TEXAS WATER DEVELOPMENT BOARD

REPORT 2

BASE-FLOW STUDIES

NUECES RIVER, TEXAS

Quantity and Quality, November 23-25, 1964

By

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FOREWORD

On September 1, 1965 the Texas Water Commission (formerly, before February 1962, the State Board of Water Engineers) experienced a far reaching realignment of functions and personnel, directed toward the increased emphasis needed for planning and developing Texas' water resources and for administering water-rights.

Realigned and concentrated in the Texas Water Development Board were the investigative, planning, development, research, financing, and supporting functions, including the reports review and publication functions. The name Texas Water Commission was changed to Texas Water Rights Commission, and responsibility for functions relating to water-rights administration was vested therein.

For the reader's convenience, references in this report have been altered, where necessary, to reflect the current (post September 1, 1965) assignment of responsibility for the function mentioned. In other words credit for a function performed by the Texas Water Commission before the September 1, 1965 realignment generally will be given in this report either to the Water Development Board or to the Water Rights Commission, depending on which agency now has responsibility for that function.

Texas Water Development Board

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INTRODUCTION

An investigation was made by the U.S. Geological Survey, under a cooperative agreement with the Texas Water Development Board, to determine the changes in quantity and chemical quality of the base flow of the Nueces River in a 52.2-mile reach beginning at U.S. Highway 90 and extending to the crossing of Farm Road 1025 north of Crystal City. Knowledge of the changes in quantity and chemical quality of base flow is necessary for any evaluation of the effectiveness of the river channel in conveying water released from potential upstream reservoirs. The investigation was made November 23-25, 1964, during a period when evaporation and transpiration were small and the discharge past the stream-gaging station, Nueces River below Uvalde, was constant. Floods of September 1964 contributed considerably to the recharge of the alluvium in the reach investigated, resulting in a higher than average base flow.

River mileage given herein was measured from U.S. Geological Survey topographic maps: Hacienda, Pulliam Ranch, and Sand Mountain Quadrangles; and, Corps of Engineers, La Pryor Quadrangle.

QUANTITATIVE RESULTS

Discharge was determined at 10 sites on the Nueces River and on all major tributaries in the 52.2-mile reach investigated. Table 1 summarizes the pertinent data for each site where discharge was determined. The following subsections discuss the quantitative results in those reaches where appreciable change in surface flow or a significant change in geology occurred.

Mile 0 to Mile 2.8

The river was not flowing at U.S. Highway 90 (mile 0), although there may have been a small amount of underflow through the gravel at this site. The geology in the reach is not well enough known to identify the origin of the 16.6 cfs (cubic feet per second) of flow at mile 2.8 (site 2). It is probable that this flow came from the alluvium and Pleistocene Leona Formation as a result of having been forced to the surface by a rapidly diminishing cross-sectional area, above the underlying Upper Cretaceous Austin Chalk.

Table 1.--Summary of discharge measurements, Nueces River base-flow investigation, November 23-25, 1964

Meas. No.	Date	Stream	Location	River Mile	Water Temp. (°F)	Discharge in cfs: Main Stream	Discharge in cfs: Tributary	Streambed	Remarks
	1964 Nov.								
1	23	Nueces River	Lat 29°12'21", long 99°54'09", at U. S. Highway 90 bridge.	0	-	0		Gravel	Discontinued partial-record station 8-1910.
2	23	Nueces River	Lat 29°10'51", long 99°53'46", 75 feet below Tom Nunn crossing and 375 feet downstream from ruins of discontinued gaging station.	2.8	65	16.6		Gravel	Discontinued stream-gaging station 8-1915.
3	23	Unnamed tributary	Lat 29°09'03", long 99°55'01", at mouth and 2.7 miles below discontinued stream-gaging station.	5.5	-		0		
4	23	Nueces River	Lat 29°07'08", long 99°53'13", 100 feet below Smyth Ranch road crossing and 0.5 mile below gaging station.	9.4	60	36.2		Gravel	Stream-gaging station 8-1920.
5	23	Elm Creek	Lat 29°07'58", long 99°52'48", at Farm Road 481 crossing.	a11.9	-		0	Gravel	
6	23	Elm Creek	Lat 29°05'18", long 99°52'07", at mouth of creek, 0.8 mile above low-water crossing at old U. S. Highway 83.	11.9	-		0	Gravel	
7	23	Nueces River	Lat 29°04'44", long 99°52'19", 75 feet above Missouri Pacific Railroad bridge at the old U. S. Highway 83 bridge site and 8 miles north of La Pryor.	12.8	65	31.7		Gravel	
8	23	Unnamed tributary	Lat 29°04'05", long 99°50'59", on left bank 875 feet above U. S. Highway 83 crossing.	14.5	-		.01		
9	24	Nueces River	Lat 29°02'07", long 99°50'10", 0.4 mile above old Uvalde-La Pryor road crossing, 3,000 feet above point where transmission line crosses river, and 0.4 mile above mouth of Live Oak Creek.	18.4	61	32.5		Gravel	Fault crosses channel 100 feet below.
10	24	Live Oak Creek	Lat 29°01'59", long 99°49'46", at mouth of Live Oak Creek.	18.8	-		0	Gravel	
11	24	Nueces River	Lat 29°02'00", long 99°49'39", 300 feet below point where transmission line crosses river and 0.2 mile below mouth of Live Oak Creek.	19.0	61	33.6		Gravel	Near upper edge of Carrizo Sand under alluvium.
12	24	Unnamed tributary	Lat 29°00'10", long 99°47'55", 0.6 mile above mouth of Mustang Creek on left bank of Nueces River.	21.8	-		0	Gravel	
13	24	Nueces River	Lat 29°00'08", long 99°47'56", 200 feet below unnamed tributary (site 12 above) and 0.6 mile above mouth of Mustang Creek.	21.8	64	11.7		Gravel	Near lower edge of Carrizo Sand under alluvium.
14	24	Mustang Creek	Lat 28°59'49", long 99°49'11", 1.7 miles above mouth and at Farm Road 1436 crossing.	a22.4	-		0	Gravel	
15	24	Mustang Creek	Lat 28°59'37", long 99°47'50", at mouth 7.3 miles above Farm Road 394.	22.4	-		0	Gravel	
16	24	Nueces River	Lat 28°57'52", long 99°47'40", 5.0 miles above Farm Road 394 and La Pryor-Batesville road crossing.	24.7	-	0		Gravel	At least 1 mile of reach at this site has no flow.
17	24	Sand Ridge Creek	Lat 28°56'46", long 99°46'53", at mouth of creek and 3.0 miles above Farm Road 394 at La Pryor-Batesville road crossing.	26.8	-		0	Gravel	
18	24	Nueces River	Lat 29°55'11", long 99°47'02", 800 feet below La Pryor-Batesville crossing on Farm Road 394.	29.9	64	7.90		Sand and gravel	
19	25	Sand Creek	Lat 28°52'37", long 99°50'58", at U. S. Highway 83 crossing and 7.6 miles above mouth.	a48.0	-		0	Gravel	
20	25	Combalatche Creek	Lat 28°48'35", long 99°51'04", at U. S. Highway 83 crossing and 2.8 miles above mouth.	a51.5	-		0	Gravel	
21	25	Nueces River	Channel below concrete spillway: Lat 28°46'28", long 99°50'02", 250 feet below concrete spillway. Channel below earth dam: Lat 28°46'35", long 99°49'30", 250 feet below dam at Farm Road 1025 Highway crossing. These two sites are located at discontinued gaging station site Nueces River near Cinonia, Tex. (8-1925).	52.2	(b)	13.4		Blue clay	Discharge does not include estimated 600 gpm being pumped from river 400 feet upstream.

a River miles on Nueces River at mouth of tributary.
b At this site the river was flowing in two channels.

Mile 2.8 to Mile 9.4

A discharge of 36.2 cfs was measured at mile 9.4 (site 4), a gain of 19.6 cfs in this 6.6-mile reach. As in the previous reach, this gain in discharge is attributed to seepage from the underlying alluvium and Leona Formation.

Mile 9.4 to Mile 19.0

The minor changes in surface flow in this reach--from 36.2 cfs at start to 31.7 cfs at mile 12.8 (site 7), 32.5 cfs at mile 18.4 (site 9), and 33.6 cfs at mile 19.0 (site 11)--probably are the result of changes in amounts of underflow in relation to streamflow at the measuring sites. Little, if any, interchange of surface and ground water occurs in the fault zones near the lower end of this reach.

Mile 19.0 to Mile 21.8

A loss in surface flow of 21.9 cfs was measured in this 2.8-mile reach. The Eocene Carrizo Sand underlies the Leona Formation in most of this reach. Large amounts of water are pumped from the Carrizo and the Leona in the vicinity. Although some of the loss in surface flow can be assessed to recharge of the Carrizo (Turner, et al., 1960, p. 52-65), the major portion is attributed to the extensive underflow in the alluvium and recharge of the Leona which underlies the alluvium at mile 21.8 (site 13). A major fault occurs along the contact of the Carrizo Sand and the Eocene Mount Selman Formation at about mile 21. Some of the loss in surface flow in this reach could be attributed to this fault.

Mile 21.8 to Mile 24.7

The river was not flowing at mile 24.7 (site 16) and apparently there had been no flow at this site since the last flood flow in September. The loss in this reach of the 11.7 cfs measured at mile 21.8 probably can be attributed to either or both of the following factors: (1) recharge of the alluvium and Leona Formation, which are pumped heavily in the vicinity, and (2) a continued increase in the large amounts of underflow at the downstream measuring sections.

Mile 24.7 to Mile 29.9

A flow of 7.90 cfs was measured at mile 29.9 (site 18). This gain of flow is attributed to the reappearance of some of the apparently large underflow in the river gravel at mile 24.7. A small increase in the dissolved-solids concentration of the water from that measured at mile 21.8 (see Table 2) indicates the possibility that part of the gain in flow is from irrigation upstream.

Mile 29.9 to Mile 52.2

A discharge of 13.4 cfs was measured as the outflow from a small channel dam at mile 52.2 (site 21). Also, an irrigation pump, 400 feet upstream, was pumping about 1.3 cfs. The total surface flow of 14.7 cfs found at mile 52.2

represents a gain of 6.8 cfs in this reach. As in the above reach, the gain can be attributed to a shallow water table probably influenced by a change in thickness of the alluvium.

QUALITATIVE RESULTS

Samples of water were collected for chemical analyses at eight sites on the Nueces River; from the discontinued stream-gaging station near Uvalde (mile 2.8 and site 2) to the discontinued stream-gaging station near Cinonia (mile 5.2 and site 21). Only minor changes were found in the chemical quality of samples collected from mile 2.8 (site 2) to mile 29.9 (site 18). (See Table 2.) For example, the dissolved-solids concentrations ranged from 259 to 277 ppm (parts per million) in this reach, and more than three-fourths of the dissolved solids were calcium and bicarbonate ions.

The slight increase in chloride and nitrate concentration (Table 2) and the increase in noncarbonate hardness between mile 21.8 (site 13) and mile 29.9 (site 18) could be the result of irrigation return flow through the alluvium in the reach.

A dam at mile 52.2 (site 21) backs water almost to mile 29.9 (site 18). Two samples were collected below the dam, one below the concrete spillway and one below the earthen dam. The slight difference in quality of the two samples probably resulted from differences in the amount of seepage and underflow water mixing with the surface water outflow. The dissolved-solids concentrations of the two samples collected below the dam were slightly higher than concentrations of the samples collected at upstream sites, but percentages of individual ions were about the same, except for silica and nitrate. A decrease in the concentration of these two ions would be expected in impounded water. Silica may be precipitated, and silica and nitrate are utilized by aquatic plants and animals in reservoirs.

Samples of water collected throughout the study reach were of good quality. However, the waters were all of the calcium bicarbonate type and the hardness (as calcium carbonate) was more than 220 ppm in all samples. Hard water is objectionable for domestic or industrial use because soap consumption and scale formation in water receptacles increase proportionally with water hardness. If softened, the Nueces River water should be excellent for domestic and industrial uses, and the raw water is satisfactory for irrigation.

PREVIOUS INVESTIGATIONS

Other base-flow investigations (Texas Board Water Engineers and U.S. Geological Survey, 1960, p. 113-125) have been made in this reach of the Nueces River. Although there is some similarity between the quantitative results of this investigation and those of two of the three previous investigations made under comparable climatic conditions, no direct comparison is attempted here, mainly because the difference in pumping from the alluvium and Leona Formation would nullify any such comparison. The two previous investigations with streamflow that was comparable to that found in this one were made in November 1931 and January 1932.

Table 2.--Chemical analyses and water discharge, Nueces River, November 23-25, 1964

(Analytical results in parts per million, except as indicated)

Site No.	Date 1964	Mean discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated)			Hardness as $CaCO_3$		Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25° C)	pH
													Parts per million	Tons per acre-foot	Tons per day	Calcium, magnesium	Noncarbonate				
									8-1915. NUECES RIVER NEAR UVALDE (Discontinued stream-gaging station)												
2	Nov. 23	16.6	12	74	13	7.3	1.3	260	15	13		13	277	0.38		238	25	6	0.2	481	7.3
									8-1920. NUECES RIVER BELOW UVALDE (Stream-gaging station)												
4	Nov. 23	36.2	13	71	12	7.7	1.3	238	17	15	0.1	12	266	0.36		226	33	7	0.2	464	7.5
									NUECES RIVER AT MISSOURI PACIFIC RAILWAY BRIDGE, 8 MILES NORTH OF LA PRYOR												
7	Nov. 23	31.7	13	68	12	8.0	1.7	226	22	15		12	263	0.36		219	34	7	0.2	452	7.1
									NUECES RIVER 0.4 MILE ABOVE MOUTH OF LIVE OAK CREEK												
9	Nov. 24	32.5						222		16						216	34			451	7.4
									NUECES RIVER 0.2 MILE BELOW MOUTH OF LIVE OAK CREEK												
11	Nov. 24	33.6	13	66	13	9.0	1.5	222	26	16		12	266	0.36		218	36	8	0.3	452	7.2
									NUECES RIVER 0.6 MILE ABOVE MOUTH OF MUSTANG CREEK												
13	Nov. 24	11.7	12	62	12	14		210	26	18		12	259	0.35		204	32	13	0.4	438	7.5
									NUECES RIVER AT FARM ROAD 394												
18	Nov. 24	7.90	12	64	14	10	1.7	194	26	25		19	267	0.36		217	58	9	0.3	460	7.3
									8-1925. NUECES RIVER NEAR CINONIA (LEFT CHANNEL) (Discontinued stream-gaging station)												
21	Nov. 25	11.9	4.6	80	14	17		232	33	43	0.2	10	316	0.43		257	67	12	0.5	575	7.3
									8-1925. NUECES RIVER NEAR CINONIA (RIGHT CHANNEL)												
21	Nov. 25	1.55	4.7	73	15	20		212	40	44		11	312	0.42		244	70	15	0.6	560	7.3

Data from low-flow investigations generally are quantitatively comparable only when the climate, the contiguous water table, and the proportion of surface flow and underflow at measuring sites are identical.

SUMMARY

The amount of surface-flow loss that can be attributed to recharge of the Carrizo Sand cannot be determined accurately because of the probable underflow at each measuring site in the 52.2-mile reach investigated. However, owing to the extremely heavy pumping from the Carrizo, and the likelihood that a steep hydraulic gradient exists that would induce recharge, some of the indicated loss of about 34 cfs in a 5-mile reach probably goes to recharge of the Carrizo. The indicated quantitative changes in base flow at the several points in the reach are primarily due to the changes in depth of flow in the alluvium and Leona Formation.

The consistency of the chemical character of the base flow along the reach indicates that no significant interchange of ground and surface water takes place in the numerous fault zones. Inflow from sources other than the alluvium or the Leona Formation is not indicated in the reach. Some irrigation return flow is possible at and below mile 29.9.

Considerable recharge of the alluvium occurred during the extreme floods of September 1964. Therefore, if any of the surface flow is being lost by recharge of the Carrizo, the recharge rate is higher than when the alluvium is dewatered and when a higher percentage of the streamflow enters the alluvium.

RECOMMENDATIONS

The results of the reconnaissance-type investigation presented in this report emphasize the need for more comprehensive studies. These studies are vital for planning the efficient operation of any reservoir that might be constructed within or upstream from the reach investigated. Accurate base-flow data as to origin, quantity, quality, and underflow in the reach are necessary. To provide these data the following recommendations for future studies are made:

1. A complete ground-water well inventory along the 52.2-mile reach covered by the investigation should be made in conjunction with a series of streamflow measurements at selected sites. Emphasis should be placed on wells near the upper end of the reach and those near the reach crossing the Carrizo Sand.

2. Sufficient well logs should be obtained for a geologic section along the reach investigated, particularly in the outcrop area of the Carrizo Sand.

3. Water samples should be obtained at each well and streamflow measurement site and analyzed for chemical composition.

4. An interpretive report containing the results of the studies should be published.

REFERENCES

Texas Board Water Engineers and U.S. Geological Survey, 1960, Channel gain and loss investigations, Texas streams, 1918-1958: Texas Board Water Engineers Bull. 5807-D.

Turner, S. F., Robinson, T. W., and White, W. N., 1960, Geology and ground-water resources of the Winter Garden district, Texas, 1948: U.S. Geol. Survey Water-Supply Paper 1481.