INFLOWS TO

SAN ANTONIO BAY

George H. Ward
Center for Research in Water Resources
The University of Texas at Austin

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Task 2 – San Antonio Bay Hydrology

Project Officer: Carla Guthrie, Ph.D.
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EXECUTIVE SUMMARY

This report addresses the historical characteristics of freshwater inflow to San Antonio Bay, including the relative contributions of various sources of freshwater, on a "climatological" time scale, that is, at a temporal resolution of one month.

The main contributors of inflow to San Antonio Bay are runoff from the land surface, and human diversions and return flows. Most of this inflow is carried into the bay in stream channels, the most important of which are the Guadalupe River and the San Antonio River, which conflow about 6 km (4 mis) upstream from the bay. Based upon analysis of the 1942-2009 period of record, some 94% of the watershed is gauged, representing about 89% of the total inflow. The remainder derives from the ungauged portions of the watershed, which are generally on the coastal prairie (including the peripheral drainage around the bay).

Averaged over the period analyzed, approximately 69% enters from the Guadalupe watershed, 33% from the San Antonio watershed, 4% from the bay periphery and -5% from net returns over diversions. These components of inflow are quantified and presented in both tabular and graphical formats. The human component, i.e., the net of returns over diversions, is minor, generally within the uncertainty of measurement of the gauged inflows. During wet conditions, especially floods, this component is negligible compared to runoff and river flow. However, during drought conditions, the proportionate influence of human water use becomes a much greater factor in the water budget.

Seasonally, the annual pattern of inflows to the bay is bimodal, with high inflows in the spring and fall. There has been a substantial increasing trend in inflow to the bay over the 1942-2009 period. The annual inflows to the bay have increased about 80% over this period. The time variability in inflow has changed as well, more recent years exhibiting increasing high-flow surges separated by more intense drought periods. Over the 1942-2009 record, the magnitude of these high-flow surges has increased by about a factor of two. Over this period, there appears to be little statistical association of wet versus dry conditions with El Niño - La Niña conditions in the Equatorial Pacific.

Ten droughts exceeding one-year duration occurred in the 1942-2009 record, representing 40.5 of the 68-year period, i.e., the bay inflows are in drought conditions about 60% of the time. A distinction is made between the severity and the intensity of a drought. The most *severe* drought on record is the Drought of the Fifties. The three most *intense* droughts on record have occurred in the last two decades. Most intense was the drought of 2008-09.*

* This work was completed before the drought of 2010-11, which will probably exceed the others in intensity.

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1. Introduction

The watershed of San Antonio Bay is comprised of the basins of the Guadalupe and San Antonio Rivers, which conflow some 4 mis upstream from the estuary proper, and a relatively small peripheral area which drains directly into the bay. This overall drainage area, totaling 1.03×10^4 sq mis, is shown in Figure 1, including the principal watercourses and some geographic features. The fact that the river inflows enter the estuary through a single channel at the head of the

Figure 1 - Watershed of San Antonio Bay showing principal tributaries

estuary is unique to San Antonio Bay of all of the Texas estuaries. In many respects, this fact greatly simplifies the analysis of the response of the estuary, both hydrographically and ecologically, to freshwater inflow. In the river channel between the river confluence and the head of the estuary is located an inflatable dam, which serves as a salt barrier under low-flow conditions. Apart from preventing upstream migration of some species, this dam has little effect on the estuary, but it is a convenient location to differentiate the inflows from the river basins upstream, and runoff from the estuary periphery downstream.

The purpose of this report is to present a summary of the general hydrological features of San Antonio Bay, in particular to delineate the historical variation of inflows, their organization into periods of surfeit and deficit flows, notably drought, and to quantify the relative contributions from each of the river basins, peripheral runoff, and withdrawals and return flows. The emphasis is upon the longer term time variability of inflow, based upon measurements or estimates of the flows of water at a monthly resolution, utilizing a data base of nearly seven decades, from 1942-2009. In addition to serving as an introduction to the hydroclimatology of the bay, it is hoped that this chapter may find utility as a convenient reference, given the current interest in San Antonio Bay, the activities of the National Estuarine Research Reserve, and the present focus of the Senate Bill 3 process to formulate environmental flow standards for the Guadalupe-San Antonio basin.

2. Data sources

2.1 Streamflow

The lowest U.S. Geological Survey (USGS) gauges in the watershed are summarized in Table 1. (There is an additional recent gauge on the Guadalupe near Bloomington, but this presently reports only stage.) Gauges with appreciable records are those on the Guadalupe at Victoria, on Coleto Creek at two locations, and on the San Antonio at Goliad. The data from these gauges provide measurements of flows from 95% of the area of the combined basin at the salt barrier, and from 94% of the area of the watershed of the estuary (Table 1) for over six decades.

The remainder of the watershed below these locations is ungauged. While the flow originating from this drainage is generally a minority of that entering the bay, it is nonnegligible, and a complete accounting of the sources and variation of inflows must include this contribution. The Texas Water Development Board (TWDB) has estimated the ungauged flows using the SCS curve- number method, which relates runoff to rainfall on the watershed and some key hydrological parameters of the surface and soil layers, and is essentially statistical. This method

Table 1
Drainage areas (d/a) and periods of record (POR)
of lowest gauges on the principal rivers

	Guadalupe basin			*San Antonio basin*		*salt barrier*
	Guadalupe	Coleto Crk		San Antonio	San Antonio	Guadalupe
	Victoria	Victoria	Schroeder	Goliad	McFaddin	Tivoli
Number	8176500	8177500	8177000	8188500	8188570	8188800
d/a (mi^2)	5198	500	369	3921	4134	10128
POR	12/34-pres	7/39 - pres	1/30–10/79	7/24-pres	12/2005-pres	8/2000-pres
Missing		10/54-6/78	1/34 - 9/52	4/29-2/39		

Table 2
Texas Water Development Board TxRR model watersheds

Guadalupe Basin		
ID no	*d/a (mi²)*	*comments*
18012	215.27	below Victoria, including Coleto Crk downstream from Victoria gauge (8177500), to point above confluence of Linn Bayou
18014	141.70	between Schroeder gauge and Victoria gauge on Coleto Creek
18020	43.90	from a point above confluence of Linn Bayou to the salt barrier
San Antonio Basin		
ID no	*d/a (mi²)*	*comments*
19011	101.53	Manahuilla Creek watershed
19012	166.80	from Goliad gauge to confluence with Guadalupe

San Antonio Bay Periphery				***Espiritu Santo (north shore)***	
ID no	*d/a (mi²)*	*ID no*	*d/a (mi²)*	*ID no*	*d/a (mi²)*
24601	22.90	24605	11.69	24608	47.11
24602	42.38	24606	6.83		
24603	7.02	24607	22.45		
24604	10.93				

was published as part of the SCS *National Engineering Handbook* based upon data from "small watersheds" collected by ARS in the 1950's and early 1960's (Mockus, 1972, see also the review in Ward and Benaman, 1999). In the 1970's TWDB developed a computer-model adaptation of the SCS method, called TxRR. TxRR has the capability to accept daily rainfall data and produce modeled runoff flows on a daily resolution. The watershed identification scheme of TWDB, for the watersheds modeled by TxRR and presently used by TWDB in its water budgeting of San Antonio Bay, is summarized in Table 2, and depicted in the stem diagram of Figure 2 (cf. Fig. 1). The TWDB calculations of ungauged runoff is the source for the ungauged watershed inflows used in the present study; however, we prefer to exclude the flow contribution to Espiritu Santo (24608 in Table 2) from the inflows to San Antonio Bay because we regard this as a distinct estuarine system. (This leads to minor numerical differences in some of the monthly San Antonio Bay inflow values between these results and those of the TWDB.)

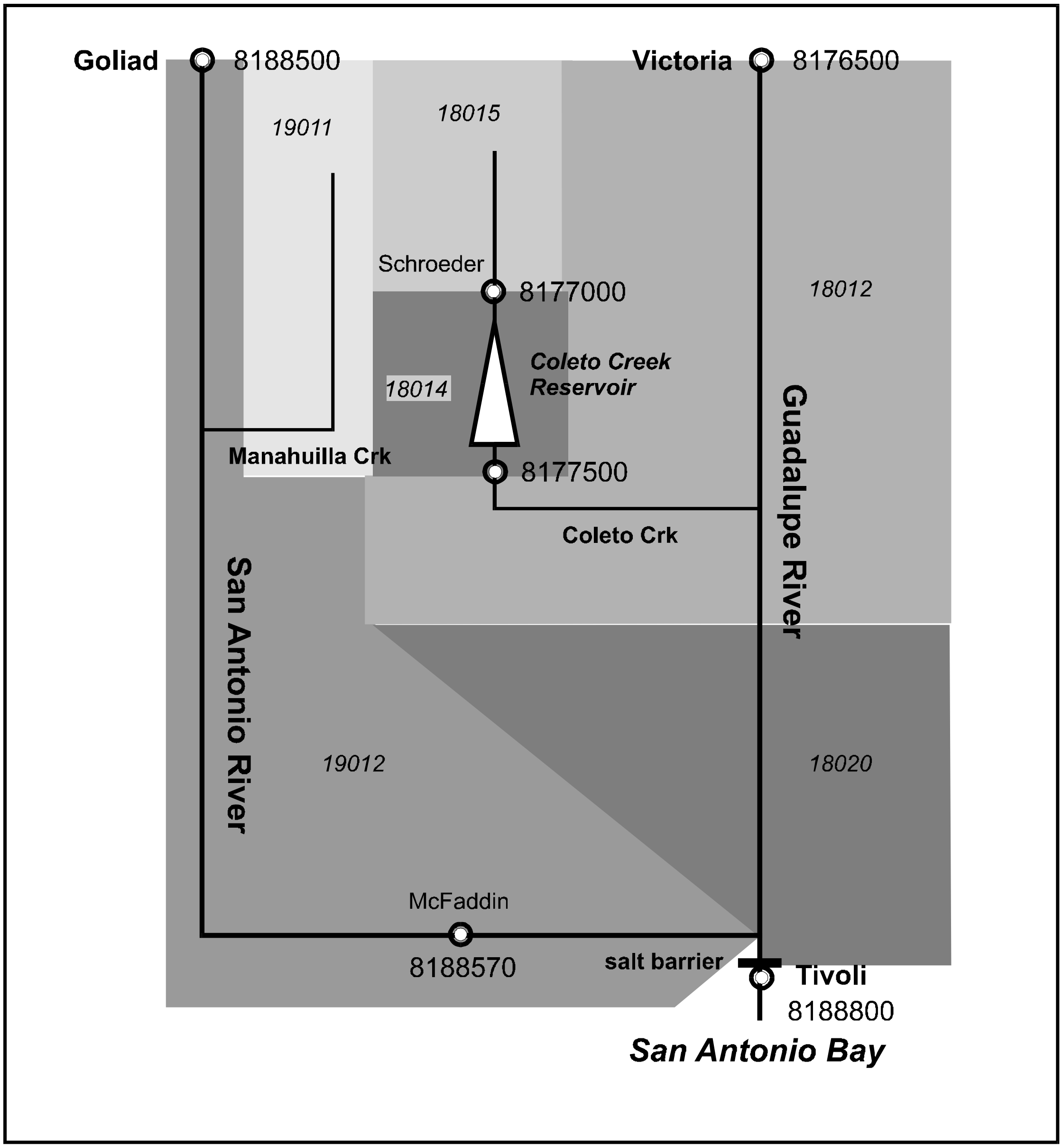

Figure 2 - Stem diagram of San Antonio Bay watershed downstream from principal gauges

There are two complications in using the TWDB ungauged runoff data for San Antonio Bay. The first arises from the two gauges on Coleto Creek. As indicated in Table 1, Schroeder (8177000) operated for about five years starting in 1930. Victoria (8177500) was installed in 1939 and operated until 1954. Meanwhile, Schroeder was re-activated in 1952, and operated until 1979 when it was inundated by Coleto Creek reservoir. Victoria was re-activated prior to the reservoir construction, and is now the operating gauge on the stream. Apart from minor periods of overlap, the operating gauge on Coleto Creek was Victoria from 1939 through the early 1950's, Schroeder from the early 1950's through the beginning of impoundment in Coleto Creek Reservoir in 1979, and Victoria thereafter. For the period of record in which Schroeder was the functional gauge on Coleto Creek, TWDB computed runoff for the watershed 18014 between the two gauges (Fig. 2).

The second complication derives from the history of computing water budgets in the Bays and Estuaries program at TWDB. The early development of a methodology for relating inflows to productivity in the 1960's and 70's culminated in the LP-series of reports for each major estuary of Texas, notably TDWR (1980) for San Antonio Bay, based upon the 1941-76 period of data. The ungauged runoff calculations were a direct application of the SCS method (and may have been performed manually) using a coarser watershed segmentation than employed later for TxRR (Fig. 2). The only results to have survived are the *monthly total ungauged* inflows for the bay. The later work at TWDB during the 1980's and 90's led to the formulation of the State Methodology presented in Longley (1994). This extended the period of hydrological data to include 1977-1986. Ungauged flows for 1977-1986 were determined using TxRR. TWDB has not re-run TxRR for the 1941-76 period, but continues to use the *total* ungauged flows in its bay water budget. Subsequent to the Longley (1994) report, TxRR runs were carried out through 2008, and in the summer of 2010 runs were extended through 2009. For the period 1977-2009, therefore, we have available *daily* TxRR model values of runoff flows for each of the watersheds of Table 2, except that 18014 results are only for the 1977-79 period (when the Schroeder gauge was operative).

The present objective is to use this data to construct a history of inflows into San Antonio Bay from 1942 through 2009 at a monthly resolution, to quantify the relative importance of contributors to the total flow, and to exhibit their long-term variation over time.* This requires being able to separate the component subwatershed inflows. For those TxRR data prior to 1977, this cannot be done, because we have only the *total* ungauged flow into the bay. Moreover, the

* 1941 is not included in the analysis because the gauge data for the San Antonio at Goliad appear corrupted.

“ungauged” data include watershed 18014 for 1954-76, but not for 1942-54. (Nor is it certain that TWDB began the 18014 simulation in 1954, but that is likely, as there exist gauge data from the Victoria station on Coleto Creek through September.)

This problem was approached by a synthetic separation of the 1942-76 monthly total ungauged inflow into its components. First, statistical relations between post-1976 *monthly* rainfall and the TxRR *monthly* runoff flows were established for each of the watersheds: (1) ungauged Guadalupe (w/s 18012 + 18020, plus the runoff from w/s 18014 whenever the Victoria gauge on Coleto Creek is unavailable), (2) ungauged San Antonio (w/s 19011 + 19012), (3) bay periphery (w/s 24601-07), and (4) Espiritu Santo watershed (24608). To determine these relations, the 1977-2008 TxRR runoff values* for the watersheds in Table 2 were used together with corresponding rainfall data from the optimal combination of National Climatic Data Center (NCDC) data from Victoria, Goliad, Port O’Connor, and Aransas National Wildlife Refuge (ANWR) + Austwell (ANWR and Austwell being nearly the same location). A least-squares fit to a quadratic function of runoff flow versus precipitation was used, with respective explained variances of 0.57, 0.52, 0.84, and 0.70. This is an attempt to depict the TxRR predicted flows as a rather simple function of rainfall. TxRR in fact exhibits a complex lagged relation between rainfall and runoff, because of the variation of rate of infiltration as soil water increases, so the relation is not one-to-one, and is further corrupted by the parsing of the two variables, rainfall and runoff, at the break between months. For smaller watersheds (*viz*., the bay periphery and 24608), the response is faster, and the statistical relation exhibits higher explained variance than for larger watersheds (*viz*., the Guadalupe and San Antonio).

From these relations, the runoff flows for the period 1942-76 for each of the four ungauged watersheds can be estimated from the NCDC records of monthly rainfall. Since we have the TWDB total for each month, one of these four runoff flow values is redundant, as it can be obtained by subtracting the sum of the other three from the known total. An optimum process was pursued in which the three flow values to be used were selected to minimize the error in

* At the time this work was done, the TxRR 2009 model results were not yet available from TWDB.

total inflow compared to the TWDB value, an average error that turned out to be about 8% over the 1942-76 period. The gruesome details are relegated to Appendix A. A complete tabulation of the monthly component flows and the bay total flows is provided in Appendix C.

2.2 Diversions and return flows

The final set of data necessary to quantify inflow to the bay is the net of return flows over diversions. Since the net return-diversion flows above a streamflow gauge are implicit in the gauged record, only those returns and diversions below the primary gauges on the Guadalupe River, Coleto Creek, and San Antonio River are needed for this work. These return flows are mainly municipal and industrial wastewater discharges, and the diversions are for municipal, industrial and agricultural purposes. As these activities require permits with (monthly) reporting requirements, in principle monthly data should exist in the files of the Texas Commission on Environmental Quality (TCEQ) dating back to the first half of the last century. Unfortunately, in the 1980's, the predecessor agency (Texas Natural Resources Conservation Commission, TNRCC) embarked on a program of "records management" (a.k.a. "information destruction") in which these data and other information central to the history of water management in Texas were summarily destroyed. For several years, HDR, Inc., has sought to restore this information for the Guadalupe-San Antonio basin based upon the best sources extant, including records from Guadalupe-Blanco River Authority (GBRA), Victoria, DuPont/INVISTA, Dow/UCC, TCEQ, the South Texas Watermaster, and the Environmental Protection Agency (Brian Perkins and Sam Vaugh, HDR, pers. comm.). This data was kindly provided by HDR for use in the present study.

A chronological summary of the status of returns and diversions data is as follows:

1942-1966: No reliable independent data for all of the individual major dischargers have been found. From files of HDR (pre-1962 from TCEQ, 1963-66 from GBRA), the earlier diversion and returns of DuPont (now INVISTA) have been found. No data on the Victoria return flows exist, so these were estimated by HDR based upon population. Also, GBRA has provided monthly irrigation diversion records from the operation of the canal before it was taken over by GBRA in 1967, but these numbers are suspiciously constant from month to month, and are not considered trustworthy. From earlier basin modeling work of HDR with data provided by TCEQ's predecessor agencies, monthly values of total diversions (including *net* diversion for DuPont) have survived, although these cannot be tracked back to the original reported flows nor separated into components. These appear to be the best record of the historical diversions and have been used here, together with the estimated Victoria return flows.

1967 – 1989: The GBRA diversion data are considered reliable, as are the returns and diversions of DuPont, mainly found in the files of GBRA and INVISTA, though some data used in earlier water-basin modeling of HDR were obtained from TCEQ (née TNRCC, née Texas Water Commission, TWC). No information has survived on the Dow discharge into the Victoria Barge Canal. Victoria discharge records for 1973-1991 were obtained from HDR records for the earlier modeling work, obtained at the time from TWC/TNRCC. Victoria discharge records for 1967-1972 were estimated by HDR from population data.

1990 – 2009: Reported returns for Dow/Union Carbide Corporation (UCC) have been provided to HDR by Dow/UCC starting in 1990. DuPont returns and diversions were obtained from GBRA files through 1994, with supplemental information from TCEQ, and data for a few missing months have been estimated by HDR. Reported values provided by INVISTA start in 1995. Reported Victoria return flows from GBRA files start in 1992.

3 Historical inflows to San Antonio Bay

3.1 Historical annual flows

The general behavior of inflows to San Antonio Bay over the nearly seven-decade period of 1942-2009 is exhibited by the calendar-year annual values of the above data sources, presented in Table 3. (The bold line after year 1976 in this table is a reminder that the TWDB component

Table 3
Annual flows (calendar year) into San Antonio Bay in thousands of acre feet (Taf)

year	gauged flows			ungauged flows		returns - diversions u/s of salt barrier	flow at salt barrier	ungauged from bay periphery	total flow into bay
	Guadalupe 8176500	Coleto Cr 8177500	San Antonio 8188500	Guad TWDB	San Ant TxRR				
1942	1525.2	76.3	903.4	131.4	260.9	-0.7	2888.0	91.1	2979.1
1943	685.7	20.3	301.3	85.9	85.0	0.1	1156.5	41.4	1197.9
1944	1332.6	55.6	374.2	114.1	297.4	0.3	2169.3	80.5	2249.8
1945	1382.1	18.4	349.6	63.0	143.8	-1.3	1950.9	105.3	2056.2
1946	1740.4	179.6	1034.7	91.8	294.8	-1.3	3326.2	84.8	3410.9
1947	1102.9	41.0	317.4	85.0	86.3	-84.4	1517.8	73.7	1591.5
1948	470.4	9.3	219.1	62.7	106.1	-98.0	747.3	62.4	809.8
1949	1072.8	34.5	481.4	104.1	202.7	-48.1	1821.3	92.1	1913.5
1950	556.1	3.1	169.2	38.1	12.1	-57.2	694.7	25.6	720.3
1951	377.6	25.7	225.3	86.1	59.4	-111.5	646.8	71.4	718.2
1952	757.4	75.3	341.4	76.6	109.7	-115.2	1228.1	42.3	1270.4
1953	759.9	47.8	253.2	57.4	98.7	-125.2	1081.8	82.8	1164.6
1954	232.0	2.3	89.0	34.4	2.4	-114.4	215.6	41.2	256.8
1955	260.3	9.3	117.8	58.8	29.6	-80.4	359.9	42.8	402.6
1956	115.3	7.9	110.5	39.5	9.0	-35.2	216.2	30.8	247.0
1957	2246.5	111.0	779.9	149.0	554.4	-20.7	3807.3	75.4	3882.7
1958	2038.2	120.6	780.1	147.3	412.2	-27.3	3467.4	82.2	3549.6
1959	1108.2	42.1	312.7	89.4	299.2	-38.1	1810.4	91.4	1901.8
1960	2211.8	96.7	543.7	198.4	631.4	-39.4	3640.2	131.7	3771.9
1961	1825.0	34.0	503.9	103.3	332.2	-21.1	2767.8	89.7	2857.4
1962	534.3	15.8	214.6	64.9	52.3	-31.7	830.7	53.2	883.9
1963	367.1	5.4	148.7	51.8	4.8	-73.5	460.6	28.3	489.0
1964	465.2	14.9	225.5	89.5	78.7	-69.3	791.0	40.1	831.1
1965	1527.5	70.5	514.7	79.0	240.7	-74.7	2341.6	47.5	2389.1
1966	898.5	20.8	221.7	81.6	420.1	-33.2	1608.9	58.9	1667.9
1967	1093.9	361.0	956.2	123.6	943.2	-65.5	3410.0	150.1	3560.1

(continued)

Table 3
(Continued)

year	gauged flows Guadalupe 8176500	gauged flows Coleto Cr 8177500	gauged flows San Antonio 8188500	ungauged flows Guad TWDB	ungauged flows San Ant TxRR	returns - diversions u/s of salt barrier	flow at salt barrier	ungauged from bay periphery	total flow into bay
1968	2029.3	110.7	756.5	152.8	427.5	-60.2	3397.6	136.6	3534.2
1969	1332.3	102.2	375.8	132.2	256.4	-73.3	2081.6	68.9	2150.5
1970	1201.3	23.1	348.0	106.3	319.5	-53.4	1903.1	88.6	1991.7
1971	771.6	61.6	404.6	122.8	490.2	-76.5	1745.6	109.8	1855.4
1972	1610.6	66.4	622.0	138.2	279.2	-72.7	2553.3	74.9	2628.2
1973	2752.3	240.5	1590.2	153.7	259.7	-73.9	4830.0	103.6	4933.6
1974	1617.7	38.8	562.7	121.1	297.3	-92.8	2501.9	149.7	2651.5
1975	2198.7	30.7	764.7	110.2	340.3	-94.4	3293.4	50.8	3344.2
1976	2364.3	114.5	893.8	127.6	483.1	-68.1	3858.0	100.6	3958.6
1977	2088.3	68.6	987.4	232.6	99.8	-74.3	3402.4	94.5	3496.9
1978	1119.7	50.7	585.1	161.9	38.3	-77.8	1877.8	41.1	1918.9
1979	2394.1	117.9	924.4	227.2	106.5	-75.8	3694.2	195.4	3889.6
1980	740.4	15.6	392.5	74.3	40.8	-86.5	1177.3	30.6	1207.9
1981	2533.9	174.0	909.9	184.2	187.1	-65.1	3923.9	148.8	4072.7
1982	952.6	79.7	368.2	94.2	37.7	-54.6	1478.0	51.2	1529.2
1983	802.3	64.0	318.0	105.0	31.5	-47.2	1273.5	61.6	1335.1
1984	351.4	25.8	265.6	37.8	9.3	-58.6	631.2	35.1	666.3
1985	1534.8	53.0	515.1	134.0	35.6	-44.9	2227.6	45.7	2273.3
1986	1451.3	32.8	591.2	76.0	24.2	-55.8	2119.7	68.7	2188.4
1987	3502.1	98.1	1635.7	144.6	41.1	-62.5	5359.2	53.7	5412.9
1988	586.5	3.0	271.6	8.4	4.5	-97.2	776.8	7.5	784.3
1989	407.7	1.7	218.5	36.5	13.6	-82.1	595.9	49.1	644.9
1990	536.7	29.8	355.1	103.3	97.7	-63.5	1059.0	70.7	1142.2
1991	1798.3	81.0	705.5	223.4	67.3	-46.6	2829.0	127.7	2970.5
1992	4663.6	168.2	2229.1	374.8	118.4	-37.8	7516.2	138.1	7669.0
1993	1628.9	164.2	781.7	283.8	61.7	-43.4	2876.8	129.9	3018.8
1994	1099.8	92.9	505.9	134.8	55.9	-60.2	1829.0	40.5	1880.7
1995	996.2	12.7	323.5	84.9	29.8	-50.0	1397.2	58.6	1465.7
1996	407.8	1.4	194.2	57.2	5.9	-58.9	607.6	12.5	629.6
1997	2423.9	259.7	606.3	74.6	77.0	-36.2	3405.3	159.2	3575.6
1998	3741.0	224.2	952.2	14.8	91.0	-54.3	4968.9	85.4	5064.2
1999	844.0	9.1	351.7	53.5	31.6	-61.8	1228.1	7.9	1244.7
2000	861.7	6.7	452.7	75.0	42.2	-47.9	1390.4	110.4	1509.6
2001	1944.9	145.9	919.3	126.0	96.4	-47.5	3184.9	53.0	3248.9
2002	3510.7	102.6	2061.7	172.4	116.9	-46.9	5917.3	161.9	6089.9
2003	1479.4	52.3	672.0	62.8	32.7	-41.4	2257.7	104.4	2371.7
2004	3292.6	179.9	1406.8	398.1	67.3	-34.8	5310.0	124.6	5445.2
2005	1559.2	75.3	594.7	78.8	28.6	-46.7	2289.8	37.7	2336.2
2006	411.6	3.6	226.0	164.7	58.5	-42.9	821.4	109.3	940.8
2007	3017.6	149.1	1613.3	219.3	104.2	-24.8	5078.6	180.8	5271.3
2008	507.5	2.9	305.5	18.8	9.1	-49.5	794.3	29.2	829.2
2009	839.0	26.7	398.8	29.9	26.8	-50.8	1270.3	41.6	1317.9
mean	1429.2	72.1	597.7	115.1	160.9	-56.9	2304.8	79.5	2387.2

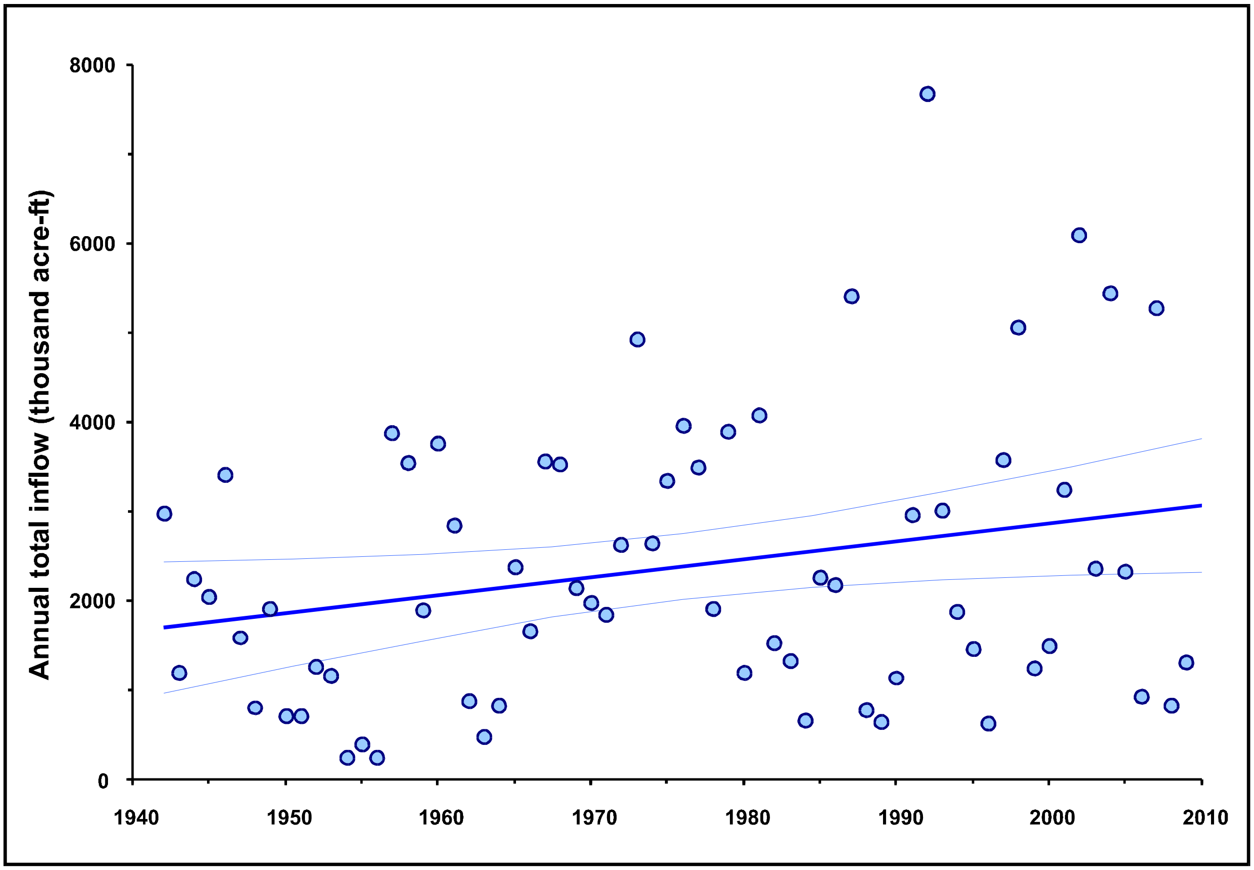

Figure 3 - Annual inflows into San Antonio Bay, 1942-2009.
Straight line is least-squares trend with 95% confidence bounds.

ungauged flows before this point in time have been estimated from the San Antonio Bay ungauged monthly totals, as summarized in Section 2.1 and detailed in Appendix A.)

The total annual flow into the bay over this period is plotted in Figure 3. Over this period there has been an upward trend in inflow, as indicated by the least-squares regression line in Fig. 3. This trend is substantial, approximately an 80% increase in flow over the 68-year period. While there is statistical uncertainty about the precise magnitude of the trend line (see Section 3.2, below), it is about 96% probable that its slope is positive. The variability of this annual flow as well as the month-to-month fluctuations are responses to hydroclimatology, and are explored in the following chapter.

3.2 Historical flows according to source

Table 3, above, presents the annual component flows from the various sources, as well as the total flows into San Antonio Bay. There are two ways of viewing these component flows, each of which has its utility, *viz*. by data source, i.e., measured by streamflow gauging versus modeled runoff based on rainfall, in this case the TxRR model and earlier SCS-based calculations; and by physical source, i.e., the component watersheds of the Guadalupe, the San Antonio, and the coastal periphery draining directly into San Antonio Bay. The data-source viewpoint also admits a physical interpretation, in that the positions of the primary gauges on the Guadalupe River, Coleto Creek, and San Antonio River are approximately along the inland boundary of the Coastal Prairie. One can therefore regard the gauged data as the contribution from the upland regions of the basin (i.e. the Interior Coastal Plain and the Edwards Plateau), and the ungauged (and modeled) data as the contribution from the Coastal Prairie.

In Table 4, the annual component flows of Table 3 are organized by data source, and displayed as the fraction of the total inflow to the bay each component represents for the given year. (Algebraic signs are preserved in this depiction, hence the returns net of diversions are negative.) On average, 89% of the inflows into the bay are gauged, versus 16% ungauged (which do not sum to zero because of the negative contribution of net return flows). Therefore, inaccuracy in modeling, rather than measuring, flows arising from the drainage area below the primary gauges and surrounding the bay does not contribute a major error in the water budget. Of course, the truth of this statement varies with year. Especially during drought conditions, the ungauged contribution can make up one third of the flow into the bay. In comparison, the net returns are smaller yet, typically 5% of the total flow, though these become proportionately more substantive during droughts. In 1954, during the infamous Drought of the Fifties, net returns represented a diversion (i.e., negative net return) of almost 45% of the bay's inflow. As a standard of uncertainty, the nominal error in a streamflow measurement is on the order of 10% (e.g., Pelletier, 1988, Sauer and Meyer, 1992).* This relative uncertainty increases as flows

* A more precise statement is that it is 95% probable that the estimated flow will lie in a range ±5% about the correct value.

diminish, and does not include the uncertainty of discharge measurements about the gauge rating relation. Nominally, therefore, the net returns are generally less than the uncertainty in the gauged inflows, but may approach this uncertainty under low flow conditions.

The annual component flows are organized by physical source in Table 5, again expressed as a (signed) fraction of total inflow to San Antonio Bay for that year. On average, the Guadalupe basin contributes about twice as much inflow to the bay as the San Antonio, about 69% from the Guadalupe compared to about 33% from the San Antonio. The contribution from the coastal drainage peripheral to the bay is only about 4%. Even under drought conditions, this peripheral contribution rarely exceeds 10%. The same information is displayed graphically in Figure 4.

While the inflows into San Antonio Bay exhibited an increasing trend over the 1942-2009 period, this was not uniformly reflected in the component flows. The least-squares trend-line analyses for each component flow are summarized in Table 6. The increasing trend is seen to be driven by the river basins, mainly above the primary gauges. Over this period each river more-or-less doubled its flow. Below the gauges, the Guadalupe trended upward, but the San Antonio trended downward substantially enough to diminish the net increase for its basin. (We note that these are TxRR-modeled flows driven by data on precipitation.) Statistically, the return flows net of diversions showed no trend, and the increasing trend of peripheral flows was modest.

Table 4
Proportions (%) of contributions to annual inflows to San Antonio Bay by data source

	gauged			ungauged		rets-divs		gauged			ungauged		rets-divs
	Guadalupe	Coleto Cr	San Antonio	u/s of salt barrier	d/s of salt barrier	u/s of salt barrier		Guadalupe	Coleto Cr	San Antonio	u/s of salt barrier	d/s of salt barrier	u/s of salt barrier
1942	51.2	2.6	30.3	12.9	3.1	0.0	1977	59.7	2.0	28.2	9.5	2.7	-2.1
1943	57.2	1.7	25.1	12.5	3.5	0.0	1978	58.4	2.6	30.5	10.4	2.1	-4.1
1944	59.2	2.5	16.6	18.1	3.6	0.0	1979	61.6	3.0	23.8	8.6	5.0	-1.9
1945	67.2	0.9	17.0	9.8	5.1	-0.1	1980	61.3	1.3	32.5	9.5	2.5	-7.2
1946	51.0	5.3	30.3	10.9	2.5	0.0	1981	62.2	4.3	22.3	9.1	3.7	-1.6
1947	69.3	2.6	19.9	8.9	4.6	-5.3	1982	62.3	5.2	24.1	8.6	3.3	-3.6
1948	58.1	1.2	27.1	18.1	7.7	-12.1	1983	60.1	4.8	23.8	10.2	4.6	-3.5
1949	56.1	1.8	25.2	14.7	4.8	-2.5	1984	52.7	3.9	39.9	7.1	5.3	-8.8
1950	77.2	0.4	23.5	3.3	3.6	-7.9	1985	67.5	2.3	22.7	7.5	2.0	-2.0
1951	52.6	3.6	31.4	18.0	9.9	-15.5	1986	66.3	1.5	27.0	4.6	3.1	-2.6
1952	59.6	5.9	26.9	13.3	3.3	-9.1	1987	64.7	1.8	30.2	3.4	1.0	-1.2
1953	65.2	4.1	21.7	12.6	7.1	-10.8	1988	74.8	0.4	34.6	1.6	1.0	-12.4
1954	90.4	0.9	34.7	2.6	16.0	-44.6	1989	63.2	0.3	33.9	7.8	7.6	-12.7
1955	64.6	2.3	29.3	13.1	10.6	-20.0	1990	47.0	2.6	31.1	17.6	6.2	-5.6
1956	46.7	3.2	44.7	7.2	12.5	-14.2	1991	60.5	2.7	23.7	9.8	4.3	-1.6
1957	57.9	2.9	20.1	17.8	1.9	-0.5	1992	60.8	2.2	29.1	6.4	1.8	-0.5
1958	57.4	3.4	22.0	15.7	2.3	-0.8	1993	54.0	5.4	25.9	11.4	4.3	-1.4
1959	58.3	2.2	16.4	20.3	4.8	-2.0	1994	58.5	4.9	26.9	10.1	2.2	-3.2
1960	58.6	2.6	14.4	21.9	3.5	-1.0	1995	68.0	0.9	22.1	7.8	4.0	-3.4
1961	63.9	1.2	17.6	14.9	3.1	-0.7	1996	64.8	0.2	30.8	10.0	2.0	-9.4
1962	60.5	1.8	24.3	11.1	6.0	-3.6	1997	67.8	7.3	17.0	4.2	4.5	-1.0
1963	75.1	1.1	30.4	2.6	5.8	-15.0	1998	73.9	4.4	18.8	2.1	1.7	-1.1
1964	56.0	1.8	27.1	18.6	4.8	-8.3	1999	67.8	0.7	28.3	6.8	0.6	-5.0
1965	63.9	3.0	21.5	12.7	2.0	-3.1	2000	57.1	0.4	30.0	7.8	7.3	-3.2
1966	53.9	1.2	13.3	30.0	3.5	-2.0	2001	59.9	4.5	28.3	6.8	1.6	-1.5
1967	30.7	10.1	26.9	29.9	4.2	-1.8	2002	57.6	1.7	33.9	4.8	2.7	-0.8
1968	57.4	3.1	21.4	15.9	3.9	-1.7	2003	62.4	2.2	28.3	4.0	4.4	-1.7
1969	62.0	4.8	17.5	16.0	3.2	-3.4	2004	60.5	3.3	25.8	8.5	2.3	-0.6
1970	60.3	1.2	17.5	19.3	4.4	-2.7	2005	66.7	3.2	25.5	4.6	1.6	-2.0
1971	41.6	3.3	21.8	31.5	5.9	-4.1	2006	43.8	0.4	24.0	23.7	11.6	-4.6
1972	61.3	2.5	23.7	12.4	2.9	-2.8	2007	57.2	2.8	30.6	6.1	3.4	-0.5
1973	55.8	4.9	32.2	6.5	2.1	-1.5	2008	61.2	0.4	36.8	3.4	3.5	-6.0
1974	61.0	1.5	21.2	14.2	5.6	-3.5	2009	63.7	2.0	30.3	4.3	3.2	-3.9
1975	65.7	0.9	22.9	11.8	1.5	-2.8							
1976	59.7	2.9	22.6	14.0	2.5	-1.7	mean	60.5	2.7	25.8	11.4	4.3	-4.8

Table 5
Proportions (%) of contributions to annual inflows to San Antonio Bay by physical source

	Guadalupe		San Antonio		rets-divs	periphery		Guadalupe		San Antonio		rets-divs	periphery
	Victoria	d/s Victoria	Goliad	d/s Goliad	u/s of salt barrier	of bay		Victoria	d/s Victoria	Goliad	d/s Goliad	u/s of salt barrier	of bay
1942	51.2	7.0	30.3	8.8	0.0	3.1	1977	59.7	8.6	28.2	2.9	-2.1	2.7
1943	57.2	8.9	25.1	7.1	0.0	3.5	1978	58.4	11.1	30.5	2.0	-4.1	2.1
1944	59.2	7.5	16.6	13.2	0.0	3.6	1979	61.6	8.9	23.8	2.7	-1.9	5.0
1945	67.2	4.0	17.0	7.0	-0.1	5.1	1980	61.3	7.4	32.5	3.4	-7.2	2.5
1946	51.0	8.0	30.3	8.6	0.0	2.5	1981	62.2	8.8	22.3	4.6	-1.6	3.7
1947	69.3	7.9	19.9	5.4	-5.3	4.6	1982	62.3	11.4	24.1	2.5	-3.6	3.3
1948	58.1	8.9	27.1	13.1	-12.1	7.7	1983	60.1	12.7	23.8	2.4	-3.5	4.6
1949	56.1	7.2	25.2	10.6	-2.5	4.8	1984	52.7	9.5	39.9	1.4	-8.8	5.3
1950	77.2	5.7	23.5	1.7	-7.9	3.6	1985	67.5	8.2	22.7	1.6	-2.0	2.0
1951	52.6	15.6	31.4	8.3	-15.5	9.9	1986	66.3	5.0	27.0	1.1	-2.6	3.1
1952	59.6	12.0	26.9	8.6	-9.1	3.3	1987	64.7	4.5	30.2	0.8	-1.2	1.0
1953	65.2	9.0	21.7	8.5	-10.8	7.1	1988	74.8	1.5	34.6	0.6	-12.4	1.0
1954	90.4	14.3	34.7	0.9	-44.6	16.0	1989	63.2	5.9	33.9	2.1	-12.7	7.6
1955	64.6	16.9	29.3	7.4	-20.0	10.6	1990	47.0	11.6	31.1	8.6	-5.6	6.2
1956	46.7	19.2	44.7	3.7	-14.2	12.5	1991	60.5	10.2	23.7	2.3	-1.6	4.3
1957	57.9	6.7	20.1	14.3	-0.5	1.9	1992	60.8	7.1	29.1	1.5	-0.5	1.8
1958	57.4	7.5	22.0	11.6	-0.8	2.3	1993	54.0	14.8	25.9	2.0	-1.4	4.3
1959	58.3	6.9	16.4	15.7	-2.0	4.8	1994	58.5	12.1	26.9	3.0	-3.2	2.2
1960	58.6	7.8	14.4	16.7	-1.0	3.5	1995	68.0	6.7	22.1	2.0	-3.4	4.0
1961	63.9	4.8	17.6	11.6	-0.7	3.1	1996	64.8	9.3	30.8	0.9	-9.4	2.0
1962	60.5	9.1	24.3	5.9	-3.6	6.0	1997	67.8	9.4	17.0	2.2	-1.0	4.5
1963	75.1	11.7	30.4	1.0	-15.0	5.8	1998	73.9	4.7	18.8	1.8	-1.1	1.7
1964	56.0	12.6	27.1	9.5	-8.3	4.8	1999	67.8	5.0	28.3	2.5	-5.0	0.6
1965	63.9	6.3	21.5	10.1	-3.1	2.0	2000	57.1	5.4	30.0	2.8	-3.2	7.3
1966	53.9	6.1	13.3	25.2	-2.0	3.5	2001	59.9	8.4	28.3	3.0	-1.5	1.6
1967	30.7	13.6	26.9	26.5	-1.8	4.2	2002	57.6	4.5	33.9	1.9	-0.8	2.7
1968	57.4	7.5	21.4	12.1	-1.7	3.9	2003	62.4	4.9	28.3	1.4	-1.7	4.4
1969	62.0	10.9	17.5	11.9	-3.4	3.2	2004	60.5	10.6	25.8	1.2	-0.6	2.3
1970	60.3	6.5	17.5	16.0	-2.7	4.4	2005	66.7	6.6	25.5	1.2	-2.0	1.6
1971	41.6	9.9	21.8	26.4	-4.1	5.9	2006	43.8	17.9	24.0	6.2	-4.6	11.6
1972	61.3	7.8	23.7	10.6	-2.8	2.9	2007	57.2	7.0	30.6	2.0	-0.5	3.4
1973	55.8	8.0	32.2	5.3	-1.5	2.1	2008	61.2	2.6	36.8	1.1	-6.0	3.5
1974	61.0	6.0	21.2	11.2	-3.5	5.6	2009	63.7	4.3	30.3	2.0	-3.9	3.2
1975	65.7	4.2	22.9	10.2	-2.8	1.5							
1976	59.7	6.1	22.6	12.2	-1.7	2.5	mean	60.5	8.6	25.8	6.8	-4.8	4.3

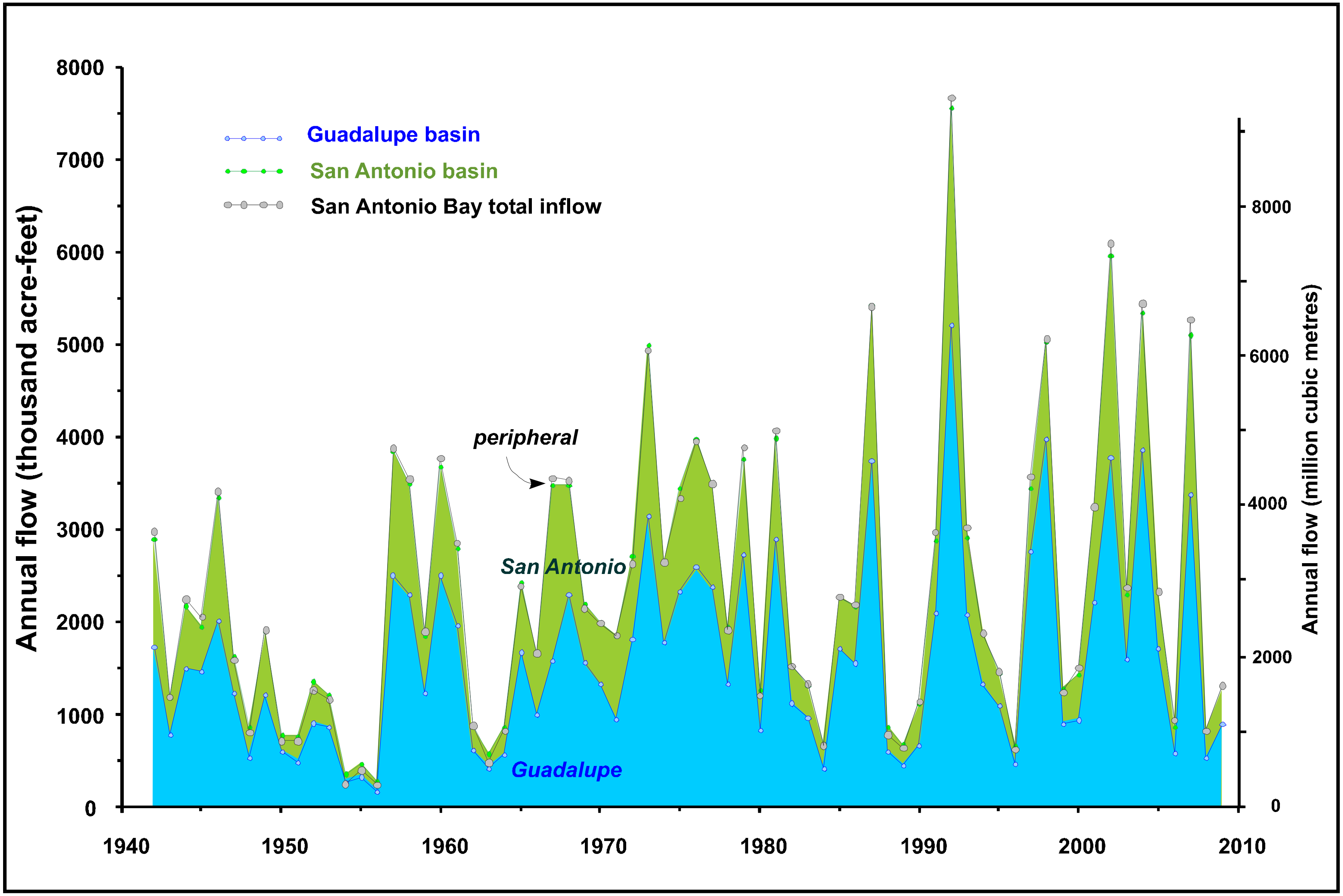

Figure 4 - Total inflow into San Antonio Bay and Guadalupe and San Antonio component flows

Table 6
Time trends (least-squares regression) in component flows into San Antonio Bay, 1942-2009

	Trend line			*Trend projection*			
	slope	*± 0.95 conf bnds*		*1942*	*2009*	*increase*	
	(Taf/yr)	*(Taf/yr)*	*(Taf/yr)*	*(Taf)*	*(Taf)*	*(Taf)*	*(%)*
Gauged flows							
Guadalupe at Victoria	13.9	0.7	27.0	956	1885	928	97
Coleto Creek	0.6	-0.4	1.6	52	91	39	74
San Antonio at Goliad	7.2	1.2	13.3	352	838	485	138
Ungauged flows							
Guadalupe	0.8	-0.3	1.8	88	140	52	59
San Antonio	-3.2	-5.6	-0.8	267	51	-216	-81
Rets - divs u/s of salt barrier	0.0	-0.4	0.4	-57	-56	1	-2
Flow at salt barrier	19.6	-1.7	41.0	1631	2948	1316	81
Bay peripheral drainage	0.3	-0.4	0.9	70	88	17	25
Total flow into bay	20.1	-1.6	41.8	1699	3044	1346	79

4. Historical hydroclimatology

In this chapter, the natural variability in the inflows to San Antonio Bay is addressed. This requires a finer time resolution than the annual time step of the previous chapter, namely data at monthly intervals. Compilations of monthly component inflows, as surveyed in Chapter 2, comprise the basic data for the present analyses. The 1942-2009 time history of total monthly inflow into San Antonio Bay is displayed in Figure 5, subdivided into two time series with 10-year overlap for clarity. (These data are tabulated in Appendix C for reference.) Even at a relatively coarse time resolution of one month, it is apparent that there is considerable fluctuation. In order to expose general features of the several contributions to inflow and their variability over time, additional processing of the data time series must be employed.

4.1 Interannual inflow variation

The largest scale of variability, annual to decadal, is exhibited by a smoothed time series. Figure 6 shows the monthly time series of the inflow components of the two river basins and the total inflow to the bay (which differs from the total of the two river basins by the algebraic sum of peripheral runoff and net returns), after being subjected to a running centered 12-month mean. (Like Fig.5, this figure is presented in two sections with a 10-year overlap to facilitate reading.) The resolution of the time traces of this figure is one-month, but the running 12-month mean in effect acts as a low-pass filter, removing much of the short-period (month-to-month) variation. There is much similarity between this figure and the plot of annual flows of Fig. 4: apart from the different flow units, Fig. 4 in effect plots a sample of Fig. 6 taken every 12 months. The same general increasing trend of inflows is apparent (as we would expect). The periods of relative inflow surfeits and deficits are now better revealed, especially sustained drought periods. There is also an apparent increase in range (or, in time-signal terminology, amplitude) of the excursions in inflow with passage of time.

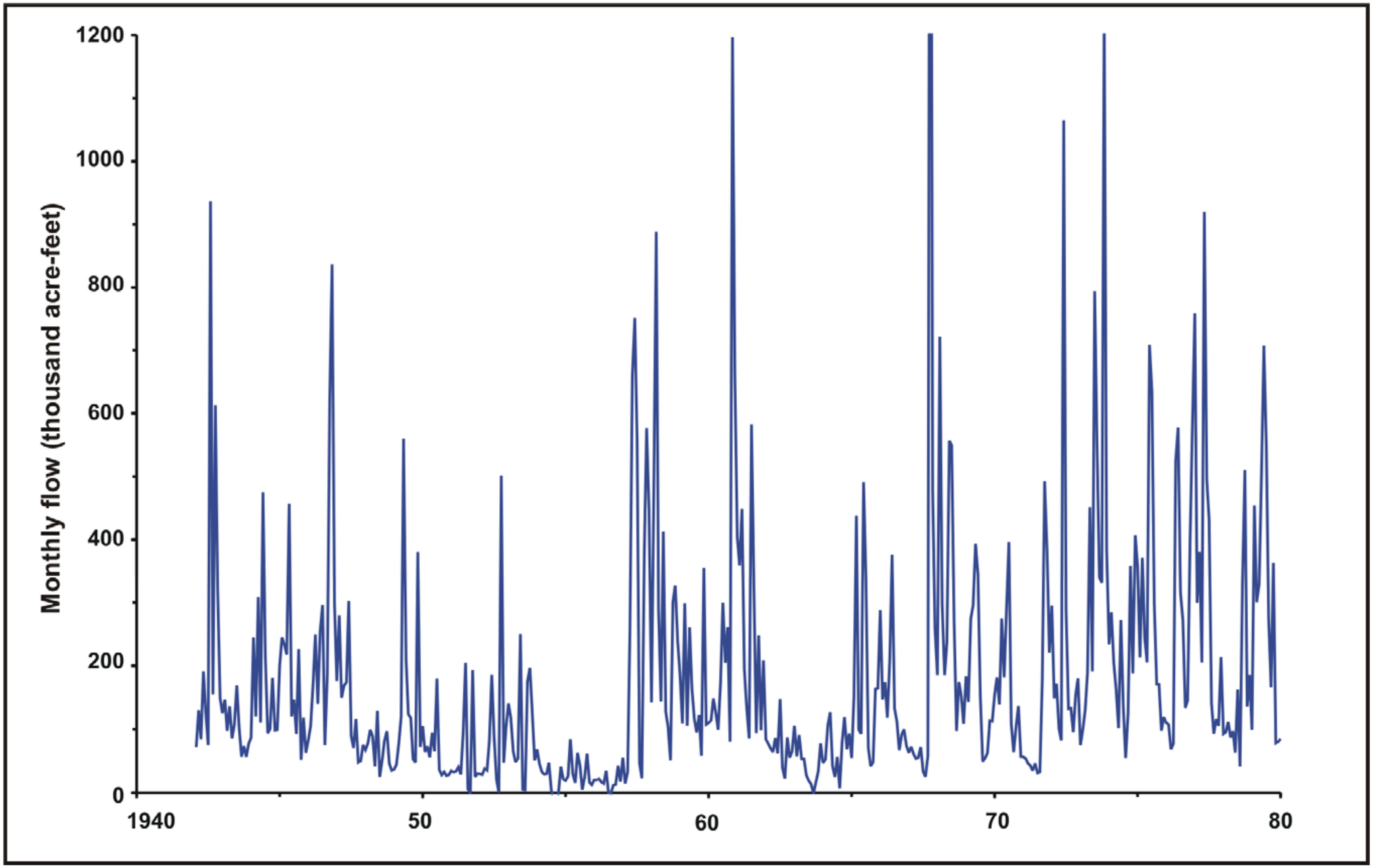

Figure 5a - Monthly total inflow into San Antonio Bay, 1942-80

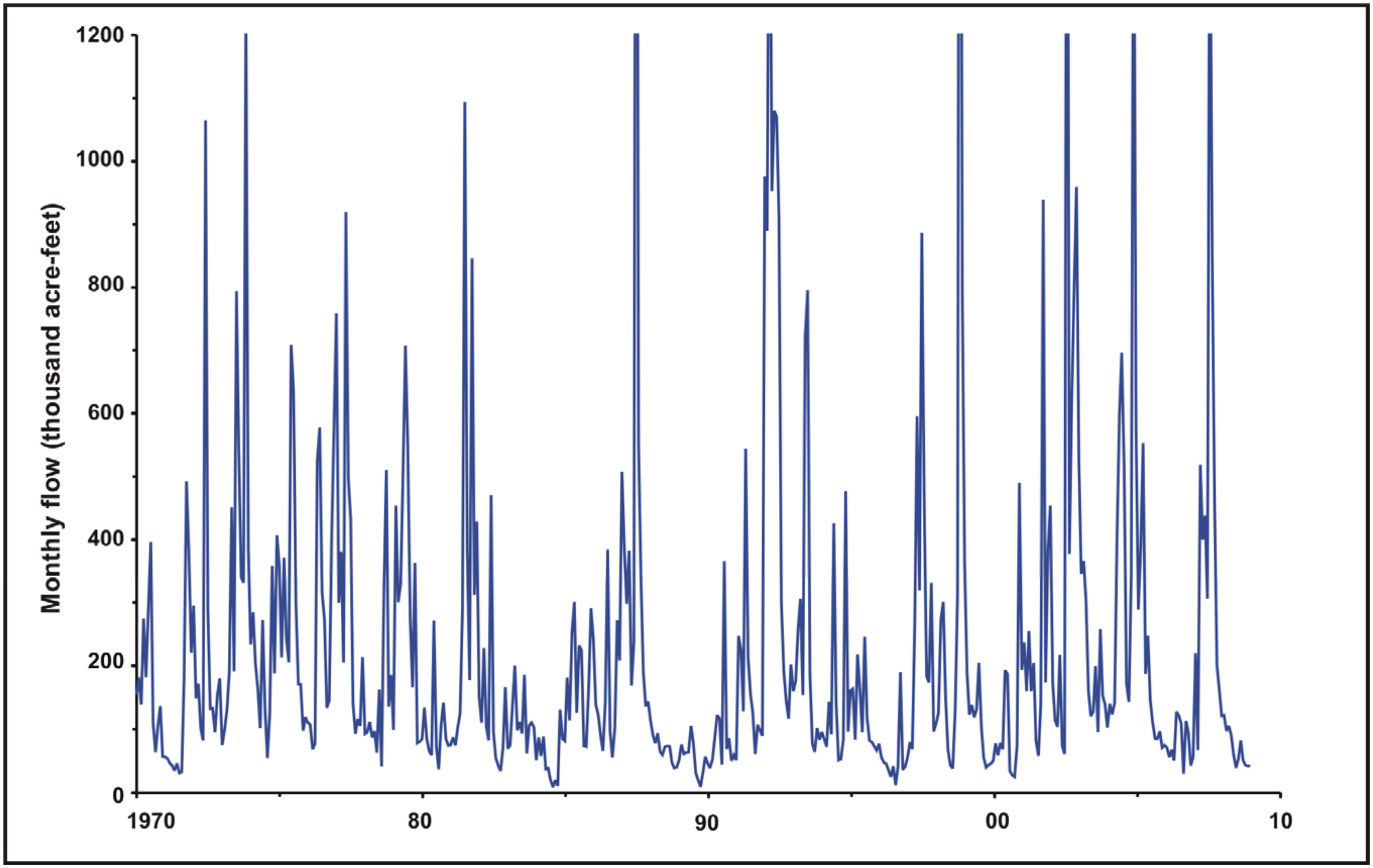

Figure 5b - Monthly total inflow into San Antonio Bay, 1970-2009

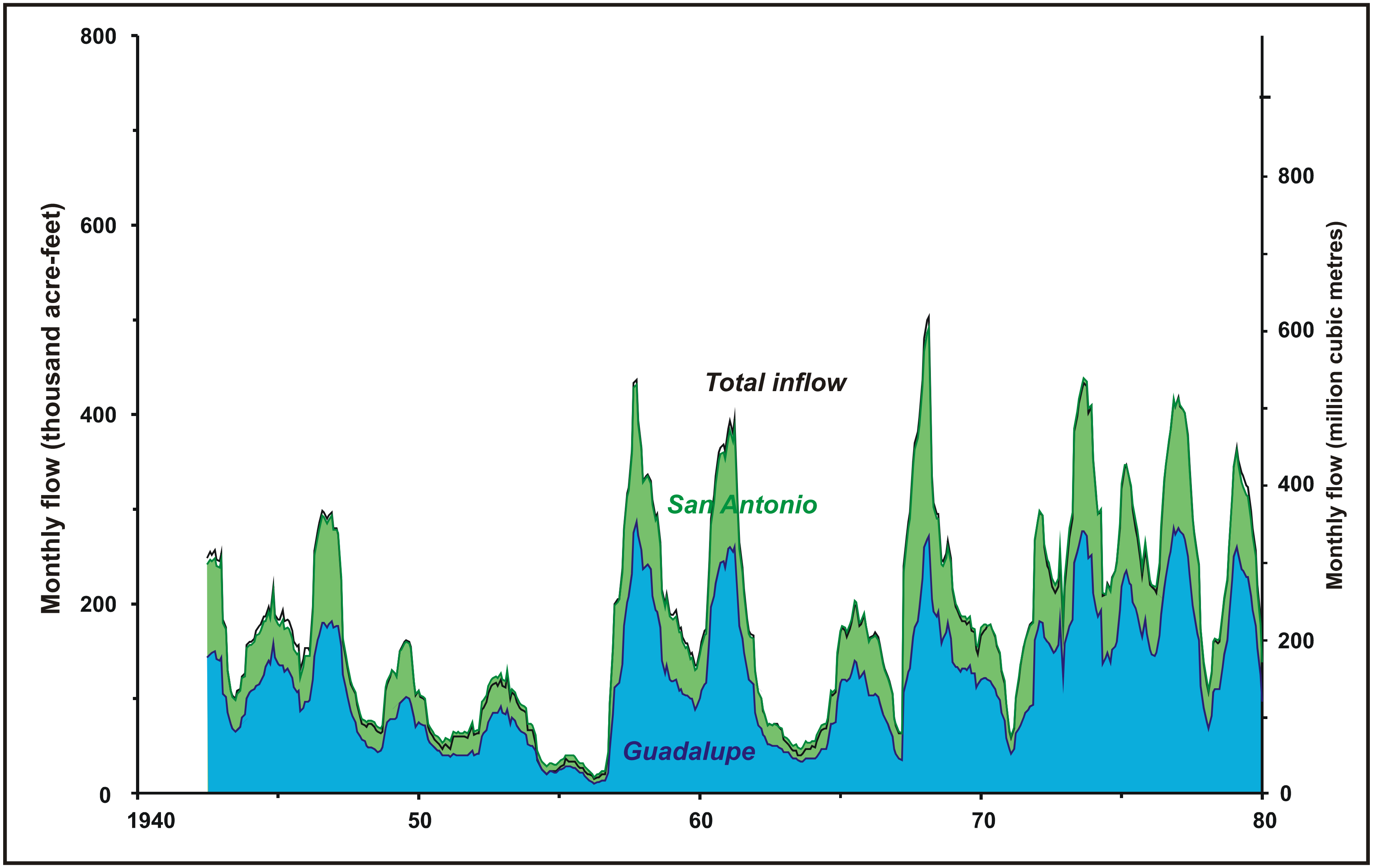

Figure 6a - Monthly total inflow into San Antonio Bay, with Guadalupe and San Antonio component flows, after running 12-month mean, 1942-80

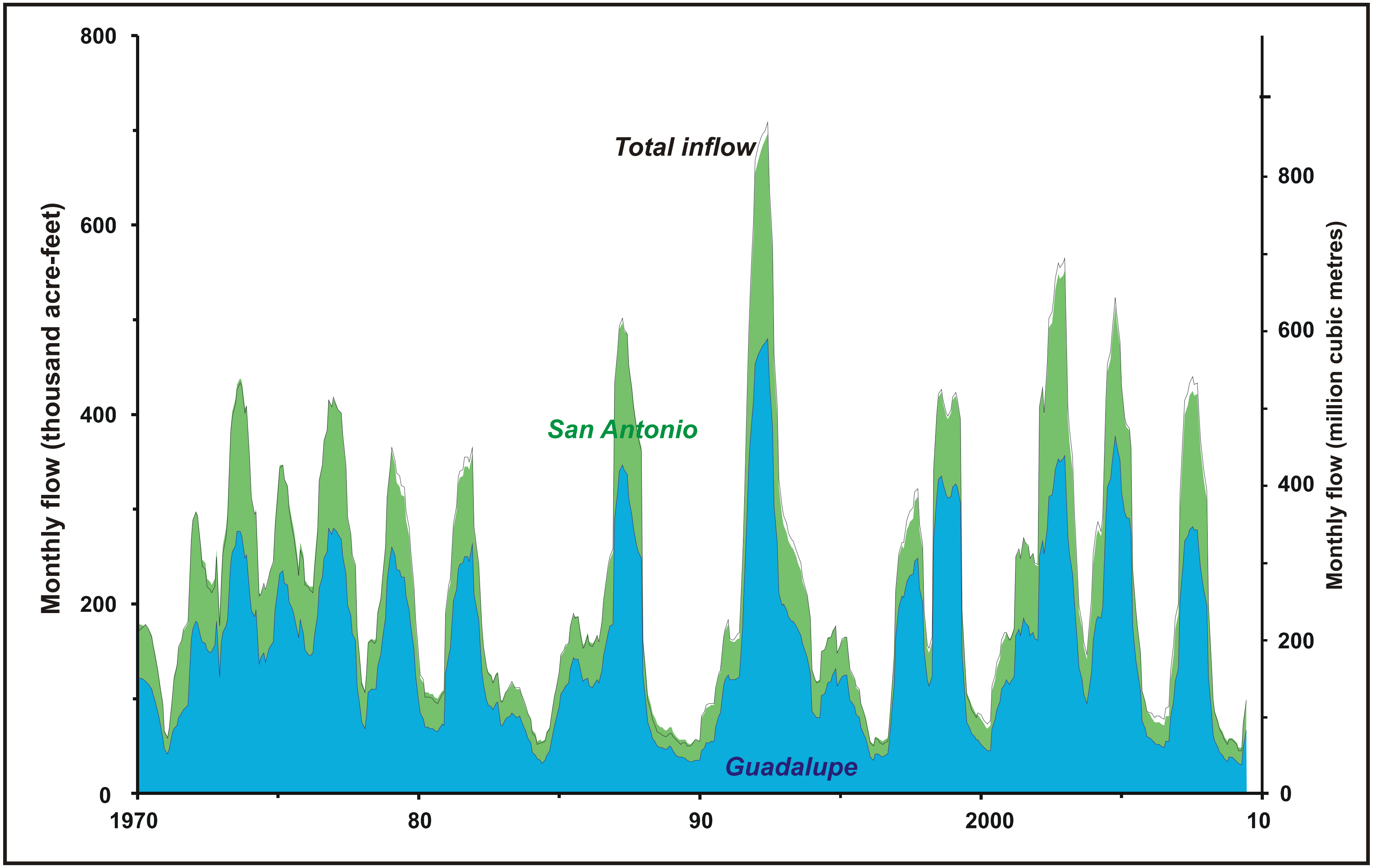

Figure 6b - Monthly total inflow into San Antonio Bay, with Guadalupe and San Antonio component flows, after running 12-month mean, 1970-2009

A more revealing display of drought occurrence is provided by an analysis of the so-called residual mass curve (Rippl, 1883, McMahon and Mein, 1986, see also Ward and Proesmans, 1996), given by the cumulative sum:

$$\sum (Q - \overline{Q})$$

where $\overline{Q}$ is the period-of-record mean (in this case, 1942-2009). This is shown in Figure 7. For present purposes, a drought is considered to be a period of more than one (1) year whose mean flow is less than 60% of the 1942-2009 average flow $\overline{Q}$. A period of below-average flow is exhibited in the cumulative-residual-flow diagram of Fig. 7 as a decline in the curve. Droughts by the present definition are diagnosed when the general downward segment of the curve is steeper than the straight line

$$y(t) = \sum(Q_o - \overline{Q}) \quad (1 - f)\ \overline{Q}\ (t - t_o) \qquad (1)$$

where (t_o, $\sum(Q_o - \overline{Q})$) is the first point of the declining segment and $f = 0.6$.*

Historical droughts so diagnosed are listed in Table 7 and indicated in Figure 7. For each drought, two lines are shown, the diagnostic line with slope $0.6\overline{Q}$, and the regression line through the drought period (see Appendix B for mathematical details). The duration of a drought is defined by the beginning of the period of decline and the intersection of the $0.6\overline{Q}$-slope line with the rising limb of the residual curve. Mass residual curves for the two primary basins are also plotted on Fig. 7, though drought periods are not explicitly identified.

* Definition of droughts is complex and would take this brief survey too far afield to explore. The definition adopted here is pragmatic. A duration of more than a year is prescribed, for no particularly compelling reason other than a threshold of severity. The 60% average flow criterion successfully identifies the historical droughts that have impacted the San Antonio Bay watershed. Many hydroclimatological studies adopt the more expansive definition of a drought as a period of below-average flows. It is interesting to observe that with this definition, inflows to San Antonio Bay would be considered to be in drought conditions from 1947 until 2004, because this long was required to recover the mathematical deficit of the Drought of the Fifties. Clearly, this does not accord with the conventional view of San Antonio basin hydroclimatology.

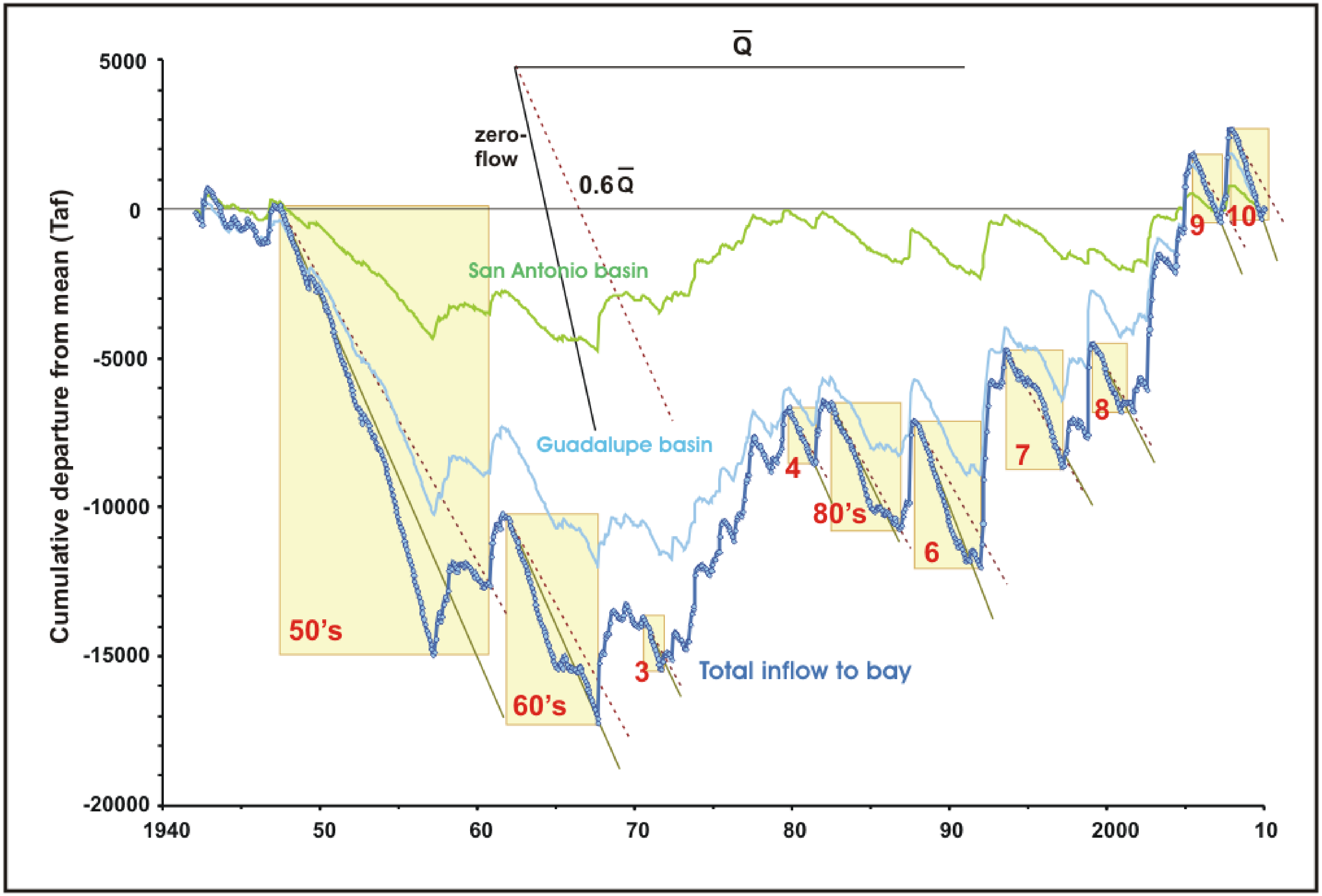

Figure 7 - Residual mass curve of monthly flow time series, prominent droughts indicated by constant-flow ($0.6\overline{Q}$) criterion lines and regression lines.

Two aspects of quantifying a drought are its intensity and its severity. Intensity is the degree by which the flow (or any other water-budget parameter) falls below a diagnostic criterion (typically long-term average, but in the present analysis, $0.6\overline{Q}$). Severity, in contradistinction to intensity, is the total cumulative stress on the surface water resource, and is affected by both intensity and duration. The intensity of the drought is measured by the (negative) slope of the regression line. The steeper the slope of the regression line, the more intense the drought in terms of average flow deficit. These slopes are given in Table 7 (as "best-fit slope"). The severity of the drought is measured by the maximum deficit below the criterion line (1). Those familiar with the use of the residual mass-curve methods for reservoir capacity estimation will recognize this deficit volume as the capacity necessary for a theoretical reservoir to provide a firm yield of the criterion slope, in this case, 60% of the period of record mean flow.

Table 7

Droughts during 1942-09 period, based upon mean flow < $0.6\ \overline{Q}$ (see text)

Drought ID	*drought period**		*best-fit*	*max depletion*		*mean*
	start (year)	*end (year)*	*slope (Taf/yr)*	*volume (Taf)*	*date (year)*	*SOI†*
50's	47.50	60.75	-1209	5777	57.17	0.26
60's	62.00	68.00	-1182	2065	65.00	0.21
3	70.58	72.17	-1089	716	71.58	1.63
4	79.83	81.42	-1173	378	81.25	-0.55
80's	82.50	86.92	-1100	1117	85.00	-1.42
6	88.00	92.00	-1374	1697	91.00	0.40
7	93.67	97.25	-933	509	97.17	-0.66
8	99.25	01.62	-1025	632	00.83	1.15
9	05.58	07.33	-1280	661	07.00	-0.33
10	08.00	10.00	-1508	1240	09.75	1.17

* Dates are given as years after 31 Dec 1900 omitting the hundreds unit. 05.58 is therefore 0.58 of a year into 2005, i.e. day 0.58 x 365 of 2005.

† Southern Oscillation Index

Several observations about the time series of monthly inflows relevant to drought are immediate from inspection of Fig. 7 and Table 7:

(1) The time series behavior of the two major river basins and the total flow to the bay are, at this scale of resolution, quite coherent.
(2) Over the seven-decade period of record, there have been ten droughts with durations exceeding one year, a frequency of roughly one every seven (7) years.
(3) Of the 68 years analyzed, 40.5 years were in drought conditions.
(4) By far, the drought with the longest duration and greatest severity is the Drought of the Fifties, for each of the two basins and for the total flow to the bay.
(5) The most intense droughts in the record are those of the early 1990's and 2008-09.

The coherence of the mass curves for the two basins indicates that drought events are correlated between the basins, and therefore the drought conditions generally occur regionally over both basins. While the average frequency of droughts during this period is about one per seven years, the distribution is much more irregular than this statistic would indicate. The first two droughts in the period together represent a total of over 19 years. The subsequent droughts average 2.7 years in duration. While there seems to be a tendency for shorter drought durations since the 1950's, there is also a tendency for increased drought intensities, the three most intense droughts having occurred in the last two decades.

The irregular spacing of drought occurrence and the variability in drought duration are, of course, intimately related to the distribution and magnitudes of high-flow sequences in the record. It was noted above that there has been an apparent increase in magnitude (i.e., amplitude) of flow excursions from low-flow conditions to high-flow conditions in recent years. But there is more to it than that, as can be assessed by the time-honored method of eyeballing. An inspection of Figs. 5-6 reveals that the behavior of the time series as indicated by the height and number of "surges" or "humps" in the graph is different for three subdivisions of the data, roughly 1942-65, 1965-85, and 1985-2009. In the first period, 1942-65 (23 years), there are seven (7) surge peaks, averaging one every 3.3 years, of average range about 190. In the second period, 1965-85 (20 years), there are nine (9) averaging one every 2.2 years, of average range about 230. In the third period, 1985-2009 (24 years), there are seven (7) averaging one every 3.4 years, of average range about 380. The precise numerical values depend upon one's generosity in identifying a "hump" and where one places its "base" for estimating its height, but two qualitative facts emerge. The average recurrence is about the same in the first and third periods, say 3.5 years or so, but is much shorter (i.e., the surges are more frequent), about every 2 years or so, in the middle period. The average height of these surges increases over the period of record, with those in the last period about double the first.

Those readers not interested in Fourier analysis, and/or not prone to masochism, are advised to skip the next paragraph and Figure 8.

This can be explored more precisely by examining the change in the frequency spectrum of monthly inflows, which were shown in Fig. 5. Figure 8 displays the spectrum, as determined by the Fast Fourier Transform, for three different time segments of the record, January 1942 – May 1963, January 1965 – May 1986, and September 1988 – December 2009.* The most dramatic feature of these spectra is the pronounced increase in power, about a factor of 2, at lower frequencies (longer periods) from the earlier to the later time segments. The higher frequencies are influenced by the month-to-month noise in the data, and are not of particular significance, so are grayed out in the figure. In terms of dominant frequencies, the earlier and later segments are more similar, the earlier evidencing a spectral peak around 3.5 years, and the later around 5.5 years. Even during the Drought of the Fifties, this interannual variation of 4-5 year periodicity was occurring, but the amplitude of the excursion did not rise to a sufficient level to break the drought. It is the increase in power of this variation, i.e., the excursion amplitude, that is the difference between the two periods. In the later period, the flood-prone ("wet") years evidence higher flows, and the drought ("dry") years more intense drought. The central time segment about 1965-85 seems more irregular, perhaps transitional, exhibiting higher frequency variation with a prominent 2-year periodicity.

*Each period encompasses 256 months. The FFT can only accommodate a number of data points equal to a power of 2 without the artifice of padding. This also accounts for the resolution in frequency in Fig. 8 of 1/256 cycles per month.

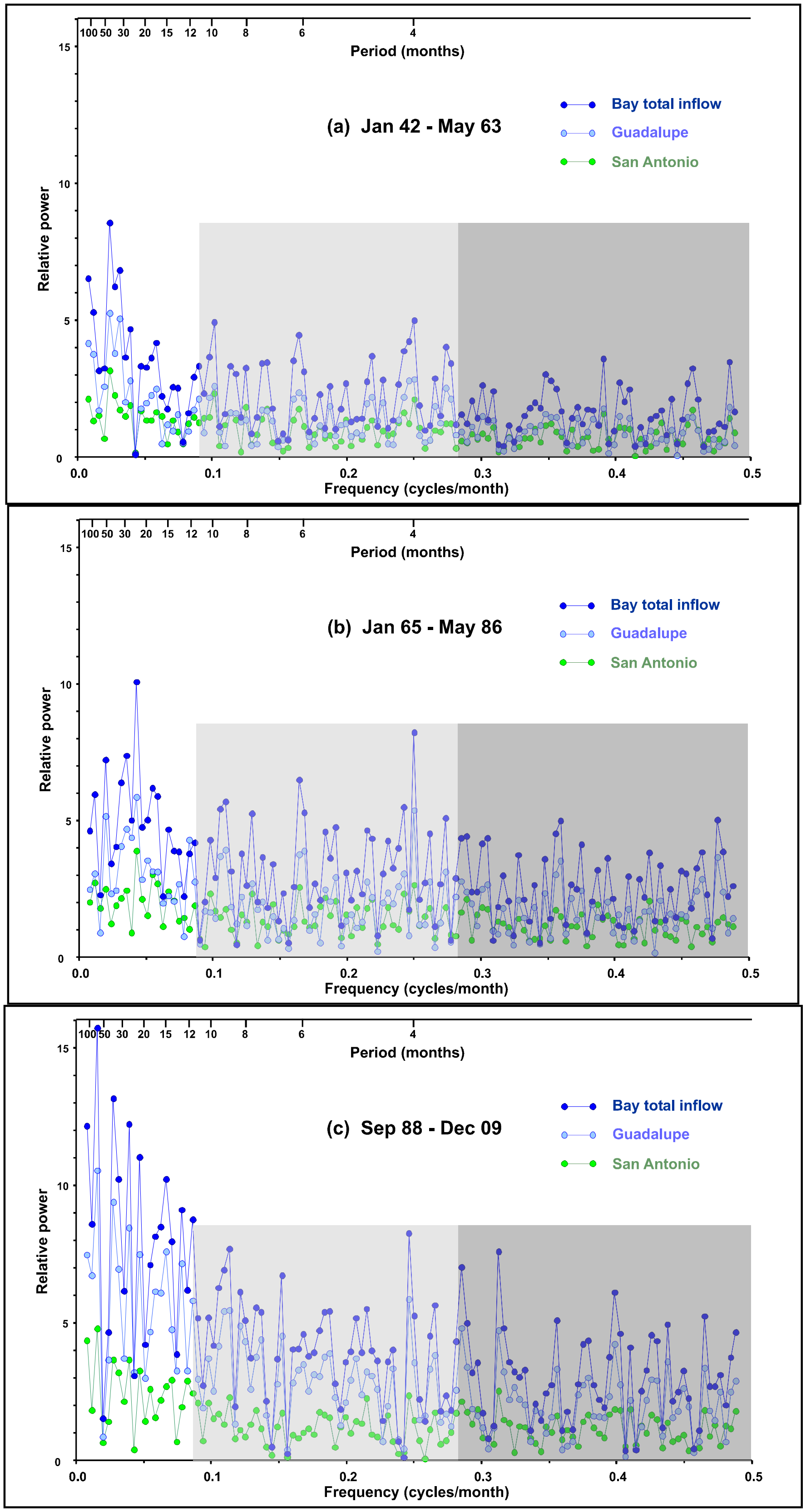

Figure 8 - Frequency spectra (Fast Fourier Transform) of subperiods of inflow time series

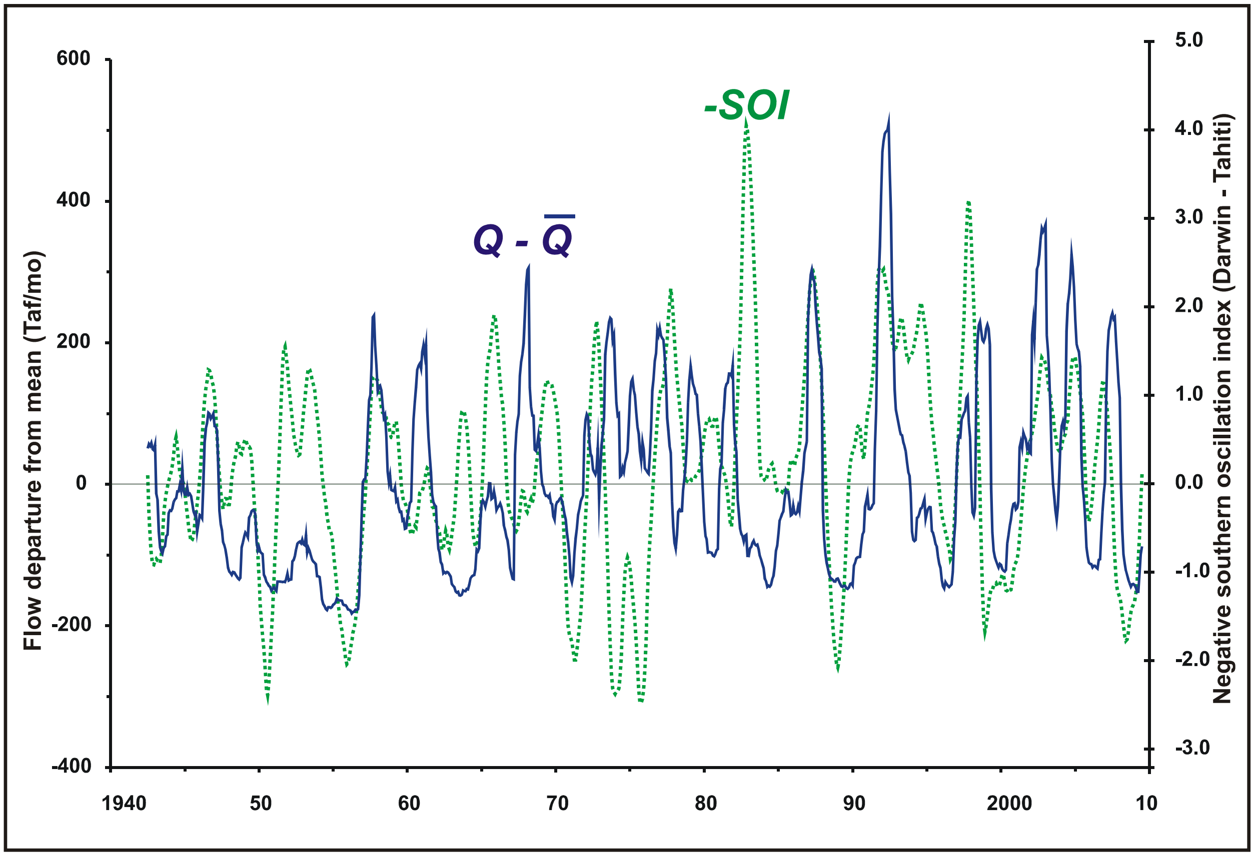

Figure 9 - Twelve-month running average of total inflow into San Antonio Bay in excess of mean, and negative Southern Oscillation Index (SOI), for 1942-2009 period. Positive values of –*SOI* correspond to El Niño.

It has recently become fashionable in some quarters to ascribe the vacillations between drought (dry) and flood-prone (wet) periods to La Niña and El Niño conditions, respectively, in the tropical Pacific. It is therefore worthwhile to examine the correlation between San Antonio Bay hydroclimatology and the tropical Pacific, to establish whether the El Niño-Southern Oscillation (ENSO) is a viable predictor for average inflows to the bay. The intensity of ENSO is measured by the Southern Oscillation Index (SOI), defined as the atmospheric pressure difference between Tahiti and Darwin, which is anticorrelated with El Niño. To examine their correspondence, we inspect the association between the monthly SOI and the monthly inflow to San Antonio Bay in excess of the 1942-2009 mean ($Q - \overline{Q}$), as a measure of wet (positive) versus dry (negative) conditions. Like the monthly inflows to San Antonio Bay, the monthly SOI is a noisy time series. Both were smoothed with a running, centered 12-month mean, and plotted to exhibit time correlations in Figure 9. The atmospheric measure in this figure is actually the negative of the SOI, i.e., the pressure difference Darwin – Tahiti. This is because negative values of the SOI are associated with El Niño conditions, and the hypothetical relation is that El Niño produces stormy conditions, hence high runoff in the San Antonio Bay watershed. By plotting –*SOI*, we would expect to see its positive values correlated with above-average inflows, thereby facilitating a visual comparison.

While there appears to be some general correlation in the post-2000 period in Fig. 9 (r = 64%), over the longer term of seven decades there is little (r = 29%). This is better exhibited by isolating those periods of larger departure of inflows from the mean, either runs of wet or dry conditions, by excluding the central third (33%) of the data (which turns out to be those 12-month mean monthly flows within ±62 taf about the mean), and computing the average flow for positive and negative runs of the remaining data, along with the same average of the corresponding (smoothed) monthly SOI values. The resulting data points are shown in Figure 10. The hypothesized association between ENSO and wet-or-dry climatology would result in the data points lying in the upper left or lower right segments. This is clearly not the case.

An important but secondary supply of moisture to the Texas atmosphere originates in the tropical Pacific off Central America, so it is not unreasonable to expect a physical coupling between ENSO and Texas hydroclimatology. The lack of correlation in Fig. 10 is due to the influence of other factors, not correlated with El Niño, such as vapor influx from the Gulf of Mexico (which is by far the more important source of moisture to the state), position of the long-waves in the westerlies, especially an omega block over the western U.S., and the frequency and characteristics of frontal passages.*

* California is far more sensitive to the ENSO cycle than Texas due to its proximity to the eastern equatorial Pacific. One need look no further for an exemplar of the maxim that large-scale atmospheric circulations trump ENSO than fall of 2010, where despite La Niña conditions, California was plagued by phenomenal rainfall, flooding and mudslides.

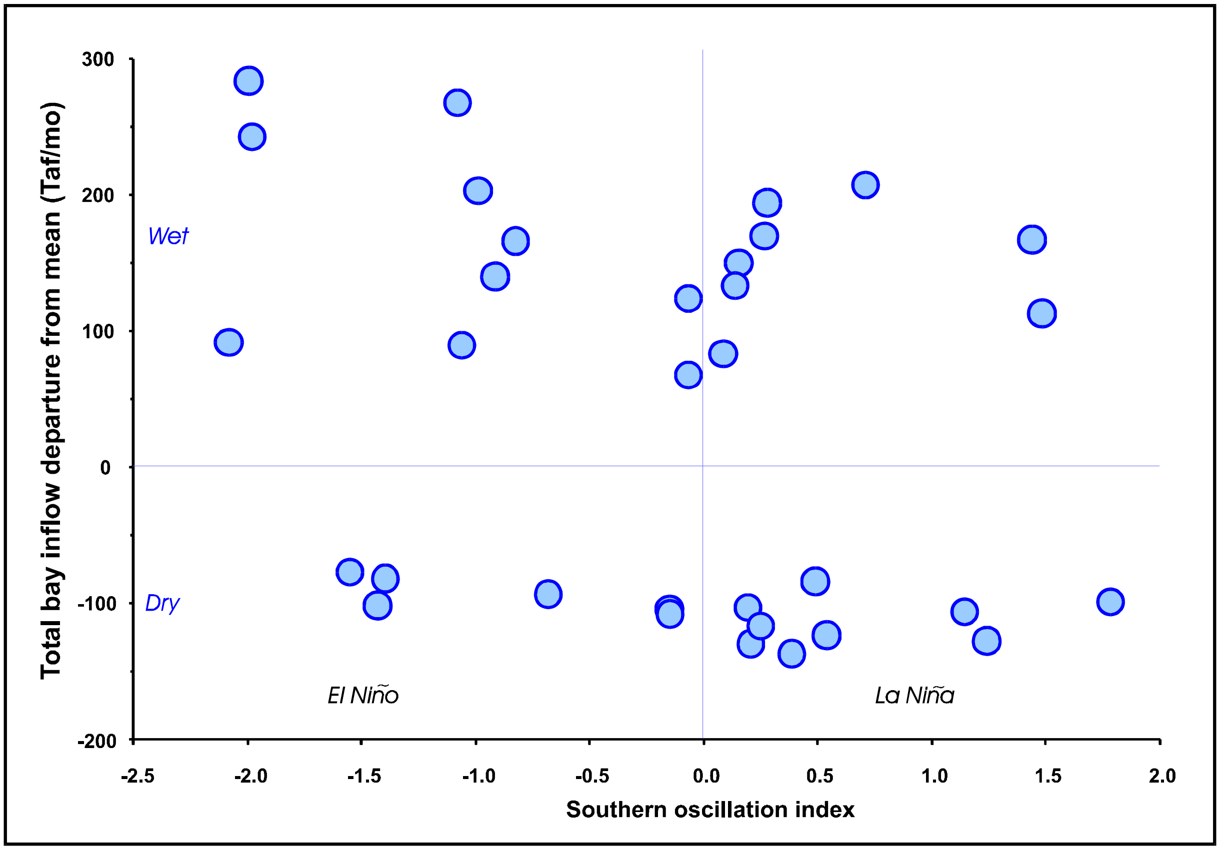

Figure 10 - Association of runs of high departure of flows from the mean, averaged over the run versus the averaged SOI over the same period.

4.2 Seasonal inflow variation

Figure 11a displays the variation in the cumulative frequency distribution (or ogive) of monthly flows into San Antonio Bay by month over the course of the year, the statistics being based on the period 1942-2009. The flows corresponding to occurrence frequencies of the quartiles (50% of course corresponding to the median) and highest and lowest deciles (i.e., 10% and 90%) are plotted versus month of the year. The mean monthly flows for each month are shown also (and differ from the medians when the monthly data are skewed). Figures 11b, 11c, and 11d plot exactly the same information on the same ordinate scale (to facilitate comparison) but are each limited to the periods 1942-65, 1966-1985, and 1986-2009, resp., which correspond roughly to the time segments of the previous section. Figures 12 and 13 are exactly the same display except for the individual river basins of the Guadalupe and San Antonio (and have the same ordinate scale, though different from Fig. 11). These figures confirm the common knowledge that the intra-annual variation of flows into San Antonio Bay tends to be bimodal, with peak flows in the spring and fall. (This bimodal behavior is responsible for another important feature of the spectra of Fig. 8, namely the power peaks at periodicities of approximately six months.)

It is immediately apparent that, while the annual variation is indeed bimodal, the peaks are not equal, the spring peak being dominant, and are not equally distributed in the calendar. (This accounts for the additional spectral peaks at 4 and 12 months in Fig. 8.) Also, the bimodality is derived more from the occurrence of the higher flows and is not nearly so clearly exhibited in the lower flows (with occurrence frequency less than 50%). Indeed, the low flows occurring in the lowest quartile of the frequency distribution have little systematic seasonal variation. Flows at this occurrence frequency tend to be predominantly baseflow, rather than directly derived from storm events, hence seasonality would not be expected.

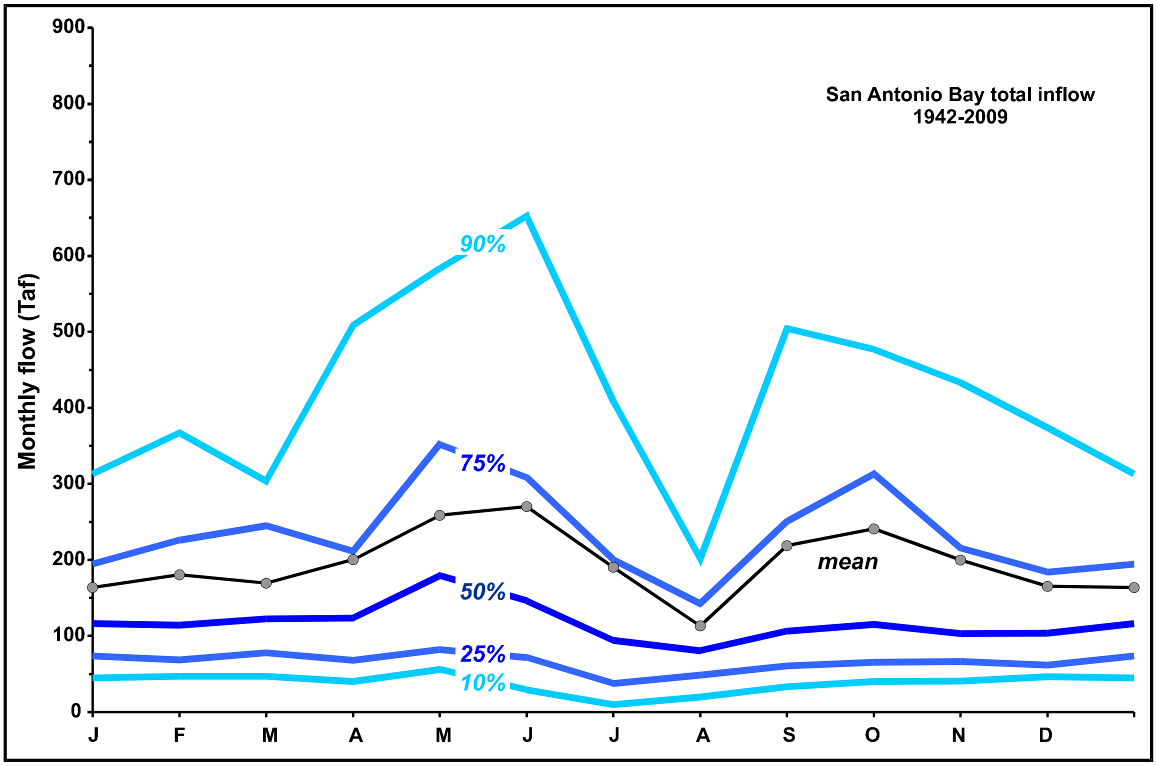

Figure 11a - Monthly total flows into San Antonio Bay at key frequencies of occurrence by month, and mean monthly flows, 1942 – 2009.

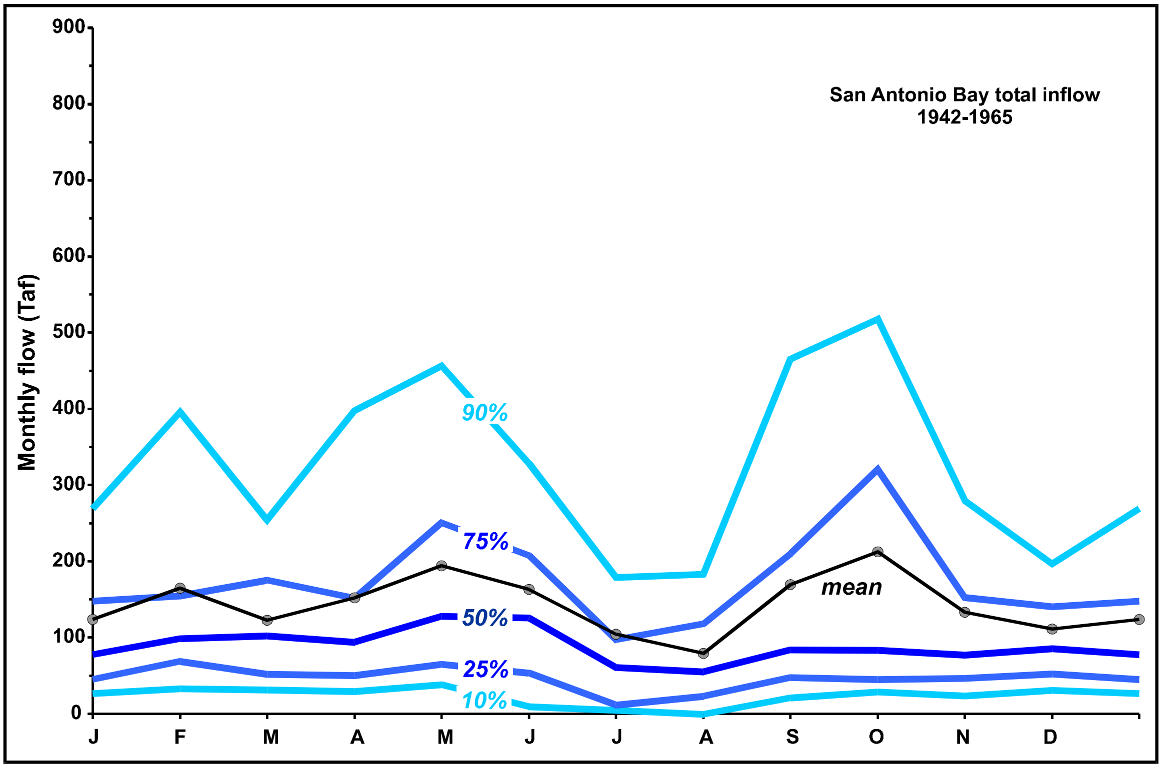

Figure 11b - As Fig. 11a, except only for the period 1942-1965 period

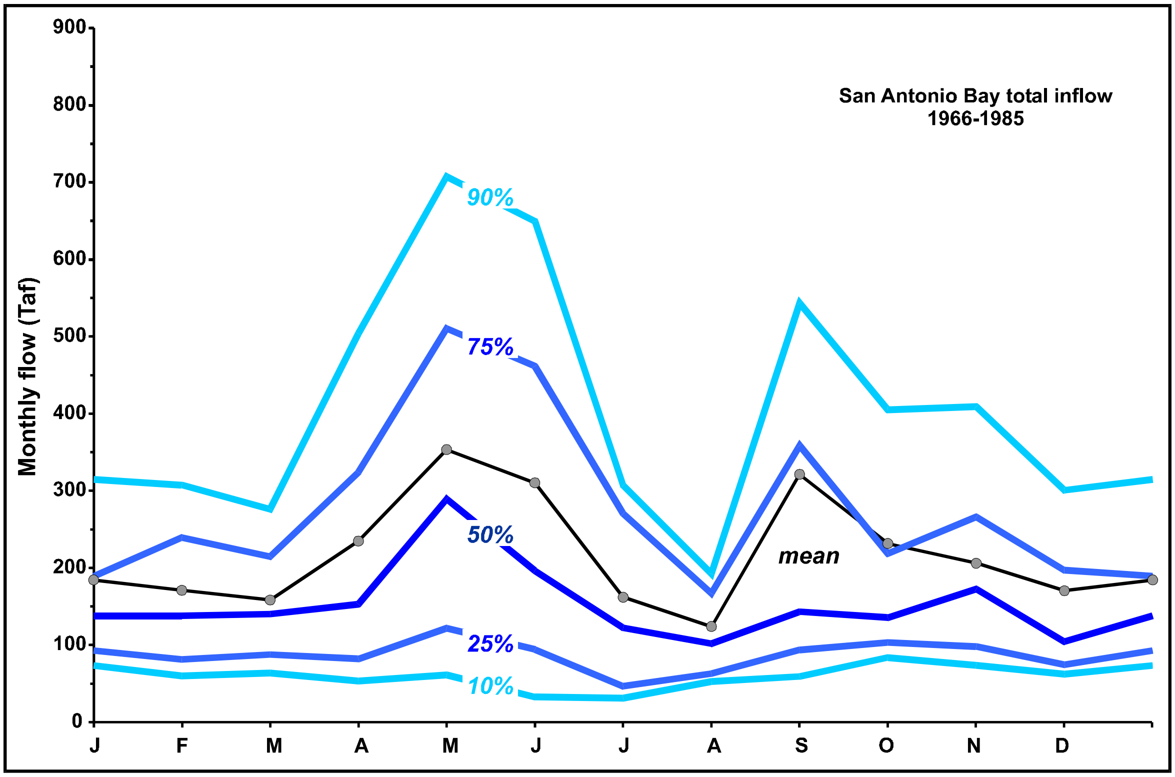

Figure 11c - As Fig. 11a, only for the period 1966 – 1985 period

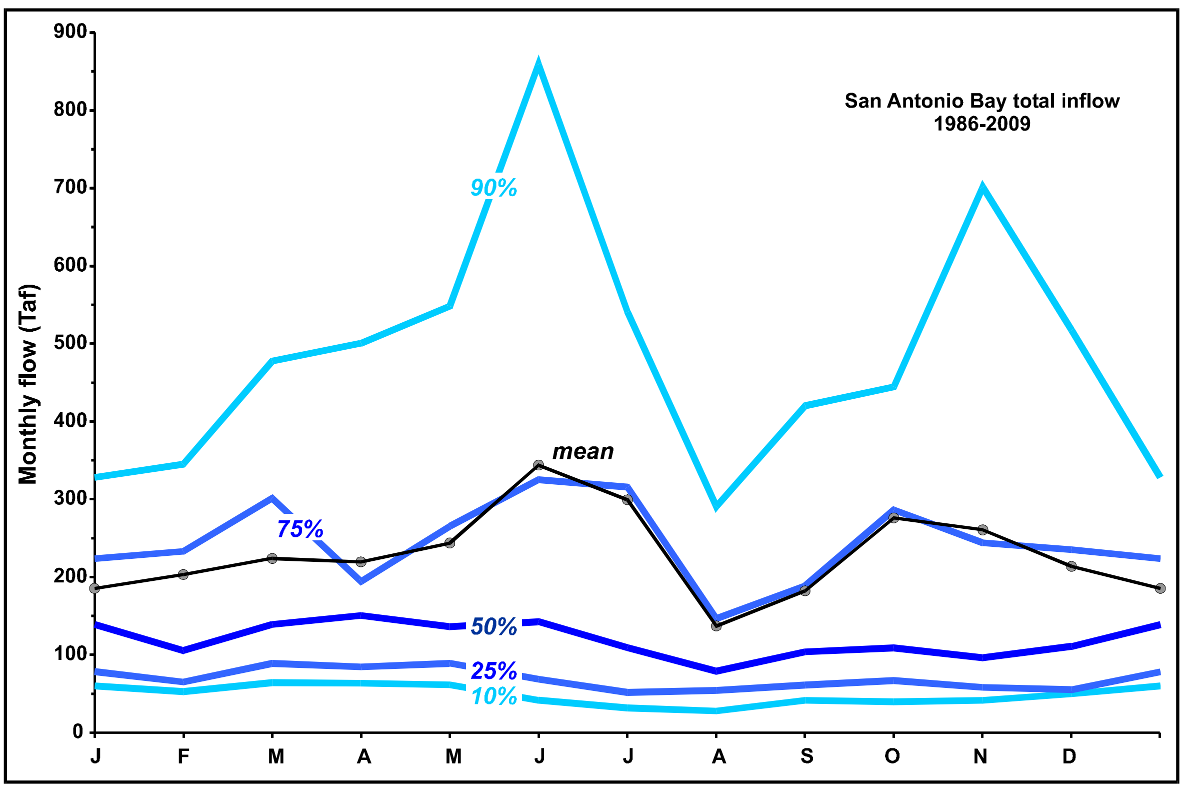

Figure 11d - As Fig. 11a, only for the period 1986 - 2009 period

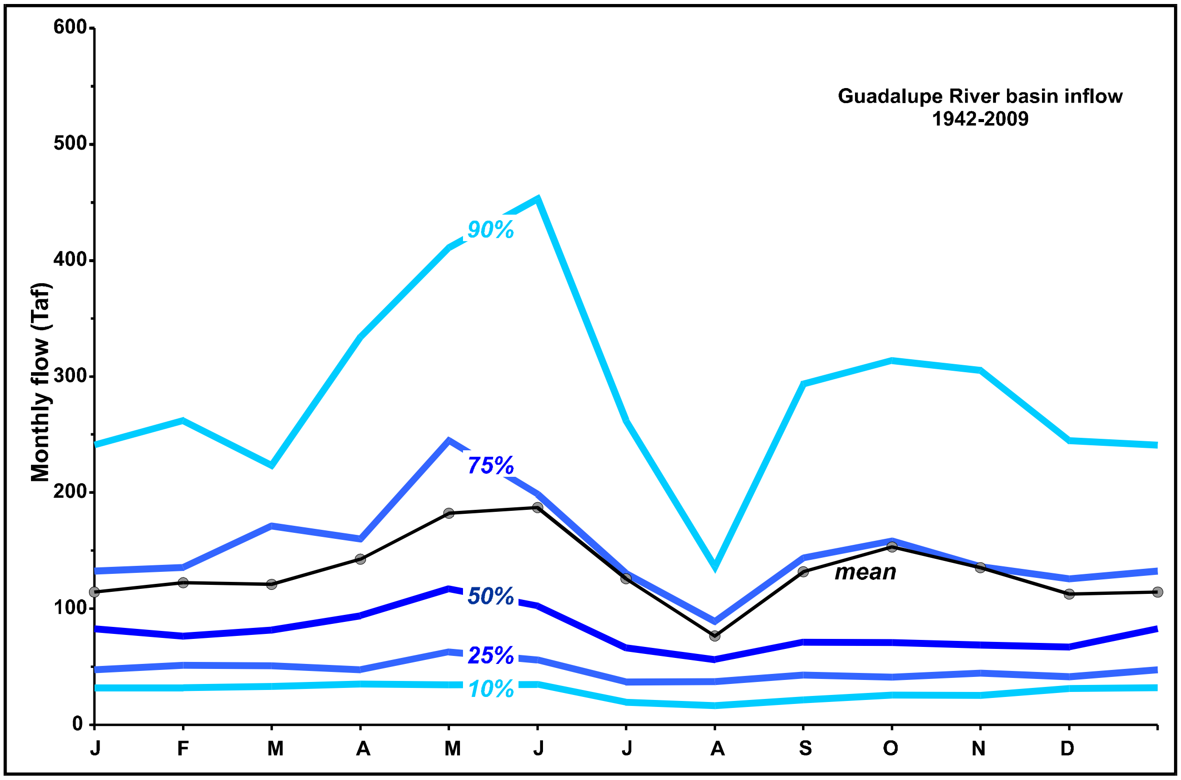

Figure 12a - As Fig. 11a, except for Guadalupe River basin only

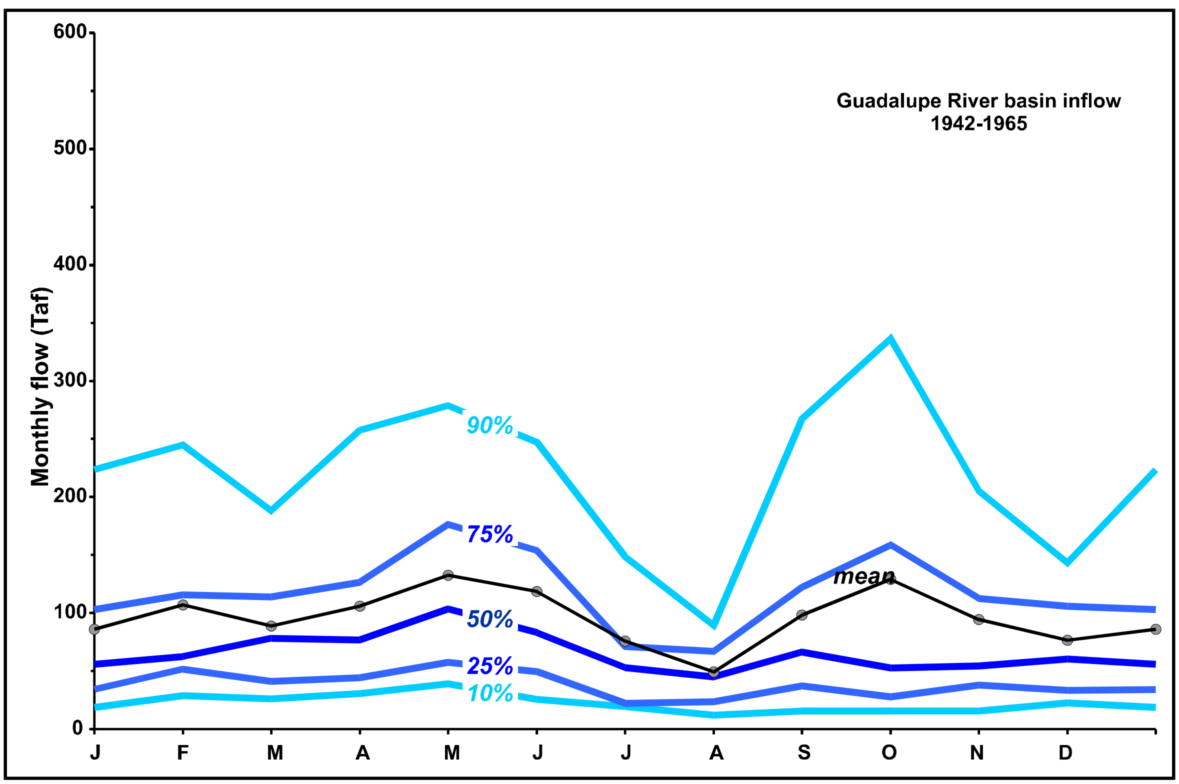

Figure 12b - As Fig. 11b, except for Guadalupe River basin only

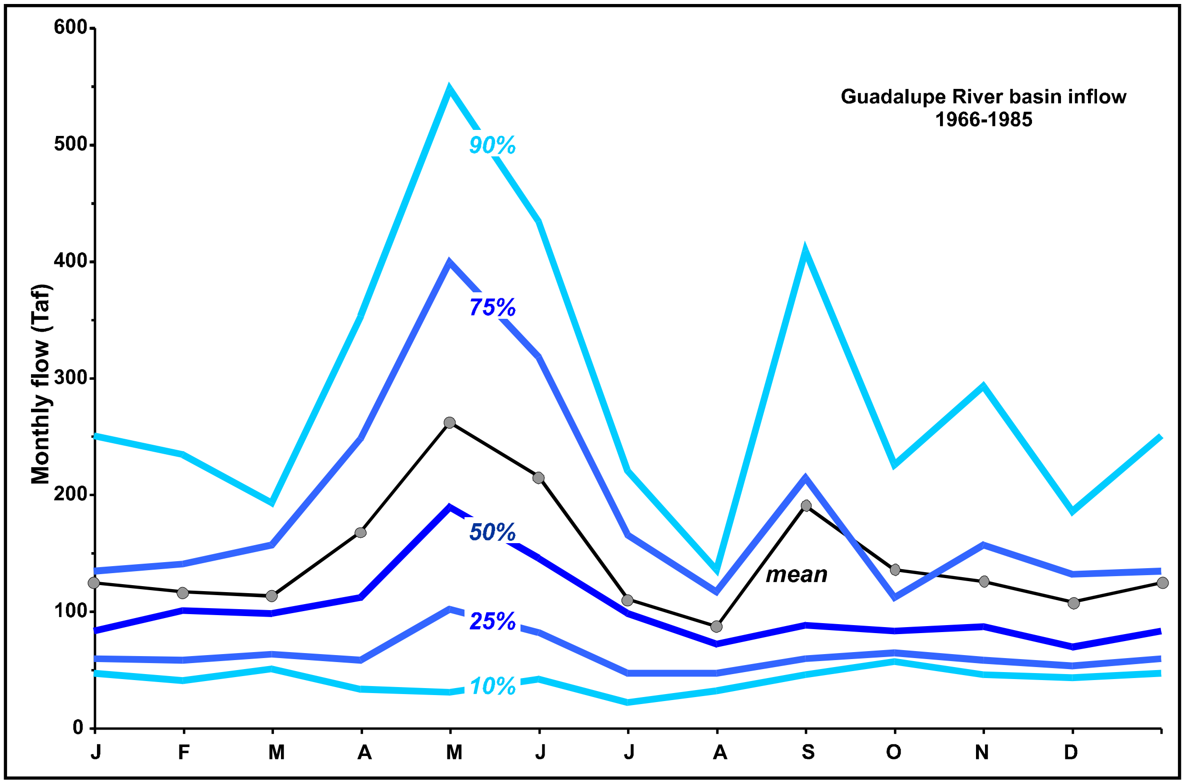

Figure 12c - As Fig. 11c, except for Guadalupe River basin only

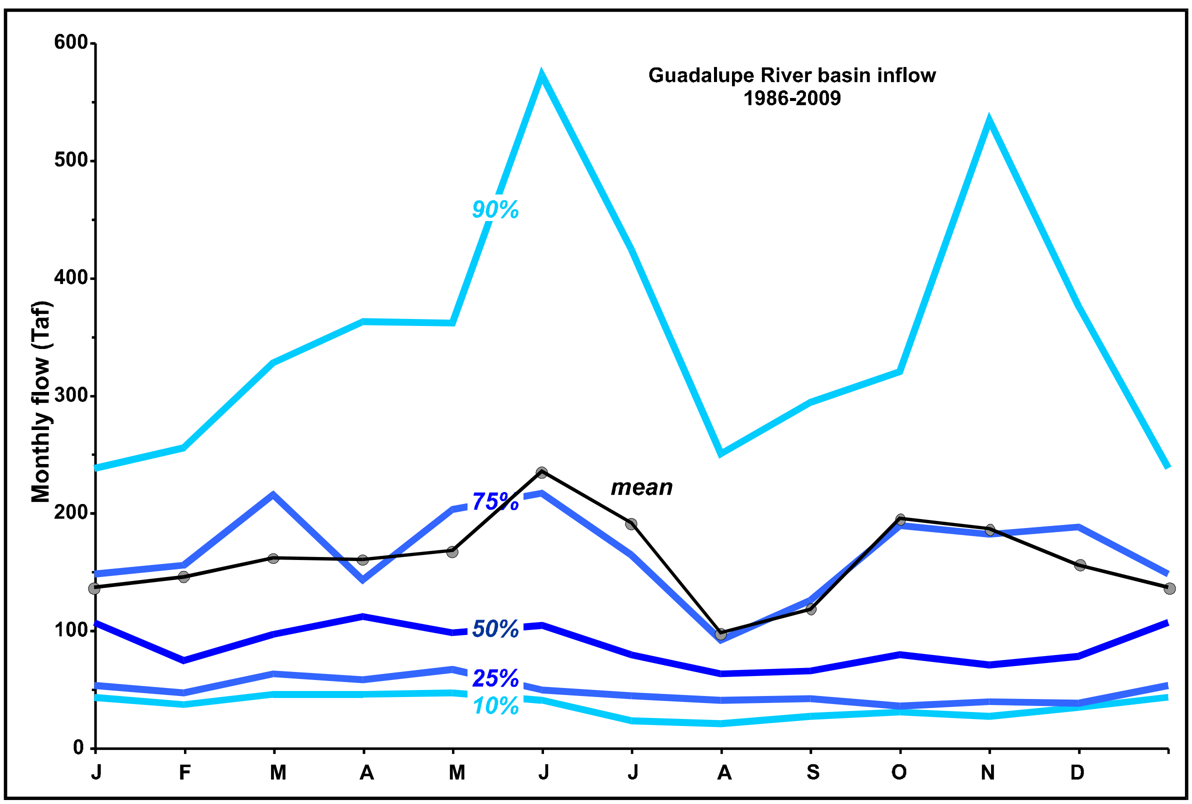

Figure 12d - As Fig. 11d, except for Guadalupe River basin only

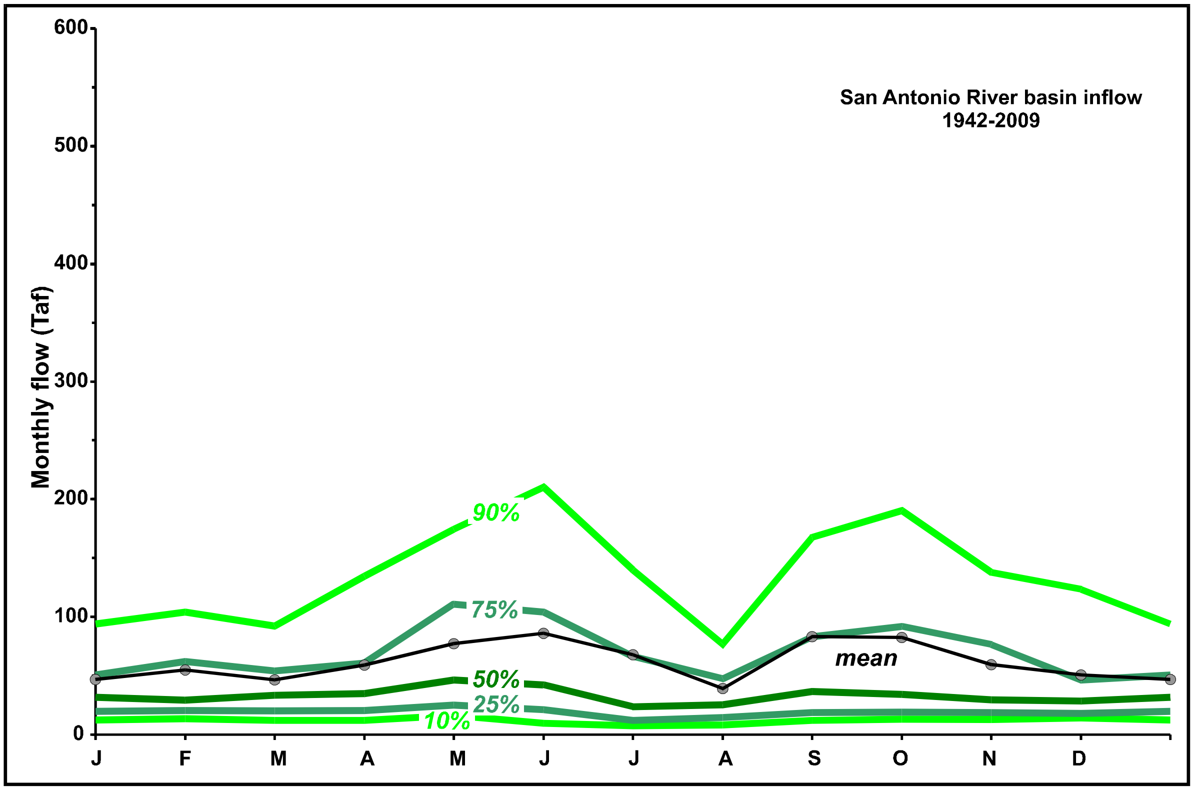

Figure 13a - As Fig. 11a, except for San Antonio River basin only

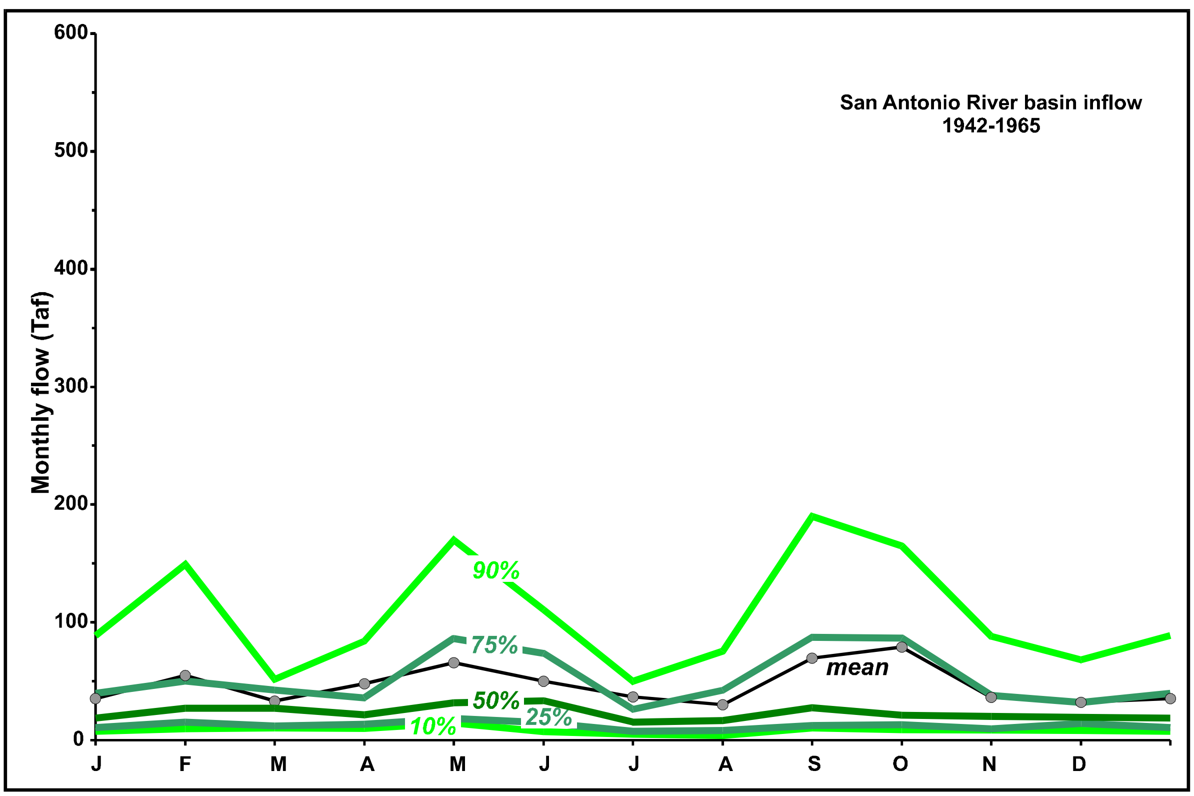

Figure 13b - As Fig. 11b, except for San Antonio River basin only

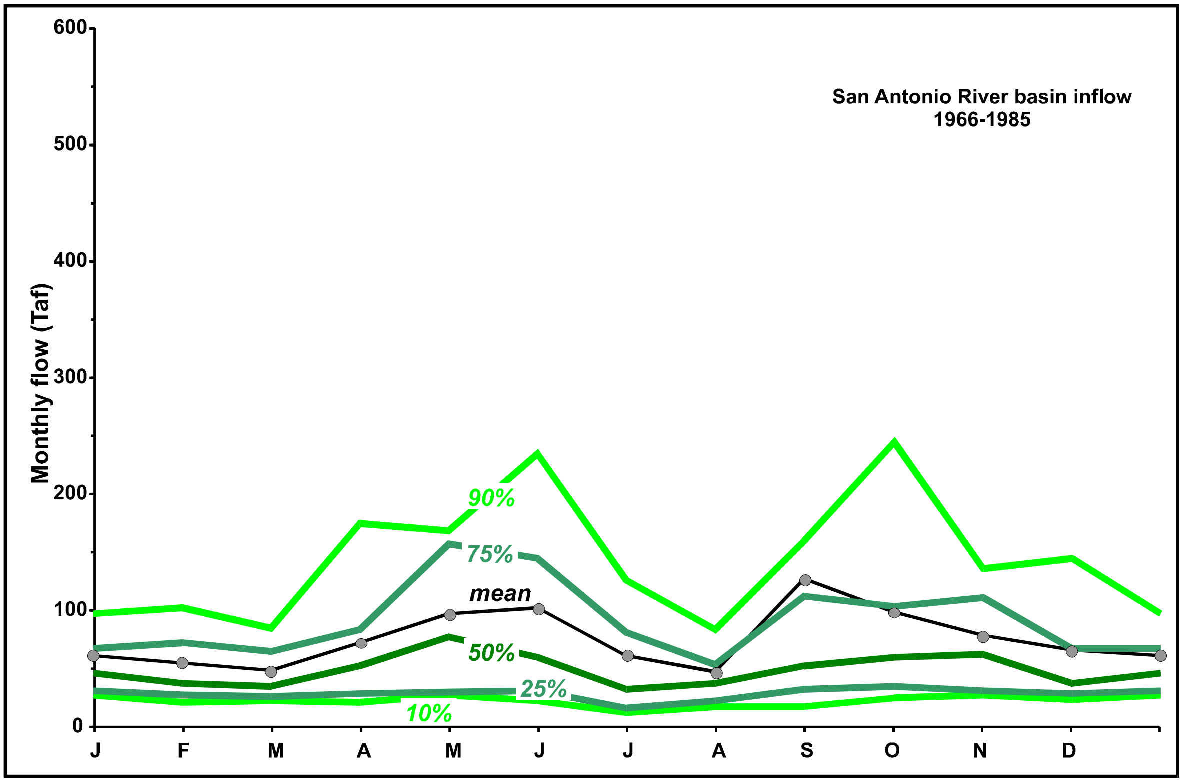

Figure 13c - As Fig. 11c, except for San Antonio River basin only

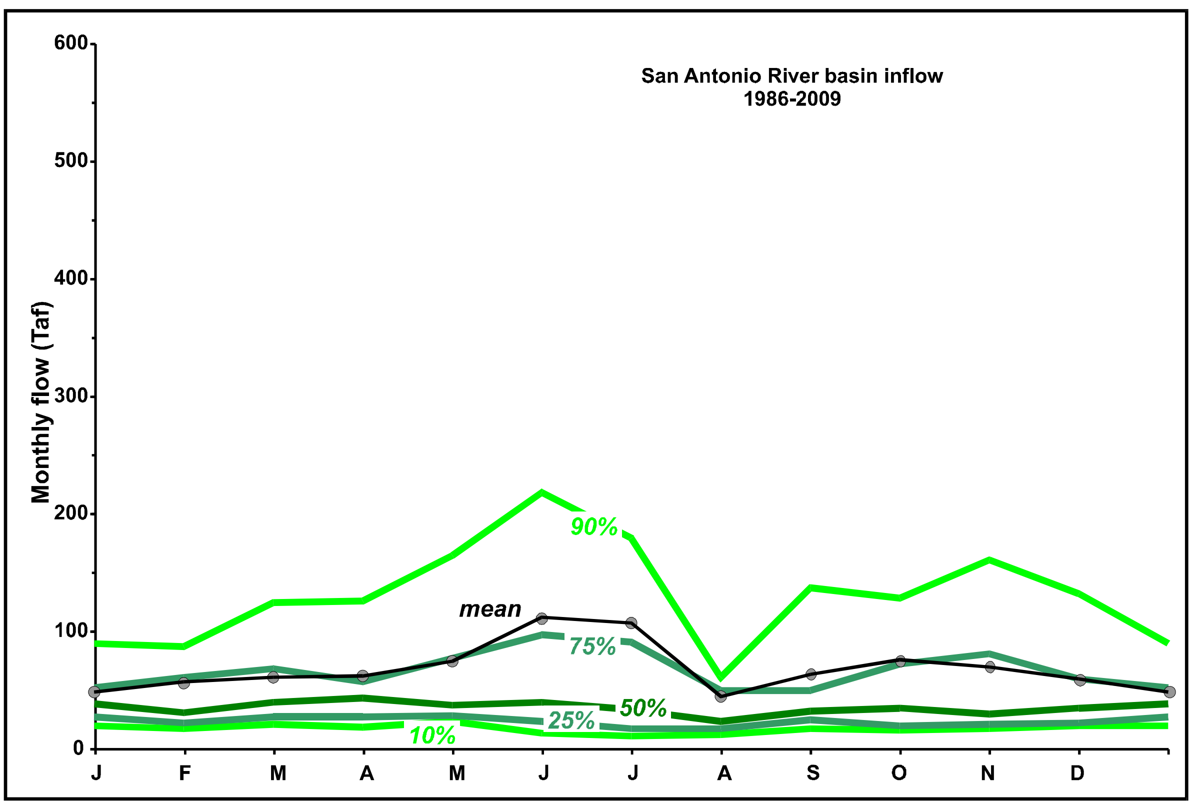

Figure 13d - As Fig. 11d, except for San Antonio River basin only

5. Summary

The principal observations and conclusions from the foregoing analyses may be summarized as follows:

1. The main contributors of inflow to San Antonio Bay are runoff from the land surface and human diversions and return flows in the stream channels. These are quantified by a combination of measured streamflow at gauging stations, modeled runoff based upon precipitation data, and measured or estimated diversions and discharges.

    1.1 The lowest gauges on the drainageways of the San Antonio Bay watershed with sufficiently long records for hydroclimatological analysis are the San Antonio at Goliad, the Guadalupe at Victoria, and Coleto Creek near Victoria or Schroeder (a major tributary of the Guadalupe conflowing downstream from Victoria).

    - 1.1.1 The total period of record utilized in the present analysis is 1942-2009.
    - 1.1.2 The three gauge stations represent about 94% of the total bay watershed.

    1.2. To estimate flows originating on the watershed below the gauges, results from the TWDB TxRR model (or for pre-1977 period, the SCS method) were employed.

    - 1.2.1 Starting in 1977, runoff data for individual subwatersheds (see Fig. 2) on a daily resolution are available.
    - 1.2.2 For 1942-76, the only TWDB results available are for the total ungauged watershed of the bay at a monthly resolution. These data were subjected to a statistical analysis to estimate the separate components of the Guadalupe, San Antonio, and bay periphery.

    1.3. Diversions and return flows associated with human activities (irrigation, municipal and industrial operations) are available from several sources, and/or can be estimated. The extent and quality of information is variable and is generally poorer for the early period of record. The most comprehensive compilation has been carried out by HDR, who provided their data for this analysis.

2. By far, the majority of the inflow to San Antonio Bay is gauged, the ungauged inflows making up a small, but nonnegligible contribution, and human activities even less. Gauged and nongauged together, the Guadalupe contributes about two-thirds of the inflow to San Antonio Bay, and the San Antonio about one-third, with the bay periphery contributing less than 5%.

   2.1 By data source, approximately 89% of the inflow to San Antonio Bay is gauged, 16% is ungauged and -5% is the net returns over diversions. Due to the locations of the gauges, the ungauged watershed is roughly the contribution from the Coastal Prairie.

   2.2 By physical source, approximately 69% enters from the Guadalupe watershed, 33% from the San Antonio watershed, 4% from the bay periphery and -5% from net returns over diversions.

   2.3 The human component, i.e., the net of returns over diversions, is minor, generally within the uncertainty of measurement of the gauged inflows.

   2.4 While these proportions obtain on average over the period 1942-2009, there is considerable variability.

      2.4.1 At times the ungauged watershed contributes a greater proportion to the bay, when prolific rainfall on the coastal plain results from marine airmasses or tropical storms.

      2.4.2 During drought conditions, the proportionate influence of ungauged flows and human activities become much greater factors in the water budget.

3. There has been a substantial increasing trend in inflow to the bay over the 1942-2009 period. The time variability in inflow has changed as well, with increasing high-flow surges separated by more intense drought periods.

3.1 The annual inflows to the bay have increased about 80% over the nearly seven-decades of data.

3.2 Ten droughts exceeding one-year duration were identified in the 1942-2009 record, representing 40.5 of the 68-year period, i.e., the bay inflows are in drought conditions about 60% of the time. The most severe drought on record is the Drought of the Fifties.

3.3 Inflows to the bay exhibit surges separated by periods of low flow. These surges generally recur every four to five years, except during the middle two decades of the record when their frequency was about every two years. Over the 1942-2009 record, the magnitude of these surges has increased by about a factor of two.

3.4 Droughts separating the surges of inflow have tended to increase in intensity over time. The three most intense droughts on record have occurred in the last two decades. Most intense was the drought of 2008-09.

3.5 The play in the popular press notwithstanding, there appears to be little association of wet versus dry conditions, as measured by departures from normal of bay inflows, with El Niño versus La Niña in the Equatorial Pacific.

3.6 While the magnitudes and year-to-year variation of inflows have changed over the past seven decades, there has been little change in their seasonal distribution, the basic bimodal pattern being maintained, with high inflows in the spring and fall.

  3.6.1 The bimodal pattern is driven mainly by the higher flows, i.e. those exceeding the monthly medians.

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APPENDIX A

Estimation of 1942-76 nongauged flows by component watershed

As noted in the text, some means of subdividing the 1942-76 TWDB monthly bay-total inflow into its component sources is needed. The method pursued here is to establish statistical regressions of monthly TxRR flow based upon monthly rainfall for each of the component watersheds for the 1977-2008 period, during which TxRR data are available for each watershed of Table 2. This in effect assumes that because local rainfall drives local runoff in the daily model of TxRR, monthly rainfall should likewise drive monthly runoff. This is, of course, imperfect. The TxRR monthly output is based upon a daily calculation, taking account of runoff when rainfall exceeds infiltration, storage of rainfall in the soil, and evapotranspiration and other losses during interstorm periods, all of which impart lag and memory into the watershed signal relative to the driver of rainfall. In addition, the partition of the monthly periods in this sequence of rainfall and runoff sorts rainfall and its responding (longer-term) runoff into different monthly compartments.

The source of precipitation data was the National Climatic Data Center (NCDC) Summary of the Day file, made up primarily of records from the NOAA Cooperative Observer program. These data are plagued by missing entries, lost records, variable instrument reading times, and other aberrations. We require a substantially continuous record over the 1942-2009 period in the general geographical area of the watershed. This requirement reduced the available stations to four: Victoria (which, in fact is a first-order National Weather Service station), Goliad, Aransas National Wildlife Reserve (ANWR), continuing the earlier cooperative record from Austwell, and Port O'Connor. (Port O'Connor had some gaps in its record, which were filled from Port Lavaca or Point Comfort.)

Both linear and quadratic regressions forms were evaluated (the latter forced through the origin), and each rainfall location was tested as well as the various pairwise and tripwise averages of locations. The quadratic relation proved better in every instance, though not by a substantial

Table A-1
Summary of statistical regressions of ungauged watershed runoff versus rainfall

Regression form: $Q = ar^2 + br$
Q = watershed runoff flow, taf / mo
r = rainfall, ins/mo

	watershed (see Table 2)			
	Guadalupe	San Antonio	Periphery	w/s 24608
versus rainfall at:	Victoria	Goliad	ANWR	Port O'Connor
a	0.262	0.141	0.156	0.038
b	1.604	0.807	1.051	0.644
explained variance	0.57	0.52	0.84	0.70

amount, and no advantage was gained by averaging together rainfall gauges. The best regressions for each of the four watershed categories are summarized in Table A-1. The Guadalupe regressions are based on the entire data set, combining those data in which watershed 18014 is included in the runoff area with those in which it is not. A separate analysis was done in which these data were separated in the regressions, but the differences proved negligible. A representative graph of the data and the linear and quadratic best-fit regression forms are shown in Figure A-1.

With these regressions, the runoff components for each ungauged watershed for the 1942-76 period were estimated from the TWDB total by:

$$\text{Guad+Santone above barrier} = max\{0, \text{TWDB total ungauged} - (\text{periphery} + \text{w/s } 24608)\} \qquad \text{(A-1)}$$

The separation of the ungauged flow into components is sought while holding their total as close as possible to the TWDB total value. In (A-1), the Guad+Santone watershed flow is estimated as

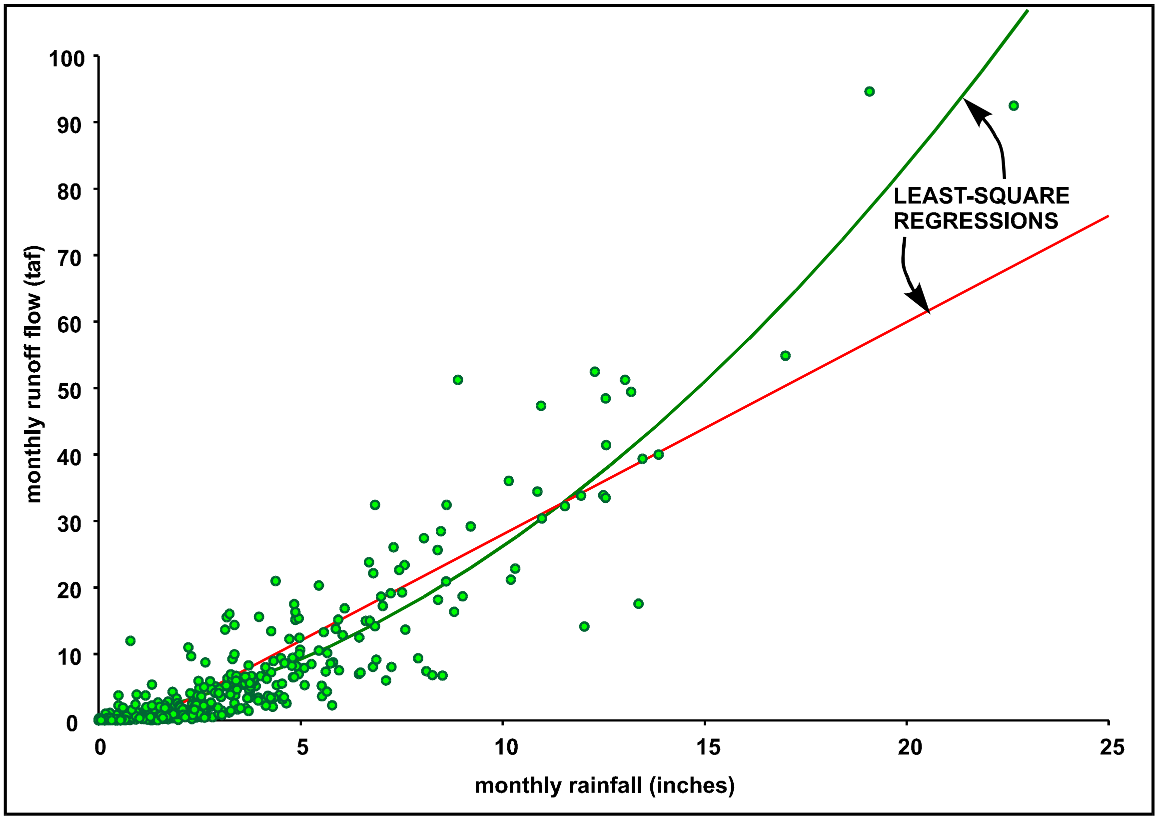

Figure A-1 – Monthly watershed inflow versus monthly rainfall, peripheral watershed (24601-34607), and best-fit regressions

the difference between the TWDB total and the regression values for the bay periphery and 24608 watersheds. The need for the *max{ }* function arises because a large positive excursion in a data point above the (periphery + w/s 24608) regressions drives this difference negative. While the total of the three watersheds indeed exactly equals the TWDN total, this is only by dint of a negative flow from Guad+Santone. Physically this is unacceptable, so the *max{}* operation assures that each value for this watershed is nonnegative. On average over the 1942-76 period, this results in about a 2% error in the computed total compared to the TWDB value.

It is messier to further separate the ungauged Guad+Santone flow into the separate contributions from the ungauged San Antonio (w/s 19011 + 19012) and the ungauged Guadalupe (w/s 18012 + 18020, plus the runoff from w/s 18014 whenever the Victoria gauge on Coleto Creek is unavailable). If the regressions from Table A-1 are employed to estimate each of these components, the 1942-76 average error in the computed total bay runoff inflow compared to the TWDB value is about 35%. An analogous equation to (A-1) that estimates the Guadalupe runoff from the regression of Table A-1 (which is slightly superior in explained variance to the San Antonio regression) and the San Antonio runoff by differencing:

$$\text{ungauged San Antonio} = max\{0, \text{Guad+Santone} - \text{ungauged Guadalupe}\} \tag{A-2}$$

encounters the same problem as (A-1) of occasional large positive residuals in the ungauged Guadalupe regression driving the answer negative, hence the need for the *max{}* function. This effect is minimized by selecting the alternative equation

$$\text{ungauged Guadalupe} = max\{0, \text{Guad+Santone} - \text{ungauged San Antonio}\} \tag{A-3}$$

for any month when the (Guad+Santone – ungauged Guadalupe) term in (A-1) is negative but the (Guad+Santone – ungauged San Antonio) term in (A-2) is positive. On average over the 1942-76 period, this strategy results in an error of about 8% in the computed total bay inflow compared to the TWDB value.

APPENDIX B

Regression line through fixed point

A line through a fixed point (x_o,y_o) has equation:

$$y = m\,(x - x_o) + y_o$$

To pass this line through *N* data points (*x*,*y*) as a least-squares fit, the minimum of

$$\sum [y - m\,(x - x_o) - y_o]^2$$

where the sum is extended over *N* data points, is given at the value of *m* where its derivative with respect to *m* is zero, i.e.

$$m = \frac{\sum yx - N\bar{x}y_O - N\bar{y}x_O + Nx_O y_O}{\sum x^2 - 2x_O \sum x + Nx_O{}^2}$$

$$= \frac{\overline{yx} - \bar{x}y_O - \bar{y}x_O + x_O y_O}{\overline{x^2} - 2\bar{x}x_O + x_O{}^2}$$

APPENDIX C
Monthly component flows into San Antonio Bay

year/mo		*component flows (Taf)* Guad	Santone	bay	ret-divs	*total bay (Taf)*	year/mo		*component flows (Taf)* Guad	Santone	bay	ret-divs	*total bay (Taf)*
1942	1	55.1	17.5	0.2	0.1	72.0	1946	1	86.7	21.0	5.9	0.2	105.3
1942	2	56.5	60.7	13.0	0.1	130.3	1946	2	113.8	53.2	4.0	0.1	171.1
1942	3	53.4	29.9	1.3	0.1	84.7	1946	3	193.1	50.6	5.7	0.1	249.5
1942	4	160.0	31.2	0.4	-0.1	191.5	1946	4	95.9	44.1	2.6	-0.2	140.0
1942	5	100.1	26.5	1.8	-0.2	127.0	1946	5	140.7	111.7	2.1	-0.3	254.3
1942	6	57.4	16.6	4.3	-0.3	75.4	1946	6	168.4	115.3	12.9	-0.5	296.2
1942	7	516.7	377.3	43.3	-0.4	936.9	1946	7	56.5	16.4	4.1	-0.5	75.2
1942	8	79.8	64.0	11.5	-0.3	155.1	1946	8	93.7	76.1	17.2	-0.4	186.6
1942	9	275.0	335.0	3.1	-0.2	612.9	1946	9	301.7	303.2	17.9	-0.2	622.5
1942	10	177.4	134.5	6.8	0.0	318.7	1946	10	390.5	439.4	6.7	0.0	836.6
1942	11	109.3	39.6	1.9	0.1	149.1	1946	11	229.1	64.0	4.1	0.2	297.4
1942	12	92.2	31.4	3.6	0.1	125.3	1946	12	141.8	34.5	1.4	0.2	176.2
1943	1	93.6	45.7	7.6	0.1	147.0	1947	1	232.9	48.9	3.2	0.2	279.7
1943	2	64.6	29.3	3.6	0.1	97.5	1947	2	121.3	28.6	0.7	-0.4	149.6
1943	3	81.4	52.2	2.7	0.1	136.4	1947	3	137.8	34.0	1.4	-1.2	168.7
1943	4	62.6	23.4	0.0	0.0	85.7	1947	4	138.0	35.4	8.6	-8.2	173.8
1943	5	72.2	29.5	5.9	-0.1	107.5	1947	5	179.7	126.9	7.6	-11.9	302.3
1943	6	96.3	72.7	0.3	-0.2	169.2	1947	6	77.1	22.2	6.7	-16.3	89.7
1943	7	64.0	36.2	3.1	-0.2	103.0	1947	7	68.7	18.8	0.7	-17.6	70.5
1943	8	43.1	15.5	0.4	-0.1	57.1	1947	8	96.4	21.4	25.7	-14.3	116.4
1943	9	66.6	20.2	5.6	-0.1	73.3	1947	9	43.0	16.2	0.9	-10.6	47.9
1943	10	41.4	15.8	0.5	0.1	57.1	1947	10	37.3	13.8	3.2	-4.2	50.0
1943	11	50.3	22.9	3.5	0.1	76.8	1947	11	44.2	20.0	11.2	0.0	75.3
1943	12	55.7	23.0	8.2	0.1	87.1	1947	12	52.4	17.5	3.8	0.2	67.4
1944	1	105.2	123.0	16.8	0.2	245.2	1948	1	46.8	24.3	6.5	0.2	77.7
1944	2	98.3	21.7	0.5	0.1	120.6	1948	2	56.7	38.4	4.7	-0.4	99.4
1944	3	211.4	90.0	6.7	0.1	308.3	1948	3	52.6	35.1	2.8	-1.4	89.0
1944	4	92.0	17.4	1.0	0.0	110.4	1948	4	37.0	14.2	2.9	-9.5	41.7
1944	5	272.7	186.2	16.3	-0.1	475.2	1948	5	107.1	34.3	1.4	-13.8	128.9
1944	6	185.7	31.0	1.2	-0.1	215.0	1948	6	34.6	9.0	0.1	-18.9	24.8
1944	7	76.7	17.0	2.6	-0.2	94.1	1948	7	50.0	24.5	0.7	-20.4	51.1
1944	8	65.1	28.3	7.2	-0.1	100.5	1948	8	45.8	46.9	17.7	-16.5	81.9
1944	9	118.1	47.2	16.2	0.0	181.5	1948	9	29.2	58.3	21.9	-12.3	97.1
1944	10	53.9	38.7	6.0	0.1	98.7	1948	10	29.2	20.3	1.7	-4.8	45.8
1944	11	78.8	18.7	1.7	0.1	99.3	1948	11	26.7	10.0	1.7	0.0	35.4
1944	12	144.3	52.3	4.3	0.2	201.1	1948	12	26.9	10.0	0.2	0.2	36.8
1945	1	201.6	43.9	1.2	0.2	245.1	1949	1	34.5	11.5	2.2	0.2	44.1
1945	2	182.0	49.4	1.5	0.1	233.0	1949	2	65.2	16.6	5.5	-0.1	78.1
1945	3	177.3	37.7	2.8	0.1	217.9	1949	3	102.1	16.3	1.9	-0.6	119.8
1945	4	349.4	101.6	6.0	-0.2	456.8	1949	4	274.0	258.8	31.4	-4.7	559.5
1945	5	94.8	25.6	0.6	-0.3	120.7	1949	5	175.0	44.1	0.1	-6.8	212.2
1945	6	93.3	44.8	9.4	-0.5	147.0	1949	6	76.3	60.1	1.6	-9.4	123.7
1945	7	63.9	20.7	8.8	-0.5	92.9	1949	7	61.6	55.3	11.6	-10.2	118.3
1945	8	65.5	96.1	64.7	-0.4	226.0	1949	8	45.0	18.2	1.3	-8.2	52.9
1945	9	41.3	12.8	1.0	-0.2	52.0	1949	9	39.0	12.5	6.3	-6.1	47.3
1945	10	82.4	29.7	6.5	0.0	118.6	1949	10	211.3	145.0	26.6	-2.3	380.5
1945	11	47.9	15.1	0.1	0.1	63.2	1949	11	52.6	19.0	0.7	0.1	72.4
1945	12	64.1	16.1	2.7	0.2	83.0	1949	12	74.9	26.8	2.9	0.2	104.8

(continued)

APPENDIX C (contined)

1950-1957

year/mo		Guad	Santone	bay	ret-divs	total bay (Taf)	year/mo		Guad	Santone	bay	ret-divs	total bay (Taf)
		component flows (Taf)							component flows (Taf)				
1950	1	45.8	17.2	1.5	0.0	64.4	1954	1	37.6	9.2	1.8	-1.3	45.8
1950	2	51.6	17.6	4.1	-0.4	72.9	1954	2	28.6	6.9	0.0	-2.1	33.0
1950	3	42.9	14.2	0.8	-1.0	56.0	1954	3	26.3	6.9	0.2	-3.3	29.3
1950	4	84.8	16.2	2.4	-5.6	94.4	1954	4	38.0	9.5	2.3	-11.0	29.8
1950	5	58.6	14.0	3.1	-7.9	65.5	1954	5	47.9	16.1	1.2	-14.6	47.2
1950	6	144.0	43.0	3.8	-10.8	180.0	1954	6	17.5	7.5	0.3	-19.6	2.9
1950	7	39.5	11.6	0.1	-11.7	36.3	1954	7	10.3	5.1	0.5	-21.2	-6.6
1950	8	25.6	13.1	1.9	-9.5	28.2	1954	8	8.7	3.1	1.1	-17.6	-6.8
1950	9	32.8	10.7	6.5	-7.2	32.8	1954	9	12.4	4.0	3.6	-13.8	0.2
1950	10	23.6	8.1	0.0	-2.9	27.0	1954	10	10.5	9.2	28.0	-6.4	41.3
1950	11	21.2	7.5	0.1	-0.2	28.5	1954	11	13.3	8.7	1.1	-1.8	21.4
1950	12	26.8	8.1	1.2	-0.1	34.5	1954	12	17.6	5.3	0.9	-1.8	19.3
1951	1	27.6	7.7	1.3	-0.7	32.5	1955	1	18.1	7.8	2.4	0.1	26.2
1951	2	24.2	11.0	0.5	-1.4	33.8	1955	2	63.1	20.7	1.3	-0.4	84.7
1951	3	33.5	10.7	5.5	-2.6	40.1	1955	3	21.6	10.9	0.1	-1.2	30.0
1951	4	28.1	11.6	1.0	-10.7	29.1	1955	4	18.8	5.3	0.7	-7.8	15.5
1951	5	63.3	40.7	4.8	-14.9	94.0	1955	5	55.6	19.3	4.1	-11.3	63.1
1951	6	149.1	75.3	0.8	-20.1	205.1	1955	6	51.9	9.9	0.4	-15.4	42.6
1951	7	20.2	7.5	0.8	-21.7	5.9	1955	7	19.4	4.2	4.2	-16.7	5.0
1951	8	11.7	5.5	0.0	-17.8	-0.9	1955	8	29.1	10.2	11.4	-13.5	25.6
1951	9	71.4	84.7	50.7	-13.7	193.2	1955	9	19.6	38.5	13.5	-10.1	61.5
1951	10	15.8	11.5	3.7	-5.9	25.1	1955	10	9.6	9.0	1.4	-4.0	16.0
1951	11	23.3	9.3	1.0	-1.0	30.4	1955	11	9.7	4.5	1.5	-0.1	12.3
1951	12	21.1	9.3	1.2	-1.0	29.8	1955	12	11.9	7.1	1.9	0.0	20.2
1952	1	21.2	8.4	0.5	-1.0	28.8	1956	1	14.2	6.4	1.8	0.1	20.3
1952	2	30.0	12.3	3.4	-1.8	37.7	1956	2	16.2	6.1	1.0	0.0	21.8
1952	3	26.1	11.8	0.7	-3.0	35.5	1956	3	10.9	5.2	3.4	-1.7	16.6
1952	4	45.4	38.1	8.8	-11.1	81.3	1956	4	13.2	5.2	4.9	-4.9	14.5
1952	5	117.0	77.8	6.0	-15.1	185.8	1956	5	20.2	20.9	1.7	-7.9	34.8
1952	6	89.5	18.4	0.5	-20.2	88.2	1956	6	5.8	1.6	1.2	-6.4	-0.1
1952	7	36.9	10.2	2.8	-21.9	20.4	1956	7	4.6	3.2	0.1	-7.3	-0.6
1952	8	14.0	4.8	2.4	-18.1	0.2	1956	8	3.0	3.7	8.4	-3.1	11.3
1952	9	290.0	218.7	7.1	-14.0	501.9	1956	9	7.7	11.9	1.2	-3.7	13.0
1952	10	44.0	9.2	0.0	-6.3	46.9	1956	10	24.1	22.6	4.3	-0.2	42.4
1952	11	72.7	23.7	8.2	-1.4	103.2	1956	11	7.7	9.3	1.1	0.0	17.6
1952	12	122.3	17.7	1.8	-1.4	140.4	1956	12	35.2	23.5	1.7	0.0	55.2
1953	1	102.7	16.7	0.6	-1.1	118.3	1957	1	8.5	6.8	0.5	-0.1	14.4
1953	2	52.1	11.9	3.4	-2.0	65.3	1957	2	30.8	9.3	3.1	-2.7	32.7
1953	3	40.8	10.5	0.4	-3.3	48.1	1957	3	106.3	139.7	10.3	0.0	256.4
1953	4	48.5	17.3	0.3	-12.0	54.1	1957	4	304.4	333.4	21.5	0.0	659.4
1953	5	182.4	74.3	9.7	-16.3	250.0	1957	5	463.2	276.2	12.3	-0.5	751.2
1953	6	21.9	5.1	1.6	-21.9	5.2	1957	6	345.0	205.7	6.5	-1.3	556.0
1953	7	21.0	7.6	1.0	-23.8	4.6	1957	7	41.9	10.1	0.0	-5.7	46.1
1953	8	68.3	74.7	52.0	-19.6	175.3	1957	8	24.0	6.7	0.4	-5.7	23.3
1953	9	112.7	98.2	1.2	-15.2	196.9	1957	9	249.4	122.5	11.3	-3.0	380.2
1953	10	114.5	14.4	7.7	-6.8	127.4	1957	10	505.5	70.9	1.6	-1.4	576.6
1953	11	42.0	9.3	1.4	-1.6	50.8	1957	11	302.5	134.8	7.2	-0.4	444.1
1953	12	58.1	12.0	3.4	-1.6	68.6	1957	12	124.9	18.2	0.6	0.1	142.3

(continued)

APPENDIX C (contined)
1958-1965

year/mo		Guad	Santone	bay	ret-divs	total bay (Taf)	year/mo		Guad	Santone	bay	ret-divs	total bay (Taf)
		component flows (Taf)							*component flows (Taf)*				
1958	1	278.5	186.8	13.3	0.1	478.8	1962	1	56.9	20.4	0.7	0.1	77.2
1958	2	558.1	322.3	8.0	0.1	888.5	1962	2	51.9	18.1	0.2	0.1	69.7
1958	3	247.1	40.4	1.9	-0.1	289.3	1962	3	50.0	15.0	0.8	0.0	64.3
1958	4	123.0	22.3	0.6	-1.9	144.0	1962	4	70.3	19.4	4.2	-1.8	86.8
1958	5	281.3	132.4	4.1	-5.2	412.6	1962	5	48.8	16.2	3.0	-6.0	61.9
1958	6	107.1	27.0	0.6	-5.2	128.1	1962	6	68.4	73.1	12.7	-6.1	148.2
1958	7	79.2	31.1	2.2	-7.1	103.7	1962	7	33.8	12.4	0.0	-6.7	39.5
1958	8	46.5	12.1	0.4	-7.2	51.0	1962	8	22.8	9.0	0.2	-7.1	22.6
1958	9	195.7	75.7	30.6	-1.0	301.0	1962	9	66.1	18.9	12.0	-3.6	87.4
1958	10	152.7	168.5	5.7	0.1	327.1	1962	10	43.2	9.4	6.4	-0.6	55.4
1958	11	136.1	98.5	4.1	0.1	238.7	1962	11	46.6	15.1	3.4	0.0	65.2
1958	12	100.8	75.3	10.6	0.1	186.8	1962	12	56.3	39.8	9.6	0.0	105.7
1959	1	79.6	28.6	1.5	0.2	109.3	1963	1	43.8	13.2	1.0	-0.1	57.5
1959	2	135.3	150.9	12.5	-0.1	298.6	1963	2	62.1	26.2	3.0	-0.2	91.1
1959	3	82.1	24.5	0.1	-0.6	105.5	1963	3	41.5	12.2	0.5	-0.3	53.6
1959	4	218.4	42.0	4.0	-3.8	260.6	1963	4	45.6	12.5	0.2	-3.6	53.2
1959	5	117.3	48.7	3.4	-5.4	164.0	1963	5	33.4	9.4	0.4	-11.9	28.0
1959	6	76.7	36.2	10.5	-7.4	116.0	1963	6	36.5	7.5	5.7	-17.2	18.7
1959	7	81.6	21.0	2.2	-8.0	94.9	1963	7	22.9	7.0	1.4	-14.9	13.5
1959	8	66.9	36.4	25.6	-6.5	122.5	1963	8	17.8	2.9	0.4	-15.0	-1.1
1959	9	46.5	14.5	2.0	-4.8	58.2	1963	9	14.3	8.9	3.8	-8.6	16.1
1959	10	177.7	155.5	23.4	-1.9	354.7	1963	10	15.6	18.1	3.9	-1.3	33.9
1959	11	79.7	26.6	1.2	0.0	107.6	1963	11	56.7	20.5	6.9	-0.2	77.7
1959	12	77.9	27.0	4.9	0.1	109.9	1963	12	34.1	15.1	1.1	-0.2	46.8
1960	1	89.5	24.2	1.3	0.1	114.2	1964	1	33.2	17.0	2.2	0.1	52.5
1960	2	93.0	48.7	6.9	0.1	148.7	1964	2	55.1	47.1	3.2	0.1	105.5
1960	3	76.8	44.4	4.5	0.1	125.7	1964	3	79.7	46.0	1.4	0.0	127.0
1960	4	79.1	20.8	1.4	-0.5	99.5	1964	4	41.4	11.5	0.1	-10.0	42.1
1960	5	152.0	22.5	3.7	-4.8	173.5	1964	5	35.2	9.4	1.9	-15.0	24.8
1960	6	190.5	100.7	18.7	-9.8	300.1	1964	6	43.0	20.3	4.2	-10.7	56.9
1960	7	177.4	37.5	1.3	-11.1	205.1	1964	7	19.8	5.5	1.2	-16.1	6.6
1960	8	144.4	97.6	28.1	-9.2	261.0	1964	8	45.3	40.9	2.5	-8.9	79.7
1960	9	67.0	15.3	2.2	-4.5	80.1	1964	9	73.3	35.3	14.9	-4.4	119.1
1960	10	727.5	432.8	35.8	0.1	1196.1	1964	10	51.9	19.4	2.1	-4.4	68.4
1960	11	485.8	169.7	7.3	0.1	663.0	1964	11	59.1	35.6	0.4	0.0	93.6
1960	12	223.6	160.9	20.4	0.1	405.0	1964	12	32.5	16.2	5.9	0.0	54.7
1961	1	246.0	105.9	7.1	0.1	359.2	1965	1	109.7	38.6	2.7	0.0	151.1
1961	2	271.7	165.6	11.2	0.1	448.5	1965	2	289.3	146.3	2.6	-0.1	438.2
1961	3	153.8	42.1	0.2	0.0	195.1	1965	3	80.5	19.9	0.6	-0.2	99.4
1961	4	102.8	28.3	1.9	-0.8	132.2	1965	4	74.6	27.5	0.7	-8.1	93.0
1961	5	73.2	16.4	1.0	-4.0	85.4	1965	5	293.0	202.8	4.6	-9.4	491.0
1961	6	436.2	117.8	32.8	-4.1	582.7	1965	6	271.8	77.8	3.8	-12.6	340.8
1961	7	187.4	131.1	7.2	-5.6	320.1	1965	7	69.5	14.2	1.3	-13.9	70.6
1961	8	77.4	23.5	4.6	-6.7	94.1	1965	8	43.7	10.6	2.4	-14.1	42.0
1961	9	135.7	95.7	17.3	-0.4	248.3	1965	9	54.0	10.5	6.2	-11.0	47.8
1961	10	65.4	34.1	0.3	0.0	98.3	1965	10	91.6	65.1	11.4	-4.9	163.2
1961	11	150.0	54.5	4.5	0.1	209.1	1965	11	122.0	37.5	5.1	-0.2	164.5
1961	12	62.7	21.1	1.6	0.1	84.4	1965	12	177.3	104.5	5.9	-0.2	287.6

(continued)

APPENDIX C (contined)
1966-1973

year/mo		component flows (Taf) Guad	Santone	bay	ret-divs	total bay (Taf)	year/mo		component flows (Taf) Guad	Santone	bay	ret-divs	total bay (Taf)
1966	1	86.4	56.1	4.5	0.0	147.0	1970	1	119.9	60.1	2.8	-0.8	182.0
1966	2	99.3	70.5	5.0	-0.1	174.7	1970	2	108.5	29.0	2.2	-0.6	139.1
1966	3	98.9	19.8	0.8	-0.2	118.6	1970	3	191.0	80.3	5.5	-2.2	274.5
1966	4	136.2	67.8	8.1	-2.5	209.6	1970	4	120.8	64.1	1.1	-3.8	182.2
1966	5	182.9	181.3	14.3	-2.6	375.9	1970	5	259.6	69.7	7.2	-5.6	289.0
1966	6	81.8	41.8	11.9	-2.6	132.9	1970	6	173.8	221.4	11.0	-9.9	396.2
1966	7	73.2	48.2	1.4	-9.6	113.2	1970	7	83.5	30.3	5.8	-10.2	109.4
1966	8	46.1	27.2	1.3	-7.6	67.1	1970	8	55.6	15.6	1.4	-8.5	64.1
1966	9	57.7	32.6	6.9	-5.4	91.7	1970	9	59.1	15.8	34.8	-4.9	104.7
1966	10	56.0	43.6	2.2	-1.9	99.9	1970	10	71.0	53.3	16.3	-3.8	136.7
1966	11	43.5	30.0	0.7	-0.4	73.8	1970	11	43.8	14.9	0.0	-1.8	57.0
1966	12	39.2	22.9	1.6	-0.2	63.5	1970	12	44.2	13.1	0.6	-1.2	56.7
1967	1	42.0	27.3	4.4	-1.3	72.4	1971	1	41.6	14.6	0.2	-2.1	54.3
1967	2	33.0	27.0	2.3	-1.1	61.2	1971	2	36.3	11.6	1.4	-1.1	46.2
1967	3	32.5	24.6	0.9	-4.0	54.1	1971	3	36.4	11.9	0.0	-5.1	42.9
1967	4	32.0	31.1	0.4	-7.8	55.7	1971	4	29.3	12.3	3.4	-10.2	34.7
1967	5	29.6	28.4	23.9	-9.9	72.0	1971	5	24.5	21.8	9.8	-10.2	45.8
1967	6	16.7	31.2	0.1	-14.4	33.6	1971	6	43.7	13.4	4.1	-14.1	31.5
1967	7	15.3	10.8	12.6	-11.0	25.2	1971	7	20.9	22.0	0.2	-10.5	32.7
1967	8	26.5	31.3	10.4	-9.7	58.6	1971	8	109.5	79.0	8.4	-8.7	177.5
1967	9	925.8	1195.4	86.8	-2.7	2205.2	1971	9	264.9	199.4	34.2	-6.5	492.0
1967	10	216.2	258.4	5.3	-2.0	478.0	1971	10	126.2	241.0	18.6	-3.5	382.2
1967	11	138.0	119.8	2.0	-1.1	258.6	1971	11	90.3	129.1	3.2	-2.0	220.6
1967	12	70.9	114.2	1.1	-0.8	185.5	1971	12	132.3	138.7	26.3	-2.4	294.9
1968	1	455.4	264.9	9.6	-0.7	721.2	1972	1	99.6	46.3	5.1	-2.0	149.0
1968	2	142.1	152.8	3.1	-0.4	297.5	1972	2	94.6	72.3	5.7	-1.3	171.4
1968	3	119.7	62.9	4.2	-1.3	185.5	1972	3	72.3	30.8	0.7	-2.7	101.1
1968	4	175.4	65.6	1.0	-4.9	237.1	1972	4	46.7	39.6	3.5	-7.1	82.6
1968	5	420.9	134.5	8.2	-7.1	556.5	1972	5	844.3	260.4	15.0	-9.2	1065.2
1968	6	415.5	59.7	82.8	-8.7	549.3	1972	6	176.8	119.1	4.7	-12.2	288.5
1968	7	115.1	161.0	7.3	-13.3	270.1	1972	7	128.0	31.8	9.4	-11.0	132.5
1968	8	63.9	40.8	2.0	-9.3	97.4	1972	8	95.8	36.9	7.0	-6.7	133.0
1968	9	130.6	50.8	10.8	-6.2	175.0	1972	9	79.8	30.8	14.4	-10.7	95.4
1968	10	56.6	97.3	2.6	-4.3	152.2	1972	10	67.1	91.2	2.4	-6.3	154.4
1968	11	68.4	39.0	3.3	-2.0	108.6	1972	11	57.7	117.7	6.7	-1.8	180.2
1968	12	129.1	54.7	1.6	-1.9	183.6	1972	12	52.6	24.3	0.4	-1.8	74.9
1969	1	58.8	84.7	1.4	-1.7	143.2	1973	1	75.7	27.2	2.6	-1.5	98.6
1969	2	207.3	62.0	6.0	-0.5	274.8	1973	2	99.4	34.3	2.4	-2.4	130.3
1969	3	193.2	99.4	3.4	-1.0	295.0	1973	3	161.0	32.1	0.5	-3.4	189.4
1969	4	294.7	87.0	16.5	-4.8	393.4	1973	4	353.1	106.6	9.1	-4.1	451.3
1969	5	236.6	110.4	5.6	-8.4	344.2	1973	5	142.9	58.2	0.6	-10.3	191.4
1969	6	114.3	50.6	1.5	-13.8	152.6	1973	6	585.8	253.1	27.0	-9.8	793.6
1969	7	57.6	10.5	0.0	-15.3	49.2	1973	7	273.0	290.4	0.5	-15.5	541.6
1969	8	53.0	14.3	5.6	-9.4	54.6	1973	8	176.0	163.8	11.1	-11.6	339.4
1969	9	73.4	19.9	2.4	-10.3	62.8	1973	9	164.9	142.6	29.0	-5.0	331.6
1969	10	93.1	23.6	10.5	-4.5	113.5	1973	10	770.0	464.6	18.3	-5.3	1247.7
1969	11	80.8	25.4	8.1	-1.7	112.6	1973	11	208.1	177.2	2.0	-2.4	384.9
1969	12	104.0	44.4	8.1	-1.8	154.8	1973	12	136.5	99.7	0.3	-2.8	233.8

(continued)

APPENDIX C (contined)
1974-1981

		component flows (Taf)				total bay			component flows (Taf)				total bay
year/mo		*Guad*	*Santone*	*bay*	*ret-divs*	*(Taf)*	*year/mo*		*Guad*	*Santone*	*bay*	*ret-divs*	*(Taf)*
1974	1	239.0	50.7	3.2	-1.8	284.2	1978	1	63.2	32.3	1.8	-1.9	95.4
1974	2	108.0	98.8	0.0	-2.6	204.2	1978	2	67.9	37.3	8.1	-1.8	111.5
1974	3	96.0	65.0	4.6	-2.8	162.8	1978	3	58.0	32.8	0.2	-3.3	87.8
1974	4	74.0	35.1	0.6	-8.0	101.6	1978	4	60.9	41.7	1.5	-7.0	97.1
1974	5	186.2	57.2	39.2	-10.0	272.6	1978	5	48.7	27.9	0.1	-13.2	63.5
1974	6	111.9	33.5	4.8	-15.0	135.1	1978	6	105.4	64.5	5.3	-12.8	162.4
1974	7	55.5	15.6	0.4	-14.9	54.8	1978	7	40.5	12.5	0.5	-12.2	41.4
1974	8	87.8	64.0	10.6	-12.0	124.7	1978	8	230.8	107.6	0.7	-10.1	329.0
1974	9	252.0	104.5	13.4	-12.0	357.8	1978	9	374.9	128.9	14.1	-8.0	510.0
1974	10	95.7	94.3	5.5	-7.2	188.3	1978	10	96.7	39.4	3.8	-4.2	135.6
1974	11	289.3	64.7	64.6	-2.7	407.3	1978	11	120.6	63.1	3.2	-1.2	185.7
1974	12	182.4	176.5	2.9	-3.8	358.1	1978	12	64.6	35.3	1.8	-2.1	99.6
1975	1	132.6	81.7	2.2	-3.3	213.3	1979	1	334.3	102.9	18.7	-1.8	454.1
1975	2	258.0	116.8	0.9	-4.3	371.5	1979	2	229.5	64.4	8.7	-2.0	300.7
1975	3	139.8	110.2	0.1	-6.8	243.4	1979	3	243.9	81.3	6.7	-2.8	329.0
1975	4	135.9	79.5	0.3	-9.7	206.0	1979	4	327.5	173.0	5.8	-4.6	501.7
1975	5	578.9	154.8	8.2	-10.8	708.5	1979	5	542.2	158.1	15.0	-7.9	707.3
1975	6	413.2	230.0	5.1	-14.6	633.8	1979	6	387.9	173.0	4.1	-15.2	549.7
1975	7	214.7	92.8	3.8	-12.4	298.9	1979	7	176.0	77.2	33.8	-12.2	274.7
1975	8	128.6	37.6	13.9	-9.1	171.1	1979	8	127.2	46.2	4.8	-12.1	166.1
1975	9	91.9	82.9	7.1	-11.2	170.6	1979	9	199.7	76.0	94.6	-7.3	363.0
1975	10	81.4	27.8	4.2	-5.5	97.7	1979	10	60.4	23.3	0.8	-6.2	78.3
1975	11	61.4	59.0	2.0	-2.9	119.4	1979	11	55.7	25.2	1.4	-2.0	80.2
1975	12	103.2	31.8	2.8	-3.8	110.1	1979	12	54.9	30.4	1.2	-1.7	84.9
1976	1	59.5	50.8	0.5	-3.4	107.4	1980	1	91.1	39.7	5.4	-2.2	134.1
1976	2	52.0	20.2	0.1	-3.3	68.3	1980	2	57.8	28.1	0.4	-1.8	84.5
1976	3	59.9	22.7	0.7	-3.1	77.3	1980	3	50.2	20.5	1.2	-6.2	65.7
1976	4	351.0	172.6	8.1	-6.9	524.8	1980	4	44.1	22.9	0.2	-7.8	59.4
1976	5	406.7	165.2	13.3	-7.6	577.7	1980	5	189.1	86.0	5.2	-8.9	271.5
1976	6	203.8	119.0	4.4	-11.0	316.2	1980	6	66.5	21.5	0.1	-16.1	72.0
1976	7	163.8	85.6	29.6	-6.9	272.2	1980	7	38.1	13.3	0.5	-14.9	37.0
1976	8	112.3	35.2	1.5	-8.7	133.9	1980	8	44.9	62.7	7.9	-8.4	107.1
1976	9	127.2	51.5	5.8	-11.4	145.6	1980	9	81.7	65.3	7.5	-12.8	141.7
1976	10	296.1	113.6	10.6	-3.2	397.1	1980	10	64.2	22.2	1.4	-2.7	85.2
1976	11	317.0	255.8	7.6	-1.0	579.4	1980	11	50.8	25.6	0.5	-2.3	74.6
1976	12	457.1	284.8	18.4	-1.6	758.6	1980	12	51.7	25.5	0.4	-2.4	75.3
1977	1	200.5	94.5	5.1	-0.6	299.6	1981	1	56.6	30.5	2.9	-2.6	87.4
1977	2	289.5	89.5	2.1	-0.3	380.7	1981	2	51.6	23.5	0.8	-1.5	74.4
1977	3	146.0	61.7	0.7	-2.6	205.8	1981	3	78.3	26.1	0.3	-1.5	103.1
1977	4	649.0	266.1	9.4	-4.5	919.9	1981	4	100.2	28.1	2.3	-5.8	124.9
1977	5	318.2	165.2	20.9	-8.8	495.6	1981	5	184.3	79.4	33.9	-7.2	290.4
1977	6	291.7	132.7	21.0	-12.8	432.5	1981	6	727.6	326.0	49.4	-9.1	1093.9
1977	7	109.6	42.9	0.3	-12.0	140.8	1981	7	257.5	120.0	14.4	-9.0	382.8
1977	8	76.5	29.1	0.8	-13.0	93.4	1981	8	130.0	49.1	8.1	-9.3	177.9
1977	9	71.0	49.7	7.2	-11.6	116.4	1981	9	697.2	154.1	5.1	-10.2	846.2
1977	10	68.3	34.7	6.3	-4.0	105.3	1981	10	186.8	115.7	14.2	-4.9	311.8
1977	11	109.5	85.9	20.3	-1.9	213.7	1981	11	312.3	106.4	12.0	-1.6	429.1
1977	12	59.6	35.2	0.3	-2.1	93.0	1981	12	109.7	38.1	5.5	-2.5	150.8

(continued)

APPENDIX C (contined)

1982-1989

		component flows (Taf)				*total bay*			*component flows (Taf)*				*total bay*
year/mo		*Guad*	*Santone*	*bay*	*ret-divs*	*(Taf)*	*year/mo*		*Guad*	*Santone*	*bay*	*ret-divs*	*(Taf)*
1982	1	78.5	31.6	0.2	-0.1	110.2	1986	1	112.3	26.5	1.4	-1.5	138.7
1982	2	137.7	62.8	28.5	-0.8	228.3	1986	2	98.3	25.7	0.1	-1.2	123.0
1982	3	69.2	34.3	0.3	-0.5	103.3	1986	3	77.0	17.2	0.0	-3.4	90.8
1982	4	59.6	26.0	1.2	-4.2	82.6	1986	4	58.6	14.7	0.2	-7.3	66.2
1982	5	393.8	72.2	9.2	-4.6	470.5	1986	5	108.7	33.0	6.8	-6.9	141.6
1982	6	81.2	25.2	0.3	-11.4	95.4	1986	6	208.9	176.3	5.3	-6.4	384.1
1982	7	47.9	17.7	0.2	-10.9	54.9	1986	7	74.2	31.6	0.2	-8.5	97.5
1982	8	31.2	18.2	0.8	-7.7	42.4	1986	8	45.9	16.9	1.4	-8.5	55.7
1982	9	28.8	15.2	1.2	-10.9	34.3	1986	9	75.0	33.0	1.0	-6.9	102.0
1982	10	39.4	33.9	0.3	-2.7	70.9	1986	10	175.6	68.5	30.4	-2.5	272.0
1982	11	116.8	41.7	8.7	-0.6	166.6	1986	11	157.7	36.7	16.0	-1.5	209.0
1982	12	42.5	27.2	0.3	-0.2	69.7	1986	12	367.8	135.3	5.9	-1.2	507.8
1983	1	46.0	26.2	3.8	-1.7	74.3	1987	1	286.7	93.8	5.0	-1.6	384.0
1983	2	99.6	31.3	8.3	-1.1	138.1	1987	2	204.4	82.9	12.4	-1.7	298.1
1983	3	153.4	43.1	4.8	-0.7	200.6	1987	3	284.5	98.4	1.2	-1.7	382.4
1983	4	82.5	19.7	0.1	-4.0	98.3	1987	4	128.0	47.0	0.1	-6.7	168.5
1983	5	91.0	26.5	0.1	-6.1	111.4	1987	5	142.2	98.9	1.7	-4.8	237.9
1983	6	77.1	23.1	1.9	-8.4	93.7	1987	6	1535.5	935.1	9.4	-6.3	2473.7
1983	7	138.6	30.4	23.8	-7.0	185.8	1987	7	438.0	113.5	10.6	-9.6	552.5
1983	8	43.3	21.9	1.2	-4.4	62.0	1987	8	283.9	52.3	3.4	-6.2	333.3
1983	9	54.8	50.7	7.4	-7.1	105.7	1987	9	152.5	43.9	2.8	-10.4	188.8
1983	10	82.0	28.7	4.7	-4.8	110.6	1987	10	108.8	32.1	3.4	-8.4	136.0
1983	11	69.3	29.7	5.4	-1.0	103.3	1987	11	103.3	39.9	3.4	-2.4	144.2
1983	12	33.7	18.2	0.2	-0.9	51.2	1987	12	77.0	39.0	0.2	-2.7	113.5
1984	1	55.8	26.1	7.0	-1.5	87.4	1988	1	59.2	35.0	0.1	-3.1	91.2
1984	2	39.8	19.6	0.2	-1.5	58.1	1988	2	51.3	29.0	0.0	-2.6	77.7
1984	3	62.9	24.7	2.2	-1.4	88.4	1988	3	65.3	32.1	0.0	-3.5	93.9
1984	4	27.6	15.2	0.0	-5.4	37.4	1988	4	47.7	25.8	0.2	-8.9	64.8
1984	5	28.2	16.8	1.7	-8.2	38.4	1988	5	50.0	21.4	0.0	-11.4	60.0
1984	6	18.9	12.1	0.1	-11.3	19.8	1988	6	60.6	24.0	1.9	-14.5	72.0
1984	7	7.9	10.3	0.5	-9.7	9.0	1988	7	60.0	25.2	1.9	-13.5	73.7
1984	8	11.0	11.6	2.7	-5.6	19.7	1988	8	66.8	15.7	0.3	-9.4	73.3
1984	9	8.4	8.7	1.0	-7.4	10.7	1988	9	36.3	18.6	2.1	-9.5	47.5
1984	10	53.3	66.5	15.0	-3.9	130.9	1988	10	34.4	15.4	0.8	-12.0	38.7
1984	11	44.9	36.5	4.3	-1.0	84.7	1988	11	29.3	15.5	0.0	-4.5	40.3
1984	12	56.3	26.8	0.4	-1.8	81.7	1988	12	36.9	18.3	0.1	-4.2	51.0
1985	1	136.1	42.3	4.2	-0.7	181.9	1989	1	48.0	25.5	6.0	-3.5	76.0
1985	2	89.5	24.5	1.7	-1.1	114.6	1989	2	42.9	21.0	0.1	-2.7	61.3
1985	3	182.8	53.4	15.5	-0.8	251.0	1989	3	47.5	20.3	0.0	-4.1	63.6
1985	4	230.7	58.5	13.3	-1.3	301.1	1989	4	46.3	24.8	0.1	-7.5	63.8
1985	5	103.8	27.4	0.5	-5.7	126.0	1989	5	93.0	22.3	0.1	-10.1	105.4
1985	6	181.8	56.4	1.0	-7.4	231.7	1989	6	47.4	25.4	17.5	-11.1	79.3
1985	7	165.9	66.2	2.4	-10.0	224.6	1989	7	19.9	9.9	11.0	-9.4	31.4
1985	8	65.8	15.7	0.4	-8.4	73.5	1989	8	11.7	14.7	2.2	-8.4	20.2
1985	9	45.8	29.3	1.5	-4.0	72.6	1989	9	11.1	8.7	0.3	-10.7	9.4
1985	10	104.7	62.3	1.9	-2.6	166.3	1989	10	25.3	14.2	1.0	-9.1	31.4
1985	11	211.5	79.4	1.2	-1.5	290.5	1989	11	24.5	25.8	10.1	-3.4	57.0
1985	12	203.3	35.4	2.1	-1.2	239.6	1989	12	28.3	19.6	0.5	-2.2	46.2

(continued)

APPENDIX C (contined)
1990-1997

		component flows (Taf)				total bay			component flows (Taf)				total bay
year/mo		*Guad*	*Santone*	*bay*	*ret-divs*	*(Taf)*	*year/mo*		*Guad*	*Santone*	*bay*	*ret-divs*	*(Taf)*
1990	1	26.5	14.9	0.2	-2.3	39.3	1994	1	53.8	28.0	3.2	-0.5	84.4
1990	2	25.6	20.9	6.7	-1.2	51.9	1994	2	46.8	26.4	0.3	-0.7	72.8
1990	3	43.6	33.3	10.5	-1.4	86.0	1994	3	82.9	57.2	4.2	-0.7	143.5
1990	4	71.9	47.7	3.9	-1.1	122.3	1994	4	57.6	37.6	0.7	-3.8	92.1
1990	5	85.9	32.1	4.7	-5.3	117.5	1994	5	286.6	142.4	2.4	-5.6	425.7
1990	6	44.8	8.4	0.2	-9.6	43.8	1994	6	110.8	34.7	3.7	-8.4	140.8
1990	7	148.5	182.7	41.4	-6.8	365.8	1994	7	44.8	16.7	0.2	-10.5	51.2
1990	8	52.1	24.7	0.9	-8.8	68.9	1994	8	39.4	16.8	0.8	-4.1	52.8
1990	9	61.0	27.8	1.5	-4.3	86.0	1994	9	54.4	28.6	7.0	-6.6	83.4
1990	10	34.6	20.7	0.1	-5.5	50.0	1994	10	355.3	113.5	12.2	-4.6	476.5
1990	11	40.1	22.2	0.4	-3.4	59.4	1994	11	70.7	27.2	0.2	-1.5	96.7
1990	12	35.2	17.2	0.2	-1.3	51.4	1994	12	124.4	32.8	5.5	-1.9	160.8
1991	1	196.7	47.8	2.6	0.0	247.1	1995	1	132.8	31.1	0.5	-0.8	163.6
1991	2	164.6	59.7	1.1	-0.3	225.2	1995	2	62.0	22.4	0.8	-1.2	84.1
1991	3	96.3	27.4	4.8	-0.3	128.2	1995	3	169.3	41.4	8.2	-0.6	218.3
1991	4	400.6	126.7	17.5	-0.6	544.1	1995	4	126.6	33.7	2.6	-1.5	161.4
1991	5	162.5	51.1	2.6	-3.5	212.7	1995	5	66.2	27.7	6.5	-5.2	95.2
1991	6	103.2	36.5	22.8	-5.9	156.6	1995	6	196.8	47.8	8.6	-7.1	246.2
1991	7	100.2	31.4	1.1	-8.3	124.4	1995	7	78.0	46.5	1.9	-8.4	118.0
1991	8	44.1	17.9	5.2	-6.2	61.1	1995	8	67.6	19.1	1.0	-5.5	82.2
1991	9	68.2	23.4	19.2	-4.0	106.9	1995	9	56.1	28.3	0.3	-4.9	79.8
1991	10	60.7	19.0	22.1	-3.4	98.5	1995	10	41.2	17.4	18.2	-3.6	73.2
1991	11	55.4	21.0	13.4	-0.1	89.7	1995	11	45.3	16.2	6.2	-0.7	67.0
1991	12	650.2	310.9	15.2	-0.3	975.9	1995	12	52.0	21.7	3.7	-0.6	76.8
1992	1	693.2	181.3	15.1	0.2	889.9	1996	1	39.7	17.8	0.1	-1.2	56.5
1992	2	1154.4	466.1	32.4	1.5	1654.5	1996	2	34.3	14.3	0.0	-0.9	47.7
1992	3	657.1	280.3	15.4	-0.2	952.5	1996	3	32.8	15.4	0.0	-2.5	45.8
1992	4	753.5	310.9	13.6	2.1	1080.1	1996	4	28.4	12.2	0.9	-5.7	35.9
1992	5	655.3	394.0	23.4	-2.3	1070.4	1996	5	23.7	11.3	0.0	-9.9	25.1
1992	6	546.8	353.4	9.7	-3.9	906.0	1996	6	36.6	14.9	1.0	-10.6	41.8
1992	7	208.3	94.8	4.7	-8.4	299.5	1996	7	10.6	9.9	0.0	-8.5	12.0
1992	8	133.0	58.9	6.3	-6.8	191.4	1996	8	28.1	14.3	2.3	-3.1	41.6
1992	9	102.6	43.6	3.0	-3.2	146.0	1996	9	141.1	45.6	6.5	-3.3	189.9
1992	10	85.2	33.7	0.7	-2.6	117.0	1996	10	26.4	11.7	0.3	-2.0	36.4
1992	11	113.4	75.7	12.5	0.1	201.7	1996	11	27.1	14.4	0.8	-1.1	41.2
1992	12	103.7	54.7	1.4	0.3	160.1	1996	12	37.7	18.1	0.5	-0.5	55.8
1993	1	123.2	50.3	2.5	-0.2	175.8	1997	1	61.9	16.0	1.6	-0.3	79.3
1993	2	150.3	59.3	48.5	-0.2	257.9	1997	2	52.5	16.9	0.3	-0.6	69.1
1993	3	212.6	66.0	27.4	-0.3	305.7	1997	3	190.3	30.6	40.0	0.3	261.2
1993	4	111.1	41.3	3.3	-1.3	154.4	1997	4	506.1	82.9	6.3	0.1	595.4
1993	5	484.0	220.7	19.1	-2.0	721.8	1997	5	240.2	62.1	18.6	-1.8	319.2
1993	6	581.3	201.7	15.6	-4.1	794.5	1997	6	668.4	222.6	0.6	-4.7	887.0
1993	7	121.2	73.2	0.3	-9.1	185.6	1997	7	388.0	88.1	0.2	-7.2	469.0
1993	8	57.2	26.1	0.1	-6.5	76.9	1997	8	167.7	19.9	1.1	-4.8	183.9
1993	9	46.3	21.4	0.2	-3.7	64.3	1997	9	112.8	31.5	33.5	-3.8	173.9
1993	10	71.2	29.5	3.8	-2.5	102.1	1997	10	223.5	56.0	52.5	-0.7	331.2
1993	11	56.0	28.6	0.5	-1.2	83.9	1997	11	68.7	25.2	3.9	-0.9	96.8
1993	12	62.2	25.4	8.6	-0.2	96.0	1997	12	78.2	31.4	0.5	-0.7	109.4

(continued)

APPENDIX C (contined)

1998-2005

year/mo		component flows (Taf) Guad	Santone	bay	ret-divs	total bay (Taf)	year/mo		component flows (Taf) Guad	Santone	bay	ret-divs	total bay (Taf)
1998	1	93.3	33.7	0.3	-1.5	125.8	2002	1	126.3	44.5	2.7	-1.0	172.6
1998	2	201.8	67.3	3.1	-0.1	272.2	2002	2	85.0	29.8	0.2	-0.9	114.1
1998	3	232.6	67.2	2.3	-1.0	301.0	2002	3	76.8	29.6	0.1	-2.6	103.9
1998	4	121.7	30.9	0.2	-5.0	147.9	2002	4	160.3	59.8	1.0	-3.8	217.3
1998	5	61.7	15.0	0.0	-9.3	67.5	2002	5	55.2	23.6	0.8	-6.2	73.4
1998	6	44.5	10.0	0.0	-11.6	42.9	2002	6	47.9	16.9	3.8	-7.4	61.2
1998	7	36.5	10.1	0.3	-8.6	38.3	2002	7	1102.6	957.1	13.8	-2.7	2070.8
1998	8	80.7	46.5	6.7	-4.6	129.3	2002	8	292.2	85.9	6.0	-6.7	377.3
1998	9	239.0	56.6	16.3	-1.2	310.7	2002	9	375.8	220.8	27.0	-4.2	619.4
1998	10	1952.5	494.7	29.2	-1.1	2475.3	2002	10	434.7	318.3	47.3	-1.0	799.3
1998	11	620.9	144.9	26.0	0.3	792.2	2002	11	653.4	254.1	51.2	0.6	959.3
1998	12	294.8	66.3	0.8	-0.7	361.2	2002	12	375.4	138.2	8.0	-0.2	521.4
1999	1	137.4	50.0	1.7	-0.7	188.3	2003	1	248.4	90.7	6.7	-0.5	345.3
1999	2	89.3	33.2	2.0	-1.3	123.2	2003	2	275.5	87.2	3.6	-0.4	365.9
1999	3	95.1	45.0	0.1	-2.2	138.1	2003	3	219.9	77.5	6.6	-1.1	302.9
1999	4	78.9	43.9	0.9	-4.5	119.2	2003	4	113.2	49.2	0.2	-2.1	160.5
1999	5	99.3	39.4	0.2	-7.2	131.7	2003	5	94.1	32.6	0.1	-5.5	121.3
1999	6	151.2	61.1	0.3	-7.5	205.0	2003	6	86.0	40.4	7.2	-5.6	127.9
1999	7	77.2	31.6	2.2	-6.7	104.3	2003	7	99.8	67.9	36.0	-4.6	199.1
1999	8	44.8	16.1	0.1	-5.6	55.4	2003	8	68.0	28.8	2.4	-3.7	95.4
1999	9	32.7	14.2	0.1	-7.2	39.8	2003	9	119.5	107.2	34.4	-3.1	258.1
1999	10	32.1	14.6	0.3	-3.4	43.6	2003	10	98.8	51.2	5.9	-2.0	153.9
1999	11	33.6	16.6	0.0	-4.3	45.9	2003	11	101.2	37.7	0.9	-1.3	138.5
1999	12	35.0	17.6	0.0	-2.5	50.2	2003	12	70.0	34.4	0.4	-1.8	103.0
2000	1	47.6	29.1	3.5	-2.5	77.6	2004	1	99.8	38.2	3.3	-1.4	140.0
2000	2	38.1	22.7	0.1	-1.6	59.3	2004	2	86.2	37.6	0.5	-0.4	123.8
2000	3	51.6	22.8	6.4	-2.5	78.3	2004	3	97.6	44.4	0.3	-1.3	141.0
2000	4	43.4	26.3	1.7	-2.8	68.6	2004	4	241.1	153.6	3.0	-0.6	397.1
2000	5	89.5	53.3	54.9	-4.5	193.1	2004	5	374.3	171.5	51.2	-1.5	595.5
2000	6	105.6	54.5	32.4	-5.5	187.0	2004	6	492.7	184.5	22.6	-3.8	696.0
2000	7	27.1	12.6	0.3	-5.8	34.3	2004	7	351.8	165.1	3.9	-6.4	514.4
2000	8	19.8	8.6	3.4	-4.1	27.7	2004	8	117.1	60.4	0.5	-5.7	172.4
2000	9	16.4	12.6	0.9	-4.6	25.3	2004	9	95.4	49.4	0.5	-1.9	143.4
2000	10	31.2	45.6	0.6	-3.0	74.4	2004	10	234.7	87.9	21.2	-1.2	342.6
2000	11	322.8	165.0	3.6	-1.3	490.0	2004	11	1218.4	362.9	16.9	0.8	1598.9
2000	12	150.2	42.0	2.5	-1.0	193.8	2004	12	461.4	118.7	0.7	-0.7	580.0
2001	1	174.5	54.8	8.9	-1.1	237.1	2005	1	208.2	82.6	0.6	-2.6	288.8
2001	2	126.1	35.6	0.2	-1.5	160.5	2005	2	299.4	89.4	1.5	-1.1	389.2
2001	3	209.9	46.9	0.5	-2.3	255.1	2005	3	414.4	133.2	5.1	0.0	552.7
2001	4	111.0	53.0	0.1	-3.7	160.3	2005	4	135.0	54.3	0.4	-2.2	187.5
2001	5	139.2	67.9	1.2	-3.6	204.7	2005	5	188.3	58.4	3.4	-2.3	247.8
2001	6	62.7	27.0	0.4	-8.5	81.6	2005	6	102.0	46.5	1.7	-4.6	145.6
2001	7	49.9	12.4	0.8	-4.8	58.2	2005	7	80.7	32.3	4.3	-6.5	110.9
2001	8	82.4	53.5	8.0	-5.3	138.7	2005	8	67.8	26.0	0.3	-8.1	85.9
2001	9	538.6	396.5	6.9	-3.0	939.0	2005	9	59.2	29.6	1.8	-5.2	85.4
2001	10	117.3	52.1	6.7	-2.0	174.0	2005	10	63.8	25.5	9.4	-1.9	96.9
2001	11	248.1	120.5	17.2	-0.2	385.6	2005	11	46.4	19.6	7.3	-2.4	70.9
2001	12	357.0	95.6	2.0	-0.5	454.1	2005	12	48.1	25.9	1.8	-1.2	74.6

(continued)

APPENDIX C (contined)
2006-2009

year/mo		*component flows (Taf)* *Guad*	*Santone*	*bay*	*ret-divs*	*total bay (Taf)*	*year/mo*		*component flows (Taf)* *Guad*	*Santone*	*bay*	*ret-divs*	*total bay (Taf)*
2006	1	47.6	24.4	0.2	-1.3	71.0	2008	1	71.0	43.9	8.5	-1.1	122.2
2006	2	42.7	15.2	0.1	-1.7	56.3	2008	2	60.3	35.5	2.7	-1.0	97.5
2006	3	46.3	23.1	0.3	-1.9	67.8	2008	3	69.5	34.4	1.9	-0.4	105.4
2006	4	39.1	15.6	0.0	-4.4	50.4	2008	4	57.1	34.6	1.6	-2.7	90.6
2006	5	88.9	30.4	13.6	-5.6	127.4	2008	5	44.0	22.8	0.1	-6.4	60.5
2006	6	82.2	31.2	12.9	-4.4	121.8	2008	6	35.2	12.9	0.0	-8.7	39.4
2006	7	56.7	17.9	39.4	-5.1	108.9	2008	7	37.0	23.0	0.4	-7.7	52.7
2006	8	19.9	8.7	3.5	-2.0	30.0	2008	8	39.6	37.7	9.1	-4.0	82.3
2006	9	42.4	47.6	25.6	-2.0	113.5	2008	9	32.7	21.1	0.3	-3.4	50.6
2006	10	56.7	29.4	10.0	-1.1	95.0	2008	10	28.2	17.5	2.2	-4.5	43.4
2006	11	24.9	17.7	1.6	-1.4	42.8	2008	11	25.8	15.3	2.4	-1.8	41.8
2006	12	32.4	23.3	2.0	-1.8	55.9	2008	12	28.9	15.9	0.0	-2.1	42.7
2007	1	125.9	61.5	32.2	0.1	219.7	2009	1	29.3	18.2	0.0	-1.7	45.7
2007	2	48.0	19.4	0.4	-0.7	67.1	2009	2	25.0	14.5	0.0	-2.5	37.1
2007	3	343.6	169.2	5.9	0.0	518.7	2009	3	30.5	19.1	0.5	-2.4	47.8
2007	4	269.6	119.9	10.0	0.4	399.8	2009	4	111.1	21.9	0.6	-2.4	131.3
2007	5	327.3	108.2	5.3	-2.4	438.4	2009	5	33.6	27.6	9.8	-5.4	65.6
2007	6	235.9	69.0	5.6	-4.3	306.2	2009	6	16.9	12.5	0.2	-7.4	22.2
2007	7	936.7	480.4	92.5	0.3	1509.9	2009	7	10.7	7.5	0.0	-8.0	10.2
2007	8	477.5	367.1	16.3	-1.8	859.2	2009	8	9.3	7.6	0.3	-9.9	7.3
2007	9	315.4	147.0	5.6	-0.6	467.5	2009	9	22.8	31.1	4.0	-3.8	54.1
2007	10	120.2	79.6	2.2	-1.1	201.0	2009	10	235.4	132.8	2.9	-0.3	370.7
2007	11	108.8	51.9	4.1	-2.0	162.8	2009	11	246.0	89.6	14.5	0.5	350.6
2007	12	77.1	44.3	0.7	-1.0	121.1	2009	12	124.9	43.3	8.8	-1.6	175.4

Key:

Guad - Inflow from Guadalupe basin

Santone - Inflow from San Antonio basin

bay - Inflow from peripheral drainage around San Antonio Bay

ret – divs - Return flows net of diversions, total above salt barrier and directly into bay

total bay - Total inflows into San Antonio Bay

All units: thousands of acre feet per month

Note - Prior to 1977, the component flows were estimated from rainfall, using the methods of Appendix A, and will not total exactly to the "total bay" value. See Section 2.1.

APPENDIX D

Points (Taf/mo) on 1942-2009 cumulative frequency distribution by frequency of occurrence

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	annual
max	889.9	1654.5	952.5	1080.1	1070.4	2473.7	2070.8	859.2	2205.2	2475.3	1598.9	975.9	2475.3
0.99	776.9	1141.3	684.6	972.8	1066.9	1549.2	1695.0	536.3	1356.9	1652.8	1170.4	830.3	1180.8
0.98	638.8	738.9	541.1	831.3	958.4	1030.0	1315.1	364.4	907.4	1230.1	902.5	697.9	938.4
0.95	429.6	421.0	363.7	582.8	717.2	854.6	548.7	331.8	621.4	823.5	633.7	516.7	620.2
0.90	313.3	367.5	303.7	508.7	583.0	652.4	408.7	201.8	504.3	476.9	433.6	374.4	449.9
0.85	278.1	298.0	288.5	399.7	490.2	549.6	299.4	177.9	379.3	380.0	383.2	285.2	343.8
0.83	246.8	293.7	272.3	396.5	474.4	529.9	294.9	177.1	362.1	368.1	341.7	238.6	312.5
0.80	241.9	266.5	255.8	284.9	433.3	391.4	271.3	171.8	323.2	338.0	277.8	198.2	288.5
0.75	194.6	226.0	244.9	211.5	352.1	308.7	200.6	142.8	250.8	313.5	215.5	184.0	226.6
0.70	175.4	171.3	205.3	186.9	290.3	284.3	140.0	128.8	189.8	186.9	200.1	160.7	187.9
0.65	150.1	149.2	187.7	165.3	263.7	210.5	118.1	112.2	174.5	159.2	165.6	147.0	166.3
0.60	144.0	131.9	147.4	155.5	239.9	181.4	109.7	95.8	145.7	139.8	145.2	121.9	143.2
0.55	132.8	123.1	135.2	138.9	203.0	156.0	103.6	85.4	118.7	130.4	112.0	109.8	126.2
0.50	116.3	114.3	122.7	123.6	179.6	146.3	94.5	80.8	106.3	115.2	103.3	103.9	112.1
0.45	107.7	100.3	105.4	102.9	133.2	133.2	73.9	73.4	97.8	102.6	96.7	93.5	100.9
0.40	94.6	89.8	102.7	96.5	126.8	123.3	57.6	63.7	87.1	98.4	84.6	84.1	92.9
0.35	85.7	80.8	92.2	91.3	118.9	94.5	51.9	57.8	81.6	95.9	77.2	76.0	81.8
0.30	77.6	73.1	87.8	82.9	105.6	82.3	46.4	54.7	72.7	74.8	73.9	70.2	72.7
0.25	73.8	68.9	78.0	68.0	82.4	72.0	38.0	48.8	60.6	65.6	66.5	61.8	63.4
0.20	67.0	62.9	64.9	61.1	66.3	49.1	33.3	34.6	51.2	50.0	58.0	55.5	54.3
0.17	56.6	59.7	57.2	54.3	63.8	42.7	26.2	27.8	47.8	46.0	51.8	51.9	47.8
0.15	54.4	58.1	54.2	53.2	63.1	41.9	20.7	25.7	47.5	43.7	46.1	51.2	45.8
0.10	45.2	47.2	47.2	40.4	56.2	29.5	9.8	20.0	33.8	40.5	40.9	46.6	35.5
0.05	30.1	34.9	37.2	31.5	36.1	19.1	5.3	2.7	14.1	32.2	29.2	35.3	22.1
0.02	22.3	32.8	29.6	20.1	26.1	3.7	1.1	-1.0	9.9	25.7	18.9	23.5	9.6
0.01	18.4	29.1	25.1	15.2	25.0	2.0	-2.6	-3.0	6.4	22.1	15.9	19.9	3.2
min	14.4	21.8	16.6	14.5	24.8	-0.1	-6.6	-6.8	0.2	16.0	12.3	19.3	-6.8
means	163.6	180.4	169.3	200.4	258.7	270.4	190.4	113.2	219.0	240.9	199.9	165.2	197.6

ADDENDUM
18 February 2011

In its determinations of inflow requirements to San Antonio Bay, the Guadalupe/San Antonio Basin & Bay Expert Science Team (BBEST) focused on total flows during the 3-month periods: January – March, April – June, July – September, and October – December. During discussions in the 17 February 2011 BBEST meeting about the reconciliation of the instream requirements with the inflow requirements for the bay, it was observed that the instream recommendations would be formulated for gauge stations on the two rivers, while for the estuary *total* inflows to the bay are being determined. The question arose as to how much of the total inflow to the bay will be accounted for by the gauged flows in the rivers. This was addressed in the present report, which was available to the BBEST, by month, year and period of record.

It was useful to the BBEST to have similar determinations for the above trimonthly seasons. This addendum supplied these data, as well as related component partitions of inflows. For each seasonal flow, three tables are presented, corresponding to Tables 3-6 of Section 3.2, though organized in a somewhat more convenient form for the purposes of the BBEST. It should be noted that the units for all flow data presented below are the *3-month totals* in thousands of acre-feet. (These are therefore not directly comparable to monthly or annual flows in Tafs.) These may be converted to cubic feet per second by multiplying by the following:

Jan – Mar	5.60185
except leap year	5.54029
Apr – Jun	5.54029
Jul – Sep	5.48007
Oct – Dec	5.48007

Table 1
January - March seasonal flows into San Antonio Bay in thousands of acre feet (Taf)

year	gauged flows Guadalupe 8176500	gauged flows Coleto Cr 8177500	gauged flows San Antonio 8188500	ungauged flows Guad TWDB	ungauged flows San Ant TxRR	returns - diversions u/s of salt barrier	flow at salt barrier	ungauged from bay periphery	total flow into bay
1942	146.6	5.4	49.2	13.1	58.9	0.4	272.6	0.2	287.0
1943	217.9	6.1	81.0	15.6	46.1	0.4	367.1	7.6	380.9
1944	359.3	19.0	78.1	36.6	156.7	0.4	650.1	16.8	674.1
1945	549.6	3.4	125.0	7.9	5.9	0.4	690.4	1.2	696.0
1946	370.0	5.1	73.9	18.5	50.9	0.4	510.4	5.9	525.9
1947	472.5	8.6	111.5	10.9	0.0	-1.4	592.8	3.2	598.0
1948	135.8	3.1	49.0	17.1	48.7	-1.7	252.1	6.5	266.1
1949	182.0	1.2	44.3	18.7	0.1	-0.6	232.3	2.2	242.0
1950	135.0	1.8	43.1	3.4	5.9	-1.4	186.9	1.5	193.3
1951	74.0	0.4	29.4	11.0	0.0	-4.6	99.2	1.3	106.5
1952	64.3	1.3	31.5	11.6	1.0	-5.7	97.4	0.5	102.1
1953	187.9	1.6	36.3	6.2	2.8	-6.4	227.4	0.6	231.8
1954	89.2	0.6	23.0	2.7	0.0	-6.7	106.1	1.8	108.1
1955	88.9	3.8	38.2	10.1	1.2	-1.5	137.1	2.4	140.9
1956	36.4	0.1	17.7	4.8	0.0	-1.6	52.5	1.8	58.7
1957	101.7	5.9	46.3	38.1	109.4	-2.8	289.6	0.5	303.5
1958	971.5	83.4	300.3	28.8	249.2	0.1	1633.3	13.3	1656.5
1959	267.4	12.4	81.7	17.1	122.2	-0.5	499.2	1.5	513.4
1960	248.8	1.7	70.4	8.8	46.9	0.3	376.0	1.3	388.6
1961	644.6	15.4	170.9	11.5	142.7	0.3	984.4	7.1	1002.8
1962	153.8	2.2	53.5	2.8	0.0	0.1	209.6	0.7	211.3
1963	141.6	2.1	46.8	3.8	4.8	-0.5	197.8	1.0	202.2
1964	147.8	5.7	71.4	14.5	38.6	0.2	278.2	2.2	285.1
1965	439.4	27.5	153.5	12.6	51.3	-0.3	682.6	2.7	688.7
1966	266.3	2.9	57.7	15.3	88.7	-0.4	429.9	4.5	440.4
1967	98.2	0.5	32.4	8.7	46.5	-6.3	180.1	4.4	187.7
1968	688.4	13.7	363.1	15.2	117.6	-2.5	1187.3	9.6	1204.3
1969	425.5	9.8	112.6	24.0	133.5	-3.2	702.3	1.4	712.9
1970	387.0	10.2	97.1	22.1	72.3	-3.6	585.2	2.8	595.6
1971	111.1	0.8	38.1	2.4	0.0	-8.3	141.7	0.2	143.4
1972	244.9	13.6	80.7	8.0	68.8	-6.0	410.0	5.1	421.4
1973	315.8	6.7	93.5	13.7	0.0	-7.3	412.8	2.6	418.3
1974	419.3	12.7	124.4	10.9	90.2	-7.2	643.5	3.2	651.2
1975	523.5	3.8	218.0	3.2	90.7	-14.4	824.8	2.2	828.1
1976	163.9	2.6	68.8	4.9	24.9	-9.8	251.7	0.5	253.0
1977	586.1	24.0	236.7	25.9	9.1	-3.6	878.2	5.1	886.1
1978	169.3	4.4	97.3	15.4	5.1	-6.9	284.6	1.8	294.7
1979	745.7	36.1	235.0	26.0	13.6	-6.6	1049.7	18.7	1083.7
1980	168.5	12.6	82.8	18.0	5.5	-10.2	277.3	5.4	284.2
1981	180.5	1.0	75.4	5.0	4.7	-5.6	261.0	2.9	264.9
1982	234.8	29.6	110.2	20.9	18.5	-1.3	412.7	0.2	441.8
1983	260.5	18.1	91.6	20.5	8.8	-3.5	396.1	3.8	413.0
1984	131.3	18.3	67.2	8.8	3.2	-4.4	224.4	7.0	233.8
1985	354.6	21.0	114.7	33.0	5.5	-2.7	526.0	4.2	547.4

(continued)

Table 1 (continued)
January – March flows (Taf) into San Antonio Bay

year	gauged flows Guadalupe 8176500	gauged flows Coleto Cr 8177500	gauged flows San Antonio 8188500	ungauged flows Guad TWDB	ungauged flows San Ant TxRR	returns - diversions u/s of salt barrier	flow at salt barrier	ungauged from bay periphery	total flow into bay
1986	285.2	0.9	67.8	1.5	1.6	-6.1	351.0	1.4	352.5
1987	732.9	25.0	269.5	17.7	5.6	-5.0	1045.8	5.0	1064.5
1988	174.1	1.1	96.0	0.7	0.1	-9.3	262.7	0.1	262.8
1989	133.2	0.5	64.0	4.6	2.7	-10.4	194.8	6.0	200.9
1990	89.8	0.5	64.3	5.3	4.8	-7.9	156.8	0.2	177.1
1991	413.1	0.6	127.8	43.9	7.2	-4.1	588.4	2.6	600.5
1992	2298.8	78.6	887.5	127.4	40.1	-2.7	3429.8	15.1	3497.0
1993	449.5	17.8	150.3	18.8	25.3	-4.0	657.8	2.5	739.4
1994	161.5	3.2	107.0	18.8	4.5	-4.8	290.1	3.2	300.7
1995	344.7	9.5	91.9	9.8	3.0	-5.4	453.6	0.5	466.0
1996	105.6	0.4	47.4	0.8	0.2	-7.6	146.7	0.1	149.9
1997	260.7	34.0	55.8	10.0	7.8	-4.0	364.2	1.6	409.7
1998	495.0	21.6	157.5	11.1	10.7	-5.4	690.5	0.3	699.0
1999	316.0	3.2	119.6	2.5	8.6	-6.5	443.5	1.7	449.6
2000	122.5	1.3	66.2	13.5	8.3	-8.9	203.0	3.5	215.2
2001	497.3	6.7	135.1	6.6	2.2	-7.7	640.2	8.9	652.6
2002	286.3	1.0	103.0	0.9	0.9	-7.6	384.5	2.7	390.6
2003	728.6	10.1	252.0	5.1	3.3	-5.0	994.2	6.7	1014.0
2004	256.8	15.9	117.8	10.9	2.5	-5.5	398.4	3.3	404.9
2005	825.7	56.6	290.3	39.8	14.8	-6.3	1220.9	0.6	1230.7
2006	134.6	1.0	62.7	1.0	0.0	-6.8	192.6	0.2	195.1
2007	451.1	36.8	229.6	29.5	20.5	-3.5	764.0	32.2	805.5
2008	189.3	1.1	111.0	10.4	2.9	-4.3	310.3	8.5	325.1
2009	83.5	0.5	50.7	0.8	1.0	-7.8	128.8	0.0	130.6
average	331.4	11.6	116.9	15.0	31.3	-4.3	500.2	4.1	513.3

Table 2
Time trends (least-squares regression) in January - March flows, 1942-2009

	Trend line			*Trend projection*			
	slope (Taf/yr)	*± 0.95 conf bnds (Taf/yr)*	*(Taf/yr)*	*1942 (Taf)*	*2009 (Taf)*	*increase (Taf)*	*(%)*
Gauged flows							
Guadalupe at Victoria	2.6	-1.9	7.2	243	420	177	73
Coleto Creek	0.1	-0.1	0.4	7	16	9	137
San Antonio at Goliad	1.6	-0.1	3.2	65	169	104	161
Ungauged flows							
Guadalupe	0.0	-0.2	0.3	14	16	2	15
San Antonio	-0.9	-1.5	-0.3	61	1	-60	-98
Rets - divs u/s of salt barrier	-0.1	-0.1	-0.1	-1	-7	-6	554
Flow at salt barrier	3.5	-3.3	10.2	384	616	232	60
Bay peripheral drainage	0.0	0.0	0.1	3	5	2	52
Total flow into bay	3.6	-3.3	10.5	393	634	241	61

Table 3

Proportions (%) of contributions to January - March inflows to San Antonio Bay by data source and by physical source

	gauged			ungauged		rets-divs	Guadalupe		San Antonio		bay
	Guadalupe	Coleto Cr	San Antonio	u/s barrier	d/s barrier	u/s barrier	Victoria	d/s Victoria	Goliad	d/s Goliad	periphery
1942	51.1	1.9	17.1	24.8	0.1	0.13	51.1	6.4	17.1	20.5	0.1
1943	57.2	1.6	21.3	16.2	2.0	0.10	57.2	5.7	21.3	12.1	2.0
1944	53.3	2.8	11.6	28.7	2.5	0.06	53.3	8.3	11.6	23.2	2.5
1945	79.0	0.5	18.0	1.7	0.2	0.06	79.0	1.6	18.0	0.8	0.2
1946	70.4	1.0	14.0	11.6	1.1	0.08	70.4	4.5	14.0	9.7	1.1
1947	79.0	1.4	18.6	0.3	0.5	-0.23	79.0	3.3	18.6	0.0	0.5
1948	51.0	1.2	18.4	24.8	2.5	-0.64	51.0	7.6	18.4	18.3	2.5
1949	75.2	0.5	18.3	2.2	0.9	-0.24	75.2	8.2	18.3	0.0	0.9
1950	69.8	0.9	22.3	4.3	0.8	-0.72	69.8	2.7	22.3	3.0	0.8
1951	69.5	0.4	27.6	0.0	1.2	-4.37	69.5	10.7	27.6	0.0	1.2
1952	63.0	1.3	30.9	5.9	0.5	-5.63	63.0	12.7	30.9	1.0	0.5
1953	81.1	0.7	15.7	3.5	0.3	-2.74	81.1	3.3	15.7	1.2	0.3
1954	82.5	0.6	21.3	0.0	1.7	-6.22	82.5	3.1	21.3	0.0	1.7
1955	63.1	2.7	27.1	5.5	1.7	-1.10	63.1	9.9	27.1	0.8	1.7
1956	61.9	0.2	30.1	0.0	3.1	-2.77	61.9	8.3	30.1	0.0	3.1
1957	33.5	1.9	15.2	45.6	0.2	-0.92	33.5	14.5	15.2	36.1	0.2
1958	58.6	5.0	18.1	16.8	0.8	0.01	58.6	6.8	18.1	15.0	0.8
1959	52.1	2.4	15.9	26.9	0.3	-0.10	52.1	5.7	15.9	23.8	0.3
1960	64.0	0.4	18.1	14.1	0.3	0.08	64.0	2.7	18.1	12.1	0.3
1961	64.3	1.5	17.0	15.3	0.7	0.03	64.3	2.7	17.0	14.2	0.7
1962	72.8	1.0	25.3	0.0	0.3	0.07	72.8	2.4	25.3	0.0	0.3
1963	70.0	1.0	23.1	3.9	0.5	-0.26	70.0	2.9	23.1	2.4	0.5
1964	51.8	2.0	25.1	18.6	0.8	0.06	51.8	7.1	25.1	13.5	0.8
1965	63.8	4.0	22.3	9.1	0.4	-0.04	63.8	5.8	22.3	7.4	0.4
1966	60.5	0.7	13.1	23.5	1.0	-0.09	60.5	4.1	13.1	20.1	1.0
1967	52.3	0.3	17.3	29.4	2.3	-3.37	52.3	4.9	17.3	24.8	2.3
1968	57.2	1.1	30.1	10.4	0.8	-0.21	57.2	2.4	30.1	9.8	0.8
1969	59.7	1.4	15.8	22.1	0.2	-0.44	59.7	4.7	15.8	18.7	0.2
1970	65.0	1.7	16.3	15.9	0.5	-0.61	65.0	5.4	16.3	12.1	0.5
1971	77.5	0.6	26.5	0.0	0.2	-5.79	77.5	2.2	26.5	0.0	0.2
1972	58.1	3.2	19.2	18.2	1.2	-1.42	58.1	5.1	19.2	16.3	1.2
1973	75.5	1.6	22.4	1.0	0.6	-1.74	75.5	4.9	22.4	0.0	0.6
1974	64.4	2.0	19.1	14.5	0.5	-1.11	64.4	3.6	19.1	13.8	0.5
1975	63.2	0.5	26.3	11.3	0.3	-1.73	63.2	0.8	26.3	11.0	0.3
1976	64.8	1.0	27.2	10.4	0.2	-3.88	64.8	3.0	27.2	9.8	0.2

Table 3
(continued)

	gauged			ungauged		rets-divs	Guadalupe		San Antonio		bay
	Guadalupe	Coleto Cr	San Antonio	u/s barrier	d/s barrier	u/s barrier	Victoria	d/s Victoria	Goliad	d/s Goliad	periphery
1977	66.1	2.7	26.7	3.9	0.6	-0.41	66.1	5.6	26.7	1.0	0.6
1978	57.4	1.5	33.0	7.0	0.6	-2.36	57.4	6.7	33.0	1.7	0.6
1979	68.8	3.3	21.7	3.7	1.7	-0.61	68.8	5.7	21.7	1.3	1.7
1980	59.3	4.4	29.1	8.3	1.9	-3.57	59.3	10.8	29.1	1.9	1.9
1981	68.1	0.4	28.4	3.7	1.1	-2.10	68.1	2.2	28.4	1.8	1.1
1982	53.2	6.7	24.9	8.9	0.1	-0.31	53.2	11.4	24.9	4.2	0.1
1983	63.1	4.4	22.2	7.1	0.9	-0.84	63.1	9.3	22.2	2.1	0.9
1984	56.1	7.8	28.7	5.1	3.0	-1.87	56.1	11.6	28.7	1.4	3.0
1985	64.8	3.8	20.9	7.0	0.8	-0.49	64.8	9.8	20.9	1.0	0.8
1986	80.9	0.3	19.2	0.9	0.4	-1.72	80.9	0.7	19.2	0.5	0.4
1987	68.9	2.4	25.3	2.2	0.5	-0.47	68.9	4.0	25.3	0.5	0.5
1988	66.3	0.4	36.5	0.3	0.0	-3.53	66.3	0.7	36.5	0.0	0.0
1989	66.3	0.3	31.9	3.7	3.0	-5.15	66.3	2.6	31.9	1.4	3.0
1990	50.7	0.3	36.3	5.7	0.1	-4.48	50.7	3.3	36.3	2.7	0.1
1991	68.8	0.1	21.3	8.5	0.4	-0.68	68.8	7.4	21.3	1.2	0.4
1992	65.7	2.2	25.4	4.8	0.4	-0.08	65.7	5.9	25.4	1.1	0.4
1993	60.8	2.4	20.3	6.0	0.3	-0.54	60.8	4.9	20.3	3.4	0.3
1994	53.7	1.1	35.6	7.7	1.1	-1.61	53.7	7.3	35.6	1.5	1.1
1995	74.0	2.0	19.7	2.7	0.1	-1.16	74.0	4.2	19.7	0.6	0.1
1996	70.5	0.2	31.6	0.6	0.1	-5.06	70.5	0.7	31.6	0.1	0.1
1997	63.6	8.3	13.6	4.3	0.4	-0.98	63.6	10.7	13.6	1.9	0.4
1998	70.8	3.1	22.5	3.1	0.0	-0.77	70.8	4.7	22.5	1.5	0.0
1999	70.3	0.7	26.6	2.5	0.4	-1.44	70.3	1.3	26.6	1.9	0.4
2000	56.9	0.6	30.8	10.1	1.6	-4.11	56.9	6.8	30.8	3.9	1.6
2001	76.2	1.0	20.7	1.4	1.4	-1.17	76.2	2.0	20.7	0.3	1.4
2002	73.3	0.3	26.4	0.5	0.7	-1.94	73.3	0.5	26.4	0.2	0.7
2003	71.8	1.0	24.9	0.8	0.7	-0.49	71.8	1.5	24.9	0.3	0.7
2004	63.4	3.9	29.1	3.3	0.8	-1.35	63.4	6.6	29.1	0.6	0.8
2005	67.1	4.6	23.6	4.4	0.1	-0.51	67.1	7.8	23.6	1.2	0.1
2006	69.0	0.5	32.1	0.5	0.1	-3.46	69.0	1.0	32.1	0.0	0.1
2007	56.0	4.6	28.5	6.2	4.0	-0.44	56.0	8.2	28.5	2.5	4.0
2008	58.2	0.3	34.1	4.1	2.6	-1.33	58.2	3.5	34.1	0.9	2.6
2009	64.0	0.3	38.9	1.4	0.0	-5.98	64.0	1.0	38.9	0.8	0.0
average	64.6	2.3	22.8	8.7	0.8	-0.84	64.6	5.2	22.8	6.1	0.8

Table 4
April - June seasonal flows into San Antonio Bay in thousands of acre feet (Taf)

year	gauged flows Guadalupe 8176500	gauged flows Coleto Cr 8177500	gauged flows San Antonio 8188500	ungauged flows Guad TWDB	ungauged flows San Ant TxRR	returns - diversions u/s of salt barrier	flow at salt barrier	ungauged from bay periphery	total flow into bay
1942	308.6	2.3	74.2	6.6	0.1	-0.6	387.5	0.4	394.0
1943	199.7	9.4	103.1	22.0	22.6	-0.3	356.1	0.0	362.4
1944	480.5	21.1	162.8	48.8	71.9	-0.2	782.0	1.0	800.5
1945	504.5	13.8	122.8	19.2	49.2	-0.9	708.6	6.0	724.6
1946	358.6	25.4	206.7	21.0	64.4	-0.9	672.8	2.6	690.5
1947	332.3	29.9	104.9	32.6	79.6	-36.5	542.8	8.6	565.8
1948	153.2	5.1	41.3	20.4	16.2	-42.3	191.1	2.9	195.5
1949	481.5	15.7	240.3	28.1	122.6	-20.9	862.3	31.4	895.4
1950	271.7	0.9	67.0	14.7	6.2	-24.3	330.4	2.4	339.8
1951	197.4	7.1	108.2	36.0	19.4	-45.7	321.5	1.0	328.2
1952	198.7	26.4	59.9	26.9	74.4	-46.3	340.0	8.8	355.3
1953	220.4	13.7	75.2	18.6	21.5	-50.3	297.6	0.3	309.3
1954	86.6	1.6	33.0	15.2	0.0	-45.1	76.1	2.3	79.9
1955	112.1	3.9	34.5	10.2	0.0	-34.5	116.0	0.7	121.2
1956	26.7	0.8	18.5	11.7	9.0	-19.2	41.5	4.9	49.3
1957	990.4	63.8	466.3	58.4	349.0	-1.9	1926.1	21.5	1966.5
1958	488.8	17.7	175.8	4.8	6.0	-12.3	679.5	0.6	684.8
1959	367.0	25.5	97.0	20.0	29.9	-16.6	522.7	4.0	540.6
1960	394.3	5.8	74.4	21.7	69.6	-15.1	549.2	1.4	573.1
1961	575.0	11.6	122.9	25.5	39.6	-8.9	764.6	1.9	800.3
1962	154.5	7.5	76.4	25.5	32.5	-13.9	276.9	4.2	296.9
1963	95.9	0.8	29.4	18.8	0.0	-32.7	93.6	0.2	99.9
1964	101.1	0.5	38.1	18.1	3.1	-35.8	117.6	0.1	123.8
1965	577.7	37.6	231.2	24.0	76.9	-30.2	915.6	0.7	924.7
1966	353.7	13.7	81.6	33.5	209.3	-7.7	684.0	8.1	718.3
1967	69.0	0.4	25.7	8.8	64.9	-32.1	136.9	0.4	161.3
1968	847.5	69.5	217.4	94.9	42.4	-20.7	1251.0	1.0	1343.0
1969	509.9	87.6	158.3	48.1	89.8	-27.0	866.6	16.5	890.2
1970	489.4	10.9	167.7	53.9	187.5	-19.4	848.2	1.1	867.5
1971	70.6	5.9	32.2	21.0	15.3	-34.6	94.9	3.4	112.1
1972	962.9	45.3	357.3	59.5	61.7	-28.5	1413.1	3.5	1436.3
1973	893.3	110.1	396.4	78.3	21.5	-24.1	1399.6	9.1	1436.3
1974	309.3	13.3	109.5	49.4	16.2	-33.0	464.8	0.6	509.4
1975	1060.4	15.5	336.7	52.1	127.7	-35.1	1534.6	0.3	1548.3
1976	890.5	43.9	299.9	27.1	156.9	-25.4	1392.9	8.1	1418.7
1977	1052.4	34.1	485.9	172.5	78.1	-26.1	1796.8	9.4	1848.0
1978	191.2	6.2	124.4	17.6	9.6	-33.0	316.1	1.5	322.9
1979	1127.1	65.9	474.8	64.5	29.3	-27.8	1733.9	5.8	1758.7
1980	273.9	0.9	125.0	24.9	5.3	-32.8	397.3	0.2	402.8
1981	827.3	94.2	364.3	90.6	69.2	-22.1	1423.5	2.3	1509.2
1982	471.2	28.5	116.1	34.9	7.4	-20.2	637.8	1.2	648.5
1983	247.0	1.1	67.5	2.4	1.9	-18.6	301.3	0.1	303.4
1984	67.0	1.0	42.4	6.6	1.7	-24.9	93.8	0.0	95.6
1985	410.7	22.9	127.4	82.6	14.9	-14.5	644.0	13.3	658.8

(continued)

Table 4 (continued)
April - June flows (Taf) into San Antonio Bay

year	gauged flows Guadalupe 8176500	gauged flows Coleto Cr 8177500	gauged flows San Antonio 8188500	ungauged flows Guad TWDB	ungauged flows San Ant TxRR	returns - diversions u/s of salt barrier	flow at salt barrier	ungauged from bay periphery	total flow into bay
1986	342.7	2.9	216.2	30.7	7.7	-20.7	579.5	0.2	591.8
1987	1677.4	70.5	1059.8	57.9	21.1	-17.7	2869.0	0.1	2880.1
1988	156.8	0.9	69.6	0.5	1.6	-34.8	194.7	0.2	196.9
1989	169.3	0.6	68.4	16.9	4.1	-28.6	230.7	0.1	248.4
1990	187.2	4.2	83.1	11.3	5.1	-18.6	272.3	3.9	283.6
1991	482.7	49.8	187.4	133.7	26.8	-13.5	867.1	17.5	913.5
1992	1649.7	87.9	989.1	218.0	69.2	-8.1	3005.7	13.6	3056.5
1993	792.5	143.8	430.9	240.1	32.8	-11.0	1629.1	3.3	1670.7
1994	400.0	22.1	205.5	32.9	9.2	-20.7	649.0	0.7	658.6
1995	367.6	2.4	95.3	19.7	13.9	-16.3	482.5	2.6	502.8
1996	70.3	0.4	35.7	18.0	2.8	-28.2	99.0	0.9	102.9
1997	1210.3	182.8	341.1	21.6	26.6	-8.9	1773.5	6.3	1801.6
1998	226.3	0.8	55.4	0.8	0.5	-28.4	255.4	0.2	258.2
1999	284.0	3.8	124.5	41.5	19.9	-21.1	452.6	0.9	455.9
2000	180.5	4.0	103.2	54.0	30.8	-15.1	357.5	1.7	448.8
2001	277.6	10.1	138.9	25.2	9.0	-18.4	442.4	0.1	446.6
2002	233.5	0.7	96.9	29.2	3.5	-19.6	344.2	1.0	351.9
2003	290.6	0.5	121.5	2.3	0.6	-15.3	400.2	0.2	409.7
2004	788.5	86.4	469.0	233.3	40.6	-8.9	1608.8	3.0	1688.6
2005	391.9	16.8	150.8	16.5	8.3	-11.1	573.3	0.4	580.8
2006	115.8	1.1	57.0	93.3	20.2	-16.5	270.9	0.0	299.6
2007	766.8	10.9	268.7	55.1	28.4	-8.6	1121.3	10.0	1144.4
2008	129.0	0.9	65.9	6.4	4.3	-19.3	187.2	1.6	190.5
2009	159.0	0.4	56.9	2.3	5.1	-16.5	207.1	0.6	219.1
average	443.4	25.3	181.8	43.1	40.7	-21.6	708.5	3.9	729.6

Table 5
Time trends (least-squares regression) in April-June flows, 1942-2009

	Trend line			*Trend projection*			
	slope (Taf/yr)	*± 0.95 conf bnds (Taf/yr)*	*(Taf/yr)*	*1942 (Taf)*	*2009 (Taf)*	*increase (Taf)*	*(%)*
Gauged flows							
Guadalupe at Victoria	2.3	-3.0	7.5	368	519	151	41
Coleto Creek	0.2	-0.3	0.7	18	33	15	84
San Antonio at Goliad	1.8	-1.0	4.5	123	241	118	96
Ungauged flows							
Guadalupe	0.6	-0.1	1.3	22	64	42	193
San Antonio	-0.8	-1.6	0.0	67	14	-53	-79
Rets - divs u/s of salt barrier	0.1	-0.1	0.3	-24	-19	5	-23
Flow at salt barrier	4.3	-4.7	13.3	566	851	285	50
Bay peripheral drainage	0.0	-0.1	0.0	5	2	-3	-55
Total flow into bay	4.4	-4.8	13.5	583	876	294	50

Table 6
Proportions (%) of contributions to April - June inflows to San Antonio Bay by data source and by physical source

	gauged			ungauged		rets-divs	Guadalupe		San Antonio		bay
	Guadalupe	Coleto Cr	San Antonio	u/s barrier	d/s barrier	u/s barrier	Victoria	d/s Victoria	Goliad	d/s Goliad	periphery
1942	78.3	0.6	18.8	0.7	0.1	-0.15	78.3	2.3	18.8	0.0	0.1
1943	55.1	2.6	28.4	12.2	0.0	-0.08	55.1	8.7	28.4	6.2	0.0
1944	60.0	2.6	20.3	14.7	0.1	-0.02	60.0	8.7	20.3	9.0	0.1
1945	69.6	1.9	16.9	9.4	0.8	-0.12	69.6	4.6	16.9	6.8	0.8
1946	51.9	3.7	29.9	12.0	0.4	-0.13	51.9	6.7	29.9	9.3	0.4
1947	58.7	5.3	18.5	19.8	1.5	-6.45	58.7	11.1	18.5	14.1	1.5
1948	78.4	2.6	21.1	17.3	1.5	-21.64	78.4	13.0	21.1	8.3	1.5
1949	53.8	1.8	26.8	16.3	3.5	-2.34	53.8	4.9	26.8	13.7	3.5
1950	79.9	0.3	19.7	4.4	0.7	-7.15	79.9	4.6	19.7	1.8	0.7
1951	60.1	2.2	33.0	16.6	0.3	-13.92	60.1	13.1	33.0	5.9	0.3
1952	55.9	7.4	16.9	28.5	2.5	-13.05	55.9	15.0	16.9	21.0	2.5
1953	71.3	4.4	24.3	12.5	0.1	-16.27	71.3	10.5	24.3	6.9	0.1
1954	108.3	2.0	41.3	0.0	2.9	-56.48	108.3	21.1	41.3	0.0	2.9
1955	92.5	3.2	28.5	0.0	0.6	-28.48	92.5	11.6	28.5	0.0	0.6
1956	54.2	1.5	37.6	29.8	9.9	-38.92	54.2	25.3	37.6	18.3	9.9
1957	50.4	3.2	23.7	20.7	1.1	-0.09	50.4	6.2	23.7	17.7	1.1
1958	71.4	2.6	25.7	1.4	0.1	-1.80	71.4	3.3	25.7	0.9	0.1
1959	67.9	4.7	17.9	9.2	0.7	-3.07	67.9	8.4	17.9	5.5	0.7
1960	68.8	1.0	13.0	15.7	0.3	-2.64	68.8	4.8	13.0	12.1	0.3
1961	71.9	1.5	15.4	8.0	0.2	-1.11	71.9	4.6	15.4	4.9	0.2
1962	52.0	2.5	25.7	17.7	1.4	-4.69	52.0	11.1	25.7	10.9	1.4
1963	96.0	0.8	29.4	0.2	0.2	-32.73	96.0	19.6	29.4	0.0	0.2
1964	81.6	0.4	30.8	11.0	0.1	-28.88	81.6	15.0	30.8	2.5	0.1
1965	62.5	4.1	25.0	10.7	0.1	-3.26	62.5	6.7	25.0	8.3	0.1
1966	49.2	1.9	11.4	33.8	1.1	-1.07	49.2	6.6	11.4	29.1	1.1
1967	42.8	0.3	15.9	45.7	0.3	-19.87	42.8	5.8	15.9	40.3	0.3
1968	63.1	5.2	16.2	10.2	0.1	-1.54	63.1	12.2	16.2	3.2	0.1
1969	57.3	9.8	17.8	15.5	1.9	-3.04	57.3	15.2	17.8	10.1	1.9
1970	56.4	1.3	19.3	23.0	0.1	-2.23	56.4	7.5	19.3	21.6	0.1
1971	63.0	5.2	28.7	18.5	3.0	-30.85	63.0	24.0	28.7	13.6	3.0
1972	67.0	3.2	24.9	5.3	0.2	-1.98	67.0	7.3	24.9	4.3	0.2
1973	62.2	7.7	27.6	1.7	0.6	-1.68	62.2	13.1	27.6	1.5	0.6
1974	60.7	2.6	21.5	12.9	0.1	-6.48	60.7	12.3	21.5	3.2	0.1
1975	68.5	1.0	21.7	10.1	0.0	-2.27	68.5	4.4	21.7	8.2	0.0
1976	62.8	3.1	21.1	13.0	0.6	-1.79	62.8	5.0	21.1	11.1	0.6

Table 6
(continued)

	gauged			ungauged		rets-divs	Guadalupe		San Antonio		bay
	Guadalupe	Coleto Cr	San Antonio	u/s barrier	d/s barrier	u/s barrier	Victoria	d/s Victoria	Goliad	d/s Goliad	periphery
1977	56.9	1.8	26.3	13.6	0.5	-1.41	56.9	11.2	26.3	4.2	0.5
1978	59.2	1.9	38.5	8.4	0.4	-10.22	59.2	7.4	38.5	3.0	0.4
1979	64.1	3.7	27.0	5.3	0.3	-1.58	64.1	7.4	27.0	1.7	0.3
1980	68.0	0.2	31.0	7.5	0.1	-8.15	68.0	6.4	31.0	1.3	0.1
1981	54.8	6.2	24.1	10.6	0.2	-1.46	54.8	12.2	24.1	4.6	0.2
1982	72.7	4.4	17.9	6.5	0.2	-3.12	72.7	9.8	17.9	1.1	0.2
1983	81.4	0.4	22.3	1.4	0.0	-6.12	81.4	1.1	22.3	0.6	0.0
1984	70.1	1.1	44.3	8.6	0.1	-26.00	70.1	8.0	44.3	1.7	0.1
1985	62.3	3.5	19.3	14.8	2.0	-2.20	62.3	16.0	19.3	2.3	2.0
1986	57.9	0.5	36.5	6.5	0.0	-3.49	57.9	5.7	36.5	1.3	0.0
1987	58.2	2.4	36.8	2.7	0.0	-0.62	58.2	4.5	36.8	0.7	0.0
1988	79.7	0.5	35.4	1.1	0.1	-17.69	79.7	0.7	35.4	0.8	0.1
1989	68.2	0.2	27.5	8.4	0.0	-11.51	68.2	7.0	27.5	1.6	0.0
1990	66.0	1.5	29.3	5.8	1.4	-6.55	66.0	5.4	29.3	1.8	1.4
1991	52.8	5.5	20.5	17.6	1.9	-1.47	52.8	20.1	20.5	2.9	1.9
1992	54.0	2.9	32.4	9.4	0.4	-0.27	54.0	10.0	32.4	2.3	0.4
1993	47.4	8.6	25.8	16.3	0.2	-0.66	47.4	23.0	25.8	2.0	0.2
1994	60.7	3.4	31.2	6.4	0.1	-3.14	60.7	8.4	31.2	1.4	0.1
1995	73.1	0.5	19.0	6.7	0.5	-3.25	73.1	4.4	19.0	2.8	0.5
1996	68.3	0.4	34.7	20.3	0.9	-27.43	68.3	17.9	34.7	2.8	0.9
1997	67.2	10.1	18.9	2.7	0.3	-0.49	67.2	11.3	18.9	1.5	0.3
1998	87.6	0.3	21.4	0.5	0.1	-11.00	87.6	0.6	21.4	0.2	0.1
1999	62.3	0.8	27.3	13.5	0.2	-4.64	62.3	9.9	27.3	4.4	0.2
2000	40.2	0.9	23.0	18.9	0.4	-3.36	40.2	12.9	23.0	6.9	0.4
2001	62.1	2.3	31.1	7.7	0.0	-4.11	62.1	7.9	31.1	2.0	0.0
2002	66.4	0.2	27.5	9.3	0.3	-5.56	66.4	8.5	27.5	1.0	0.3
2003	70.9	0.1	29.7	0.7	0.1	-3.74	70.9	0.7	29.7	0.2	0.1
2004	46.7	5.1	27.8	16.2	0.2	-0.52	46.7	18.9	27.8	2.4	0.2
2005	67.5	2.9	26.0	4.3	0.1	-1.91	67.5	5.7	26.0	1.4	0.1
2006	38.6	0.4	19.0	37.9	0.0	-5.50	38.6	31.5	19.0	6.7	0.0
2007	67.0	1.0	23.5	7.3	0.9	-0.75	67.0	5.8	23.5	2.5	0.9
2008	67.7	0.5	34.6	5.6	0.9	-10.13	67.7	3.8	34.6	2.3	0.9
2009	72.6	0.2	26.0	3.4	0.3	-7.53	72.6	1.2	26.0	2.3	0.3
average	60.8	3.5	24.9	10.9	0.5	-2.96	60.8	9.4	24.9	5.6	0.5

Table 7
July - September seasonal flows into San Antonio Bay in thousands of acre feet (Taf)

year	gauged flows Guadalupe 8176500	gauged flows Coleto Cr 8177500	gauged flows San Antonio 8188500	ungauged flows Guad TWDB	ungauged flows San Ant TxRR	returns - diversions u/s of salt barrier	flow at salt barrier	ungauged from bay periphery	total flow into bay
1942	704.7	66.3	576.2	100.4	200.1	-0.8	1647.0	43.3	1704.9
1943	143.9	2.2	65.2	27.6	6.7	-0.4	224.4	3.1	233.5
1944	233.8	13.1	72.2	13.0	20.3	-0.3	350.1	2.6	376.1
1945	138.5	0.5	43.5	31.8	86.0	-1.1	296.4	8.8	370.8
1946	401.6	14.9	324.3	35.4	71.4	-1.1	845.0	4.1	884.3
1947	180.1	1.3	53.3	26.8	3.0	-42.5	207.6	0.7	234.9
1948	103.0	0.8	88.6	21.2	41.2	-49.3	189.8	0.7	230.2
1949	129.7	4.7	78.5	11.1	7.4	-24.5	199.3	11.6	218.4
1950	81.5	0.2	35.4	16.3	0.0	-28.3	88.7	0.1	97.3
1951	52.8	16.9	60.0	33.6	37.7	-53.2	146.7	0.8	198.2
1952	277.7	32.9	211.7	30.4	21.9	-54.0	510.2	2.8	522.5
1953	152.4	30.5	106.0	19.0	74.4	-58.6	322.5	1.0	376.8
1954	22.0	0.0	12.1	9.4	0.0	-52.6	-18.4	0.5	-13.2
1955	35.5	1.5	28.8	31.1	24.1	-40.3	63.0	4.2	92.0
1956	8.7	0.6	18.9	6.0	0.0	-14.1	14.0	0.1	23.7
1957	293.1	4.8	137.3	17.4	2.0	-14.4	437.9	0.0	449.6
1958	242.2	7.9	98.6	71.3	20.2	-15.3	422.5	2.2	455.7
1959	174.1	1.6	48.1	19.4	23.9	-19.3	245.8	2.2	275.6
1960	337.9	9.9	80.6	41.0	69.8	-24.8	514.5	1.3	546.2
1961	347.5	3.3	107.4	49.7	143.0	-12.7	633.4	7.2	662.5
1962	95.6	4.3	38.1	22.8	2.2	-17.3	137.2	0.0	149.5
1963	41.2	1.3	18.9	12.6	0.0	-38.5	22.8	1.4	28.5
1964	75.3	8.5	46.8	54.6	34.9	-29.4	186.9	1.2	205.5
1965	153.6	0.6	35.3	13.0	0.0	-39.0	150.6	1.3	160.5
1966	146.0	3.9	48.7	27.0	59.2	-22.6	262.3	1.4	272.0
1967	586.9	292.4	752.0	88.3	485.4	-23.3	2179.2	12.6	2289.0
1968	259.9	24.3	101.9	25.4	150.7	-28.8	522.4	7.3	542.5
1969	146.6	2.3	44.6	35.0	0.0	-35.0	158.5	0.0	166.5
1970	173.9	1.2	41.9	23.0	19.8	-23.6	236.2	5.8	278.2
1971	289.8	37.1	145.0	68.4	155.4	-25.7	659.4	0.2	702.1
1972	241.7	5.2	94.6	56.7	4.9	-28.4	330.1	9.4	360.9
1973	560.5	15.6	510.0	37.8	86.8	-32.1	1171.9	0.5	1212.6
1974	347.7	8.0	178.4	39.5	5.7	-38.9	512.9	0.4	537.2
1975	413.0	3.2	127.0	18.9	86.4	-32.7	615.8	3.8	640.6
1976	340.1	11.5	155.6	51.7	16.7	-27.0	514.8	29.6	551.7
1977	242.0	3.7	118.2	11.5	3.5	-36.6	342.3	0.3	350.7
1978	489.8	34.7	229.6	121.6	19.4	-30.3	865.0	0.5	880.4
1979	362.8	11.9	138.2	128.1	61.1	-31.6	670.6	33.8	803.8
1980	139.6	1.2	116.5	24.0	24.8	-36.1	269.9	0.5	285.8
1981	1025.7	25.5	276.9	33.4	46.3	-28.4	1379.4	14.4	1406.9
1982	106.6	0.9	50.5	0.5	0.6	-29.4	129.6	0.2	131.6
1983	166.1	22.4	89.4	48.2	13.6	-18.4	321.2	23.8	353.6
1984	20.7	0.9	29.1	5.6	1.5	-22.6	35.2	0.5	39.4
1985	260.4	8.2	99.4	9.0	11.9	-22.4	366.4	2.4	370.7

(continued)

Table 7 (continued)
July - September flows (Taf) into San Antonio Bay

year	gauged flows Guadalupe 8176500	gauged flows Coleto Cr 8177500	gauged flows San Antonio 8188500	ungauged flows Guad TWDB	ungauged flows San Ant TxRR	returns - diversions u/s of salt barrier	flow at salt barrier	ungauged from bay periphery	total flow into bay
1986	186.3	0.6	78.7	8.3	2.8	-23.9	252.6	0.2	255.2
1987	831.2	1.3	202.2	41.8	7.4	-26.3	1057.7	10.6	1074.6
1988	160.0	0.5	58.8	2.6	0.7	-32.4	190.2	1.9	194.5
1989	39.2	0.3	29.0	3.2	4.3	-28.5	47.5	11.0	61.0
1990	156.7	24.8	148.2	80.1	87.0	-23.5	473.3	41.4	520.7
1991	195.5	3.6	69.8	13.5	2.9	-22.1	263.1	1.1	292.4
1992	421.8	0.9	190.5	21.2	6.8	-21.2	620.0	4.7	636.8
1993	221.4	1.7	119.4	1.8	1.2	-21.7	323.8	0.3	326.8
1994	120.1	0.8	59.2	17.6	2.9	-24.0	176.7	0.2	187.4
1995	160.5	0.5	84.6	40.7	9.3	-20.5	275.1	1.9	279.9
1996	143.1	0.3	67.6	36.3	2.2	-16.7	232.8	0.0	243.5
1997	628.0	1.4	124.3	39.0	15.2	-18.2	789.8	0.2	826.9
1998	296.6	59.4	93.0	0.1	20.2	-16.8	452.4	0.3	478.3
1999	144.6	1.3	59.1	8.9	2.8	-21.6	195.0	2.2	199.6
2000	60.1	0.9	33.1	2.4	0.7	-16.1	81.0	0.3	87.4
2001	545.8	94.3	420.9	30.8	41.5	-15.6	1117.7	0.8	1135.9
2002	1668.7	29.1	1210.0	72.8	53.7	-15.9	3018.5	13.8	3067.5
2003	239.0	27.8	178.2	20.5	25.6	-13.6	477.5	36.0	552.6
2004	539.0	4.9	268.3	20.5	6.5	-16.5	822.7	3.9	830.1
2005	198.2	1.0	84.0	8.4	3.9	-21.6	274.0	4.3	282.2
2006	81.3	0.8	49.9	36.9	24.2	-12.5	180.6	39.4	252.4
2007	1499.5	100.4	941.4	129.8	53.1	-6.6	2717.6	92.5	2836.5
2008	107.1	0.5	80.6	1.6	1.2	-16.5	174.6	0.4	185.7
2009	41.4	0.3	42.9	1.0	3.3	-22.9	66.0	0.0	71.6
average	285.8	16.2	153.3	32.5	37.1	-24.7	495.0	7.6	522.6

Table 8
Time trends (least-squares regression) in July - September flows, 1942-2009

	Trend line			*Trend projection*			
	slope (Taf/yr)	*± 0.95 conf bnds (Taf/yr)*	*(Taf/yr)*	*1942 (Taf)*	*2009 (Taf)*	*increase (Taf)*	*(%)*
Gauged flows							
Guadalupe at Victoria	3.8	-0.4	7.9	160	412	252	158
Coleto Creek	0.0	-0.5	0.6	15	17	2	16
San Antonio at Goliad	1.9	-1.0	4.9	89	218	129	146
Ungauged flows							
Guadalupe	-0.1	-0.5	0.3	35	30	-5	-15
San Antonio	-0.7	-1.7	0.2	61	13	-48	-79
Rets - divs u/s of salt barrier	0.1	-0.1	0.3	-29	-21	8	-29
Flow at salt barrier	5.2	-2.8	13.3	320	670	350	109
Bay peripheral drainage	0.2	0.0	0.4	2	13	11	485
Total flow into bay	5.2	-3.1	13.5	349	696	346	99

Table 9

Proportions (%) of contributions to July - September inflows to San Antonio Bay by data source and by physical source

	gauged			ungauged		rets-divs	Guadalupe		San Antonio		bay
	Guadalupe	Coleto Cr	San Antonio	u/s barrier	d/s barrier	u/s barrier	Victoria	d/s Victoria	Goliad	d/s Goliad	periphery
1942	41.3	3.9	33.8	17.6	2.5	-0.05	41.3	9.8	33.8	11.7	2.5
1943	61.6	0.9	27.9	5.8	1.3	-0.17	61.6	12.7	27.9	2.9	1.3
1944	62.2	3.5	19.2	8.3	0.7	-0.08	62.2	7.0	19.2	5.4	0.7
1945	37.4	0.1	11.7	31.0	2.4	-0.30	37.4	8.7	11.7	23.2	2.4
1946	45.4	1.7	36.7	11.9	0.5	-0.13	45.4	5.7	36.7	8.1	0.5
1947	76.7	0.6	22.7	6.6	0.3	-18.10	76.7	11.9	22.7	1.3	0.3
1948	44.7	0.3	38.5	20.3	0.3	-21.42	44.7	9.6	38.5	17.9	0.3
1949	59.4	2.2	35.9	4.9	5.3	-11.19	59.4	7.3	35.9	3.4	5.3
1950	83.8	0.2	36.4	0.0	0.1	-29.14	83.8	17.0	36.4	0.0	0.1
1951	26.7	8.5	30.3	35.4	0.4	-26.85	26.7	25.5	30.3	19.0	0.4
1952	53.1	6.3	40.5	8.0	0.5	-10.33	53.1	12.1	40.5	4.2	0.5
1953	40.4	8.1	28.1	24.5	0.3	-15.55	40.4	13.1	28.1	19.8	0.3
1954	-167.1	0.0	-91.9	0.0	-4.1	399.02	-167.1	-71.6	-91.9	0.0	-4.1
1955	38.6	1.7	31.3	40.6	4.6	-43.80	38.6	35.4	31.3	26.2	4.6
1956	36.7	2.5	79.5	0.0	0.4	-59.55	36.7	27.8	79.5	0.0	0.4
1957	65.2	1.1	30.5	3.8	0.0	-3.19	65.2	4.9	30.5	0.4	0.0
1958	53.2	1.7	21.6	19.6	0.5	-3.36	53.2	17.4	21.6	4.4	0.5
1959	63.2	0.6	17.4	15.0	0.8	-7.00	63.2	7.6	17.4	8.7	0.8
1960	61.9	1.8	14.8	20.3	0.2	-4.53	61.9	9.3	14.8	12.8	0.2
1961	52.5	0.5	16.2	28.4	1.1	-1.92	52.5	8.0	16.2	21.6	1.1
1962	64.0	2.9	25.5	11.1	0.0	-11.60	64.0	18.1	25.5	1.4	0.0
1963	144.7	4.5	66.2	0.0	4.9	-135.16	144.7	48.5	66.2	0.0	4.9
1964	36.6	4.1	22.8	41.7	0.6	-14.31	36.6	30.7	22.8	17.0	0.6
1965	95.7	0.4	22.0	0.0	0.8	-24.30	95.7	8.5	22.0	0.0	0.8
1966	53.7	1.4	17.9	31.7	0.5	-8.29	53.7	11.4	17.9	21.8	0.5
1967	25.6	12.8	32.9	25.0	0.5	-1.02	25.6	16.6	32.9	21.2	0.5
1968	47.9	4.5	18.8	30.4	1.4	-5.31	47.9	9.2	18.8	27.8	1.4
1969	88.1	1.4	26.8	0.0	0.0	-21.03	88.1	22.4	26.8	0.0	0.0
1970	62.5	0.4	15.1	15.4	2.1	-8.49	62.5	8.7	15.1	7.1	2.1
1971	41.3	5.3	20.7	30.4	0.0	-3.66	41.3	15.0	20.7	22.1	0.0
1972	67.0	1.4	26.2	4.7	2.6	-7.86	67.0	17.2	26.2	1.3	2.6
1973	46.2	1.3	42.1	9.7	0.0	-2.64	46.2	4.4	42.1	7.2	0.0
1974	64.7	1.5	33.2	3.3	0.1	-7.24	64.7	8.8	33.2	1.1	0.1
1975	64.5	0.5	19.8	16.4	0.6	-5.11	64.5	3.5	19.8	13.5	0.6
1976	61.6	2.1	28.2	6.3	5.4	-4.89	61.6	11.5	28.2	3.0	5.4

Table 9
(continued)

	gauged			ungauged		rets-divs	Guadalupe		San Antonio		bay
	Guadalupe	Coleto Cr	San Antonio	u/s barrier	d/s barrier	u/s barrier	Victoria	d/s Victoria	Goliad	d/s Goliad	periphery
1977	69.0	1.0	33.7	4.3	0.1	-10.44	69.0	4.3	33.7	1.0	0.1
1978	55.6	3.9	26.1	16.0	0.1	-3.44	55.6	17.8	26.1	2.2	0.1
1979	45.1	1.5	17.2	23.5	4.2	-3.93	45.1	17.4	17.2	7.6	4.2
1980	48.8	0.4	40.8	17.1	0.2	-12.65	48.8	8.8	40.8	8.7	0.2
1981	72.9	1.8	19.7	5.7	1.0	-2.02	72.9	4.2	19.7	3.3	1.0
1982	81.0	0.7	38.4	0.8	0.1	-22.35	81.0	1.0	38.4	0.5	0.1
1983	47.0	6.3	25.3	17.5	6.7	-5.22	47.0	20.0	25.3	3.8	6.7
1984	52.6	2.3	73.8	18.0	1.3	-57.39	52.6	16.6	73.8	3.8	1.3
1985	70.2	2.2	26.8	5.6	0.7	-6.04	70.2	4.6	26.8	3.2	0.7
1986	73.0	0.2	30.8	4.3	0.1	-9.37	73.0	3.5	30.8	1.1	0.1
1987	77.4	0.1	18.8	4.6	1.0	-2.45	77.4	4.0	18.8	0.7	1.0
1988	82.3	0.3	30.2	1.7	1.0	-16.67	82.3	1.6	30.2	0.3	1.0
1989	64.2	0.5	47.5	12.3	18.0	-46.63	64.2	5.7	47.5	7.1	18.0
1990	30.1	4.8	28.5	32.1	8.0	-4.51	30.1	20.1	28.5	16.7	8.0
1991	66.9	1.2	23.9	5.6	0.4	-7.57	66.9	5.8	23.9	1.0	0.4
1992	66.2	0.1	29.9	4.4	0.7	-3.33	66.2	3.5	29.9	1.1	0.7
1993	67.7	0.5	36.5	0.9	0.1	-6.64	67.7	1.1	36.5	0.4	0.1
1994	64.1	0.4	31.6	11.0	0.1	-12.80	64.1	9.8	31.6	1.6	0.1
1995	57.3	0.2	30.2	17.8	0.7	-7.32	57.3	14.7	30.2	3.3	0.7
1996	58.8	0.1	27.8	15.8	0.0	-6.88	58.8	15.1	27.8	0.9	0.0
1997	76.0	0.2	15.0	6.6	0.0	-2.20	76.0	4.9	15.0	1.8	0.0
1998	62.0	12.4	19.4	4.2	0.1	-3.52	62.0	12.4	19.4	4.2	0.1
1999	72.5	0.6	29.6	5.8	1.1	-10.83	72.5	5.1	29.6	1.4	1.1
2000	68.8	1.0	37.9	3.6	0.4	-18.48	68.8	3.8	37.9	0.8	0.4
2001	48.1	8.3	37.1	6.4	0.1	-1.37	48.1	11.0	37.1	3.7	0.1
2002	54.4	1.0	39.4	4.1	0.4	-0.52	54.4	3.3	39.4	1.8	0.4
2003	43.2	5.0	32.3	8.4	6.5	-2.47	43.2	8.7	32.3	4.6	6.5
2004	64.9	0.6	32.3	3.2	0.5	-1.98	64.9	3.1	32.3	0.8	0.5
2005	70.2	0.3	29.8	4.4	1.5	-7.64	70.2	3.3	29.8	1.4	1.5
2006	32.2	0.3	19.8	24.2	15.6	-4.97	32.2	14.9	19.8	9.6	15.6
2007	52.9	3.5	33.2	6.4	3.3	-0.23	52.9	8.1	33.2	1.9	3.3
2008	57.7	0.3	43.4	1.5	0.2	-8.86	57.7	1.2	43.4	0.6	0.2
2009	57.8	0.5	59.9	6.1	0.0	-32.01	57.8	1.9	59.9	4.7	0.0
average	54.7	3.1	29.3	12.3	1.5	-4.73	54.7	9.3	29.3	7.1	1.5

Table 10
October - December seasonal flows into San Antonio Bay in thousands of acre feet (Taf)

year	gauged flows			ungauged flows		returns -	flow at	ungauged	total
	Guadalupe 8176500	Coleto Cr 8177500	San Antonio 8188500	Guad TWDB	San Ant TxRR	diversions u/s of salt barrier	salt barrier	from bay periphery	flow into bay
1942	365.2	2.4	203.9	11.3	1.7	0.3	580.9	6.8	593.2
1943	124.2	2.5	52.0	20.7	9.7	0.3	208.8	0.5	221.0
1944	259.0	2.4	61.1	15.6	48.6	0.4	387.1	6.0	399.1
1945	189.5	0.7	58.2	4.2	2.7	0.3	255.5	6.5	264.8
1946	610.3	134.2	429.8	16.9	108.1	0.3	1298.0	6.7	1310.2
1947	118.0	1.1	47.6	14.7	3.7	-4.0	174.6	3.2	192.8
1948	78.5	0.3	40.2	4.0	0.0	-4.7	114.4	1.7	118.0
1949	279.7	12.8	118.2	46.2	72.6	-2.1	527.5	26.6	557.6
1950	68.0	0.1	23.7	3.6	0.0	-3.1	88.7	0.0	90.0
1951	53.4	1.3	27.8	5.5	2.3	-7.9	79.4	3.7	85.3
1952	216.6	14.7	38.3	7.7	12.3	-9.1	280.5	0.0	290.5
1953	199.2	2.0	35.7	13.5	0.0	-10.0	234.3	7.7	246.8
1954	34.2	0.1	20.9	7.1	2.4	-10.0	51.9	28.0	81.9
1955	23.7	0.1	16.2	7.4	4.4	-4.0	43.8	1.4	48.5
1956	43.5	6.4	55.4	17.1	0.0	-0.2	108.2	4.3	115.3
1957	861.3	36.5	130.0	35.1	93.9	-1.7	1153.7	1.6	1163.0
1958	335.7	11.5	205.4	42.5	136.9	0.3	732.1	5.7	752.6
1959	299.8	2.6	86.0	33.0	123.2	-1.8	542.7	23.4	572.2
1960	1230.8	79.2	318.2	126.9	445.1	0.2	2200.5	35.8	2264.1
1961	257.9	3.6	102.7	16.5	6.9	0.2	385.4	0.3	391.8
1962	130.4	1.9	46.6	13.8	17.7	-0.6	206.9	6.4	226.3
1963	88.4	1.3	53.7	16.6	0.0	-1.7	146.4	3.9	158.4
1964	141.1	0.2	69.1	2.3	2.2	-4.3	208.4	2.1	216.8
1965	356.7	4.8	94.6	29.4	112.5	-5.2	592.8	11.4	615.2
1966	132.5	0.3	33.7	5.8	62.8	-2.5	232.6	2.2	237.2
1967	339.8	67.6	146.0	17.8	346.4	-3.8	913.7	5.3	922.1
1968	233.6	3.2	74.2	17.3	116.8	-8.2	436.9	2.6	444.4
1969	250.3	2.5	60.3	25.2	33.1	-8.1	354.2	10.5	380.9
1970	150.9	0.8	41.4	7.3	39.9	-6.8	233.5	16.3	250.4
1971	300.1	17.7	189.4	31.0	319.5	-8.0	849.7	18.6	897.8
1972	161.1	2.3	89.4	14.0	143.8	-9.8	400.2	2.4	409.6
1973	982.7	108.1	590.2	23.9	151.3	-10.5	1845.7	18.3	1866.3
1974	541.3	4.8	150.4	21.3	185.2	-13.7	880.7	5.5	953.7
1975	201.9	8.2	83.1	36.0	35.5	-12.2	318.3	4.2	327.2
1976	969.8	56.5	369.4	43.8	284.7	-5.8	1698.5	10.6	1735.1
1977	207.7	6.9	146.6	22.7	9.2	-8.0	385.1	6.3	412.1
1978	269.3	5.3	133.7	7.3	4.1	-7.6	412.1	3.8	420.9
1979	158.4	4.0	76.4	8.6	2.5	-9.8	240.1	0.8	243.5
1980	158.4	0.9	68.2	7.4	5.2	-7.3	232.8	1.4	235.1
1981	500.3	53.4	193.4	55.2	66.9	-9.1	860.0	14.2	891.7
1982	140.1	20.8	91.5	37.9	11.3	-3.6	297.9	0.3	307.2
1983	128.6	22.4	69.4	33.9	7.2	-6.8	254.8	4.7	265.1
1984	132.3	5.5	126.9	16.7	3.0	-6.7	277.7	15.0	297.4
1985	509.1	1.0	173.7	9.3	3.4	-5.3	691.2	1.9	696.4

(continued)

Table 10 (continued)
October - December flows (Taf) into San Antonio Bay

year	gauged flows Guadalupe 8176500	Coleto Cr 8177500	San Antonio 8188500	ungauged flows Guad TWDB	San Ant TxRR	returns - diversions u/s of salt barrier	flow at salt barrier	ungauged from bay periphery	total flow into bay
1986	637.2	28.4	228.5	35.5	12.1	-5.2	936.5	30.4	988.8
1987	260.5	1.3	104.2	27.3	6.9	-13.5	386.7	3.4	393.7
1988	95.5	0.5	47.1	4.6	2.1	-20.7	129.2	0.8	130.1
1989	65.9	0.4	57.1	11.7	2.4	-14.7	122.9	1.0	134.6
1990	103.0	0.4	59.4	6.6	0.8	-13.5	156.7	0.1	160.8
1991	706.9	27.0	320.5	32.4	30.4	-6.9	1110.4	22.1	1164.1
1992	293.2	0.9	162.0	8.2	2.2	-5.7	460.7	0.7	478.8
1993	165.4	0.9	81.0	23.1	2.4	-6.7	266.1	3.8	281.9
1994	418.1	66.7	134.1	65.5	39.3	-10.7	713.2	12.2	733.9
1995	123.4	0.4	51.6	14.7	3.7	-7.8	186.0	18.2	217.0
1996	88.8	0.3	43.6	2.1	0.7	-6.4	129.1	0.3	133.4
1997	324.7	41.6	85.2	4.1	27.4	-5.0	477.9	52.5	537.4
1998	2723.1	142.4	646.3	2.8	59.6	-3.7	3570.5	29.2	3628.7
1999	99.4	0.8	48.4	0.6	0.3	-12.6	136.9	0.3	139.6
2000	498.6	0.5	250.2	5.1	2.4	-7.8	748.9	0.6	758.2
2001	624.2	34.8	224.5	63.3	43.7	-5.8	984.7	6.7	1013.7
2002	1322.3	71.7	651.7	69.6	58.8	-3.8	2170.2	47.3	2280.0
2003	221.3	13.9	120.2	34.9	3.0	-7.5	385.9	5.9	395.4
2004	1708.3	72.7	551.7	133.4	17.7	-4.0	2480.0	21.2	2521.5
2005	143.3	1.0	69.5	14.0	1.5	-7.7	221.5	9.4	242.4
2006	80.0	0.7	56.4	33.4	14.1	-7.2	177.4	10.0	193.7
2007	300.2	1.0	173.6	4.9	2.1	-6.1	475.8	2.2	484.9
2008	82.0	0.5	48.0	0.4	0.8	-9.5	122.2	2.2	127.9
2009	555.1	25.5	248.3	25.7	17.4	-3.6	868.4	2.9	896.7
average	359.9	18.4	142.7	23.2	49.9	-6.1	585.8	9.1	606.0

Table 11
Time trends (least-squares regression) in October - December flows, 1942-2009

	Trend line			*Trend projection*			
	slope	*± 0.95 conf bnds*		*1942*	*2009*	*increase*	
	(Taf/yr)	*(Taf/yr)*	*(Taf/yr)*	*(Taf)*	*(Taf)*	*(Taf)*	*(%)*
Gauged flows							
Guadalupe at Victoria	5.2	-0.8	11.2	186	534	348	187
Coleto Creek	0.2	-0.3	0.6	12	24	12	95
San Antonio at Goliad	2.0	0.0	4.0	76	210	134	177
Ungauged flows							
Guadalupe	0.2	-0.2	0.5	17	29	12	71
San Antonio	-0.8	-2.0	0.4	77	23	-54	-70
Rets - divs u/s of salt barrier	-0.1	-0.2	0.0	-3	-9	-6	223
Flow at salt barrier	6.7	-2.3	15.7	361	810	449	124
Bay peripheral drainage	0.1	-0.1	0.2	6	12	5	84
Total flow into bay	6.9	-2.3	16.1	374	838	465	124

Table 12

Proportions (%) of contributions to October - December inflows to San Antonio Bay by data source and by physical source

	gauged			ungauged		rets-divs	Guadalupe		San Antonio		bay
	Guadalupe	Coleto Cr	San Antonio	u/s barrier	d/s barrier	u/s barrier	Victoria	d/s Victoria	Goliad	d/s Goliad	periphery
1942	61.6	0.4	34.4	1.5	1.1	0.05	61.6	2.3	34.4	0.3	1.1
1943	56.2	1.1	23.5	13.5	0.2	0.16	56.2	10.5	23.5	4.4	0.2
1944	64.9	0.6	15.3	16.1	1.5	0.09	64.9	4.5	15.3	12.2	1.5
1945	71.5	0.3	22.0	2.6	2.4	0.11	71.5	1.8	22.0	1.0	2.4
1946	46.6	10.2	32.8	9.4	0.5	0.02	46.6	11.5	32.8	8.3	0.5
1947	61.2	0.6	24.7	6.1	1.7	-2.07	61.2	8.2	24.7	1.9	1.7
1948	66.5	0.3	34.1	0.0	1.4	-3.97	66.5	3.7	34.1	0.0	1.4
1949	50.2	2.3	21.2	21.3	4.8	-0.37	50.2	10.6	21.2	13.0	4.8
1950	75.5	0.2	26.4	0.0	0.0	-3.48	75.5	4.1	26.4	0.0	0.0
1951	62.6	1.5	32.6	5.7	4.3	-9.29	62.6	8.0	32.6	2.7	4.3
1952	74.6	5.1	13.2	6.9	0.0	-3.12	74.6	7.7	13.2	4.2	0.0
1953	80.7	0.8	14.5	3.0	3.1	-4.04	80.7	6.3	14.5	0.0	3.1
1954	41.8	0.1	25.5	8.2	34.2	-12.20	41.8	8.7	25.5	2.9	34.2
1955	48.9	0.3	33.4	16.0	2.8	-8.30	48.9	15.4	33.4	9.0	2.8
1956	37.7	5.6	48.1	2.7	3.7	-0.19	37.7	20.4	48.1	0.0	3.7
1957	74.1	3.1	11.2	11.0	0.1	-0.14	74.1	6.2	11.2	8.1	0.1
1958	44.6	1.5	27.3	23.8	0.8	0.04	44.6	7.2	27.3	18.2	0.8
1959	52.4	0.5	15.0	27.3	4.1	-0.31	52.4	6.2	15.0	21.5	4.1
1960	54.4	3.5	14.1	25.3	1.6	0.01	54.4	9.1	14.1	19.7	1.6
1961	65.8	0.9	26.2	5.4	0.1	0.04	65.8	5.1	26.2	1.8	0.1
1962	57.6	0.8	20.6	12.6	2.8	-0.27	57.6	7.0	20.6	7.8	2.8
1963	55.8	0.8	33.9	3.1	2.5	-1.10	55.8	11.3	33.9	0.0	2.5
1964	65.1	0.1	31.9	1.0	0.9	-1.98	65.1	1.1	31.9	1.0	0.9
1965	58.0	0.8	15.4	23.1	1.9	-0.85	58.0	5.6	15.4	18.3	1.9
1966	55.9	0.1	14.2	29.0	0.9	-1.05	55.9	2.6	14.2	26.5	0.9
1967	36.8	7.3	15.8	39.5	0.6	-0.41	36.8	9.3	15.8	37.6	0.6
1968	52.6	0.7	16.7	30.2	0.6	-1.85	52.6	4.6	16.7	26.3	0.6
1969	65.7	0.7	15.8	12.9	2.8	-2.12	65.7	7.3	15.8	8.7	2.8
1970	60.3	0.3	16.5	18.9	6.5	-2.72	60.3	3.2	16.5	15.9	6.5
1971	33.4	2.0	21.1	39.0	2.1	-0.89	33.4	5.4	21.1	35.6	2.1
1972	39.3	0.6	21.8	38.4	0.6	-2.40	39.3	4.0	21.8	35.1	0.6
1973	52.7	5.8	31.6	9.4	1.0	-0.56	52.7	7.1	31.6	8.1	1.0
1974	56.8	0.5	15.8	20.8	0.6	-1.44	56.8	2.7	15.8	19.4	0.6
1975	61.7	2.5	25.4	11.4	1.3	-3.74	61.7	13.5	25.4	10.8	1.3
1976	55.9	3.3	21.3	17.8	0.6	-0.34	55.9	5.8	21.3	16.4	0.6

Table 12
(continued)

	gauged			ungauged		rets-divs	Guadalupe		San Antonio		bay
	Guadalupe	Coleto Cr	San Antonio	u/s barrier	d/s barrier	u/s barrier	Victoria	d/s Victoria	Goliad	d/s Goliad	periphery
1977	50.4	1.7	35.6	7.7	1.5	-1.93	50.4	7.2	35.6	2.2	1.5
1978	64.0	1.3	31.8	2.7	0.9	-1.81	64.0	3.0	31.8	1.0	0.9
1979	65.1	1.6	31.4	4.5	0.3	-4.05	65.1	5.2	31.4	1.0	0.3
1980	67.4	0.4	29.0	5.3	0.6	-3.12	67.4	3.5	29.0	2.2	0.6
1981	56.1	6.0	21.7	13.7	1.6	-1.02	56.1	12.2	21.7	7.5	1.6
1982	45.6	6.8	29.8	16.0	0.1	-1.16	45.6	19.1	29.8	3.7	0.1
1983	48.5	8.5	26.2	15.5	1.8	-2.55	48.5	21.3	26.2	2.7	1.8
1984	44.5	1.9	42.7	6.6	5.0	-2.26	44.5	7.5	42.7	1.0	5.0
1985	73.1	0.1	24.9	1.8	0.3	-0.76	73.1	1.5	24.9	0.5	0.3
1986	64.4	2.9	23.1	4.8	3.1	-0.53	64.4	6.5	23.1	1.2	3.1
1987	66.2	0.3	26.5	8.7	0.9	-3.43	66.2	7.3	26.5	1.8	0.9
1988	73.4	0.4	36.3	5.1	0.6	-15.89	73.4	3.9	36.3	1.6	0.6
1989	49.0	0.3	42.4	10.5	0.7	-10.91	49.0	9.0	42.4	1.8	0.7
1990	64.1	0.3	36.9	4.6	0.1	-8.41	64.1	4.3	36.9	0.5	0.1
1991	60.7	2.3	27.5	5.4	1.9	-0.59	60.7	5.1	27.5	2.6	1.9
1992	61.2	0.2	33.8	2.2	0.2	-1.19	61.2	1.9	33.8	0.5	0.2
1993	58.7	0.3	28.7	9.1	1.3	-2.39	58.7	8.5	28.7	0.9	1.3
1994	57.0	9.1	18.3	14.3	1.7	-1.46	57.0	18.0	18.3	5.4	1.7
1995	56.9	0.2	23.8	8.5	8.4	-3.58	56.9	6.9	23.8	1.7	8.4
1996	66.5	0.3	32.7	2.1	0.2	-4.79	66.5	1.8	32.7	0.5	0.2
1997	60.4	7.7	15.9	5.8	9.8	-0.94	60.4	8.5	15.9	5.1	9.8
1998	75.0	3.9	17.8	1.7	0.8	-0.10	75.0	4.0	17.8	1.6	0.8
1999	71.2	0.6	34.7	0.6	0.2	-9.00	71.2	1.0	34.7	0.2	0.2
2000	65.8	0.1	33.0	1.0	0.1	-1.03	65.8	0.7	33.0	0.3	0.1
2001	61.6	3.4	22.1	10.6	0.7	-0.57	61.6	9.7	22.1	4.3	0.7
2002	58.0	3.1	28.6	5.6	2.1	-0.17	58.0	6.2	28.6	2.6	2.1
2003	56.0	3.5	30.4	9.6	1.5	-1.89	56.0	12.3	30.4	0.8	1.5
2004	67.7	2.9	21.9	6.0	0.8	-0.16	67.7	8.2	21.9	0.7	0.8
2005	59.1	0.4	28.7	6.4	3.9	-3.20	59.1	6.2	28.7	0.6	3.9
2006	41.3	0.3	29.1	24.5	5.2	-3.70	41.3	17.6	29.1	7.3	5.2
2007	61.9	0.2	35.8	1.5	0.5	-1.26	61.9	1.2	35.8	0.4	0.5
2008	64.1	0.4	37.5	0.9	1.7	-7.39	64.1	0.7	37.5	0.6	1.7
2009	61.9	2.8	27.7	4.8	0.3	-0.40	61.9	5.7	27.7	1.9	0.3
average	59.4	3.0	23.6	11.7	1.5	-1.01	59.4	6.9	23.6	8.2	1.5