870
Do	Rosita pump	9	2,910
Do	Indio ranch	18	2,925
Jan. 12 to Apr. 12	Eagle Pass	0	2,685
Do	Indio ranch	18	2,740
Feb. 22 to Apr. 12	Eagle Pass	0	2,420
Do	Indio ranch	18	2,455
Do	Palafox (upper)	87	2,445
Do	Palafox (lower)	87	2,505
Do	Islitas	108	2,385
Do	Laredo	128	2,410
Apr. 3 to 22	Eagle Pass	0	2,105
Do	Palafox (upper)	87	2,080
Do	Palafox (lower)	87	2,140
Do	Darwin Ferry	100	2,090
Do	Islitas	108	2,010
Do	Laredo	128	2,030
Feb. 22 to Apr. 22	Eagle Pass	0	2,370
Do	Laredo	128	2,345

Delivery of Water Investigations

DIVERSIONS FROM RED RIVER TO LAKE DALLAS, TEXAS; AND RELATED CHANNEL LOSSES * FEBRUARY AND MARCH 1954

Introduction

As a drought emergency measure the city of Dallas in 1953 constructed a pumping plant on Red River directly north of Gainesville for the purpose of diverting Red River water over the Red-Trinity River divide and into Lake Dallas to supplement its municipal supply. Six electric pumps deliver water from Red River through a concrete pipe line and a cut channel a distance of about 3 miles to the head of Pecan Creek - a tributary of Elm Fork Trinity River. During the investigation from February 10 to March 3 each of the pumps delivered an average of 19 cfs at the lower end of the cut channel just upstream from the uppermost gaging station.

In August 1953 the city of Dallas requested that the Geological Survey and its cooperating agency, the Texas Board of Water Engineers, make an investigation of channel losses during a test run. Due to mechanical difficulties at the pumping plant, the test was delayed until February 1954. On February 10 three temporary recording gages were installed in the reach in addition to the regular gaging station on Elm Fork Trinity River near Sanger. The locations of the gages are shown in figure 7. The lower gage was installed at State Highway 10, northeast of Denton, which is the farthest downstream accessible point above backwater from Lake Dallas.

Results

During the period Feb. 10 to Mar. 3, 1954, the city of Dallas pumped 1,363 acre-feet of water from its Red River plant into Pecan Creek (a tributary of Elm Fork Trinity River) 3.5 miles above Gainesville; 1,272 acre-feet of this diversion reached the head of Lake Dallas. Discharge records were obtained at four points along the channels. This water was transported down the channels of Pecan Creek and Elm Fork Trinity River to Lake Dallas, a distance of about 31 miles. Total flow of pumped water for three of the locations is given in the following tabulation of results.

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* U. S. Geological Survey Open File Report No. 47 by Pat H. Holland

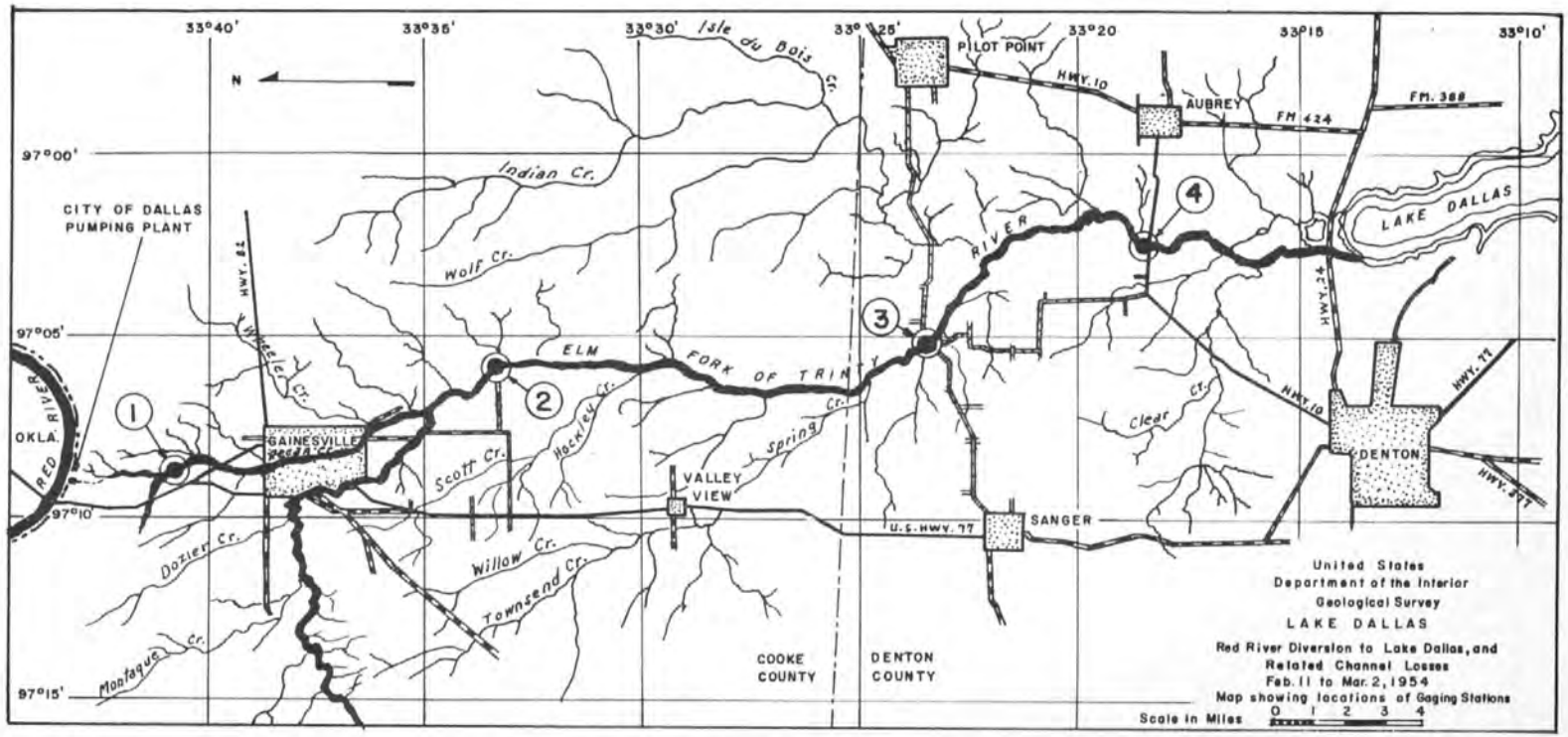


FIGURE 7.- MAP SHOWING LOCATION OF STREAM-GAGING STATIONS, RED RIVER DIVERSIONS TO LAKE DALLAS-1954.

Tabulation of Results

Total acre-feet Feb. 11 to Mar. 3, 1954

	Pecan Creek 3.5 mi. north of Gainesville	Elm Fork Trinity R. 6 mi. south of Gainesville	Elm Fork Trinity R. at Highway 10 northeast of Denton	Loss in Acre-feet	Loss %
Channel Mile from Pumping Plant	3.0	12.6	33.9		
6 Pumps Operating 72 hours	685	683	645	40	5.8
4 Pumps Operating 72 hours	454	421	421	33	7.3
2 Pumps Operating 72 hours	224	220	206	18	8.0
Total Pumpage	1,363	1,324	1,272	91	6.7

Discussion

Prior to the investigation K. F. Hoefle, Superintendent of Dallas Water Department, and Pat H. Holland, Geological Survey engineer-in-charge of field investigations, agreed upon the following method of pump operation:

1. The interval of flow method be used to determine losses, with interval of 72 hours pumping and 72 hours shutdown or recession time between runs.

2. Three rates of flow be investigated - flow from 6, 4, and 2 pumps.

3. 6 pumps be started at noon February 11.

The pumps were started and operated as scheduled with only two interruptions when a single pump was stopped for a short time. The chart records from the continuous recorders were complete and a full range of discharge measurements was obtained. The investigation was completed on March 3 but the recording gages were operated until March 18 and pumping continued after that time.

Prior to the investigation some pump tests had been made. One of these, of 4 days duration, had ended about noon of February 8. A residue of this water was present at all three of the Elm Fork stations when recorders were installed on February 10. Elm Fork Trinity River was flowing 5.0 cfs just above the mouth of Pecan Creek on February 12 and 4.0 cfs on February 19. Pecan Creek was dry above Gainesville and had only slight flow at its mouth. On February 11 all tributaries within the reach were inspected and all flow measured. A total of

2.9 cfs was measured in Isle du Bois, Spring, and Scott Creeks.

Hourly discharges were computed and figure 8 shows actual discharge hydrograph for the three stations and figure 9 shows discharge hydrograph with normal or base flow eliminated. Figure 10 is a time of travel curve between the upper and lower gages.

After careful analysis it was decided that the data obtained at Elm Fork Trinity River near Sanger was not sufficiently accurate to include in this report. The stage-discharge relation for medium and low stages is controlled by a clay and mud bar a short distance downstream from the gage. The highway bridge at this site is too weak to carry heavy equipment and therefore bulldozers and other equipment must be forded. The gage control, being the shallowest point near the bridge, is used as a ford for this equipment and often dirt is pushed into the channel before the vehicles are crossed, thereby changing the stage-discharge relation. During the investigation the control at the Sanger station was disturbed to such an extent that the low and medium records could not be computed to good accuracy.

Minor shifting of the stage-discharge relation occurred at the gage below Gainesville and therefore this record, although good, is not considered as accurate as that at Pecan Creek and Elm Fork Trinity northeast of Denton.

Base data are considered excellent and except for some minor uncertainties in determining the normal flow at the two Elm Fork stations, the results as a whole are considered excellent. There was no normal or base flow at the Pecan Creek station. Accuracy of the interval of flow method depends on an accurate definition of the interval as it progresses downstream. This can be done by sandwiching the foreign water between two troughs that return to the normal flow. Considerable time would be required to allow the troughs or the flow recession to return to absolute base flow. The 72 hour pumping interval proved sufficient to produce desired volumes of flow but the 72 hour shutdown or recession time was not long enough for recession flows to return to normal. Probably twice the allotted recession time would have been enough but 72 hours was the maximum that could be allowed due to the imminence of weather changes. Rainfall of consequence would end this type of study and past history indicates that some rains are almost certain during February in this section of northeast Texas. However, the inaccuracies due to uncertain normal flow are of small consequence owing to the small percentages involved.

The small percentage of loss encountered in delivery of Red River water can be attributed largely to the low seasonal evaporation and transpiration losses and the relatively impervious nature of the streambed material. The geologic formations across which the streams flow are of the Washita group of the Cretaceous age consisting generally of clays and marls with a few thin beds of limestone and sandy clay, all of which are relatively impervious.

The weather was ideal for this type of investigation because no rain fell in the vicinity and the sun was shining much of the time. Evaporation losses, however, might have been higher than the seasonal average because brisk winds blew from the north, south and west with accompanying dust clouds at times from the west and northwest. Conditions were ideal for high evaporation and transpiration for this season of the year and the losses experienced should be near the maximum for a winter season.

Field work and partial computation of data in this report was performed under the direction of R. L. Allen, Area Engineer, Fort Worth Area office.

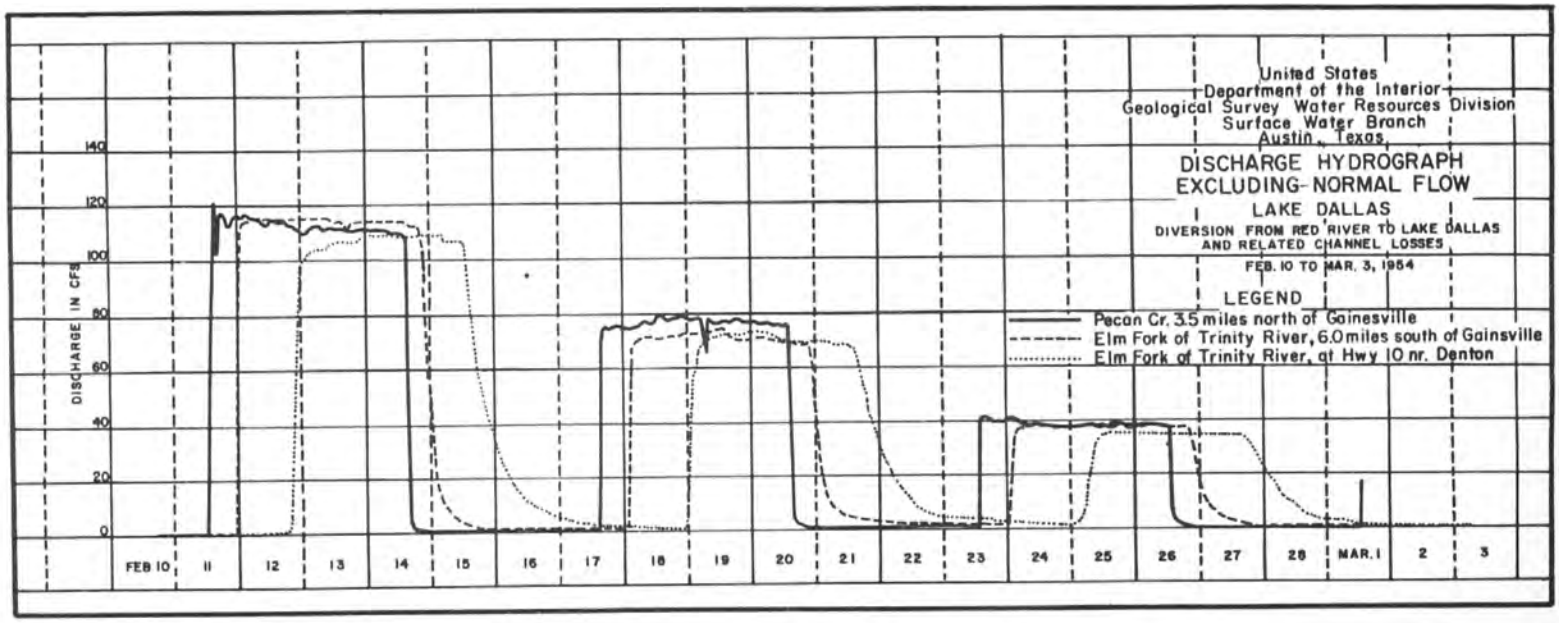
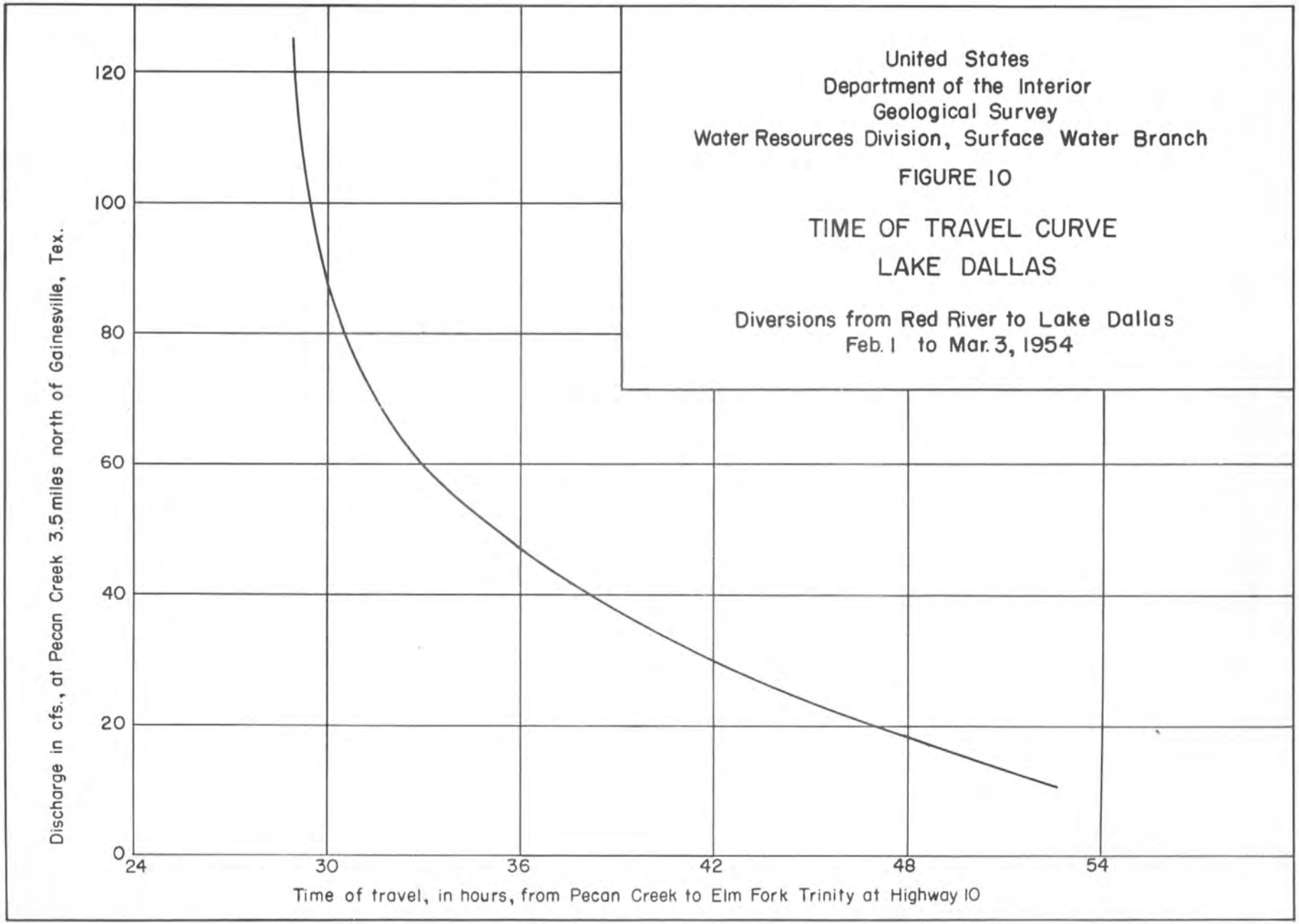


FIGURE 9.- DISCHARGE HYDROGRAPHS EXCLUDING NORMAL FLOW, RED RIVER DIVERSIONS TO LAKE DALLAS-1954.


United States
Department of the Interior
Geological Survey
Water Resources Division, Surface Water Branch
FIGURE 10
TIME OF TRAVEL CURVE
LAKE DALLAS
Diversions from Red River to Lake Dallas
Feb. 1 to Mar. 3, 1954
Discharge in cfs., at Pecan Creek 3.5 miles north of Gainesville, Tex.
0
20
40
60
80
100
120
24
30
36
42
48
54
Time of travel, in hours, from Pecan Creek to Elm Fork Trinity at Highway 10

DELIVERY OF WATER FROM POSSUM KINGDOM RESERVOIR TO RICHMOND, TEXAS VIA BRAZOS RIVER CHANNEL * AUGUST AND SEPTEMBER 1948

Introduction and Purpose

Unusual drought conditions in the summer of 1948 led the irrigators in the lower Brazos River Valley to request releases from Possum Kingdom Reservoir primarily for the irrigation of rice.

The purpose of this study was to determine the time of travel of released water from Possum Kingdom Reservoir to Richmond, Texas.

Results

An average time of travel graph, showing the time of travel from Possum Kingdom Reservoir to Richmond, Texas, is given in figure 11. The first release of water required 340 hours to travel from Possum Kingdom Reservoir to Richmond, while the second release required 370 hours to travel this distance. Travel time of the third release could not be determined accurately because of flood runoff.

Discussion

The first release is identified as that passing the Palo Pinto stream-gaging station, 20 miles downstream from the reservoir, during the period August 9-16, 1948; the second release is that during the period August 16-30; and the third release is that during the period August 30 to September 6, 1948.

The first release of 11,800 acre-feet, as measured at the Palo Pinto gaging station, could be followed fairly accurately downstream to Richmond. This

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* U. S. Geological Survey Open File Report No. 41 by D. E. Havelka

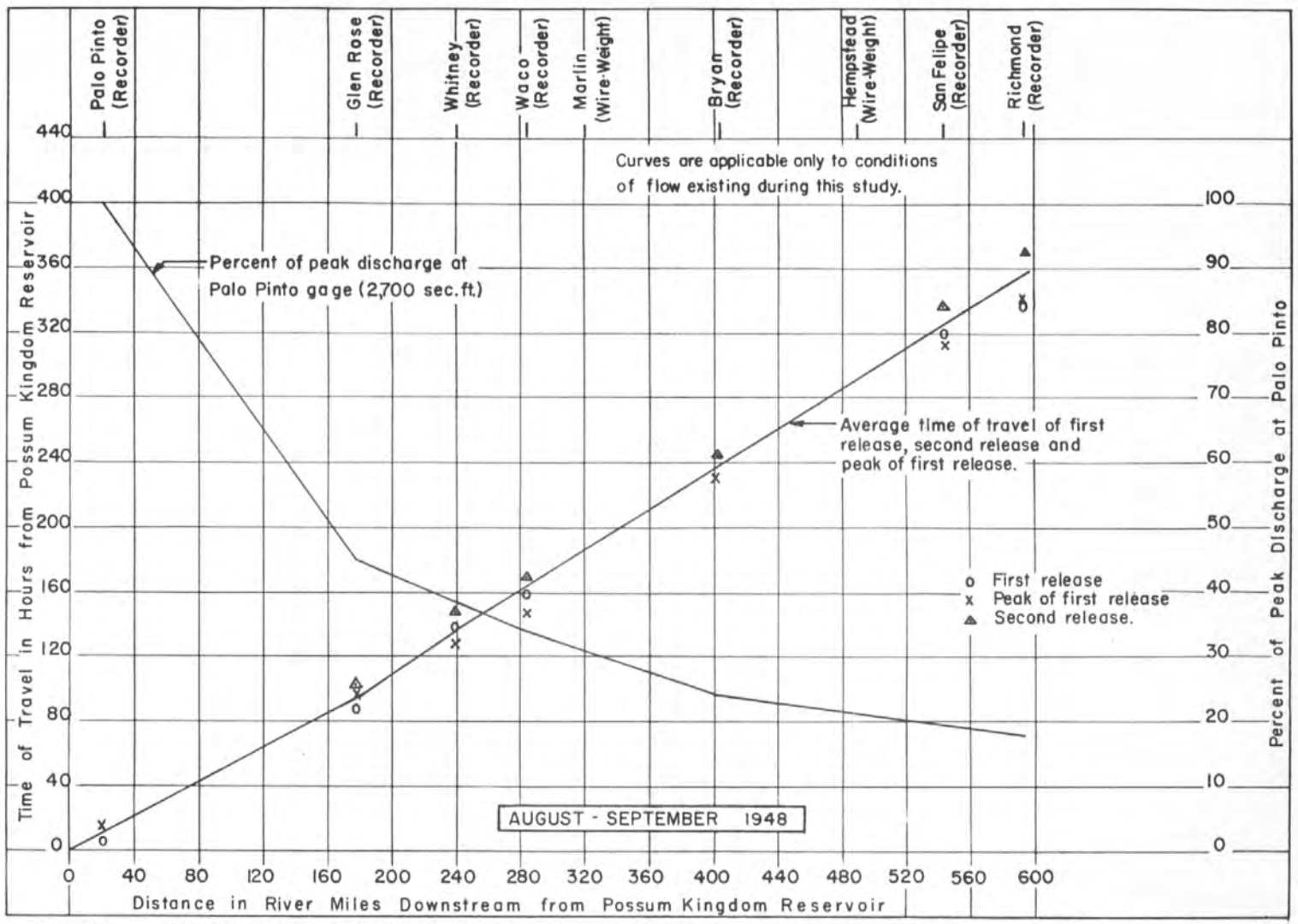

FIGURE II.- TIME OF TRAVEL AND REDUCTION IN PEAK OF WATER RELEASED FROM POSSUM KINGDOM RESERVOIR
U.S. Geological Survey- Surface Water Branch- Austin, Texas

release traveled in a relatively dry channel. The peak discharge at the Palo Pinto gaging station was only 610 cfs (cubic feet per second) during the 9-day period preceding this release and no runoff from rain was indicated during time of travel to Richmond.

A graph showing percent of the momentary peak discharge of the first release of 2,700 cfs at the Palo Pinto gaging station that reached each gaging station is shown in figure 11. Only 18 percent or 490 cfs of this peak reached Richmond. This chart does not include base flow. The peak discharge of the second and third releases were increased by runoff due to rain and a satisfactory determination of peak reduction could not be made.

Discharge hydrographs of gaging stations on the Brazos River near Palo Pinto, near Glen Rose, at Waco, near Bryan and at Richmond, Tex., are shown in figure 12. The hydrograph of flow at Richmond includes the flow of the American Canal Company's Canal near Fulshear, Tex., and Richmond Irrigation Company's Canal near Richmond, Tex., both of which divert water from Brazos River upstream from the Richmond gaging station. In addition to the gaging stations shown in figure 12, those near Whitney and near San Felipe were used in computing time of travel of released water. All of the gaging stations mentioned above were equipped with continuous water-stage recorders.

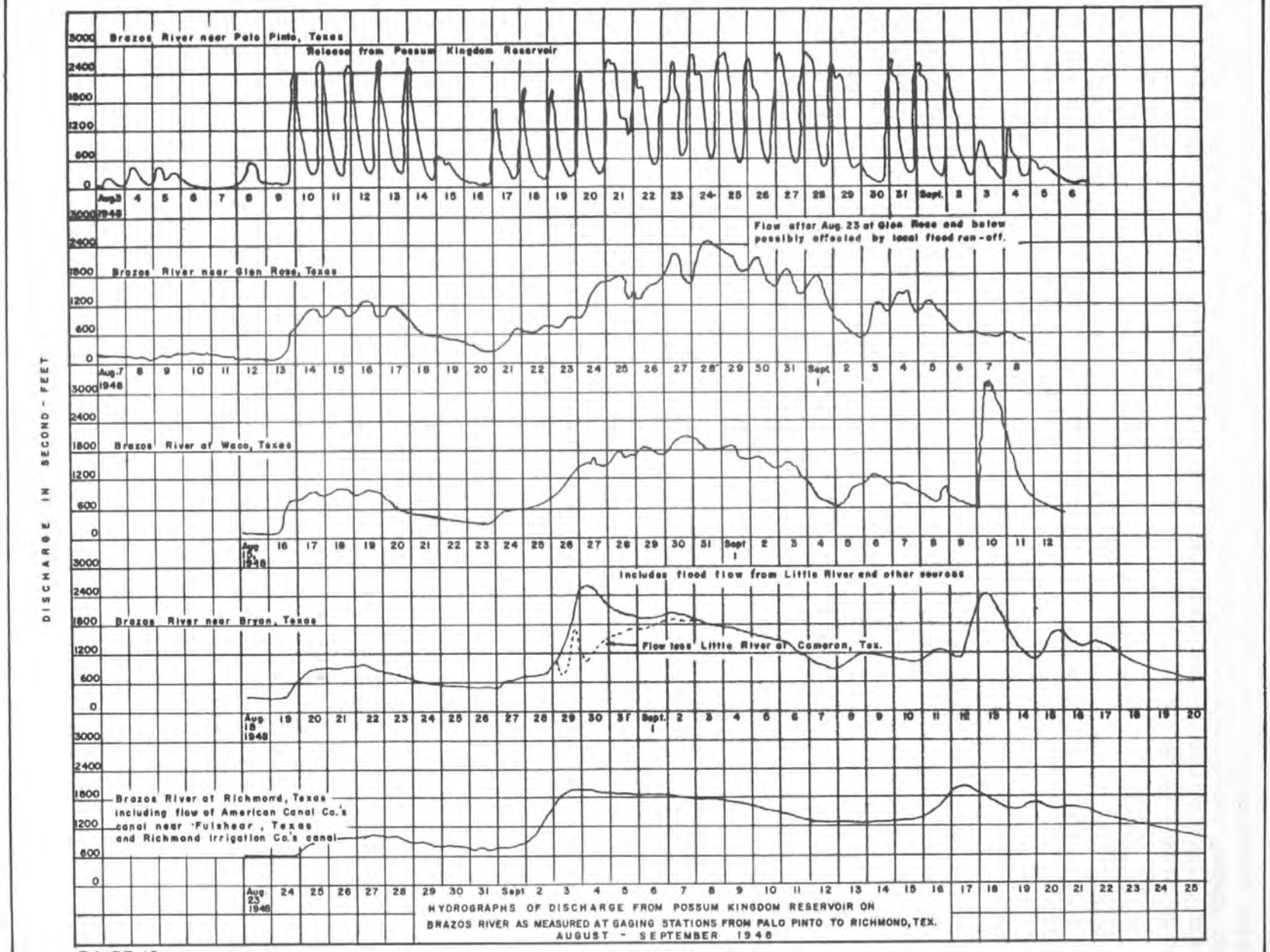
DISCHARGE IN SECOND - FEET
Brazos River near Palo Pinto, Texas
Release from Possum Kingdom Reservoir
Brazos River near Glen Rose, Texas
Flow after Aug. 23 at Glen Rose and below possibly affected by local flood run-off.
Brazos River at Waco, Texas
Brazos River near Bryan, Texas
Includes flood flow from Little River and other sources
Flow less Little River at Cameron, Tex.
Brazos River at Richmond, Texas including flow of American Canal Co.'s canal near Fulshear, Texas and Richmond Irrigation Co.'s canal
HYDROGRAPHS OF DISCHARGE FROM POSSUM KINGDOM RESERVOIR ON BRAZOS RIVER AS MEASURED AT GAGING STATIONS FROM PALO PINTO TO RICHMOND, TEX. AUGUST - SEPTEMBER 1948

FIGURE 12.

DELIVERY OF WATER
WHITNEY RESERVOIR TO RICHMOND, TEXAS
VIA BRAZOS RIVER CHANNEL *
1954

Problem

The problems involved in this study were as follows:

1. To determine the percentage of water released from Whitney Reservoir and transported down the Brazos River channel that would be available near Richmond, Tex.

2. To determine the time of travel from Whitney Reservoir to Richmond.

The gaging station near Whitney, which is the upstream point for measuring released water, is 3 miles downstream from Whitney Reservoir, and the gaging station at Richmond is the downstream point for measuring releases. All determinations in this study were made from the Whitney gage to the Richmond gage or to gages between.

Results

During the period Aug. 1-31, 1954, 47,700 acre-feet of water was released from Whitney Reservoir for the use of irrigators below Richmond, Tex. (See fig. 13) Of this released water, 76 percent (36,200 acre-feet), arrived at Hempstead 243 miles downstream from the Whitney gage, and 69 percent (33,100 acre-feet) arrived at Richmond 346 miles downstream from the Whitney gage. (See figs. 14 and 15.) The time of travel was 137 hours to Hempstead and about 193 hours to Richmond. The river channel was already wet, owing to the presence of residual water from previous releases in the channel and in river sand and gravel beds, and no extra initial loss occurred. About 9,500 acre-feet of the 14,600 acre-feet lost in transit from Whitney to Richmond is attributed to evaporation. These results can be expected only when conditions are similar to those existing during the period of this investigation.

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* U. S. Geological Survey Open File Report No. 53 by Seth D. Breeding and Pat H. Holland

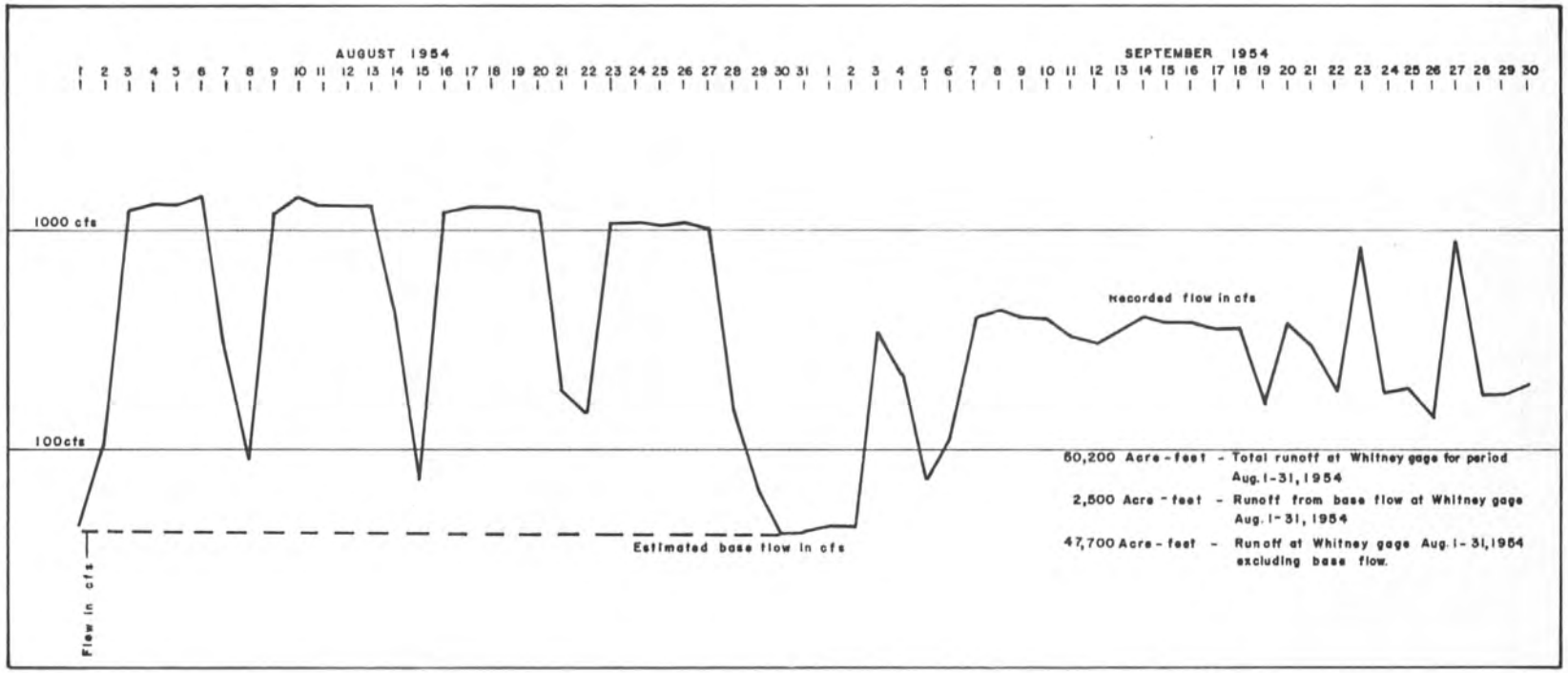

FIGURE 13.- DISCHARGE HYDROGRAPH, BRAZOS RIVER NEAR WHITNEY, TEX.-1954.

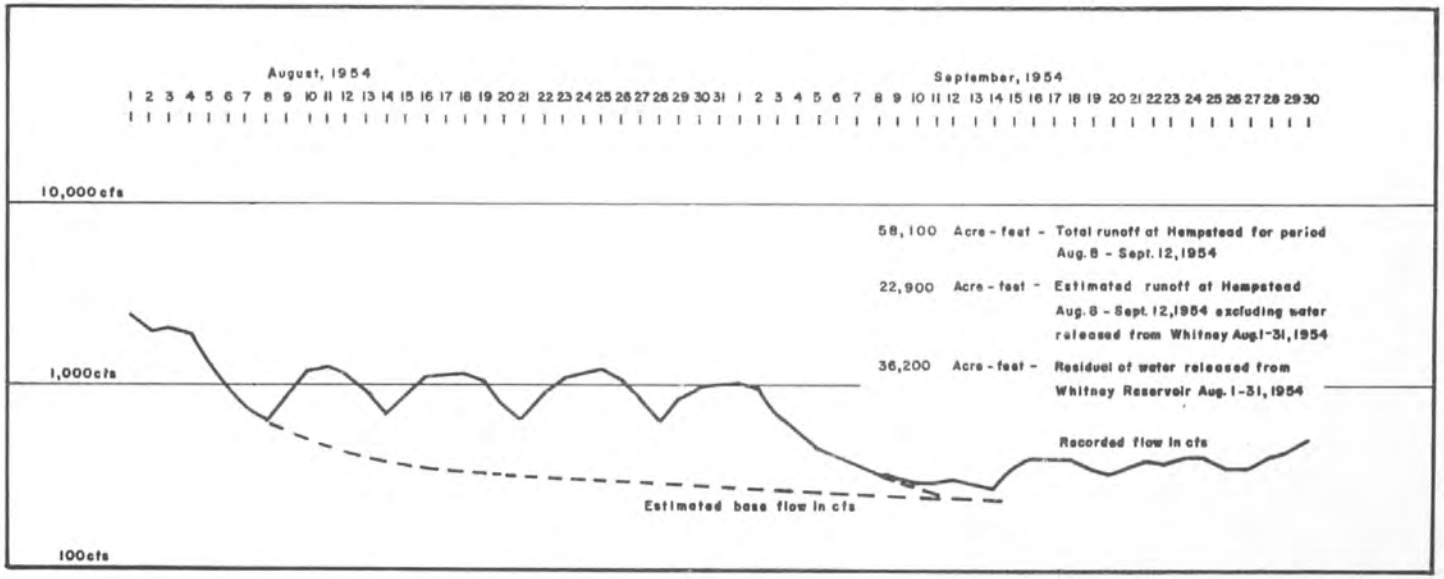

FIGURE 14.-DISCHARGE HYDROGRAPH, BRAZOS RIVER NEAR HEMPSTEAD, TEX.-1954.

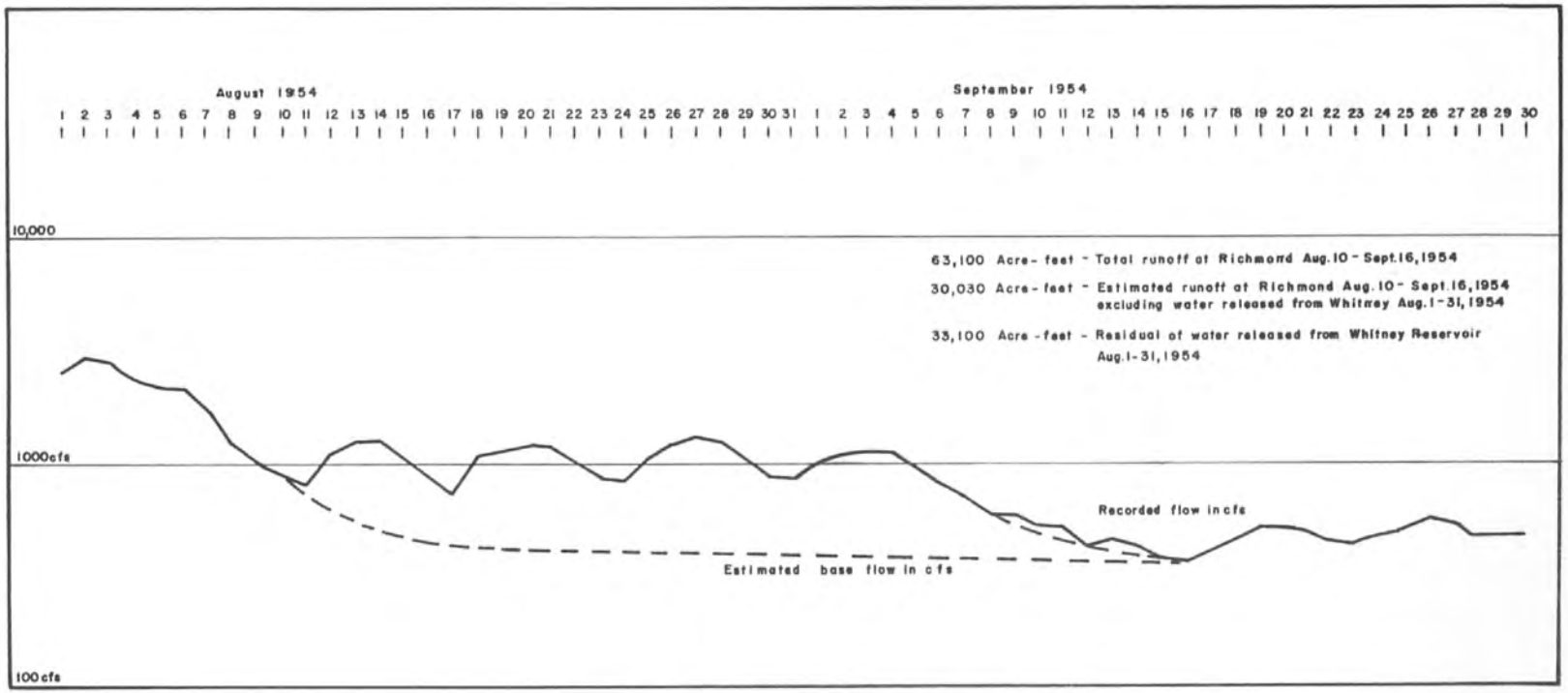

FIGURE 15.- DISCHARGE HYDROGRAPH,
BRAZOS RIVER AT RICHMOND, TEXAS + AMERICAN CANAL + RICHMOND CANAL, AUG. & SEPT. 1954

Scope of Study

The river reach concerned is 346 miles between the U. S. Geological Survey-Corps of Engineers, U. S. Army gaging stations near Whitney (3 miles downstream from Whitney Dam and Reservoir) and at Richmond, Tex. Four other gaging stations in the reach are those at Waco, near Bryan, near Hempstead, and near San Felipe, which are located 35, 154, 243, and 297 miles, respectively, downstream from the Whitney gage. Records from the Waco, Bryan, and San Felipe gaging stations are not included in this report. The period August 1-31 was selected for study because there was very little inflow from tributaries and very little runoff from rainfall, and the water released could be clearly identified, owing to periods of low flow at the beginning and at end of month. Also, the river channel was in condition for determining average loss owing to the fact that releases had been made previous to this period and no material initial loss would be involved.

Field Investigation

Recorder charts were removed and discharge measurements were made once a week at each of the gaging stations in the reach.

Office Computations and Discussion

The records were computed weekly and reports were made to the State Board of Water Engineers and other interested organizations.

Discharge hydrographs were plotted for each of the six gaging stations in the reach for the months of August and September. These hydrographs were plotted from mean daily discharges as previously computed except for the Whitney station. The Richmond hydrograph was plotted on basis of the record at Richmond plus records for the Richmond and American Canals. These two canals divert water from the Brazos River between San Felipe and Richmond. For the purpose of this study the daily discharges for August 1-31 at the Whitney gaging station were revised slightly from those published in Water-Supply Paper 1342 on the basis of a re-analysis of the stage-discharge relation. These slightly revised records will be used only in this study and do not supersede the published record. A line showing estimated base flow from antecedent releases was drawn on each graph. The difference between base flow and measured flow is the residual of water released from Whitney Reservoir.

The water was released from Whitney Reservoir through the power plant, which automatically adjusts gate openings to power demand. The low power demand on Saturday and Sunday is the cause of the low discharges on week-ends. These lows, or troughs, on the gage-height charts can be followed downstream to all the gages. The time of the week-end trough was picked from recorder charts and plotted on a graph that shows time of travel to all gages between Whitney and San Felipe. (See fig. 16)

The loss to evaporation was estimated on basis of 346 miles of river having an estimated average width of 300 feet and average evaporation of 9 inches. Records of evaporation for August at Waco (10.8 in.), College Station (8.82 in.) and Prairie View (7.87 in.) were used to determine the average for the reach.

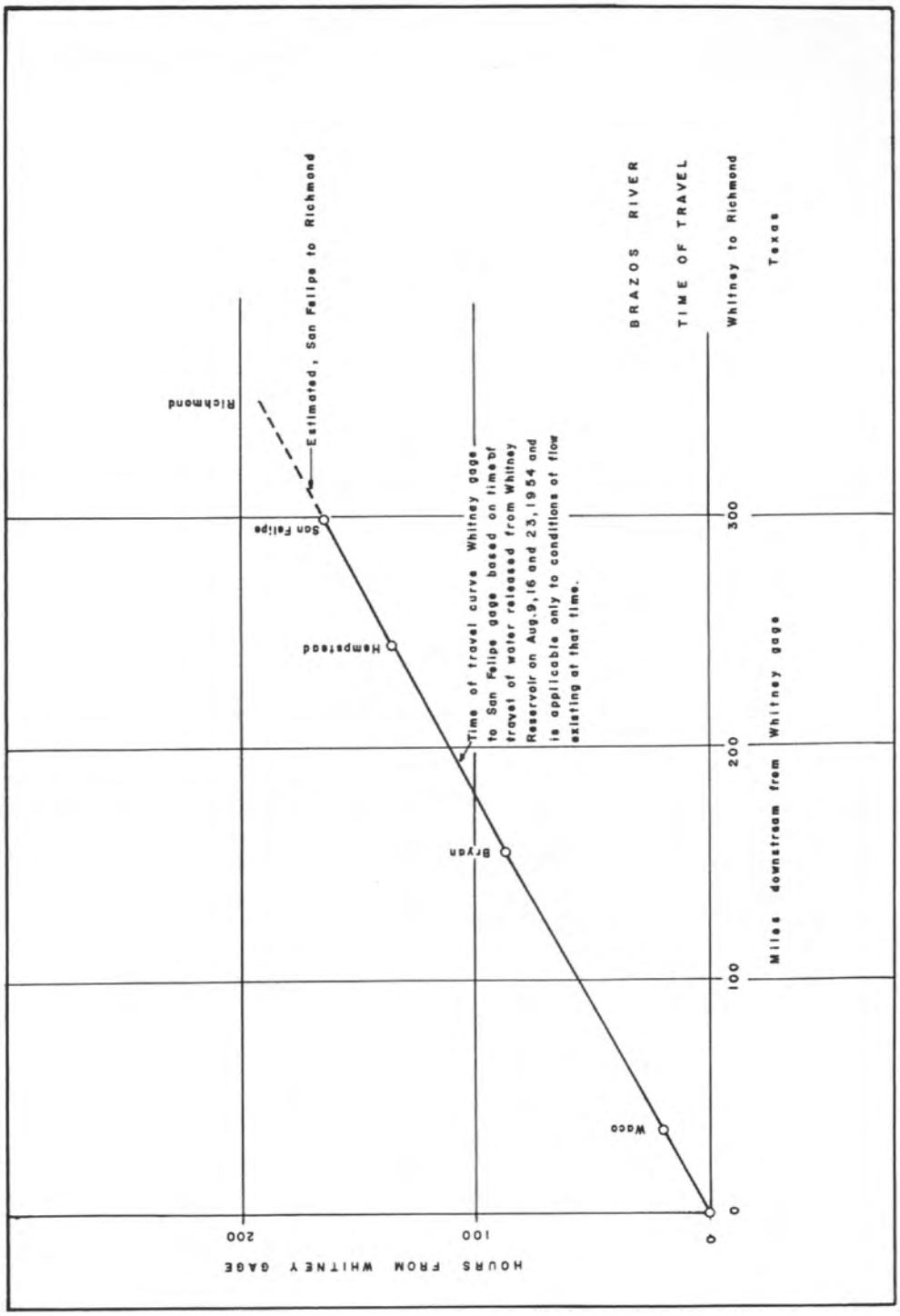

FIGURE 16.-BRAZOS RIVER TIME OF TRAVEL CURVE, WHITNEY TO RICHMOND, TEX.-1954.

DELIVERY OF WATER
WHITNEY RESERVOIR TO RICHMOND, TEXAS
VIA BRAZOS RIVER CHANNEL *
1956

Problem

The problems involved in this study were as follows:

1. To determine losses in transit of water released from Whitney Reservoir and transported down the Brazos River channel to Richmond, Tex.

2. To determine time of travel of released water from Whitney Reservoir to gaging station at Richmond.

The gaging station near Whitney, which is the upstream point for measuring water released from Whitney Reservoir, is 3 miles downstream from Whitney Dam, and the gaging station at Richmond is the downstream point for measuring releases. All determinations in this study were made from the Whitney gage to the Richmond gage or to gages between.

The quantity of flow reaching Juliff gage (located 26 miles downstream from Richmond) could not be determined because of lack of records of diversions between Richmond and Juliff.

Results

During the period July 2 to August 5, 1956, 103,000 acre-feet of water was released from Whitney Reservoir for the use of irrigators below Richmond, Tex. (See fig. 17) Of the released water, 71,300 acre-feet (fig.18), or 69 percent of the total volume arrived at the Richmond gaging station 346 miles downstream. The time of travel of the first water released was about 198 hours. Shown on the following page is a table giving data for each gaging station in the reach from Whitney to Richmond.

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* U. S. Geological Survey Open File Report No. 59 by Pat H. Holland

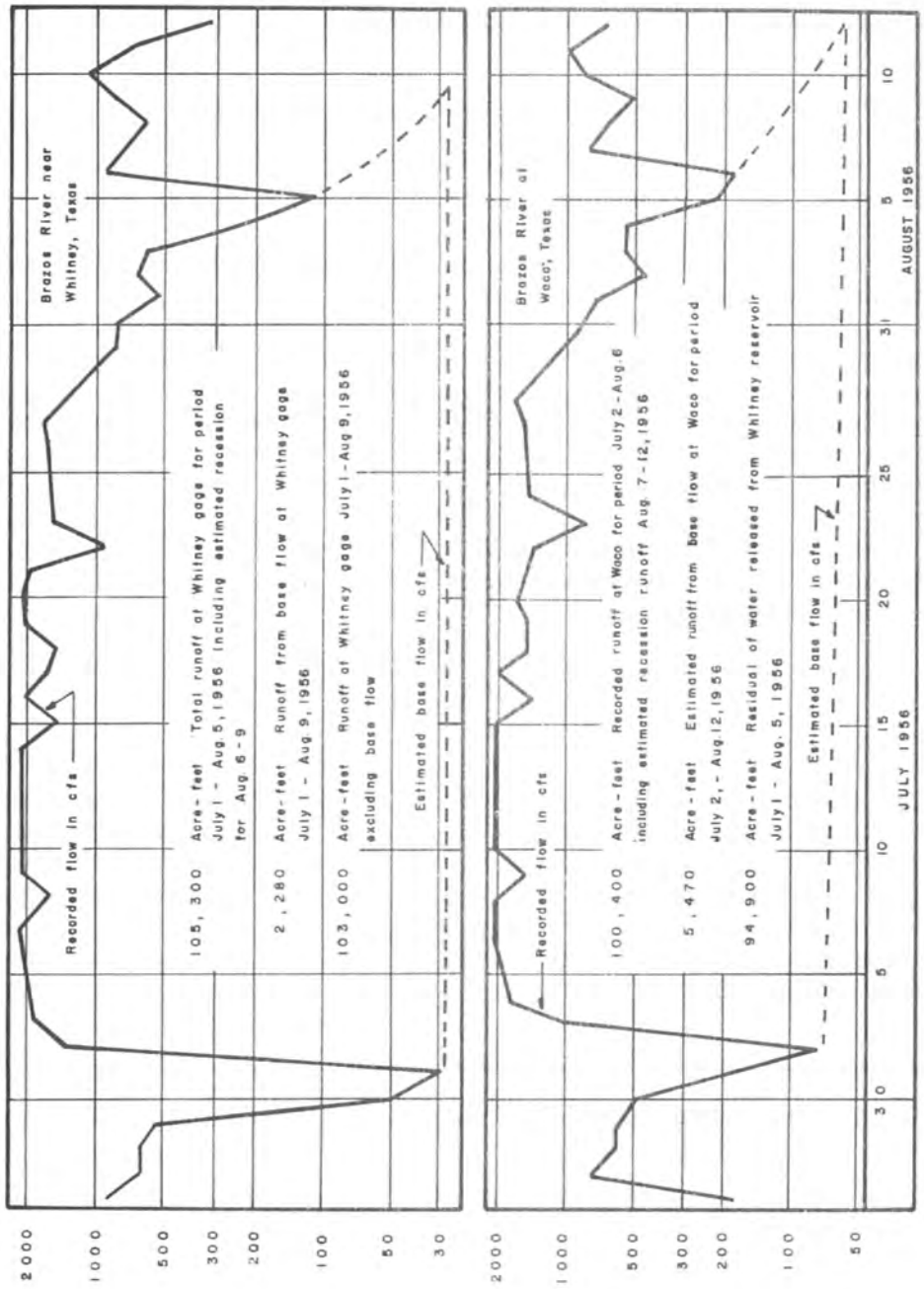

FIGURE 17.-DISCHARGE HYDROGRAPHS, BRAZOS RIVER NEAR WHITNEY AND AT WACO, TEX.-1956.

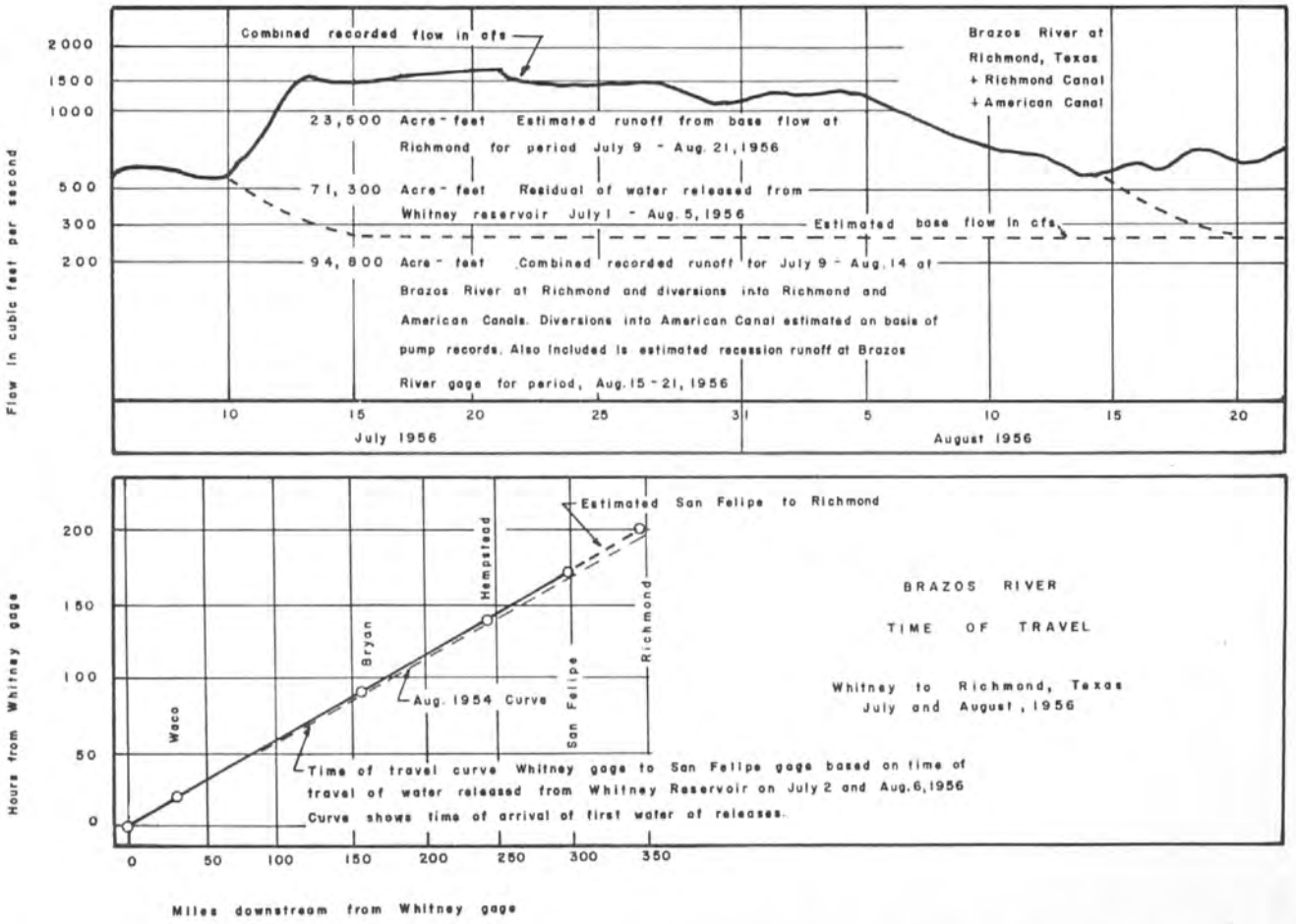

FIGURE 18. DISCHARGE HYDROGRAPH, BRAZOS RIVER AT RICHMOND, TEX.-1956.
TIME OF TRAVEL CURVE, BRAZOS RIVER, WHITNEY TO RICHMOND, TEX.

Tabulation of Results

Gaging station	Amount of water arriving (ac.-ft.)	Percent of released water	Lost in transit (ac.-ft.)	Percent of release lost between gages	Travel time of first water (hours)	Miles below Whitney gaging station
Whitney	103,000	100	--	--	--	--
Waco	94,900	92	8,100	8	18	35
Bryan	79,400	77	15,500	15	90	154
Hempstead	74,500	72	4,900	5	140	243
Richmond	71,300	69	3,200	3	198	346

No initial loss occurred, as previous releases had conditioned the channel and saturated the alluvium beds in the reach.

About 15,000 of the 31,700 acre-feet lost in transit is attributed to evaporation. The above results can be expected to occur only when conditions are similar to those existing during the period of this investigation.

Comparisons of Results with Previous Investigations

During the period Aug. 1-31, 1954, 47,700 acre-feet of water was released from Whitney Reservoir for the use of irrigators below Richmond. Results of that study are contained in Open File Release No. 53, August 1956, "Delivery of Water, Whitney Reservoir to Richmond, Tex. via Brazos River Channel, 1954". Also, Open File Release No. 57, February 1957, "Delivery of Water from Belton Reservoir to the Brazos River Gaging Station at Richmond, Tex., by way of the Leon, Little, and Brazos River Channels, 1956", covers delivery of 73,000 acre-feet of water from Belton Reservoir to industrial users in the vicinity of Freeport, Tex.

The following table contains a comparison of results shown in the three reports.

Comparison of Release to Delivery

Reservoir releasing water	Period of release	Amount of release (acre-feet)	Amount lost in transit (acre-feet)	Percent of released water arriving at Richmond	Distance below reservoir (miles)	Time of travel of first water (hours)
Whitney	Aug. 1-31, 1954	47,700	14,600	69	346	193
Whitney	July 1 to Aug. 5, 1956	103,000	31,700	69	346	198
Belton	Nov. 1 to Dec. 14, 1956	73,000	18,700	74	342	202

Scope of Study

During the period July 9-16, 1956, a special water release was made from Whitney Reservoir for the use of Briscoe Irrigation Company. This water was obtained from the Brazos River Authority, and the Board of Water Engineers granted a permit for its transportation down the Brazos River channel. The Whitney releases were repaid by the Brazos River Authority from Possum Kingdom Reservoir. The Board of Water Engineers requested daily reports during this period at six gaging stations between Whitney Reservoir and Briscoe Irrigation Company, located below Richmond. Several discharge measurements were made and recording gages inspected regularly during the period.

The period July 2 to August 5 was selected for study because it encompasses the period of this special release. It was impossible to study the period July 9-16 because no definition of the interval could be recognized as it progressed downstream. The longer interval was defined by periods of low flow at the beginning and end of the period and could be clearly identified at all gaging stations.

Also during this period inflow from tributaries was at a minimum and rainfall was either lacking or very scant.

The river reach concerned is 346 miles between the gaging stations near Whitney (3 miles downstream from Whitney Dam and Reservoir) and at Richmond, Tex. Other gaging stations in the reach are at Waco, near Bryan, near Hempstead, and near San Felipe, which are located 35, 154, 243, and 297 miles, respectively, downstream from the Whitney gage. Records for the San Felipe gaging station are not included in this report.

The river channel was in a favorable condition for determining average loss, owing to the fact that releases had been made previous to this period and no material initial loss was involved.

Field Investigation

During the period July 9-16, 1956 gaging stations were vistied frequently and several discharge measurements were made at each gage to better define the stage-discharge relation.

Discharge measurements were made at Whitney on July 9, 10, 16, 30 and Aug. 15; at Waco, June 21, July 9, 10, 16, 30 and Aug. 30; near Bryan, June 11, July 9, 10, 16, 30 and Aug. 13; near Hempstead, July 2, 9, 10, 16, Aug. 4, 10, 13 and 20; and at Richmond, July 5, 9, 10, 11, 16, Aug. 6, 10, 13 and 20.

Office Computations and Discussion

Daily reports of flow were made to the Board of Water Engineers during the period of the special release, July 9-16, 1956, on the basis of special measurements listed above.

No work was done on this report until the 1956 water year computations were completed for the stations included. From these records discharge

hydrographs were plotted (figs. 17 to 19) using mean daily discharge as published in Water-Supply Paper 1442, except for the station at Richmond. The Richmond hydrograph was plotted on basis of the Brazos River record at Richmond plus record of diversions into Richmond Canal and estimated diversions into American Canal. The American Canal diverts from the left bank of Brazos River 18 miles upstream from Richmond, and Richmond Canal diverts from right bank 6 miles upstream from Richmond. The American Canal record was estimated on basis of total daily pumpage as reported by the Canal Company.

The discharge hydrographs also show a line representing estimated base flow, some of which is from antecedent releases at Whitney Reservoir. Information on base flow in the reach is very sketchy due to release procedure and operation of a hydroelectric power plant at Whitney Dam. The operation schedule of the power plant does not allow sufficient drain-down time for the river to return to base flow conditions at stations below Waco.

The periods of low flow prior to and following the period of the investigation facilitated the computation of time of travel of the first water. The instant of first rise was picked from recorder charts at each station and the information used to plot a time-of-travel curve. (See fig. 18) Although only about half as much water was released during the investigation of Aug. 1-31, 1954, the time of travel agreed very closely with that determined for the current investigation. For comparison, the information from the 1954 investigation was plotted on the time-of-travel curve.

The loss to evaporation was estimated on basis of 346 miles of river having an estimated width of 325 feet and average evaporation of 11.32 inches. Records of evaporation for July and August at Waco (Riesel), 12.00 and 11.21 inches, College Station, 13.34 and 11.89 inches, and Prairie View, 10.39 and 9.10 inches, were used to determine the average evaporation of 11.32 inches for an average period of 1.2 months.

Accuracy of Results

The time-of-travel curve, based on time of appearance of the first water, is considered excellent, as it agrees closely with previous determinations of time-of-travel.

The daily discharges at gaging stations are good to excellent, due to the numerous discharge measurements for better definition of the stage-discharge relation at each station. All gage-height records were complete and no estimates were necessary except to determine base flow at each station and diversions into American Canal. The Hempstead gage is non-recording and the record is based on twice daily readings of wire-weight gage by an observer. The observer's readings were complete and numerous additional readings were made by engineers while making discharge measurements.

The estimates of base flow at Whitney and Waco are considered good. Those at the other stations are poor due to lack of definition on gage-height charts or lack of discharge measurements of base flow. Base flows at Bryan, Hempstead, and Richmond were based on poorly defined curves of increases in daily discharge between stations during short periods of relatively constant flow. The recessions at beginning and end of the base flow periods were estimated by comparison with at least one normal recession that was undisturbed by inflow.

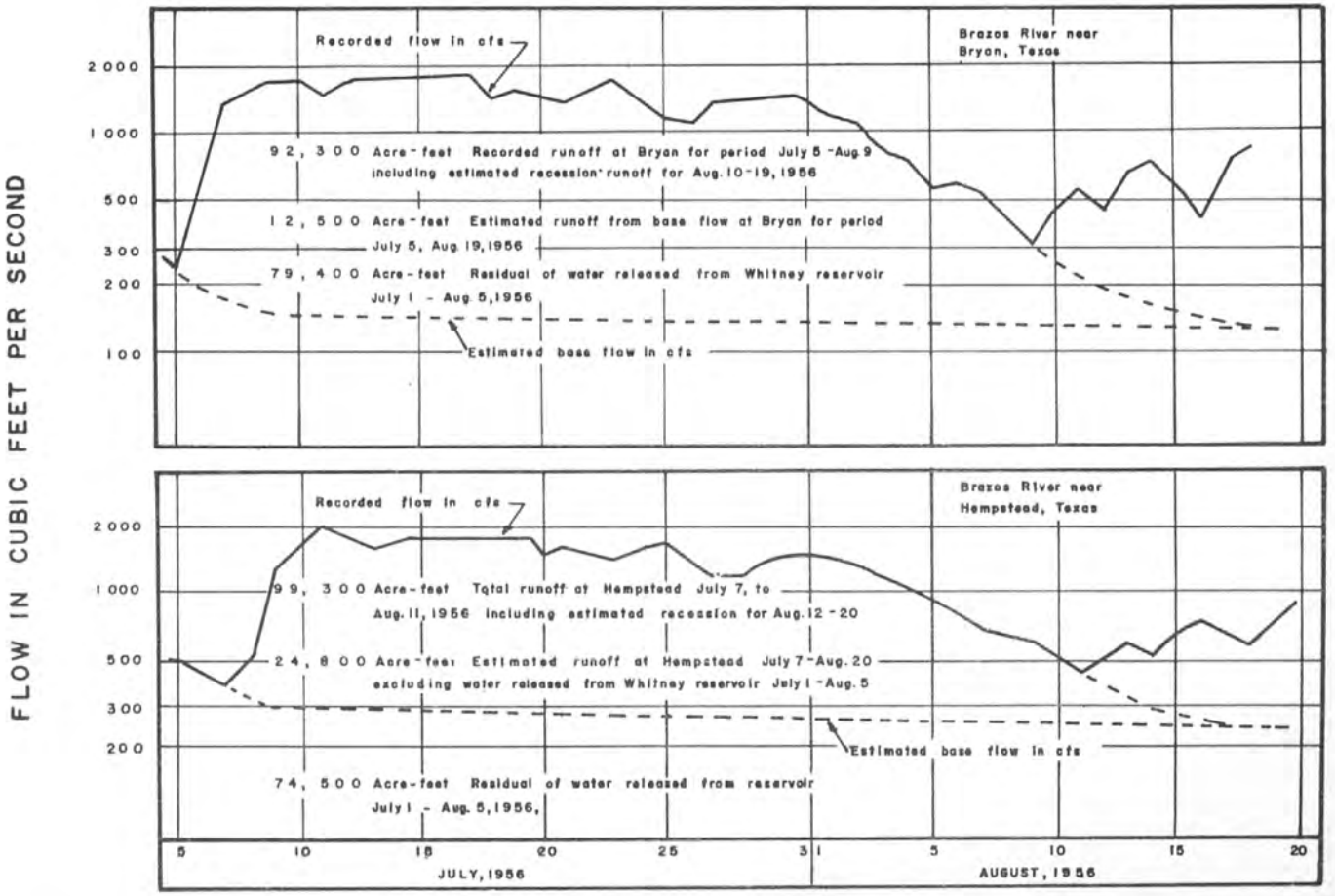

FIGURE 19:- DISCHARGE HYDROGRAPHS, BRAZOS RIVER NEAR BRYAN AND NEAR HEMPSTEAD, TEX. - 1956.

Rainfall was very light during this period. The main tributaries on which gaging stations are located indicated contributions as follows: Above Waco the gages on North Bosque at Clifton and Aquilla Creek near Aquilla recorded zero flow for both July and August; Little River at Cameron had a maximum day of 3.4 cfs and contributed 120 acre-feet for the complete period; Navasota River near Bryan had a maximum day of 4.6 cfs and contributed a total of 33 acre-feet for the period; and Yegua Creek near Somerville recorded zero flow for July and August.

DELIVERY OF WATER FROM BELTON RESERVOIR TO THE BRAZOS RIVER GAGING STATION AT RICHMOND, TEXAS, BY WAY OF THE LEON, LITTLE AND BRAZOS RIVER CHANNELS *
1956

Introduction

Beginning Nov. 1, 1956 and ending Dec. 14, 1956, the Corps of Engineers, in cooperation with the Brazos River Authority, released 73,000 acre-feet of water (as measured at the gaging station on Leon River near Belton) from the Belton Reservoir for industrial use in the vicinity of Freeport, Tex. (See fig. 20) The need for this water at Freeport came as a result of the prolonged drought conditions causing flows in the Brazos River in the vicinity of Freeport to be insufficient to satisfy the industrial and other uses of vital importance.

Purpose

The purpose of this report is to show the quantity of water released from the Belton Reservoir, the time of its travel downstream to Richmond, and the quantity of released water reaching the gaging station on Brazos River at Richmond, Tex.

The reservoir water traversed 342 miles of river channel before it reached the Richmond gaging station. Analysis of the streamflow records shows that about 54,300 acre-feet of the released water reached Richmond. The quantity of water reaching the Juliff station and other points downstream from Richmond could not be determined because of the lack of records of diversion and other basic data between Richmond and Juliff, essential for a complete analysis.

The gaging stations, operated cooperatively by the Geological Survey, the Brazos River Authority, the Corps of Engineers, U. S. Army, and the Board of Water Engineers, recorded the flow as the water was released from Belton Reservoir and also when it passed gaging stations on Little River at Cameron and on the Brazos River near Bryan, near San Felipe, at Richmond, and near Juliff. The study of this flow was complicated by rises resulting from rainfall occurring at the beginning and end of the period of release; consequently,

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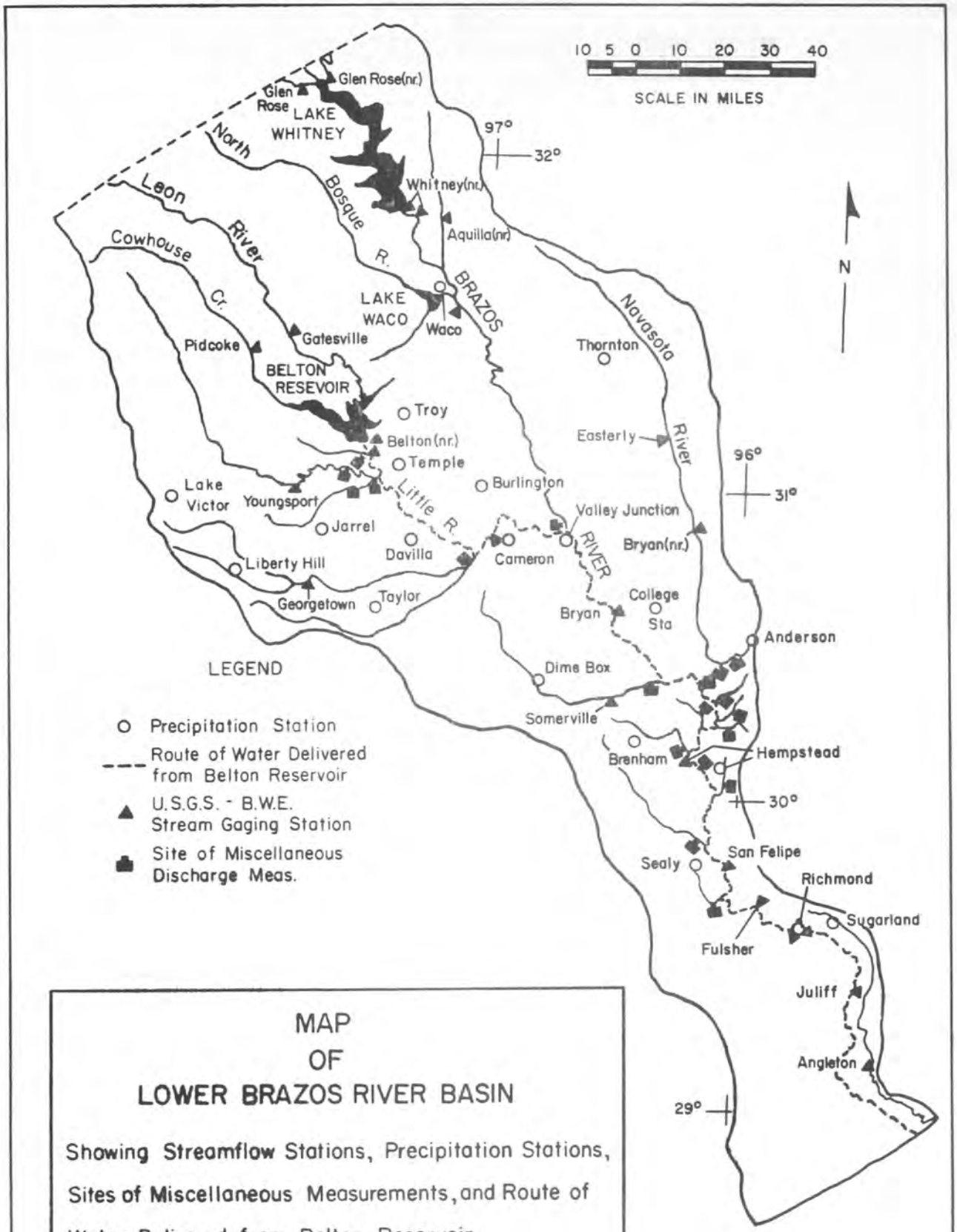
* U. S. Geological Survey Open File Report No. 57 by D. E. Havelka and E. M. Parten



MAP
OF
LOWER BRAZOS RIVER BASIN

Showing **Streamflow** Stations, Precipitation Stations, **Sites of Miscellaneous** Measurements, and Route of **Water Delivered from** Belton Reservoir.

From U.S. Weather Bureau Maps No. 52 and 53.

FIGURE 20.

records of discharge during periods of steady flow of the water released at Belton were used when possible as basic data in the study.

Records for the Brazos River gaging station near Juliff, which is 26 river miles downstream from the gaging station at Richmond, were omitted from this study because the amount of diversions was unknown between the Richmond and Juliff gaging stations. Streamflow data used in this study were analyzed to determine the following:

1. Quantity of water released from Belton Reservoir.

2. Quantity of water released from Belton Reservoir which reached the gaging station on the Brazos River at Richmond.

3. Travel time required for discharges occurring during the delivery.

Scope of Study

The reaches of the river directly involved in this study, in downstreams order, are: Leon River from the gaging station near Belton to its confluence with Little River; Little River from the mouth of Leon River to its confluence with the Brazos River; and the Brazos River from the mouth of Little River to the gaging station near Juliff. Indirectly involved are the reach of the Brazos River from Waco to the mouth of Little River, and all tributaries adding appreciable inflow to the streams named above during the period of delivery.

From a hydrologic standpoint, the losses and rates of travel determined in this study may be expected only for conditions such as those existing during the period under study, with emphasis placed on season of the year, climatic conditions, and channel conditions.

Field Work

Frequent current-meter measurements of discharge were made at each gaging station to maintain an accurate stage-discharge relation for computing the flow. Miscellaneous discharge measurements were made on the Brazos River just upstream from the mouth of Little River, and on all Brazos River tributaries contributing appreciable inflow to the reach under study. The miscellaneous measurement sites are indicated on figure 20, and the location and results of the miscellaneous measurements are shown in the following table.

Miscellaneous discharge measurements on streams contributing appreciable inflow to the released water.

Measurement Site	Location	Date of measurement	Discharge (cfs)
Nolan Creek at Belton at E. Central Ave. crossing	Lat 31°03' Long 97°28'	Dec. 6, 1956	3.18
Lampasas River 30 feet below mouth of Salado Creek	Lat 29°59' Long 97°25'	Dec. 7, 1956	15.1

(Continued on next page)

Miscellaneous discharge measurements on streams contributing appreciable inflow to the released water. (Continued)

Measurement Site	Location	Date of measurement	Discharge (cfs)
San Gabriel River 5 mi NW of Rockdale, at FR 487	Lat 30°44' Long 97°03'	Dec. 5, 1956	0.43
Elm Creek near Cameron at State Hwy 77 & US Hwy 190	Lat 30°54' Long 96°59'	Dec. 4, 1956	0.83
Brazos River above Hwy 190 above Little River nr. Hearne	Lat 30°52' Long 96°42'	Dec. 27, 1956	108
Brazos River nr. Hearne, at US Hwy 190 & above Little R.	Lat 30°52' Long 96°42'	Dec. 4, 1956	87
Yegua Creek near Clay, at FR 50	Lat 30°22' Long 96°21'	Dec. 3, 1956	No flow
Navasota River nr. Hwy 6 near Navasota	Lat 30°25' Long 96°06'	Dec. 3, 1956	6.76
Navasota River nr. Hwy 6 near Navasota	Lat 30°25' Long 96°06'	Dec. 23, 1956	22.7
Walker Creek near Washington	Lat 30°17' Long 96°05'	Nov. 27, 1956	No flow
Doe Run near Washington	Lat 30°13' Long 96°09'	Nov. 27, 1956	do
Jackson Creek near Hempstead	Lat 30°12' Long 96°10'	Nov. 27, 1956	do
New Year Creek near Chapel Hill	Lat 30°08' Long 96°12'	Nov. 27, 1956	do
Caney Creek near Hempstead	Lat 30°04' Long 96°09'	Nov. 28, 1956	do
Piney Creek near Sunnyside	Lat 29°57' Long 96°09'	Nov. 28, 1956	do
Eight Mile Creek near Sealy	Lat 29°40' Long 96°03'	Nov. 28, 1956	do
Big Creek near Lochridge	Lat 29°23' Long 95°35'	Nov. 28, 1956	do

Other small creeks with no names shown on figure 20 were investigated and found to have no flow.

Weekly visits were made to each regular gaging station involved and water-stage recorder charts were removed for use in preparing weekly reports furnished to cooperating agencies.

In general, the field work was coordinated so as to obtain regular and miscellaneous discharge measurements at the same time the water-stage recorder charts were removed. After the water release was stopped and base-flow conditions were resumed, the water-stage recorder charts were removed and low-flow measurements were made at all gaging stations to determine base flow at each station. Local gage observers reported daily gage heights at all stations.

Rainfall

As mentioned above, the basic records used in this report were considerably complicated by inflow from rainfall at the beginning and end of the period of release. The table following shows the significant rainfall occuring during November and December 1956 on watersheds within the area of this report.

Rainfall in inches at selected stations from Climatological Data published by the U. S. Weather Bureau.

Precipitation Station	November 1956						December 1956					
	2	3	4	5	6	15	18	19	20	21	22	23
Little River basin below Belton Reservoir												
Temple	0.24	0.29	1.22	0.53			0.41	1.29	0.51			
Davilla	1.42	0.40	0.65				0.37	1.79	0.45			
Troy	0.56	0.50	0.85				1.40	0.70		0.15		
Burlington		0.75	1.65	0.22				1.10	0.36			
Cameron	0.69	0.20	0.95	0.15			1.30	0.22				
Lake Victor							2.00	0.25		0.20		
Liberty Hill												
Taylor	0.10	0.50	0.24				0.16	1.98	0.44			
Jarrell	0.65	0.20	2.15	0.55	0.10		0.20	1.07	0.58			0.10
Brazos River basin above Little River												
Waco, WB-AP	0.54	1.02	0.77				0.83	1.03				
Brazos River basin below Little River												
Valley Junction		0.59	0.30	0.70			0.43	0.90	0.19			
Brenham		0.62	0.70	0.23			2.15	0.68	0.20		0.22	1.83
Hempstead		0.25	2.44	0.22			1.45	0.27			0.53	0.91
Sealy		0.52	0.23	0.10			2.92	0.16		0.88	0.43	
Richmond		0.37	0.17				1.92	0.74			1.09	
Sugarland		0.29				0.75	1.45	0.33			1.10	
Dime Box	0.20	0.52	0.48				1.90			0.35	0.38	0.13
Thornton		1.09	0.80	0.85	0.12			1.14	0.18			
College Station	1.03	0.38	0.30	0.12			1.15	0.11		0.15	0.30	
Anderson	0.43	1.58	0.48	0.12			1.73			0.22	2.23	
Brenham		0.62	0.70	0.23		0.15	2.15	0.68	0.20		0.22	1.83
Sealy		0.52	0.23	0.10			2.92	0.16		0.88	0.43	

The rises from rainfall shown in the table above unfortunately arrived at the gaging stations when water released from Belton Reservoir was passing with the exception of the Cameron station, where the release water preceded the rise resulting from rainfall by about one day. (See fig. 21) This fact, combined with very good discharge measuring conditions at the Cameron station, greatly facilitated the separation of the released water from flood water, as well as the determination of the time of travel for all types of flow involved.

Daily and Weekly Reports During Period of Water Release

A daily report of flow at each station was compiled from previously defined stage-discharge relation curves and from once-daily gage readings received from local observers by long-distance telephone. This information (subject to later revision) was furnished immediately to cooperating agencies. In addition, a summary of daily flow at all gaging stations was furnished to cooperating agencies at the end of each week. These data were used by the Corps of Engineers and the Brazos River Authority to regulate the amounts of water released to conform with water losses and variations in travel time of water.

After the release had been completed a final summary of daily discharge

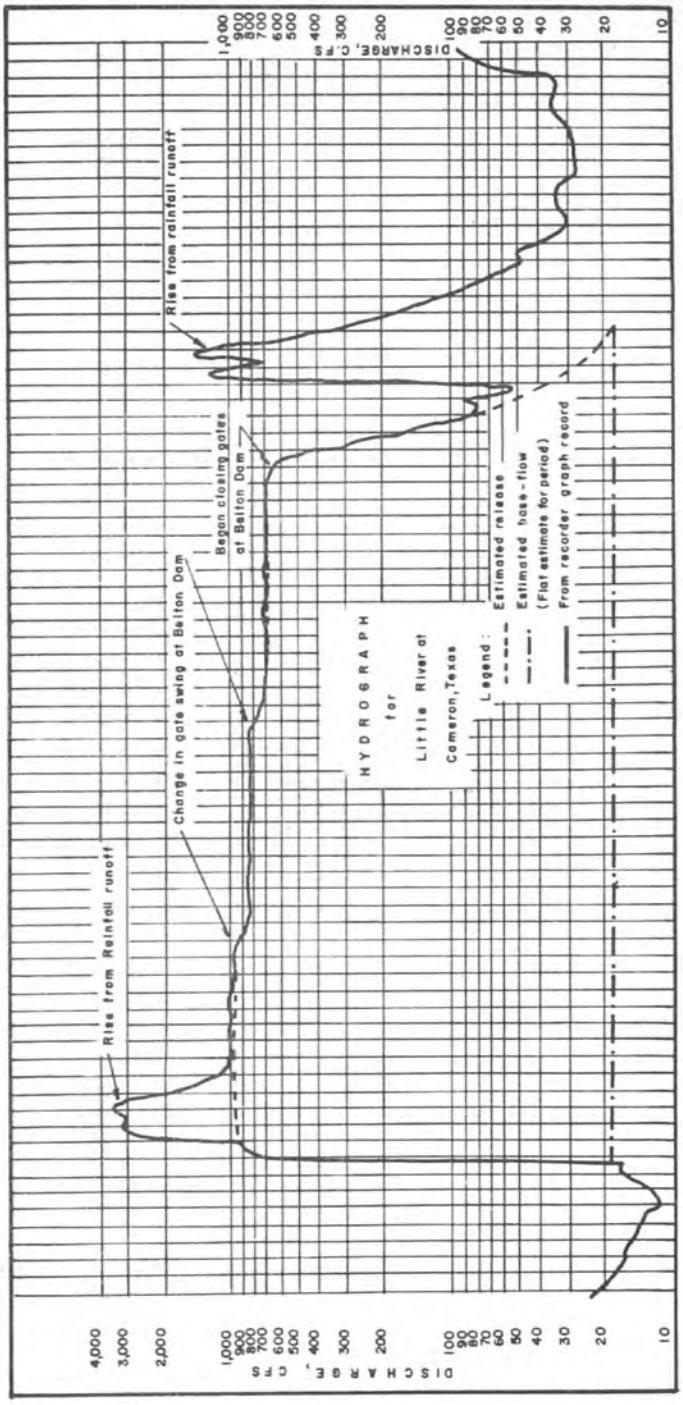


FIGURE 21.-DISCHARGE HYDROGRAPH, LITTLE RIVER AT CAMERON, TEX.-1956.

(USGS form 9-192a) was prepared for each gaging station covering the entire period of the release. These summaries, combined with actual current-meter measurements, were the basic data used in this study.

Discussion

Very early in the study of this flow-routing investigation, it became obvious that this, and probably most other similar flow-routing investigations, must be treated as special cases with emphasis placed on the following prime factors:

1. Current season of the year
   a. Regarding growth period of phreatophytes
   b. Regarding ground-water conditions affecting base flow.
   c. Regarding inflow from rainfall

2. Condition of river channels
   a. Regarding the flow existing in the channels before and during the period of the routing
   b. Regarding existing river-bed characteristics

This investigation was complicated by a considerable amount of flood inflow resulting from rains soon after release of water began, as well as at the end of the release period, and by some diversions between the stations near San Felipe and at Richmond. Also, during the time this release was in progress, other small intermittent releases were being made from Lake Whitney on the Brazos River upstream from Waco. (See fig. 23) It may be noted by inspecting the discharge hydrographs (fig. 21-26) that periods of low flow existed prior to and following the period of release, and that several long periods of steady flow existed at all gaging stations during the release. These steady-flow periods provided important data for determining water losses between Belton Reservoir and the gaging station on Brazos River at Richmond.

The typical discharge recession curve for Richmond (fig. 27) was based partly on rises following the release and partly on previous rises of a comparable magnitude for the same season of the year, and was used to define the flood-flow recession hydrograph comprising the upper limits of base flow for rises which were partly obscured by the release water. The lower limits of base flow for each station were determined from a study of low-flow records for each station prior to and following the release.

An account of inflow from Brazos River tributaries contributing appreciable amounts of water was obtained by miscellaneous discharge measurements.

Although no seepage investigation has been made on the Brazos River reach considered in this report, the following statement from the Austin, Tex. office of the Ground Water Branch of the U. S. Geological Survey is an indication of the inflow from ground water affecting base flow for this reach of the Brazos River.

> "We have made no detailed studies along the Brazos River, but based on general knowledge of hydrologic conditions in the area, we can make the following general statements:

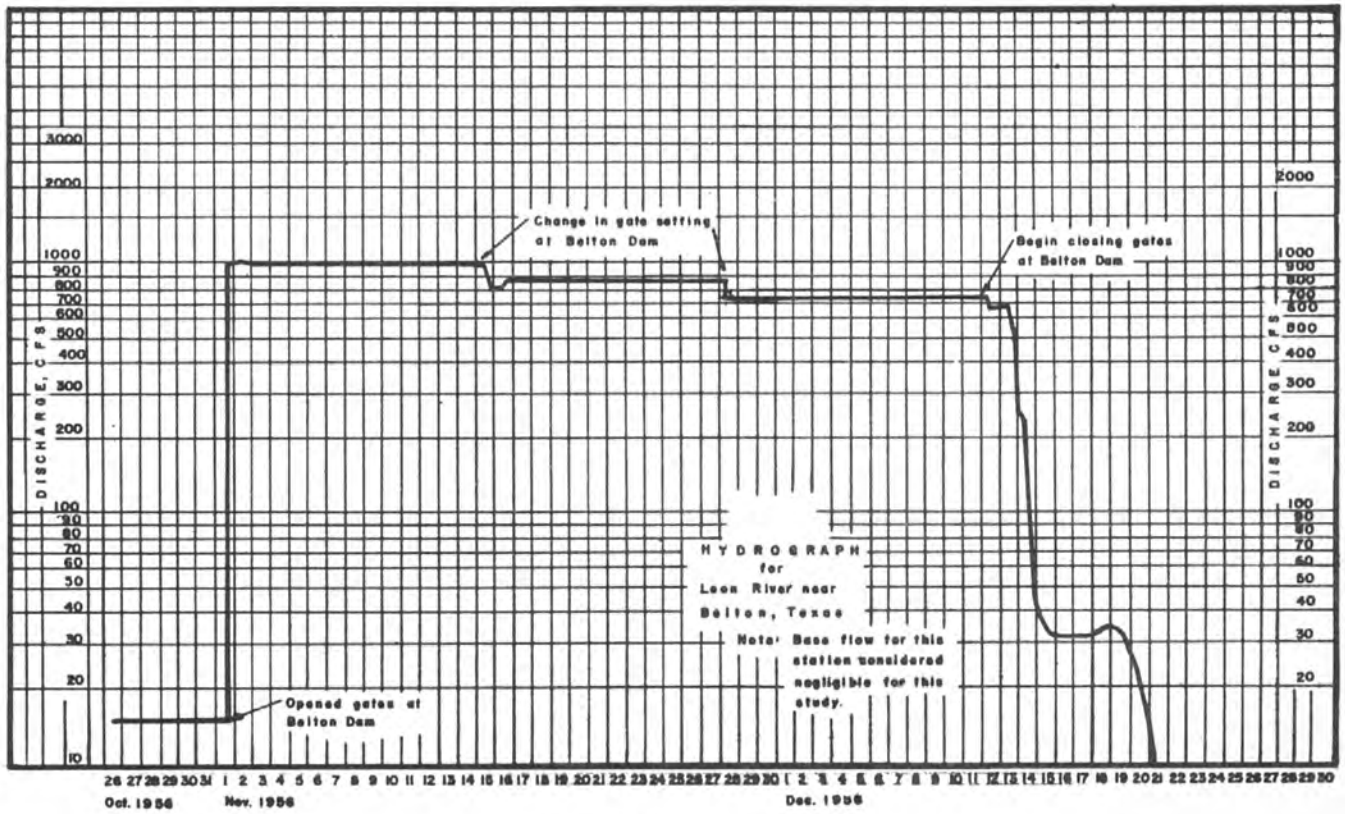


FIGURE 22.-DISCHARGE HYDROGRAPH, LEON RIVER NEAR BELTON, TEX.-1956.

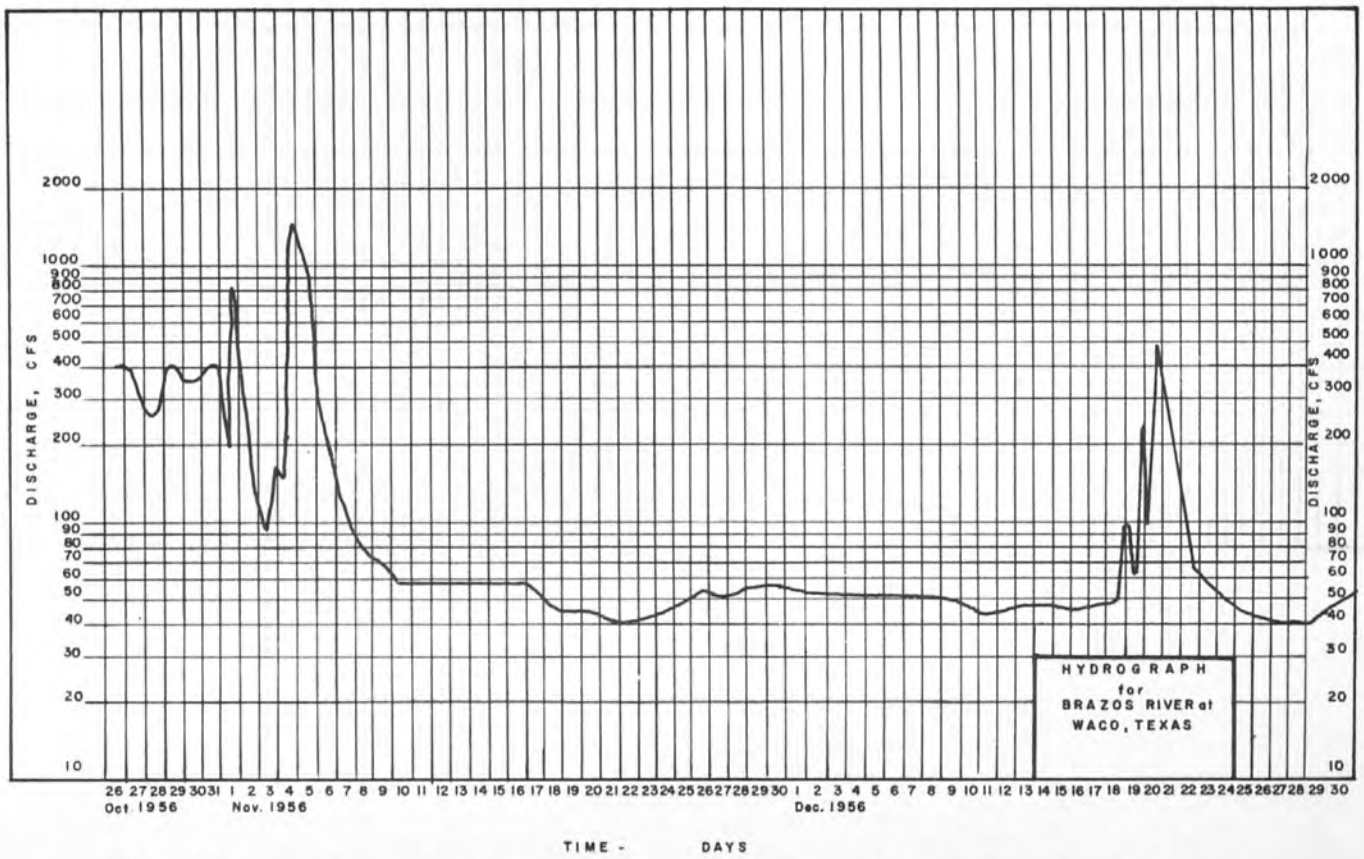


FIGURE 23.- DISCHARGE HYDROGRAPH, BRAZOS RIVER AT WACO, TEX.-1956.

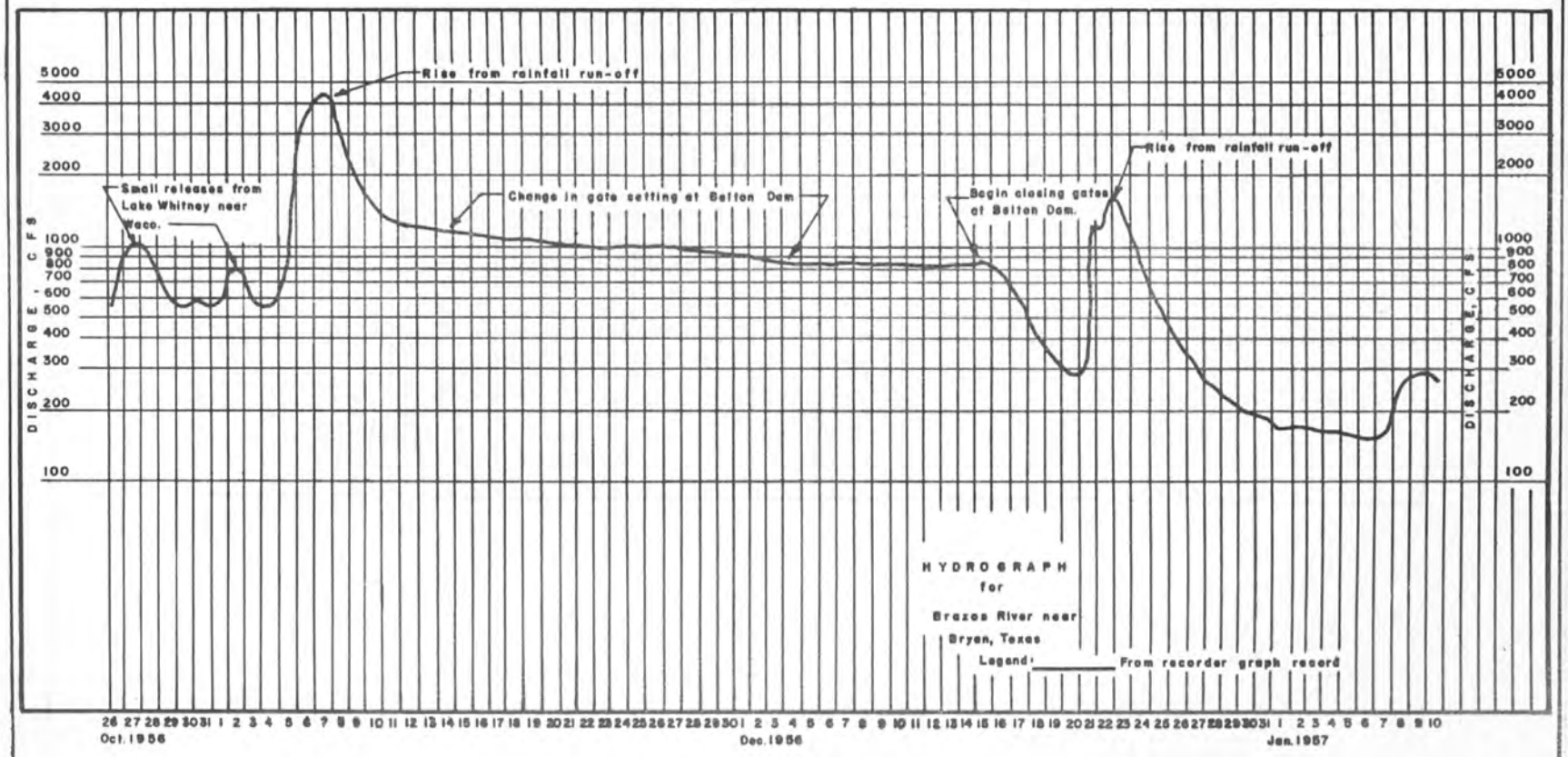


FIGURE 24.- DISCHARGE HYDROGRAPH, BRAZOS RIVER NEAR BRYAN, TEX.- 1956.

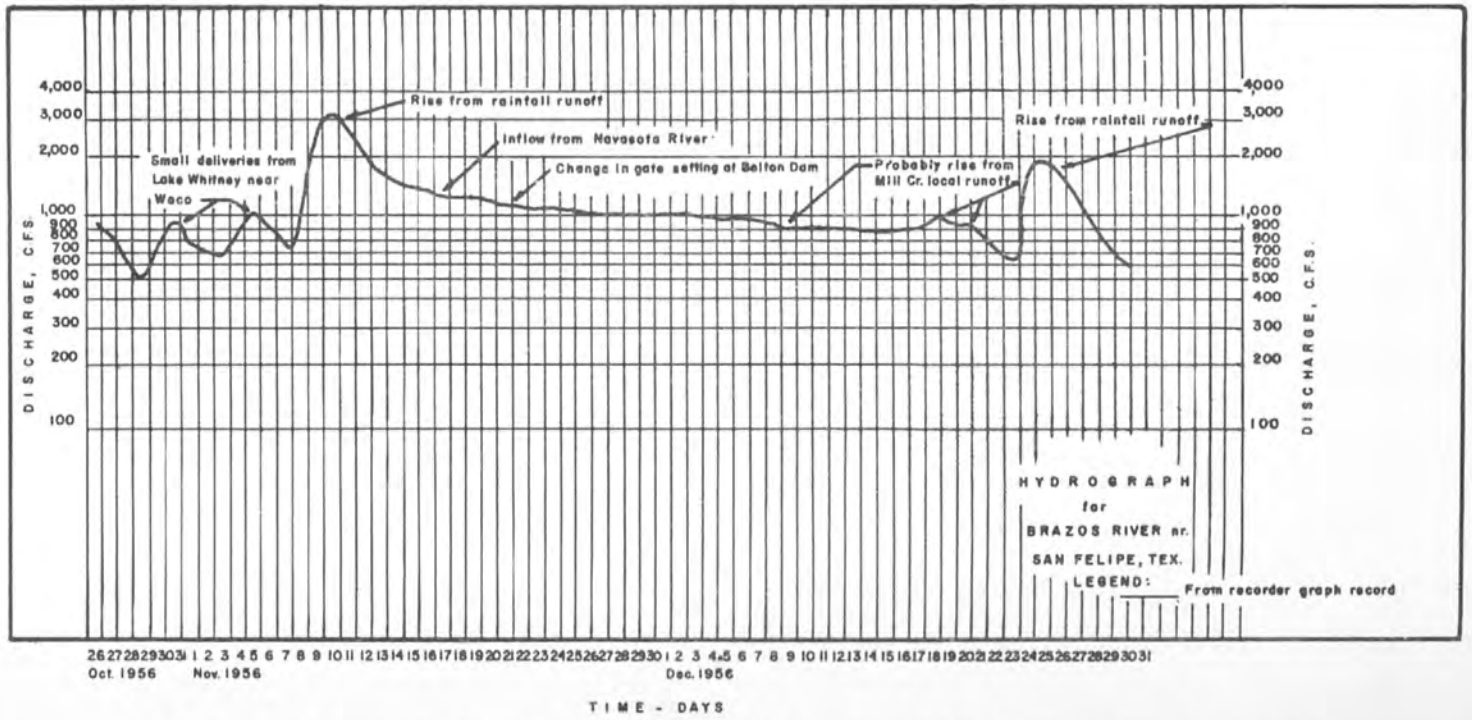


FIGURE 25.- DISCHARGE HYDROGRAPH, BRAZOS RIVER NEAR SAN FELIPE, TEX.- 1956.

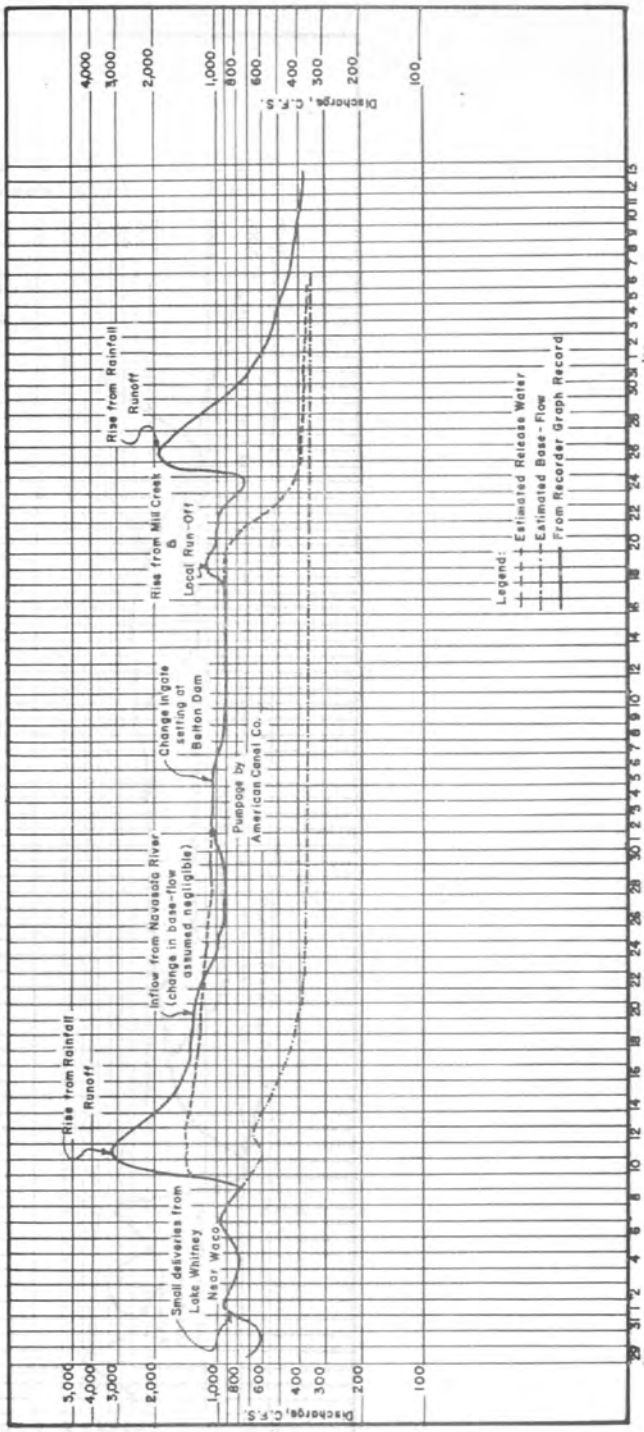


FIGURE 26.- DISCHARGE HYDROGRAPH, BRAZOS RIVER AT RICHMOND, TEX.- 1956-57.

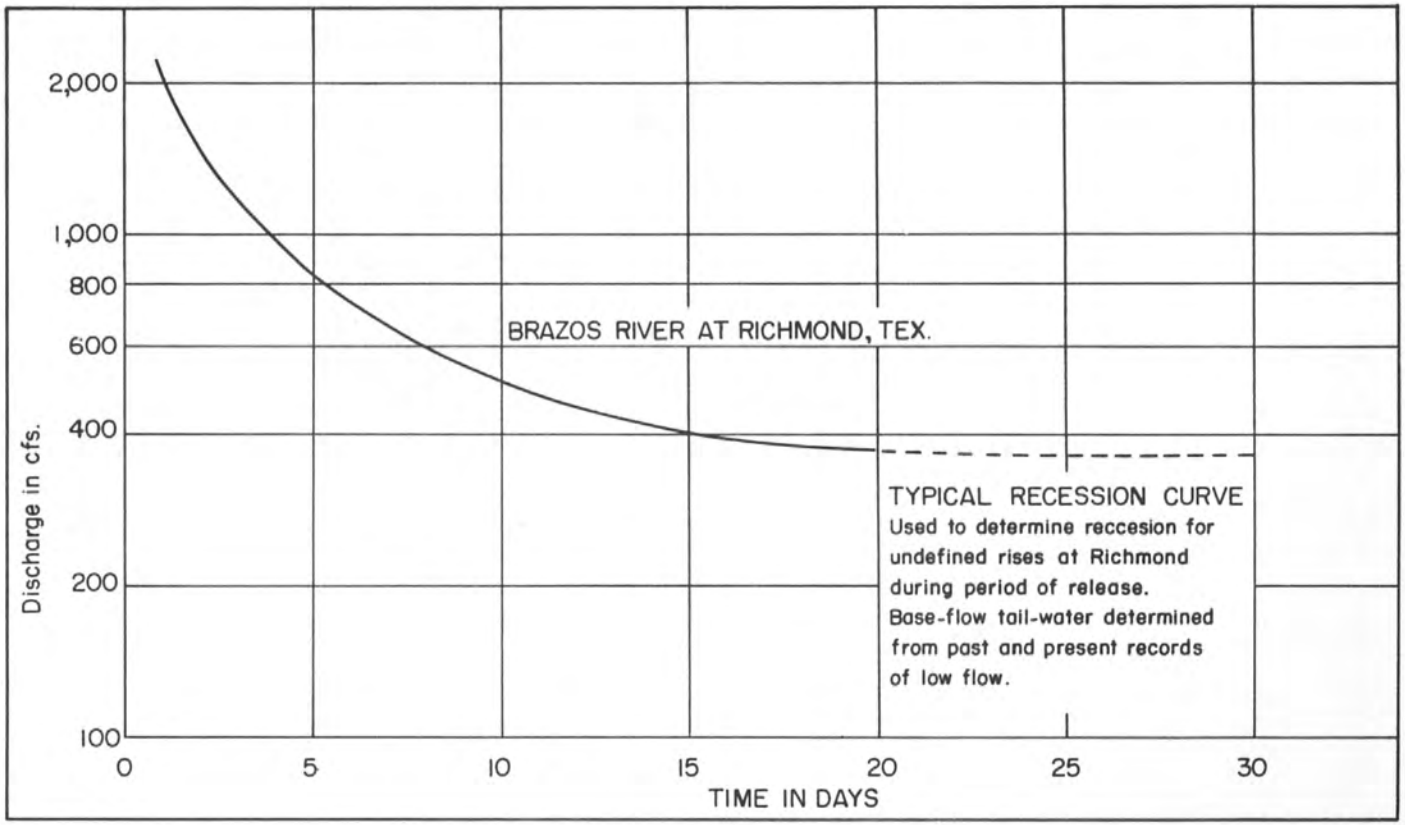


FIGURE 27.- TYPICAL RECESSION CURVE, BRAZOS RIVER AT RICHMOND, TEX.

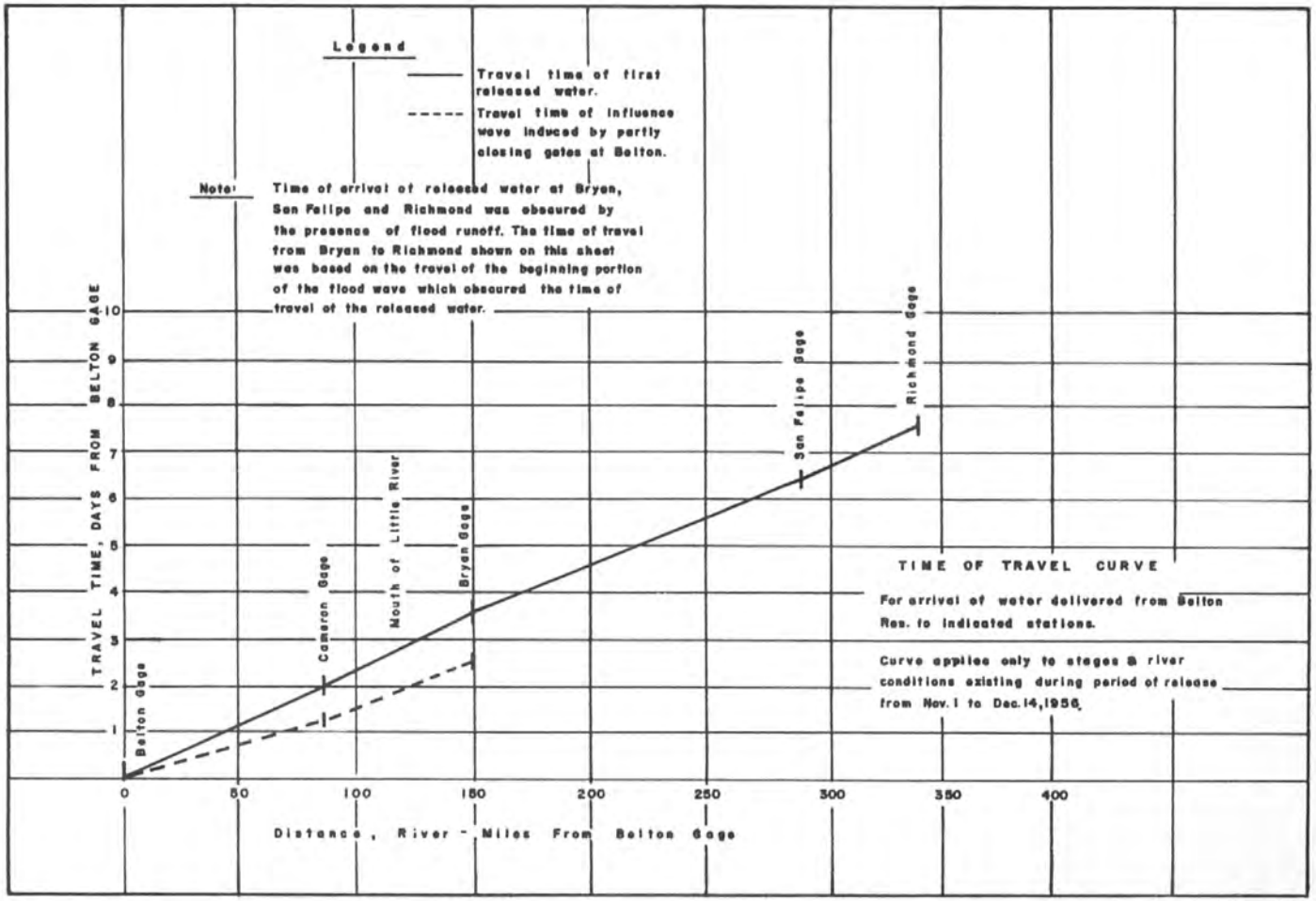


FIGURE 28.- TIME OF TRAVEL CURVE, BELTON TO RICHMOND, TEX.- 1956.

connected with delivering water through the reaches of the above-named river channels. The results of each phase of the water-separation study were combined to form a simple graphic analysis of the flow involved. The net accumulated losses from Belton to the Richmond station were obtained by separating the basic types of flow, namely, release, base flow, pumpage, and rainfall-runoff, into their proper category by comparing their respective ordinates on the hydrograph for each day throughout the period of release. (See fig. 29)

Conclusions

Upon the completion of this study of the water released from Belton Reservoir from Nov. 1 to Dec. 14, 1956 the following conclusions were drawn:

1. Each flow-routing investigation must be treated as a special case with emphasis placed on the prime factors as mentioned in first paragraph of Discussion.

2. The time of travel of the first portion of a flood wave is considerably more in many cases than that required for an influence wave as defined in this report.

3. The quantity of water released from Belton Reservoir and reaching the gaging station on Little River and on the Brazos River near Richmond is shown in the following table:

Quantity of water released from Belton Reservoir reaching streamflow stations as indicated

Station	Period of flow 1956	Belton Res. release water reaching indicated station	Percent of release water reaching indicated station
Leon River nr. Belton	Nov. 1 to Dec. 15	72,800 acre-ft.	100
Little River nr. Cameron	Nov. 3 to Dec. 19	69,900 do	96
Brazos River nr. Richmond	Nov. 19 to Dec. 30	54,300 do	74

Accuracy of Field Data and Computed Results

Application of records - The computation of quantities of released water reaching the Richmond gaging station was made complex because an estimate of base flow and flood inflow had to be made. The accuracy of these estimates is classified as "fair", or they are subject to errors of 15 percent or more.

Basic records - The basic records or total flow at all gaging stations and the miscellaneous measurements of flow of tributaries have an accuracy rating of "excellent", or the error in the total runoff past each gaging station is believed to be within 5 percent.

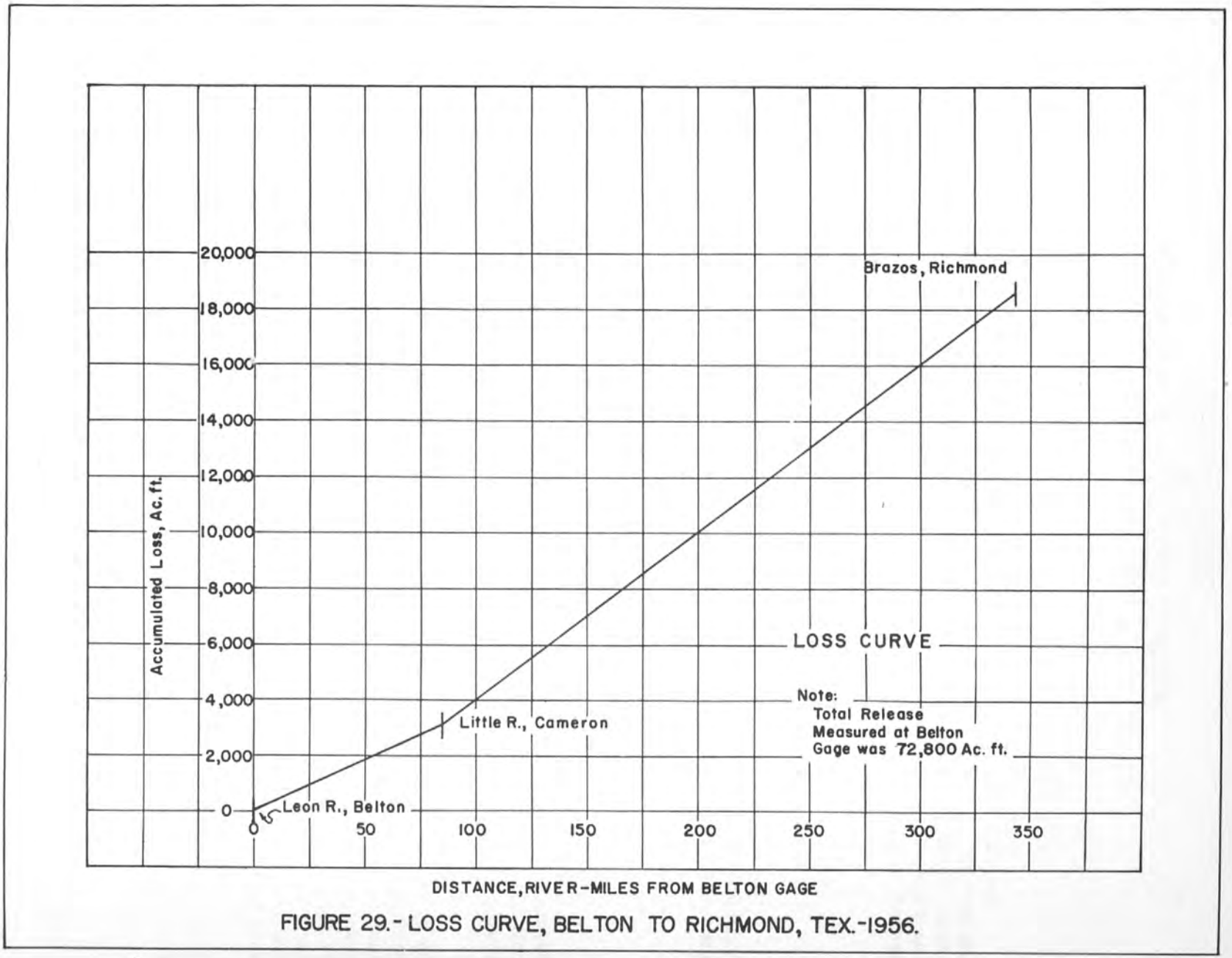


FIGURE 29.- LOSS CURVE, BELTON TO RICHMOND, TEX.-1956.

DELIVERY OF WATER FROM BROWNWOOD RESERVOIR TO WHARTON, TEXAS * JUNE AND JULY 1934

Introduction

The Bay City Water Company entered into an agreement with Brown County Water Improvement District No. 1 for the release of water from Brownwood Reservoir on Pecan Bayou ten miles upstream from Brownwood, Tex., for the purpose of irrigating rice along the Colorado River near Bay City, Tex. The first water was released on June 27, 1934.

Purpose

The purpose of this report is to show the quantity of water released from Brownwood Reservoir, the time of its travel downstream to Wharton, and the quantity of released water reaching Wharton.

Scope of Study

The reaches of the streams directly involved in this study are along Pecan Bayou from the stream-gaging station at Brownwood to its mouth, thence along the Colorado River from the mouth of Pecan Bayou to the temporary stream-gaging station at Wharton; a total distance of 458 river miles.

In addition to the gaging station at Brownwood, the U. S. Geological Survey in cooperation with the Texas Board of Water Engineers maintained during this period regular gaging stations on the Colorado River near San Saba, near Tow, at Austin, at Smithville, and near Eagle Lake. For the special study of this released water, temporary gages were established on the Colorado River at Columbus, Garwood, and Wharton. All gages were equipped with continuous water-stage recorders. The gages at Garwood and Wharton were discontinued on July 16 and at Columbus on July 17. The records at the temporary gages were used only for a study of time intervals and losses for the first part of the water released. The

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* From an unpublished report by Seth D. Breeding, Hydraulic Engineer, U. S. Geological Survey, 1934.

discharge records at the stations near San Saba and at Smithville were not used in a study of losses as they appeared to be somewhat in error.

Results

Fifty-six percent of the first 10,600 acre-feet of released water was lost between Brownwood and Eagle Lake, and 70 percent was lost between Brownwood and Wharton. Thirty-three percent of the first 65,900 acre-feet of released water was lost between Brownwood and Eagle Lake. Study of the time interval table in connection with the hydrograph for Pecan Bayou at Brownwood will indicate a number of conditions affecting the rate of water travel.

The accompanying table and hydrographs (figs. 30 and 31) show in considerable detail the losses and time intervals of various portions of the released water. In determining the loss for the first 10,600 acre-feet released, it was necessary to estimate the latter part of the graph at Columbus and below as the second water released began to overtake the first. Also, it was necessary to estimate the ordinary flow at each station during the period of study of losses. No large error is considered to have been introduced by these estimates.

Discussion

During the period June 27 to July 2, 10,600 acre-feet of water was released. On July 2 the flow had been reduced to 30 cfs (cubic feet per second) at the Brownwood gaging station. The reservoir gates were opened again on July 3 to release another increment of the purchased water and, due to an accident to their mechanism, the gates could not be closed. This permitted all of the stored water, 71,800 acre-feet as measured at the Brownwood gaging station, to drain from reservoir. The rate of released varied as numerous attempts were made to close the gates. The amount and rate of release is best shown by the accompanying hydrograph which was obtained from record of discharge at the gaging station on Pecan Bayou at Brownwood, ten miles below Brownwood Reservoir.

The only diversions of consequence between the point the water was released and the point it was to be used below Wharton are four pumping plants - Lakeside Irrigation Company near Eagle Lake, Garwood Irrigation Company at Garwood, Wilson Bros. Pumping Plant 10 or 12 miles below Garwood, and Pierce Estate Pumping Plant 3 miles above Wharton. These plants continued to divert the same quantity of water after the released water arrived as had been diverted prior to the arrival of that water until the increased flow due to the jamming of the reservoir gates had arrived. The plants were then permitted to divert to capacity.

A number of small diversions, including that of the city of Austin, were also being made during this time. These diversions were probably a constant amount both before and during the period of flow of the released water and are, therefore, taken care of as the ordinary flow at each station is eliminated.

During the period under study, regular gaging stations were also maintained on Colorado River near Milburn, San Saba River at San Saba, Llano River near Castell, and Pedernales River near Spicewood. Neither the discharge records at these stations nor the available rainfall records indicate that there was any

STATION	LOSSES						TIME INTERVALS																						
									Travel of first water released (1)			Travel of first peak (2)			Travel of second water released (3)			Travel of second peak (4)			Travel of third peak (5)			Travel of fourth peak (6)		
	Period of Flow Studied	A/V Volume in Acre-ft.	Percent Lost	Period of Flow Studied	A/V Volume in Acre-ft.	Percent Lost	Distance Downstream	Fall in feet per mile	Time interval between stations	Time interval from Brownwood	Ordinary flow in Cfs	Time interval between stations	Time interval from Brownwood	Flow at peak in Cfs	Time interval between stations	Time interval from Brownwood	Flow at arrival of water in Cfs	Time interval between stations	Time interval from Brownwood	Flow at peak in Cfs	Time interval between stations	Time interval from Brownwood	Flow at peak in Cfs	Time interval between stations	Time interval from Brownwood	Flow at peak in Cfs
Pecan Bayou at Brownwood, Tex.	June 27 to July 2	10,600	0	June 27 to July 20	65,900	0	0 mi.			0	0		0	3,590		0	30		0	2,470		0	3,420		0	3,280
								3.15	36 hrs.			33 hrs.			36 hrs.			35 hrs.			34 hrs.			31 hrs.		
Colorado River near San Saba, Tex.							70 mi.			36 hrs.	70		33 hrs.	2,580		36 hrs.	95		35 hrs.	2,380		34 hrs.	2,640		31 hrs.	3,100
									18 hrs.			16 hrs.			22 hrs.			13 hrs.			14 hrs.			11 hrs.		
Colorado River near Tow, Tex.				June 30 to July 22	61,800	6.2	114 mi.	3.65		54 hrs.	100		49 hrs.	2,330		58 hrs.	142		48 hrs.	2,250		48 hrs.	2,840		42 hrs.	3,300
									77 hrs.			90 hrs.			62 hrs.			69 hrs.			56 hrs.			50 hrs.		
Colorado River at Austin, Tex.				July 3-25	54,100	18	255.5 mi.			131 hrs.	148		139 hrs.	1,360		120 hrs.	330		117 hrs.	1,660		104 hrs.	2,320		92 hrs.	3,190
								2.06	53 hrs.			54 hrs.			45 hrs.			50 hrs.						35 hrs.		
Colorado River at Smithville, Tex.							328.5 mi.			184 hrs.	195		193 hrs.	1,160		165 hrs.	442		167 hrs.	1,540					127 hrs.	2,960
								1.62	51 hrs.			57 hrs.			46 hrs.											
Colorado River at Columbus, Tex.	July 7-16	5,100	52				400.5 mi.			235 hrs.	255		250 hrs.	902		211 hrs.	516								47 hrs.		
									13 hrs.			18 hrs.			10 hrs.											
Colorado River near Eagle Lake, Tex.	July 8-16	4,620	56	July 8-30	44,000	33	418.5 mi.			248 hrs.	20		268 hrs.	896		221 hrs.	585									174 hrs.	2,690
								1.53	18 hrs.			8 hrs.			8 hrs.											
Colorado River at Garwood, Tex.	July 8-17	3,990	62				430.5 mi.			266 hrs.	4		276 hrs.	512		229 hrs.	223										
									30 hrs.			15 hrs.			22 hrs.											
Colorado River at Wharton, Tex.	July 10-19	3,130	70				457.5 mi.			296 hrs.	4		291 hrs.	358		251 hrs.	184										

A/V- Ordinary flow at each station has been eliminated.

STUDY OF WATER RELEASED FROM BROWNWOOD RESERVOIR ON PECAN BAYOU DURING JUNE & JULY 1934, AS IT TRAVELED DOWN PECAN BAYOU & COLORADO RIVER TO WHARTON, TEXAS

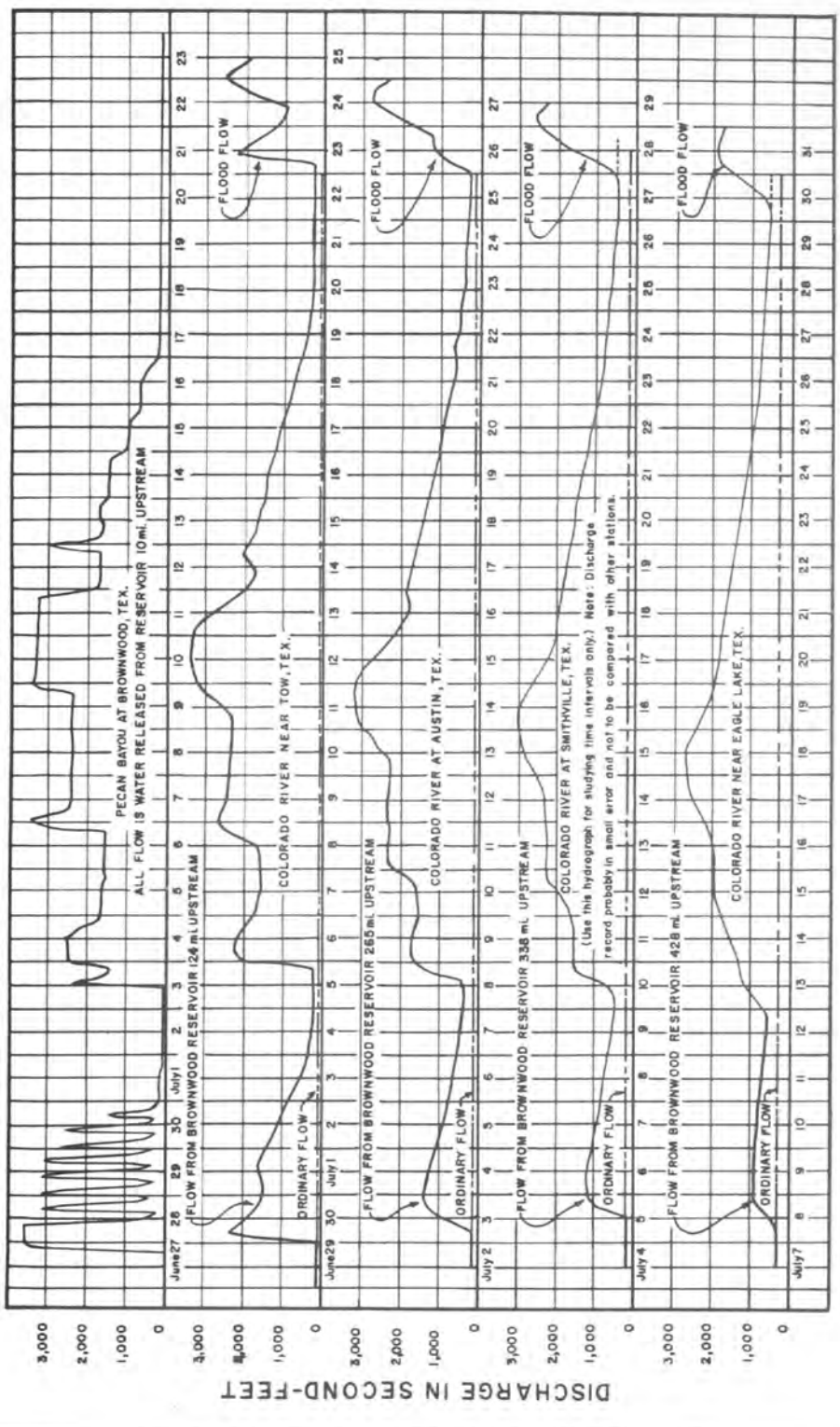

FIGURE 30. - HYDROGRAPHS: Showing Flow of Water Released From Brownwood Reservoir on Pecan Bayou During June and July, 1934.

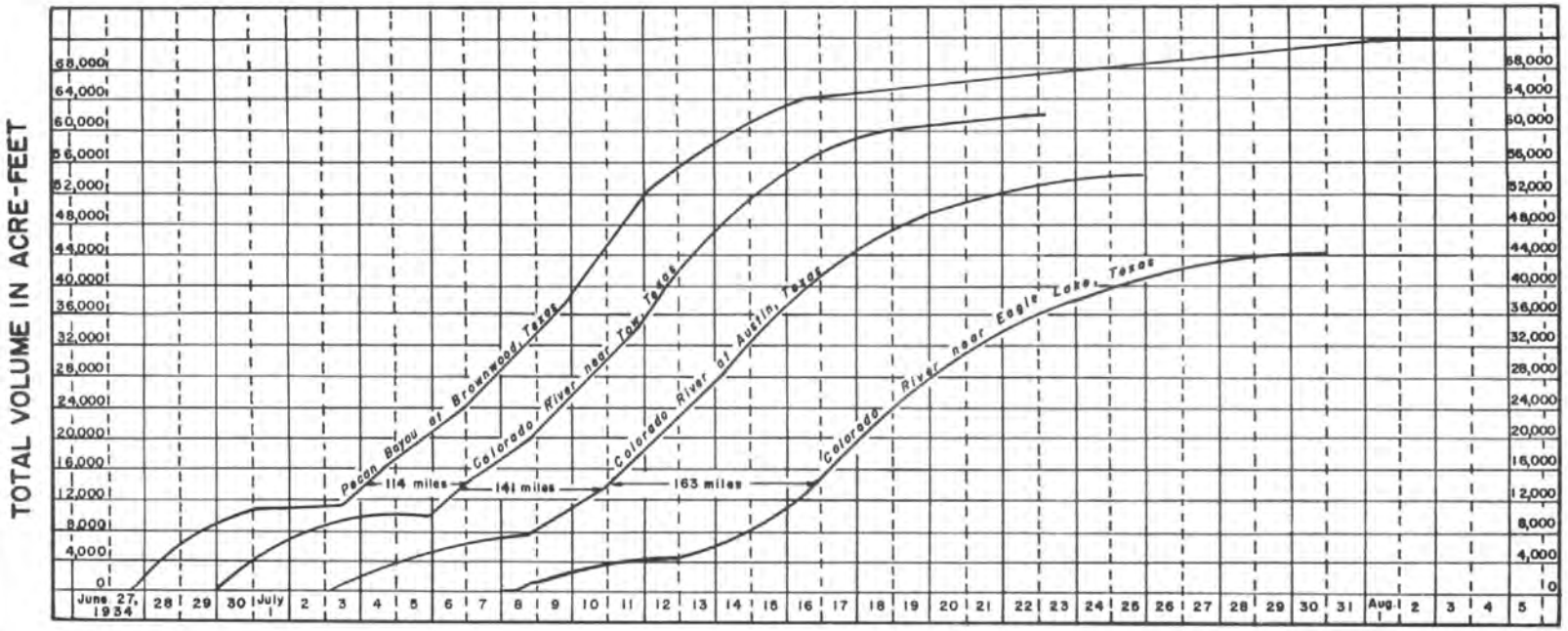

FIGURE 31. - MASS CURVES OF WATER RELEASED FROM BROWNWOOD RESERVOIR WITH NORMAL FLOW ELIMINATED

surfact runoff prior to July 22, that would interfere with a study of the losses in the released water. For over a month prior to the release of the water there was no rain nor rise of any great amount in any part of the stream between Brownwood and Wharton.

The appearance of floodwater in the Colorado River at the San Saba gaging station on July 22 and at later dates downstream made the study of loss in the total water released impossible. However, it was considered that the water released during the period June 27 to July 20, amounting to 65,900 acre-feet, could be followed through to Eagle Lake with fair accuracy.

DELIVERY OF WATER FROM LAKE AUSTIN TO BAY CITY, TEXAS VIA COLORADO RIVER CHANNEL *
JULY 1918

Introduction and Purpose

The water stored in Lake Austin on the Colorado River just upstream from Austin, Tex., was sold through order of the Federal Cort to the Markham Irrigation Co., and J. C. Carlson, et al., Trustees, and release of the water was ordered the first week in July 1918. The purchasers requested that the Texas Board of Water Engineers use its statutory authority to the end that the released water be allowed to flow undisturbed through the natural course of the Colorado River from Lake Austin to the purchasers just below Bay City, Tex. An engineer was sent to the lower Colorado River basin for the purpose of determining the amount of water which reached the purchasers.

Results

Data obtained during this investigation show that of 25,300 acre-feet of water released from Lake Austin, 19,000 acre-feet, or 75 percent passed Columbus (145 miles downstream) and 15,100 acre-feet, or 60 percent passed Wharton (202 miles downstream). The total quantity received by the purchaser (227 miles below Austin) was probably slightly less than that which passed Wharton, due to losses in "The Raft" and to a loss of about 9 cfs (cubic feet per second) which flowed through the "East Channel" of the river at Bay City and could not be recovered. The time of travel of first water was about five days to Columbus and seven days to Wharton.

Discussion

A falling stage had existed on the Colorado River at Austin for several days prior to the time stored water was released. The base flow of the river was determined by interpolation between discharge measurements made before the stored water was released and again after the supply in the reservoir had been exhausted and base-flow conditions were reached.

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* From an unpublished report by Glen A. Gray, District Engineer, U. S. Geological Survey, 1918.

The base flow of the Colorado River as determined at the stream-gaging station at the Congress Avenue viaduct in Austin, about three miles below the Austin Dam, was estimated as 200 cfs on July 5 before the gates of the reservoir were opened. Release of the water impounded by the Austin Dam was begun on the evening of July 5; the supply of stored water in the lake was exhausted at 3:30 p.m., July 24, On July 6, a flow of 786 cfs was measured at the Austin gaging station. This quantity, minus the estimated base flow of the river, gave 601 cfs of released water on July 6.

Discharge measurements were made at Columbus and Wharton to determine the rating curves for these stations. The daily gage heights were ascertained from the mean of two gage readings made each day by local observers. Although some error no doubt was introduced by taking the mean of two gage readings as the mean gage height for the day, the error in this case was not large, as the water was being released from the lake at a uniform rate. Thus, three base gaging stations - Austin, Columbus, and Wharton - were maintained to provide a check on the quantity of water as it progressed from Lake Austin to Bay City.

The records at Columbus and Wharton show that the first of the released water reached Columbus July 10, or five days after it had passed Austin, and that it reached Wharton two days later on July 12.

During the week ending July 13, a representative of the Texas Board of Water Engineers visited the pumping plants of the Lakeside Irrigation Company near Eagle Lake, The Garwood Irrigation Company at Garwood, The A. P. Borden Company above Wharton, and The Southern Irrigation Company at Lane City. Before the water which was released from Lake Austin arrived at these points, discharge measurements were made to determine the amount of water that each plant was diverting. It was impossible to reach the Lane City plant before the river began to rise. At the Lakeside plant it was found that preparations were being made to start operation of a new pumping unit capable of diverting 111 cfs. At first, it was thought that the operation of this new unit would divert the water released from Lake Austin, but it subsequently developed that the new plant was not completed until after the released water had passed Eagle Lake.

The various pumping plants above those which purchased the water were revisited after the rise in the river had reached them. In every case it was found that the plants were not diverting in excess of what had been diverted previously.

On July 9, previous to the arrival of the released water, the Lakeside Irrigation Company was diverting 90.1 cfs. On July 20 when the stage of the river at Lakeside plant had increased one foot, the amount of water diverted was measured and found to be 87.0 cfs.

The A. P. Borden system is equipped with a weir on its canal, and a staff gage and Bristol recorder are installed just above the weir. On July 11, a measurement was made on the crest of the weir at a stage of $16\frac{1}{2}$ inches, and it was found that 51.6 cfs was being diverted. Records kept by the engineer of this pumping plant show that the head over the weir was not increased above $16\frac{1}{2}$ inches during the period of the rise due to releasing of stored water.

On July 10, the Garwood plant was visited and a discharge measurement made of the amount of water diverted. The measurement showed that 112 cfs was being diverted at this plant through the operation of two pumps. This plant was again visited on July 17, and it was found that one pump was in operation. A third visit was made to this plant on July 20, and it was found that the operation of the plant was stopped for repairs during the morning of July 19, and according

to the best estimate of the engineer-in-charge, the plant would not be operated until July 23 or 24.

On July 15, the Southern Irrigation Company plant at Lane City was visited, and a discharge measurement made of water being diverted. At that time 210 cfs was being diverted by means of two pumps. This was after the released water had reached Lane City, and the owners of the plant claimed that the quantity being pumped was less than they had previously pumped. This plant was again visited on July 18, and at this time the smaller of the two pumps had been shut down, and as indicated by the level of the water in the flume, the plant was diverting only about two-thirds of the quantity of water which was being diverted on July 15.

Between Lane City and Bay City the flow is obstructed by what is known locally as "The Raft". This obstruction held the released water to such an extent that the time which elapsed before it reached the purchasers at Bay City was longer than anticipated. On July 16, measurements were made of the two pumping plants of the Markham Irrigation Company. The measurements indicated that 294 cfs was being diverted by these two plants. It was somewhat uncertain how much of this flow was base flow of the river, and how much was flow from Lake Austin release. The manager of the company was of the opinion that the flow of 118 cfs in the Markham Canal about represented the water which was being received from Lake Austin.

The Carlson pumping plant was not receiving any appreciable amount of the Lake Austin water at this time, due to the fact that the river did not rise sufficiently below "The Raft" to cause a flow into Blue Creek on which their plant is located. For this reason the Carlson Company decided to complete a canal which would carry water from the Colorado River above "The Raft" to Blue Creek. Water was first turned through this canal on July 24, and it was estimated that 11 cfs was flowing in the canal on July 25. Work of widening and deepening the canal was continued, and a measurement on July 26 indicated a flow of 31 cfs. It was believed that with one or two more days of work on the canal, the flow would be approximately doubled, provided the river above "The Raft" remained at the stage of July 26.

On July 18, measurements were again made on the Markham Canals and they were found to be diverting 307 cfs. Shortly after these measurements were made, the Markham plant increased its diversion to the full capacity of the pumps. A measurement on one Markham Canal on July 26 showed a flow of 197 cfs. Assuming the same flow in the "Northern" Canals as measured on July 18 when the Northern pumps were operating to capacity, a total diversion of 392 cfs is shown for the Markham Company. This represented at least 223 cfs in excess of the base flow of the river. In fact, it is doubtful whether the base flow at this point would have maintained a flow of 169 cfs.

The following tables show the estimated amounts of water released from Lake Austin which passed the base stations.

Colorado River at Austin, Texas

Date 1918	Mean daily discharge of Colorado River at Congress Avenue bridge in cfs	Estimated base flow of Colorado River at Congress Avenue bridge in cfs	Estimated amount of water released from Austin reservoir in cfs	Volume released from Austin reservoir in acre-feet
July 5	220	200	20	40
" 6	786	185	601	1,192
" 7	912	165	747	1,482
" 8	896	150	746	1,480
" 9	928	135	793	1,573
" 10	864	120	744	1,476
" 11	832	110	722	1,432
" 12	730	90	640	1,269
" 13	674	80	594	1,178
" 14	648	70	578	1,146
" 15	688	60	628	1,246
" 16	688	55	633	1,256
" 17	636	50	586	1,162
" 18	648	45	603	1,196
" 19	832	40	792	1,571
" 20	1,010	40	970	1,924
" 21	744	40	704	1,396
" 22	588	40	548	1,087
" 23	716	40	676	1,341
" 24	410	40	370	734
" 25	74	40	34	67
" 26	63	40	23	46
" 27	52	40	12	24
" 28	45	40	5	10
TOTAL				25,328

Colorado River at Columbus, Texas

Date 1918	Mean daily discharge of Colorado River at Columbus in cfs	Estimated base flow of Colorado River at Columbus in cfs	Estimated amount of water released from Austin reservoir which passed Columbus in cfs	Volume released from Austin reservoir which passed Columbus in acre-feet
July 8	450	450	0	0
" 9	400	400	0	0
" 10	540	410	130	258
" 11	842	400	442	877
" 12	824	390	434	861
" 13	860	375	485	962
" 14	836	365	471	934
" 15	824	355	469	930
" 16	715	345	370	734
" 17	670	335	335	664
" 18	680	320	360	714
" 19	715	315	400	793
" 20	725	300	425	843
" 21	720	290	430	853
" 22	720	280	440	873
" 23	926	270	656	1,301
" 24	1,030	260	770	1,527
" 25	824	255	569	1,129
" 26	735	250	485	962
" 27	800	240	560	1,111
" 28	660	230	430	853
" 29	530	220	310	615
" 30	388	215	173	343
" 31	332	210	122	242
Aug. 1	328	205	123	244
" 2	282	200	82	163
" 3	260	190	70	139
" 4	220	185	35	69
" 5	195	180	15	30
" 6	185	180	5	10
TOTAL				19,034

Colorado River at Wharton, Texas

Date 1918	Mean daily discharge of Colorado River at Wharton in cfs	Estimated base flow of Colorado River at Wharton in cfs	Estimated amount of water released from Austin reservoir which passed Wharton in cfs	Volume released from Austin reservoir which passed Wharton in acre-feet
July 11	238	238	0	0
" 12	409	230	179	355
" 13	630	220	410	813
" 14	640	210	430	853
" 15	650	205	445	882
" 16	605	200	405	803
" 17	533	190	343	680
" 18	502	185	317	629
" 19	497	180	317	629
" 20	546	170	376	746
" 21	560	165	395	783
" 22	515	160	355	704
" 23	470	155	315	625
" 24	452	150	302	599
" 25	625	145	480	952
" 26	670	140	530	1,051
" 27	524	135	389	771
" 28	595	130	465	922
" 29	528	125	403	799
" 30	425	125	300	595
" 31	277	120	157	311
Aug. 1	240	120	120	238
" 2	200	115	85	169
" 3	165	115	50	99
" 4	135	110	25	50
" 5	125	105	20	40
" 6	115	105	10	20
" 7	100	100	0	0
TOTAL				15,118

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