The University of Texas at Austin

MEMO:

Comparison of Annual Naturalized Flows for the Rio Grande/Rio Bravo Basin

TCEQ - CONAGUA

by

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ABSTRACT

Naturalized flows are estimations that represent the streamflow in a river basin in the absence of human development and water use. For the Rio Grande/Rio Bravo, two sets of naturalized flows are available, one from the Texas Commission on Environmental Quality (TCEQ) and other from the National Water Commission of Mexico (CONAGUA). The TCEQ naturalized flows are calculated in monthly time steps and they include data for U.S. and Mexican tributaries. CONAGUA naturalized flows are calculated in yearly time steps and they include data for the mainstream of the Rio Grande and for the Mexican tributaries, naturalized flows for U.S. tributaries are not calculated. The objective of this report is to describe and compare both naturalized flows datasets. Comparison between both datasets is performed by the Wilcoxon Rank Sum statistical test. This statistical test is selected because it can be applied to non-normal distributed samples, which is the case of both datasets. The objective of this test is to determine if both samples have the same probability distribution function and thus, both data are similar enough to conclude they come from the same population. In addition, the Hodges-Lehmann estimator is used to quantify the magnitude of the difference between two groups. In 27 control points was possible the comparison between both datasets. Results from the statistical test show that in most of the basin, 21 control points, the distribution of the values in both dataset are similar enough to conclude both come from the same population (they are similar!). Thus the differences in the data used and the assumption considered are not significant enough to make both dataset different. In four of the six control points, where the statistical similarity cannot be proven, the reasons of non similarity can be attributed to differences in the naturalization process: plant uptake and conveyance losses considerations as well as difference in the historical diversion data. For two control points, Rio Nadadores at Progreso and Rio Pesqueria at Los Herrera, both distributions seem very different and further analysis is necessary to determine which dataset is correct, but for most of the naturalized flows in the basin, the statistical similarity has been proven. Both datasets are already loaded and ready to use in the Rio Grande/Bravo WEAP model.

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1. INTRODUCTION

Naturalized flows are calculated to represent historical streamflow in a river basin in the absence of human development and water use (Danner et al, 2006). The process of flow naturalization includes gathering historical records of gage streamflow, diversions, reservoir storages, evaporation and operation, evaporation along the streams, evapotranspiration, and plant uptake, among others. Calculated naturalized flows may vary for the same control point depending on: (1) the time step considered (daily, monthly or yearly time steps); (2) the data available during the naturalization process (historical records of: streamflow gages, diversions, reservoir operations), and (3) the assumptions considered (including conveyance losses and/or plant uptake, etc.).

For the Rio Grande/Rio Bravo basin, two sets of naturalized flows are available, one from the Texas Commission on Environmental Quality (Brandes et al., 2003) and other from the National Water Commission of Mexico (CONAGUA, 2008). The TCEQ naturalized flows have been available since 2003 and they are used as inputs for the Water Availability Model (WAM) of the Rio Grande (Brandes 2003). This data set was calculated in monthly time steps and it includes data for U.S. and Mexican tributaries. Recently, in November 2008, CONAGUA made public the annual naturalized flows calculated for mean annual conditions in the Rio Bravo basin (CONAGUA, 2008). This data set was calculated in yearly time steps and it includes data for the mainstream of the Rio Grande and for the Mexican tributaries, naturalized flows for U.S. tributaries were not calculated. The objective of this report is to objectively describe and compare both naturalized flows datasets.

In the first part of this report, brief descriptions of the naturalized flows data sets of both TCEQ and CONAGUA are presented, along with the principles used and the assumptions made. In the second part a statistical test is described that was used to compare both data sets (for the annual flow in the Mexican tributaries): the Wilcoxon Rank Sum test. This statistical test was selected because it can be applied to non-normally distributed samples. Also the Hodges-Lehmann estimator is used to estimate the magnitude of the differences between the data sets. In the third part, the results for the statistical test are presented and conclusions are derived from the results. Appendix A show the plots of the annual naturalized flows of both datasets, Appendix B and C contains the TCEQ and CONAGUA annual naturalized flows, respectively, used in this analysis. In Appendix D one example of the Wilcoxon Rank Sum Test for the Rio San Juan is presented.

2. NATURALIZED FLOWS

2.1. TCEQ NATURALIZED FLOWS

A series of monthly, naturalized flows were calculated for the Rio Grande/Rio Bravo basin from El Paso to the Gulf of Mexico and along the major tributaries of the Pecos River and the Rio Conchos as part of the Texas Commission on Environmental Quality (TCEQ) Water Availability Modeling (WAM) project (Brandes, 2003). The WAM project utilizes naturalized streamflow in its simulations of water availability for water rights permits. The process of data collection and the methodology used to calculate the naturalized flow are detailed in the report by Brandes (2003). Naturalized flows were calculated for 43 points in the basin (Figure 1). These naturalized flows were calculated monthly for 61 years, over the period of January 1940 to December 2000. The 43 naturalized flow (called "control") points for the U.S. and Mexico are listed in Table 1 and Table 2, respectively.

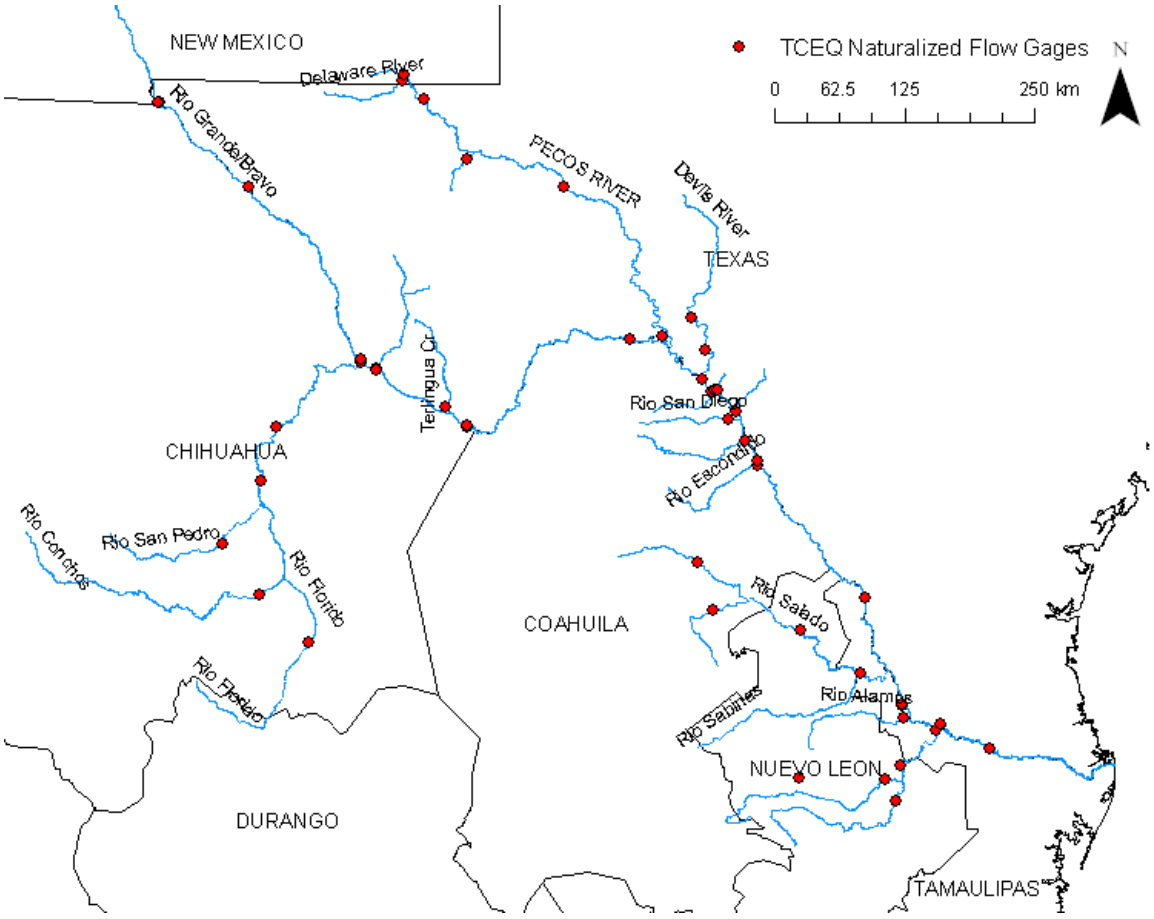

Figure 1: Location of TCEQ control points with naturalized flows

The TCEQ naturalized flow for various locations j = 1,..,43 in the basin, over period t = 1,...,732, with a variable number of upstream locations i, are calculated using the following equation (adapted from Wurbs, 2006)

$$NF_j^t = GF_j^t + \sum_{i=1\cdots?} D_{ij}^t - \sum_{i=1\cdots?} RF_{ij}^t + \sum_{i=1\cdots?} EP_{ij}^t + \sum_{i=1\cdots?} \Delta S_{ij}^t - \sum_{i=1\cdots?} Misc_{ij}^t; \quad j = 1,\cdots,43,\ t = 1,\cdots,732 \qquad (Eq.\ 1)$$

where:

NF_j^t = Naturalized flow in month t at station j

GF_j^t = Historical gaged flow in month t at station j

D_{ij}^t = Historical water diversions at site i upstream of station j and downstream of station j-1 in month t

RF_{ij}^t = Historical return flows at site i upstream of station j and downstream of station j-1 in month t

EP_{ij}^t = Historical reservoir evaporation at site i upstream of station j and downstream of station j-1 in month t

ΔS_{ij}^t = Historical changes in reservoir storage at site i upstream of station j and downstream of station j-1 in month t

$Misc_{ij}^t$ = Historical miscellaneous adjustments at site i upstream of station j and downstream of station j-1 in month t

Table 1: TCEQ Control Points With Naturalized Flows for the U.S.

CRWR_ID	HydroID	Name
AT1000PCP110	1040100174	Rio Grande at Fort Quitman, TX
AT2000PCP120	1030100007	Rio Grande at El Paso, TX
BT1000PCP130	1040100175	Rio Grande abv Rio Conchos, TX
CT1000PCP140	1080100377	Rio Grande at Del Rio
CT2000PCP150	1040100182	Devils R at Pafford Crossing nr Comstock, TX
CT2100PCP160	1040100181	Devils R nr Juno, TX
CT3000PCP170	1040100180	Rio Grande at Foster Ranch nr Langtry, TX
CT4000PCP180	1040100179	Rio Grande at Johnson Ranch nr Castolon, TX
CT5000PCP190	1040100178	Terlingua Ck nr Terlingua, TX
CT6000PCP200	1040100177	Rio Grande blw Rio Conchos, TX
CT7000PCP210	1040100176	Alamito Creek nr Presidio, TX
DT1000PCP220	1080100382	Rio Grande blw Falcon Dam
DT3000PCP230	1080100381	Rio Grande at Laredo
DT5000PCP240	1080100380	Rio Grande at Piedras Negras
DT8000PCP250	1080100379	Pinto Creek near Del Rio
DT9000PCP260	1080100378	San Felipe Ck near Del Rio,TX
ET1000PCP270	1090100422	Rio Grande blw Anzalduas Dam
ET2000PCP280	1090100423	Rio Grande at Rio Grande City
GT1000PCP290	1070100119	Pecos R nr Langtry, TX
GT2000PCP300	1070100118	Pecos R nr Girvin, TX
GT3000PCP310	1070100117	Pecos River Nr Orla Tx
GT4000PCP320	1070100115	Delaware R nr Red Bluff, NM
GT5000PCP330	1070100116	Pecos R. at Red Bluff, NM

Table 2: TCEQ Control Points With Naturalized Flows for Mexico

CRWR_ID	HydroID	NAME
EM4000PCP360	2060100002	Rio Alamo at Cd. Mier
EM3300PCP340	2060100003	Rio Salinas at Cienega de Flores
EM3200PCP330	2060100004	Rio Pesqueria at Los Herrera
EM3400PCP350	2060100005	Rio San Juan at El Cuchillo
EM3100PCP320	2060100006	Rio San Juan at Los Aldamas
EM3000PCP310	2060100007	Rio San Juan at Camargo
DM9500PCP280	2050100015	Arroyo de la Vacas at Cd. Acuna
DM7000PCP270	2050100016	Rio San Diego nr Jimenez
DM6000PCP260	2050100017	Rio San Rodrigo at El Moral
DM4000PCP240	2050100018	Rio Escondido at Villa de Fuente
DM2300PCP220	2040100009	Rio Sabinas at Sabinas
DM2200PCP210	2040100010	Rio Nadadores at Progreso
DM2100PCP200	2040100011	Rio Salado at Rodriguez
DM2000PCP190	2040100012	Rio Salado nr Las Tortillas
FM4000PCP400	2020100001	Rio San Pedro at Villalba
FM5000PCP410	2020100002	Rio Florido at Cd. Jimenez
FM3000PCP390	2020100003	Rio Conchos at Las Burras
FM2000PCP380	2020100004	Rio Conchos at El Granero
FM6000PCP420	2020100005	Rio Conchos at Presa La Boquilla
FM1000PCP370	2020100051	Rio Conchos at Ojinaga

When and where available, historical data were collected from both Texas and Mexican agencies for the calculation of naturalized flows. Historical streamflows were collected from multiple U.S. and Mexican agencies including the U.S. Geologic Survey (USGS), International Boundary Water Commission (IBWC) and Comisión Nacional de Agua (CONAGUA). Daily average historical streamflow were summed to create total monthly streamflows. Data on historical diversions include diversions for municipal, industrial, and irrigation uses, as well as the historical return flows, including returns from irrigation, industrial wastewater and municipal wastewater sources. Detailed descriptions of the data sources for these historical flows used in the TECQ calculations are contained in Sections 2.1, 2.6, 2.7, and 2.8 of Brandes (2003). For Mexico, the streamflow data used for the naturalization process was primarily obtained from the BANDAS (Banco Nacional de Datos de Aguas Superficiales) database (IMTA 2004). Water management data were provided for the TCEQ calculations by the regional CONAGUA office in Monterrey (Brandes, 2003). Sections 3.3 and 3.4 contain information about data use and assumptions for the naturalized flow calculations.

Changes in reservoir storage were calculated for major reservoirs, those having a storage capacity of 6.2 million m^3 (5,000 acre-ft) or greater. The changes in storage were calculated from historical records of reservoir storage volumes. The historical reservoir evaporation losses in Equation 1 are defined as the difference between evaporation and precipitation and they are adjusted to include the runoff that would have occurred in the absence of the reservoir.

Evaporation and precipitation rates in Texas were derived from the Texas Water Development Board (TWDB) one-degree quadrangle maps, which were developed using available data for precipitation and evaporation from the National Weather Service and the TWDB. Evaporation rates in Mexico were derived from historical pan evaporation rates and precipitation rates were collected from historical gaged rates. Runoff in the absence of the reservoir was estimated from a regression of historical streamflow and historical precipitation to create a runoff coefficient. Section 1.2 of Brandes (2003) details the methodology for calculating the reservoir evaporative losses, Section 2.5 describes the evaporation data, and Section 2.3 describes the reservoir storage data.

The miscellaneous adjustment term shown in Equation 1 refers to streamflow additions such as spring flow. Spring flows with significant contributions to streamflow were removed from the naturalized flows and accounted for as separate sources in the WAM process. Spring flow adjustments are discussed in Sections 2.2 and 3.1 (Brandes 2003).

2.1.1. CONVEYANCE LOSSES

Channel loss factors were calculated to represent losses due to channel seepage, evaporation, evapotranspiration and other unaccounted for losses. Channel loss factors were used to translate upstream flow adjustments, such as diversions or return flows, to the downstream end of a reach during the calculation of naturalized flows.

Channel seepage was determined by the analysis of previous studies of the geology and hydrogeology for the Rio Grande/Bravo basin (Brandes 2003). However, when previous studies on channel losses were not available, new channel losses were estimated. An analysis of the historical gaged streamflows, taking into account losses due to evaporation and plant uptake, was completed by subtracting upstream gaged streamflow values from downstream gaged streamflow values for a reach. This analysis was completed with streamflows that occurred during the non-irrigation season (October through March). This time period was selected because it minimized diversions and irrigation return flow related, minimized evapotranspiration and evaporation. During the non-irrigation season, temperatures are lower leading to lower evaporation and evapotranspiration rates than at other times of the year when temperatures are higher. With these three factors at their minimum values, the loss calculated between gages is assumed to reflect channel losses due to seepage.

The total streamflow losses were adjusted to include evaporation and evapotranspiration. Evaporation rates in Texas were derived from the Texas Water Development Board (TWDB) one-degree quadrangle maps. Evaporation rates in Mexico were derived from historical pan evaporation rates. Evapotranspiration rates were calculated from estimates of salt cedar coverage and an annual consumption rate. The consumption rate was applied to either known area of salt cedar or an estimated area based on an assumed width of salt cedar growth along a specific reach. Section 3.6 of Brandes (2003) contains a detailed description of the channel loss calculations and data.

2.2. CONAGUA NATURALIZED FLOWS

A series of annual naturalized flows were calculated by CONAGUA for the Rio Grande/Rio Bravo main stream, from Fort Quitman to the Gulf of Mexico, and for the main Mexican tributaries, as part of the analysis to determine the mean annual water availability in the basin (CONAGUA 2008). The CONAGUA regional offices in Monterrey collected the data. The methodology used to calculate the naturalized flows is reported in the Mexican Official Norm NOM-011-CNA-2000 (SEMARNAT 2002). Naturalized flows were calculated for 37 points in the basin (Figure 2). These naturalized flows were calculated annually for 55 years, over the period of 1950 to 2004. The 37 naturalized control points for Mexico and along the Rio Grande/Rio Bravo are listed in Table 3.

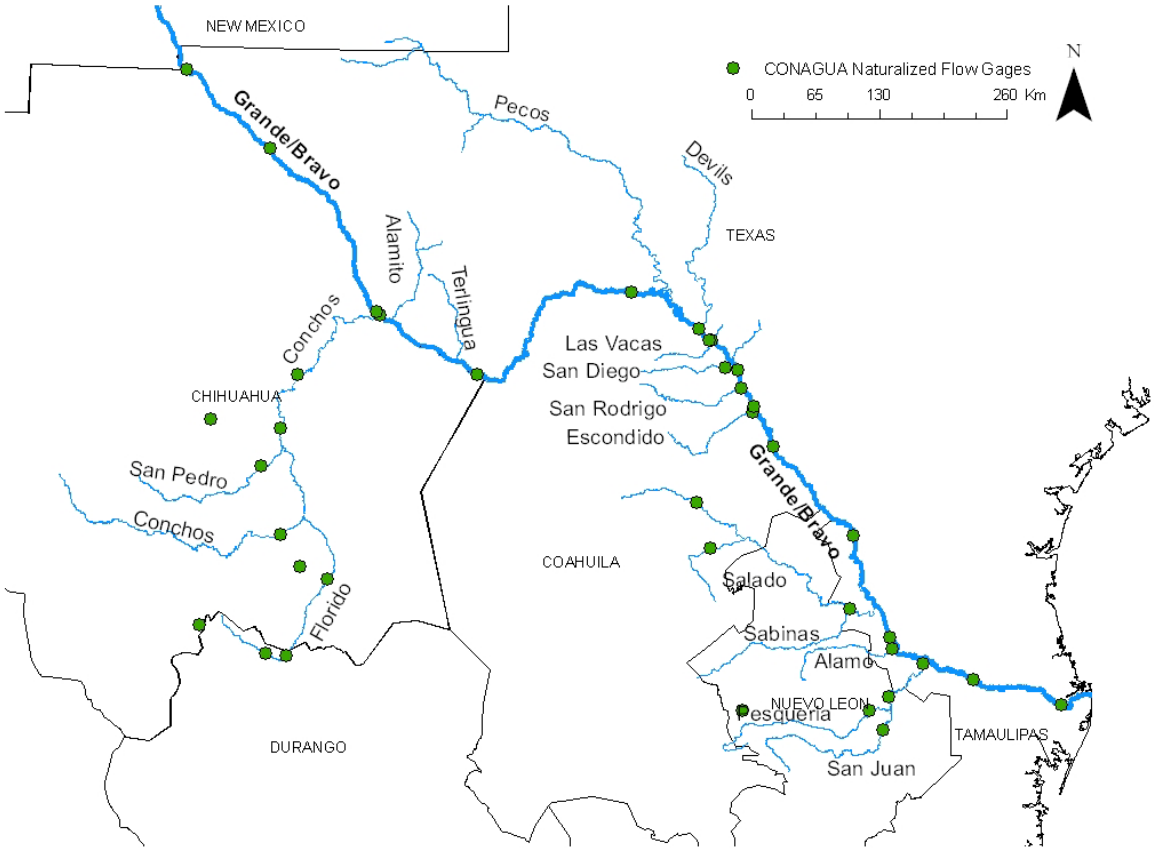

Figure 2: Location of CONAGUA control points with naturalized flows

Table 3: CONAGUA Control Points With Naturalized Flows

CONAGUA_ID	HydroID	NAME
1	104070000	Rio Bravo at Fort Quitman
2	104070000	Rio Grande above Rio Conchos near Presidio Texas
3	202010003	Rio Florido at San Gabriel
4	202010004	Rio Florido at San Antonio
5	202010001	Rio Florido at Jimenez
6	202080004	Bufalo, V. de Allende
7	202010003	Rio Balleza at Llanitos
8	202010000	Rio Conchos at Presa La Boquilla
9	202010001	Rio San Pedro at Presa Francisco I Madero
10	202090000	Rio Conchos at Las Burras
11	202080007	Rio Chuviscar
12	202010000	Rio Conchos at El Granero
13	202080009	Rio Conchos at Ojinaga
14	203010000	Rio Bravo at Johnson Ranch
15	203010000	Rio Bravo at Foster Ranch
16	203010000	Rio Bravo at Presa La Amistad
17	108070001	Rio Bravo Cd. Acuña
18	108070001	Arroyo las Vacas
19	205010001	Rio San Diego
20	108070002	Rio Bravo near Jimenez
21	108070002	Rio San Rodrigo at El Moral
22	108070002	Rio Bravo at Piedras Negras
23	108070002	Rio Escondido at Villa de Fuente
24	108070002	Rio Bravo near Villa Guerrero
25	108070002	Rio Bravo at Nuevo Laredo
26	204010000	Rio Sabinas at Sabinas
27	204010000	Rio Nadadores at Progreso
28	108070002	Rio Salado near Las Tortillas
29	108070003	Rio Bravo below Falcon
30	109070000	Rio Alamo at Cd. Mier
31	206090001	Rio Pesqueria at Icamole
32	206010004	Rio Pesqueria at Los Herrera
33	206010001	Rio San Juan at El Cuchillo
34	206010003	Rio San Juan at Los Aldamas
35	109070000	Rio San Juan at Camargo
36	207010001	Rio Bravo at Anzalduas
37	109070000	Rio Bravo at Matamoros

The CONAGUA naturalized flow for various locations j = 1, ..., 37 in the basin, over annual period t = 1, ..., 55, with a variable number of upstream locations i, are calculated using the following equation (adapted from SEMARNAT, 2002):

$$NF_j^t = GF_j^t - GF_{j-1}^t + \sum_{i=1\cdots?} D_{ij}^t - \sum_{i=1\cdots?} RF_{ij}^t + \sum_{i=1\cdots?} Ex_{ij}^t - \sum_{i=1\cdots?} \mathrm{Im}_{ij}^t ;$$

$$j = 1,\cdots,37,\ t = 1,\cdots,55 \quad Eq(2)$$

where:

NF_j^t = Naturalized Flow in year t at station j

GF_j^t = Historical gaged Flow in year t at station j

GF_{j-1}^t = Historical gaged Flow in year t at station upstream *j-1*

D_{ij}^t = Historical water diversions at site i upstream of station j and downstream of station *j-1* in year t

RF_{ij}^t = Historical return flows at site i upstream of station j and downstream of station *j-1* in year t

Ex_{ij}^t = Historical exportation of water to other basin at site i upstream of station j and downstream of station *j-1* in year t

$Im^t{}_{ij}$ = Historical importation of water from other basin at site i upstream of station j and downstream of station *j-1* in year t

For the naturalized flow calculations information about the main water users, such as irrigation districts, cities and big farmers, was provided by the CONAGUA regional office in Monterrey. All water users were considered in the naturalization process; including small agriculture users. For all the control points, historical records or documents were consulted to estimate the past water diversions for small irrigation water users. A linear relationship between the water use in 2004 and historical water use was developed to estimate the water use for small agricultural water users during the period of analysis. In some cases, the gradient was positive if the historic record showed a lower consumption in the past than in 2004; and in other cases the gradient was negative when records showed higher water use in the past than in 2004. No documentation was written in order to explain the criteria considered for these calculations.

3. STATISTICAL TESTING

3.1. WILCOXON RANK SUM TEST

In order to compare the differences or similarities in the two sets of annual naturalized flows, the Wilcoxon Rank Sum statistical test will be used. This statistical test was selected because it is a non-parametric test that can be applied to non-normally distributed samples, which is the case for both annual naturalized flows samples. The objective of this test is to identify if both samples are similar enough to say that they come from the same population. Statistical parametric characteristics such as the mean and the standard deviation may vary between the two samples, but with this test it is possible to identify if both samples come from the same source, or in our case, if both samples represent the same phenomena: Naturalized Flows.

The Wilcoxon Rank sum test is a non-parametric alternative to the two-sample *t*-test, which is based solely on the order in which the observations from the two samples fall. This test evaluates if both samples have the same probability distribution function (pdf): pdf(A) = pdf(B); which means that both samples come from the same population (Figure 3). Further explanation about this statistical test can be found in Hessel and Hirsch (2002) Chapter 5 Section 1.

Null Hypothesis: H_0: pdf(A) = pdf(B)

Both samples have the same pdf (come from the same population)

Alternative Hypothesis: H_1: pdf(A) ≠ pdf(B) (two sided test)

Both samples have different pdfs (come from different populations)

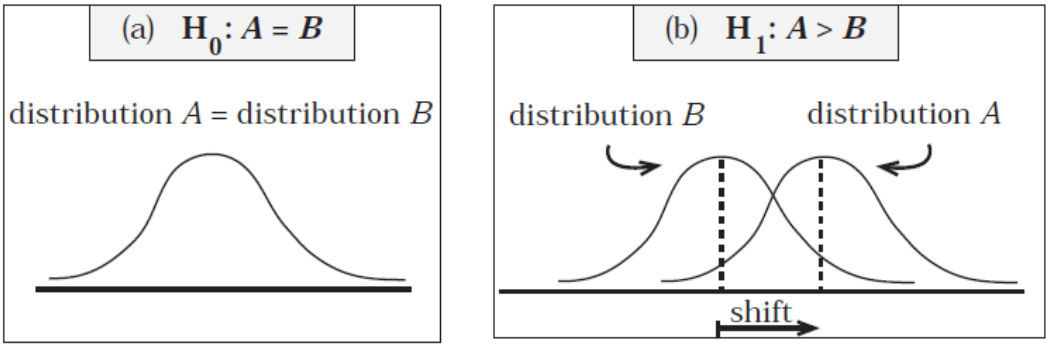

Figure 3: Illustration for the Null Hypothesis H_0: A = B versus H_1: A > B

For large samples (sample sizes greater than 10) with equal sample sizes, the following procedure is used to obtain the *p* value.

$$N = n + m$$

$$\mu_W = n * \frac{(N+1)}{2}$$

$$\sigma_W = \sqrt{n * m * \frac{(N+1)}{12}}$$

$$Z_{rs} = \begin{cases} \frac{W_{rs} - \frac{d}{2} - \mu_W}{\sigma_W} & if\ W_{rs} > \mu_W \\ 0 & if\ W_{rs} = \mu_W \\ \frac{W_{rs} + \frac{d}{2} - \mu_W}{\sigma_W} & if\ W_{rs} < \mu_W \end{cases}$$

$$P - value = \Phi(Z_{rs})$$

Where:

n	=	sample size of data set A
m	=	sample size of data set B
W_{rs}	=	sum of the ranks for sample A
d	=	width of time step, d=1 year
μ_W	=	mean of the ranks' sum (W_{rs})
σ_W	=	standard deviation of the ranks' sum (W_{rs})
$\Phi(\ \ )$	=	standard normal probability distribution
$P-$ value	=	measure how unlikely is the test is when H_0 is true

The Wilcoxon Rank Sum statistical test was performed for the TCEQ and CONAGUA naturalized flows dataset on an annual basis. The period of analysis selected was from 1950 to 2000, when data are available for both datasets. Appendix D shows an example of the calculations for the San Juan River at Camargo.

3.2. HODGES-LEHMANN ESTIMATOR - MEDIAN OF THE DIFFERENCES

One non-parametric estimate of the difference between two independent groups is a Hodges-Lehmann estimator $\hat{\Delta}$. The estimator is the median of all possible pairwise differences between two groups, in our case the TCEQ and CONAGUA naturalized flow groups. This estimator measures the magnitude of the differences between the two groups (Hessel and Hirsch 2002, Chapter 5 Section 5.4.1).

$$\hat{\Delta} = Median\ (D_t) = P_{50}(D_t);$$

where

$$D_t = TCEQ_t - CONAGUA_t$$

$TCEQ_t$	=	TCEQ annual naturalized flow for year *t*,
$CONAGUA_t$	=	CONAGUA annual naturalized flow for year *t*,

A positive value in the Hodges-Lehmann estimator suggests that the TCEQ flow values are larger than the CONAGUA flow values; on the contrary, a negative value of the estimator suggests that CONAGUA's flow values are larger than TCEQ's values.

4. STATISTICAL RESULTS

In this section the results of the Wilcoxon Ran Sum statistical test and the Hodges-Lehmann estimators are presented for the 27 control points where the comparison was possible. These control points were selected because the CONAGUA and TCEQ control points are at the same location, or the control points among datasets are close from each other.

Table 4 shows the results for the Rio Grande/Bravo streamflow. Results from the statistical test show that in all the cases, except of two stations above Ojinaga, the TCEQ and CONAGUA annual naturalized flows come from the same population, which means, they can vary in their specific values, or in the mean and variance of the sample, but the population probability distribution function is the same for both sets of flows. A positive value in the median difference column suggests that the TCEQ Naturalized flows values are larger than the CONAGUA naturalized flow values; on the contrary, a negative value in the median difference column represents that CONAGUA's naturalized flow values are larger than TCEQ's naturalized flows values.

Table 4: Rank Sum Test and Hodges-Lehmann Estimator Results for the Rio Grande/Rio Bravo Streamflow

Location	*p*-Value	α=0.05	Comment	Median Difference (MCM/year)
Between Fort Quitman and Ojinaga				
Rio Grande at Fort Quitman	0.000	<0.05	Reject H0	475
Rio Grande above Rio Conchos	0.000	<0.05	Reject H0	219
Between Ojinaga and Amistad				
Rio Grande at Johnson Ranch	0.534	>0.05	Do not Reject H0	-132
Rio Grande at Foster Ranch	0.154	>0.05	Do not Reject H0	-299
Between Amistad and Falcon				
Rio Grande at Del Rio	0.120	>0.05	Do not Reject H0	269
Rio Grande at Piedras Negras	0.076	>0.05	Do not Reject H0	338
Rio Grande at Laredo	0.211	>0.05	Do not Reject H0	163
Below Falcon				
Rio Grande below Falcon Dam	0.820	>0.05	Do not Reject H0	-328
Rio Grande below Anzalduas Dam	0.170	>0.05	Do not Reject H0	-860

Table 5 shows the results for rivers in the Rio Conchos basin. In this sub-basin results show that both data sets are very similar, in fact for all the control points compared, the data from both samples comes from the same population.

Table 5: Rank Sum Test and Hodges-Lehmann Estimator Results for the Rio Conchos Basin

Location	*p*-Value	α=0.05	Comment	Median Difference (MCM/year)
Rio Florido at Jimenez	0.056	>0.05	Do not Reject H0	-28
Rio Conchos at Presa La Boquilla	0.332	>0.05	Do not Reject H0	157
Rio San Pedro at Villalba	0.516	>0.05	Do not Reject H0	-26
Rio Conchos at Las Burras	0.952	>0.05	Do not Reject H0	18
Rio Conchos at El Granero	0.639	>0.05	Do not Reject H0	-114
Rio Conchos nr Ojinaga	0.134	>0.05	Do not Reject H0	-359

Table 6 shows the results for Arroyo Las Vacas creek, and San Diego, San Rodrigo and Escondido rivers. For Arroyo Las Vacas, San Diego and San Rodrigo, both dataset can be considered to come from the same distribution; the exception is Rio Escondido, where the test shows that the samples are different.

Table 6: Rank Sum Test and Hodges-Lehmann Estimator Results for Arroyo Las Vacas, San Diego, San Rodrigo and Escondido

Location	*p*-Value	α=0.05	Comment	Median Difference (MCM/year)
Arroyo Las Vacas	0.068	>0.05	Do not Reject H0	4
Rio San Diego at Jimenez	0.065	>0.05	Do not Reject H0	37
Rio San Rodrigo at El Moral	0.082	>0.05	Do not Reject H0	23
Rio Escondido at Villa de Fuente	0.006	<0.05	Reject H0	35

Table 7 shows the results for the Salado Basin. For this sub-basin the control points located along Rio Nadadores and Rio Salado at Tortillas showed there is not enough statistical evidence to conclude that they come from the same distribution. Specifically, for the Rio Salado at Tortillas, both data sets follow the same trend along time, but CONAGUA's values are offset above TCEQ's values, which mean CONAGUA's values were systematically bigger than TCEQ's values. This can be explained by the naturalization process followed by the two agencies, meanwhile TCEQ added the diversion for the most important water users in the basin (Irrigation districts and Municipal water users), CONAGUA included all water users (TCEQ users + Small Agriculture). This may explain the systematic offset of the CONAGUA's values compared to TCEQ's values.

Table 7: Rank Sum Test and Hodges-Lehmann Estimator Results for the Rio Salado Basin

Location	*p*-Value	α=0.05	Comment	Median Difference (MCM/year)
Rio Sabinas at Sabinas	0.703	>0.05	Do not Reject H0	-29
Rio Nadadores at Progresso	0.000	<0.05	Reject H0	-53
Rio Salado at Las Tortillas	0.032	<0.05	Reject H0	-177

Table 8 shows the results for the San Juan basin. The results show that for four control points the distributions of TCEQ's and CONAGUA's values are from the same population. In the Rio Pesqueria at Los Herrera, there is not enough statistical evidence to conclude that both data sets come from the same population.

Table 8: Rank Sum Test and Hodges-Lehmann Estimator Results for the San Juan Basin

Location	*p*-Value	α=0.05	Comment	Median Difference (MCM/year)
Rio Alamo at Cd. Mier	0.947	>0.05	Do not Reject H0	0
Rio Pesqueria at Los Herrera	0.000	<0.05	Reject H0	64
Rio San Juan at El Cuchillo	0.410	>0.05	Do not Reject H0	-56
Rio San Juan at Los Aldamas	0.080	>0.05	Do not Reject H0	152
Rio San Juan at Camargo	0.129	>0.05	Do not Reject H0	136

5. CONCLUSIONS AND RECOMMENDATIONS

This report presents an analysis of two naturalized flows datasets for the Rio Grande/Rio Bravo basin: TCEQ and CONAGUA for 27 control points. Results from the Wilcoxon Rank Sum statistical test showed that for 21 control points the distribution of the values is similar enough to conclude that both dataset come from the same population. These control points include stations along the Rio Grande/Rio Bravo main stream, the Rio Conchos, the Salado and San Juan basins, and along the rest of the tributaries. Both datasets are very similar for most of the basin and the differences in the data used and the assumptions made are not significant enough to make the datasets different. In fact, both datasets represent the naturalized flows in the basin.

Two control points are not similar: Fort Quitman and Above Ojinaga. In these cases the naturalization processes were different between the two agencies; TCEQ considered the plant uptake of salt cedar in this area, which is significant; CONAGUA did not consider this, which might be one of the reasons for the discrepancy. Also, the values for Rio Salado at Tortillas and for Rio Escondido at Villa Fuente are not statistically similar. Specifically for Rio Salado at Tortillas the CONAGUA values seem to be greater than TCEQ's values. This might be explained by the naturalization processes used by the agencies. Finally, for Rio Nadadores at Progreso and Rio Pesqueria at Los Herrera, both distributions seem to be completely different, further analysis is necessary at these locations.

For the TCEQ Dataset, the monthly data values used in the naturalization process for each of the control points should be studied to obtain a better understand of some of the considerations used in the process, such as the conveyance losses and the plant uptake in certain reaches. For the CONAGUA dataset, further refinement is necessary to estimate monthly flow values. Annual naturalized flows provide a rough idea of the volume, but do not properly represent the seasonal variation that the monthly values provide, which is important for the planning and management of the basin. Also, it is necessary to document the naturalization process and the assumptions used in estimating the CONAGUA naturalized flows. A bi-national, homogeneous set of naturalized flows should be developed for all US and Mexican tributaries in the basin. Monthly naturalized flows, important for water planning and management, are available only up to 2000; it is important to obtain monthly naturalized flows for more recent years.

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Appendix A. PLOTS OF TCEQ AND CONAGUA NATURALIZED FLOWS

A.1. RIO GRANDE/RIO BRAVO PLOTS

A.1.1. ABOVE OJINAGA

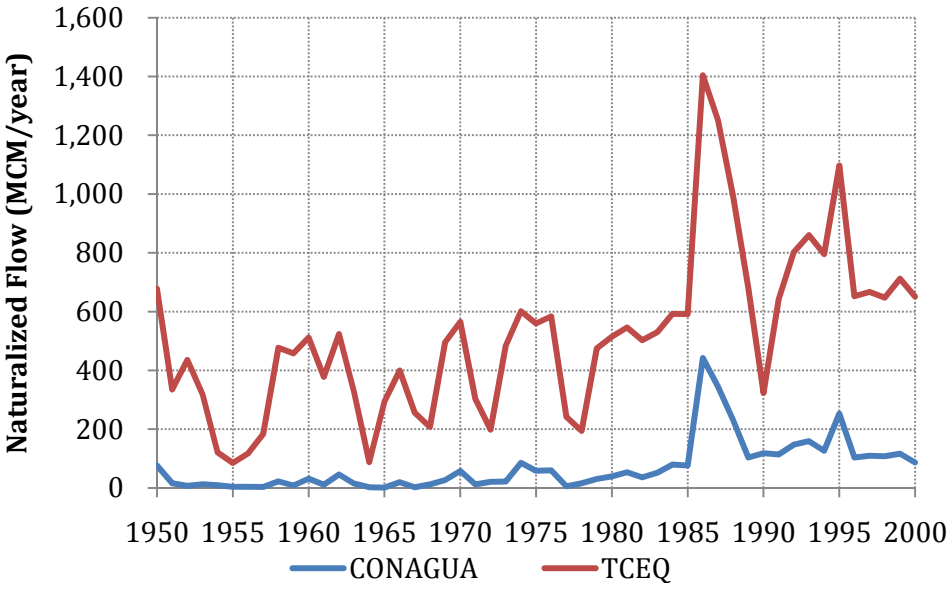

Figure A.1 - CONAGUA and TCEQ Naturalized flows; Rio Grande at Fort Quitman

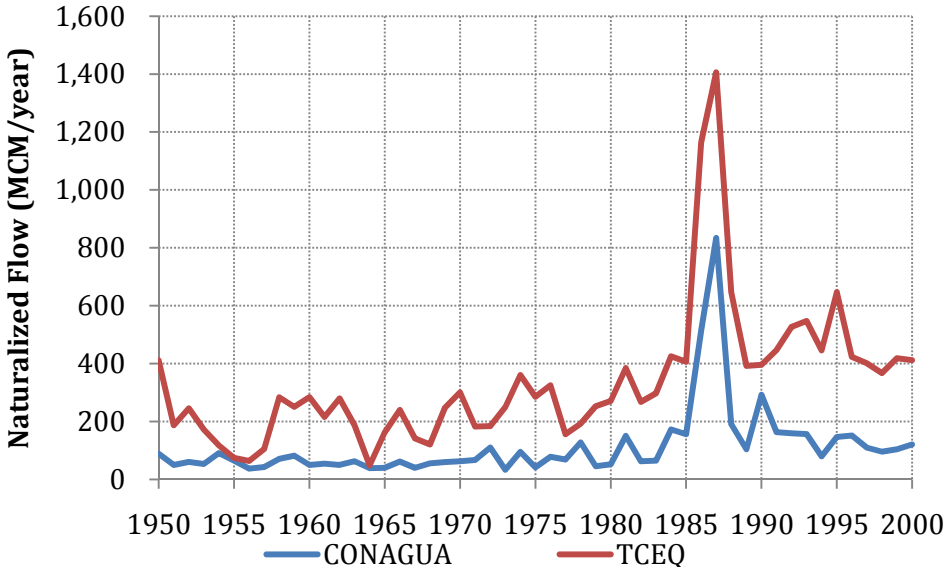

Figure A.2 - CONAGUA and TCEQ Naturalized flows; Rio Grande above Rio Ojinaga

A.1.2. BETWEEN OJINAGA AND AMISTAD

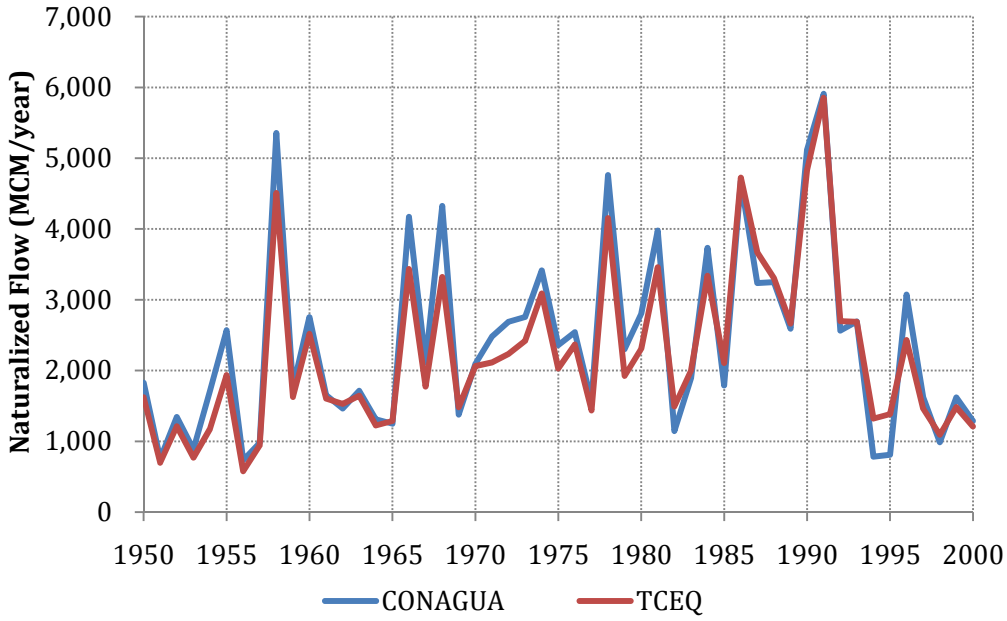

Figure A.3 - CONAGUA and TCEQ Naturalized flows; Rio Grande at Johnson Ranch

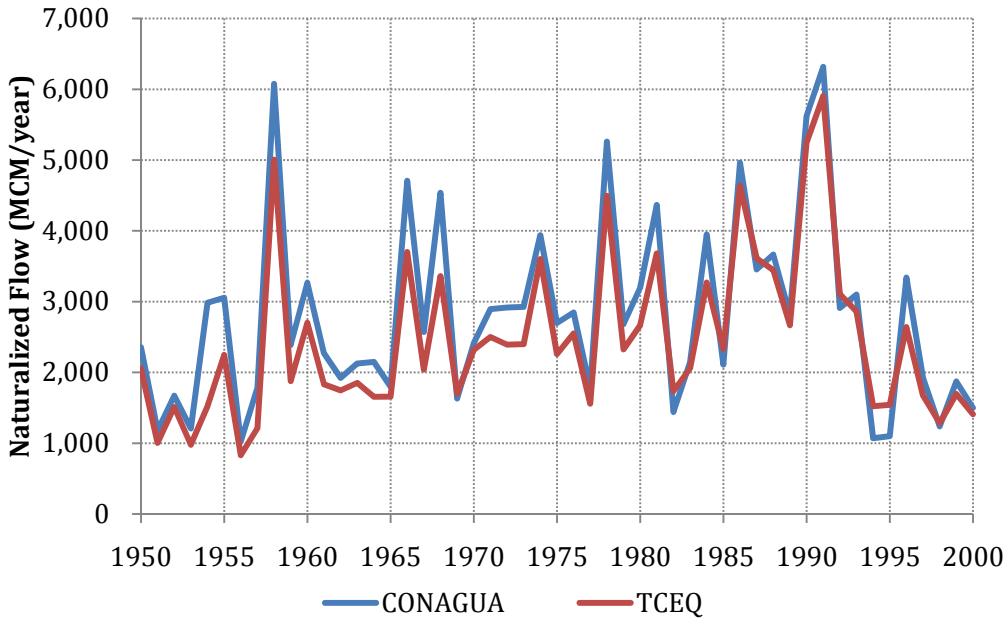

Figure A.4 - CONAGUA and TCEQ Naturalized flows; Rio Grande at Foster Ranch

A.1.3. BETWEEN AMISTAD AND FALCON

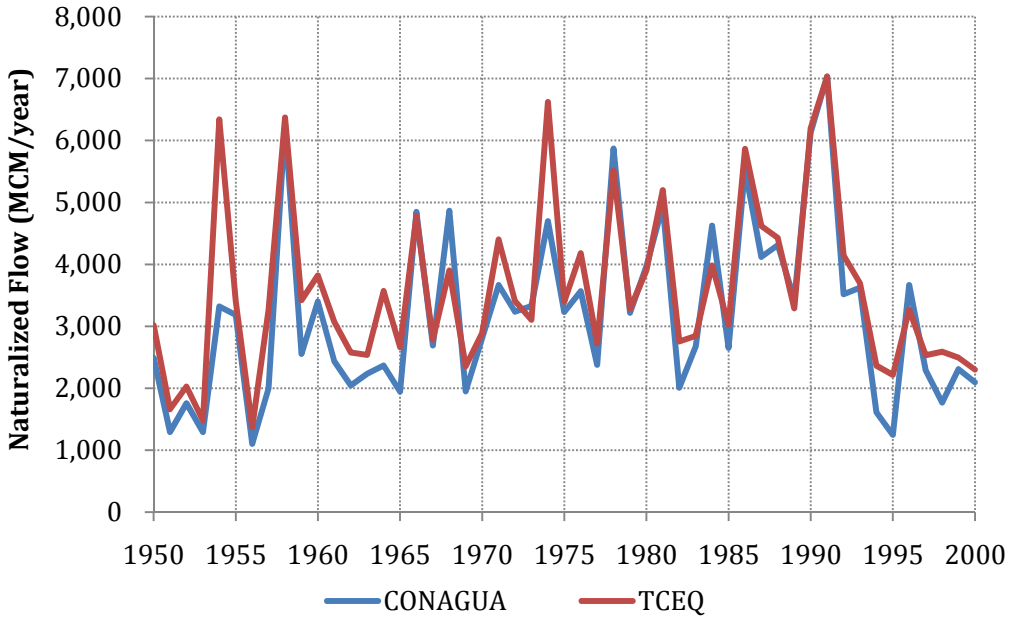

Figure A.5 - CONAGUA and TCEQ Naturalized flows; Rio Grande at Del Rio

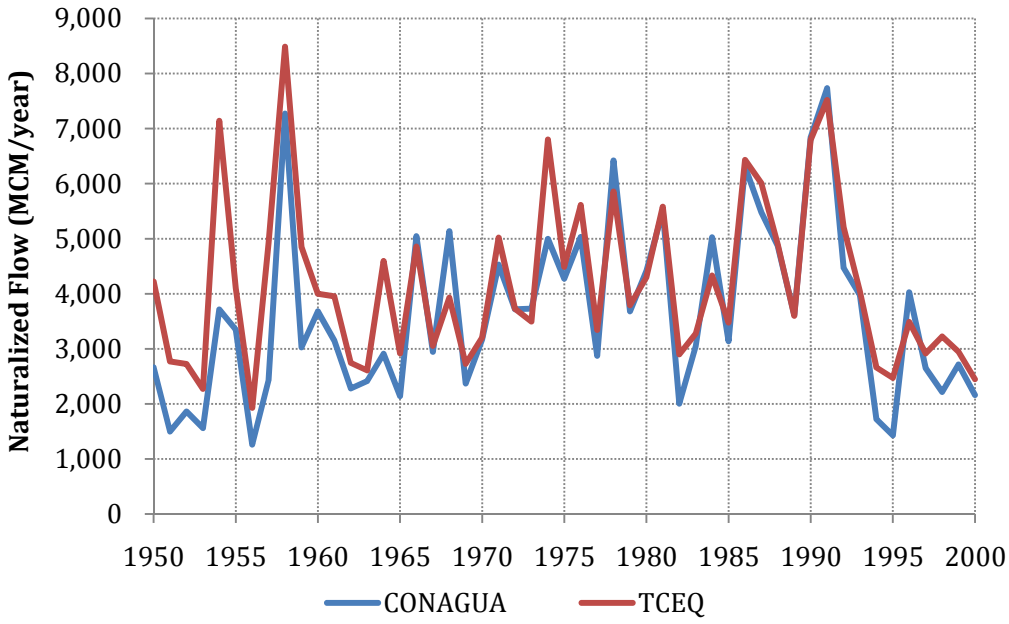

Figure A.6 - CONAGUA and TCEQ Naturalized flows; Rio Grande at Piedras Negras

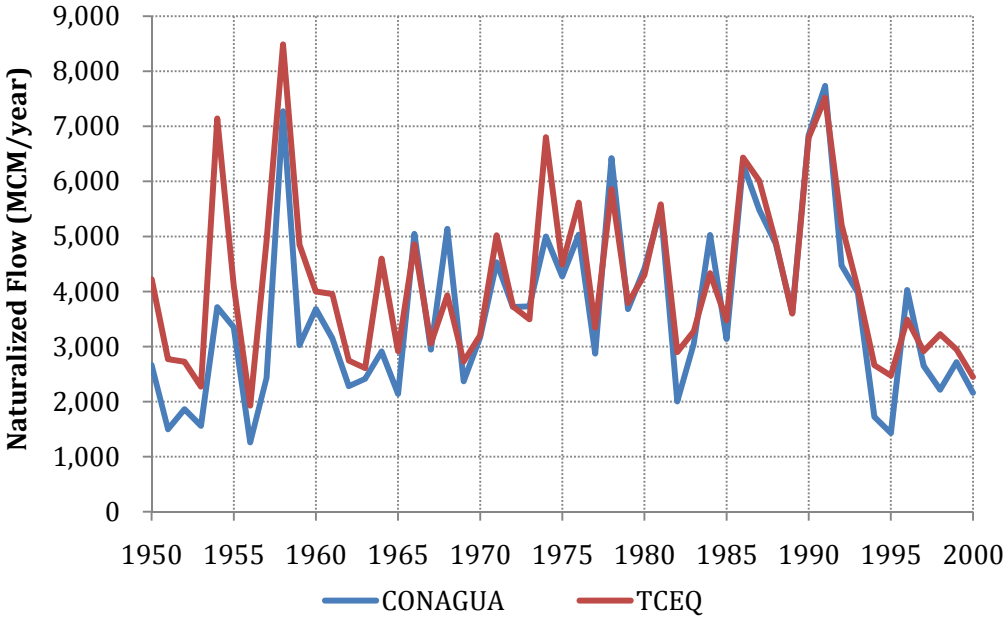

Figure A.7 - CONAGUA and TCEQ Naturalized flows; Rio Grande at Nuevo Laredo

A.1.4. BELOW FALCON

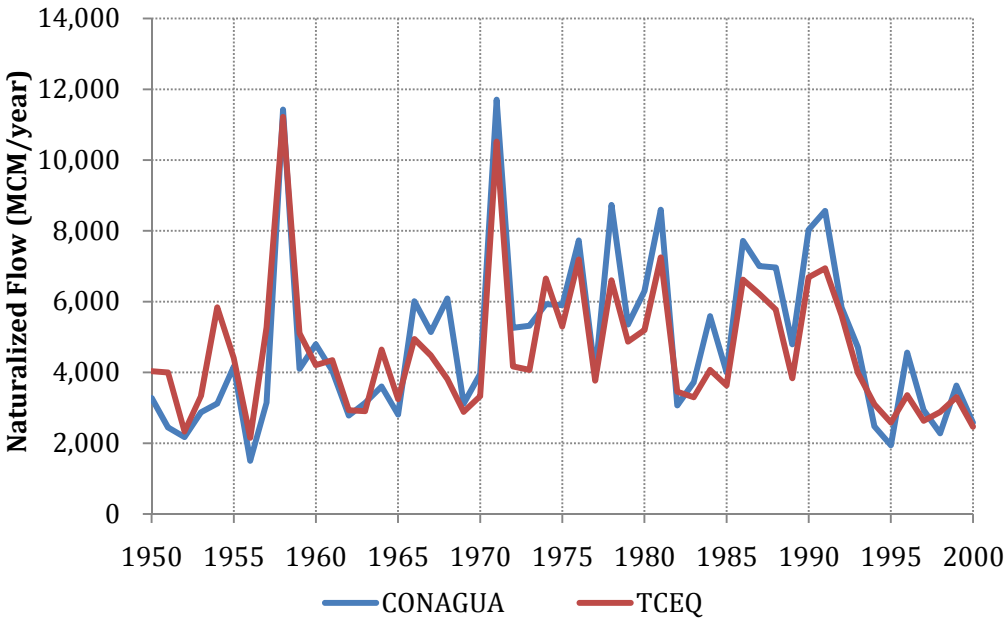

Figure A.8 - CONAGUA and TCEQ Naturalized flows; Rio Grande below Falcon

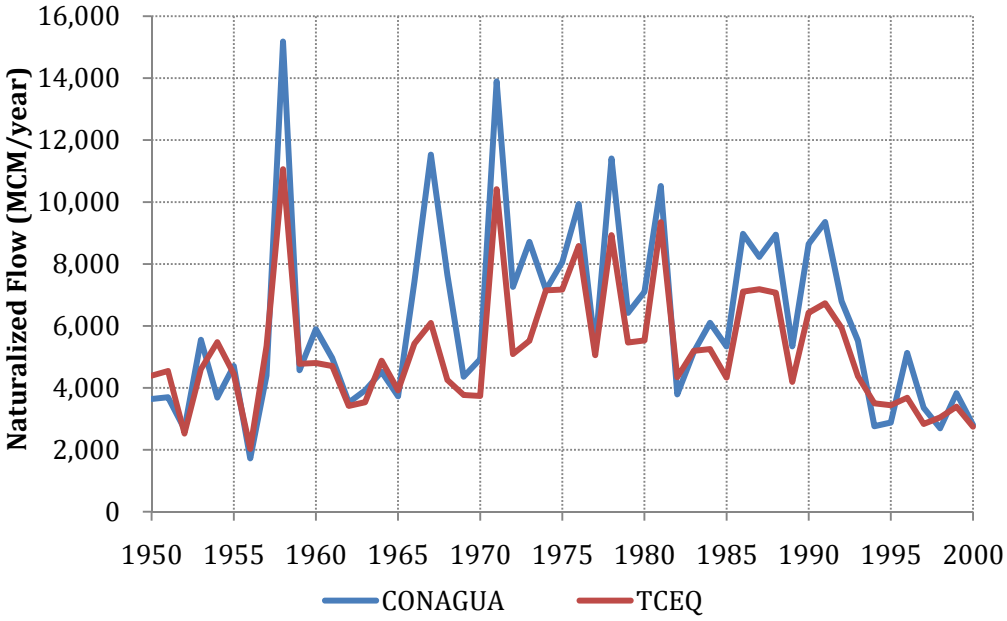

Figure A.9 - CONAGUA and TCEQ Naturalized flows; Rio Grande at Anzalduas

A.2. Rio Conchos Basin

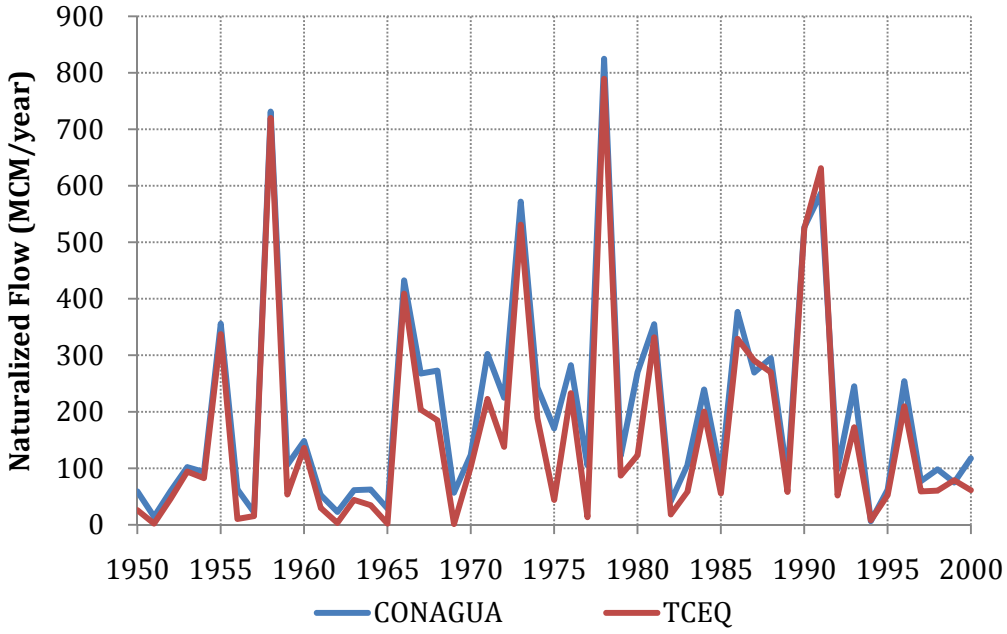

Figure A.10 - CONAGUA and TCEQ Naturalized flows; Rio Florido at Jimenez

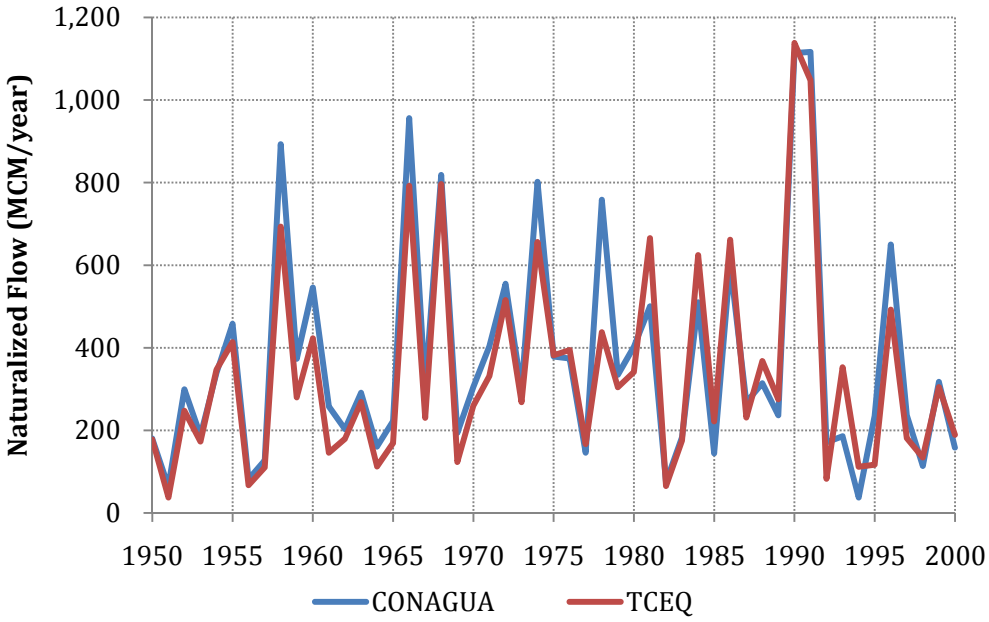

Figure A.11 - CONAGUA and TCEQ Naturalized flows; Rio San Pedro at Francisco I. Madero

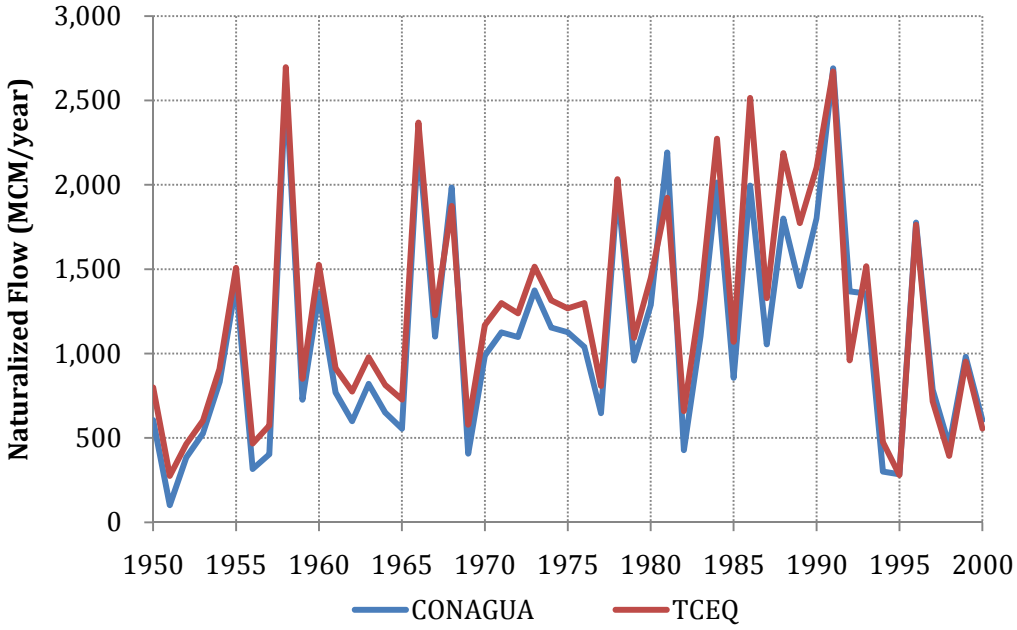

Figure A.12 - CONAGUA and TCEQ Naturalized flows; Rio Conchos at La Boquilla

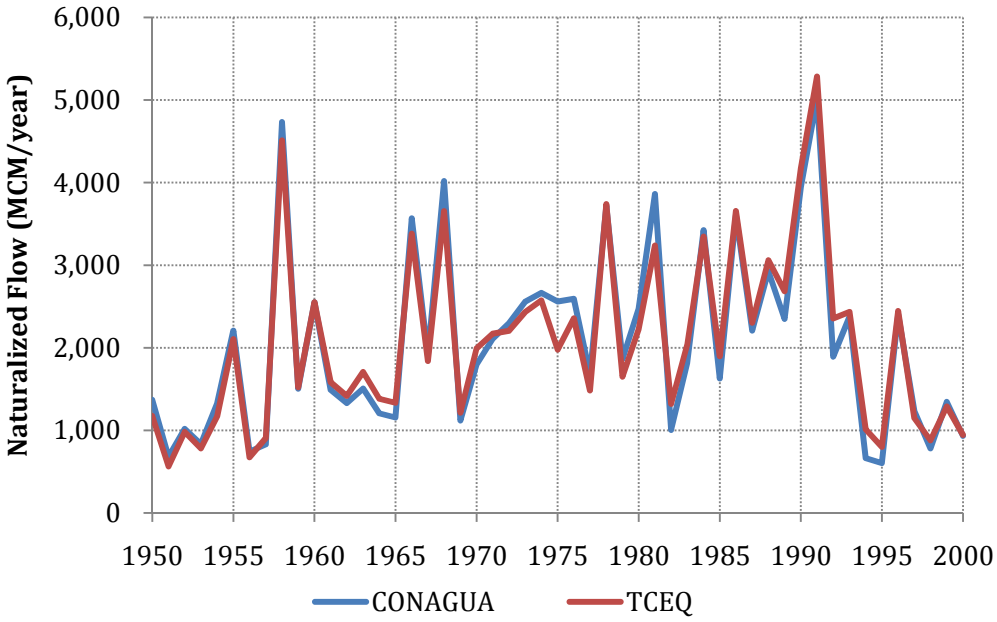

Figure A.13 - CONAGUA and TCEQ Naturalized flows; Rio Conchos at Las Burras

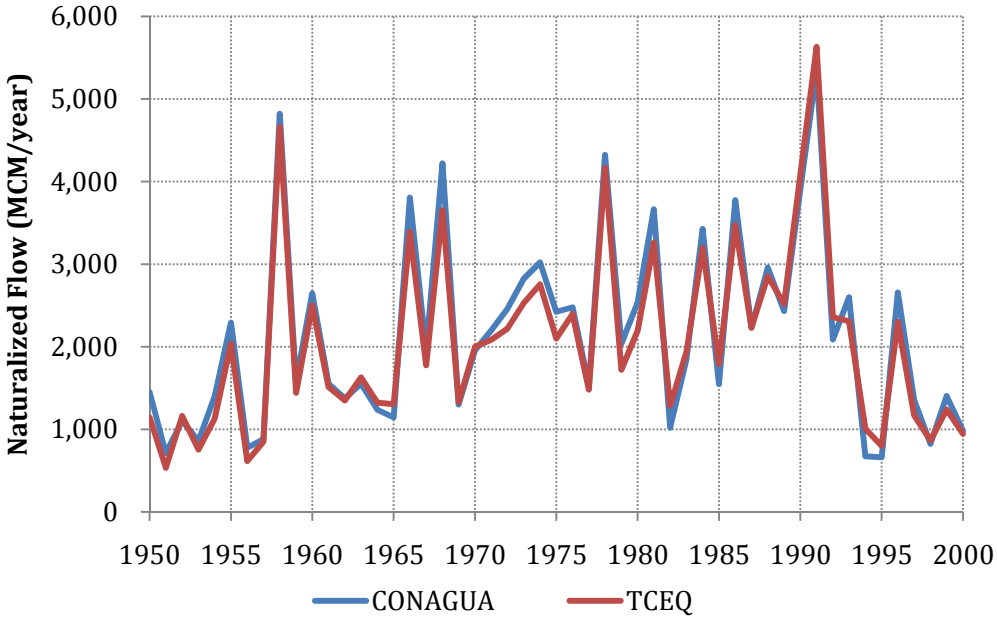

Figure A.14 - CONAGUA and TCEQ Naturalized flows; Rio Conchos at Luis L. Leon

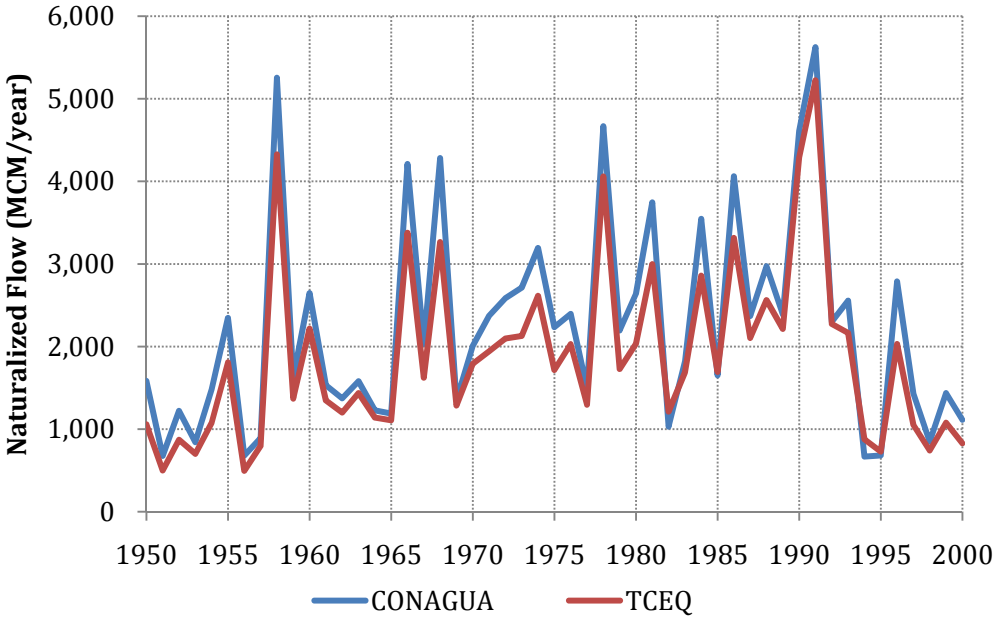

Figure A.15 - CONAGUA and TCEQ Naturalized flows; Rio Conchos at Ojinaga

A.3. FOUR TRIBUTARIES

A.3.1. ARROYO LAS VACAS

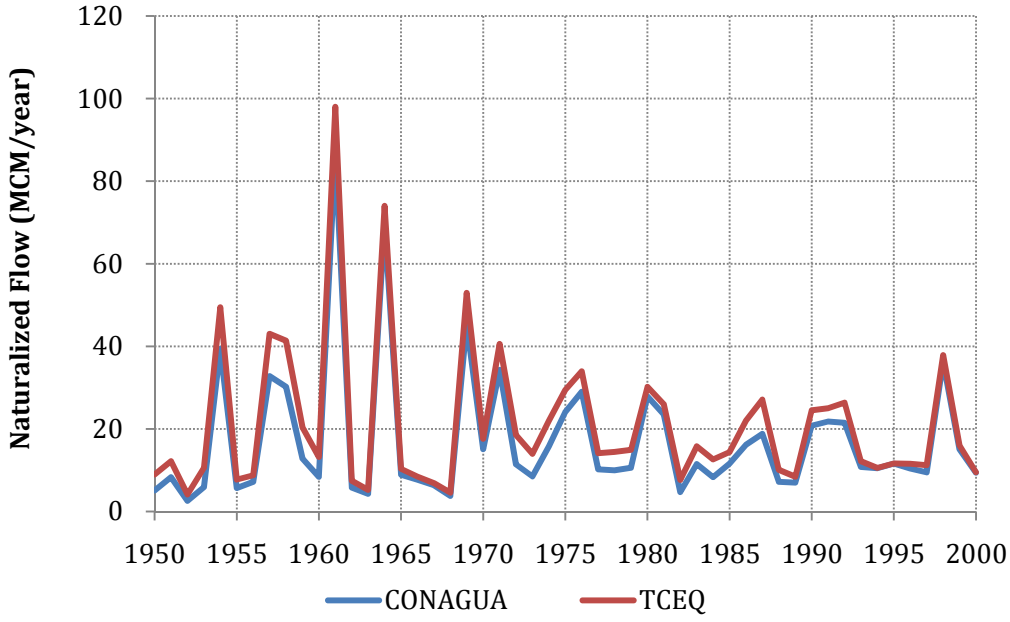

Figure A.16 - CONAGUA and TCEQ Naturalized flows; Arroyo Las Vacas

A.3.2.SAN DIEGO

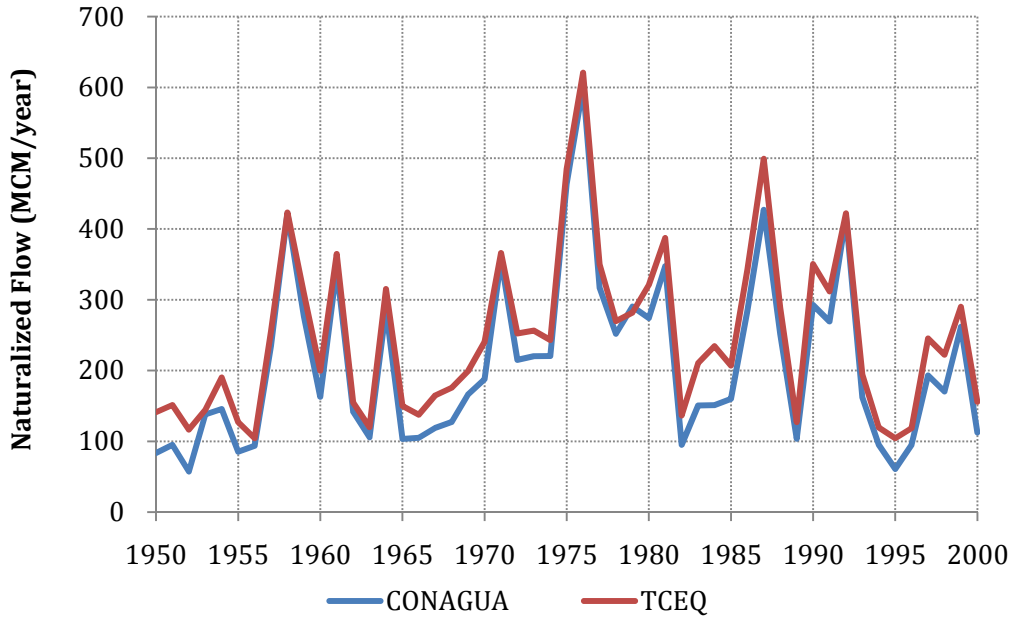

Figure A.17 - CONAGUA and TCEQ Naturalized flows; Rio San Diego

A.3.3. SAN RODRIGO

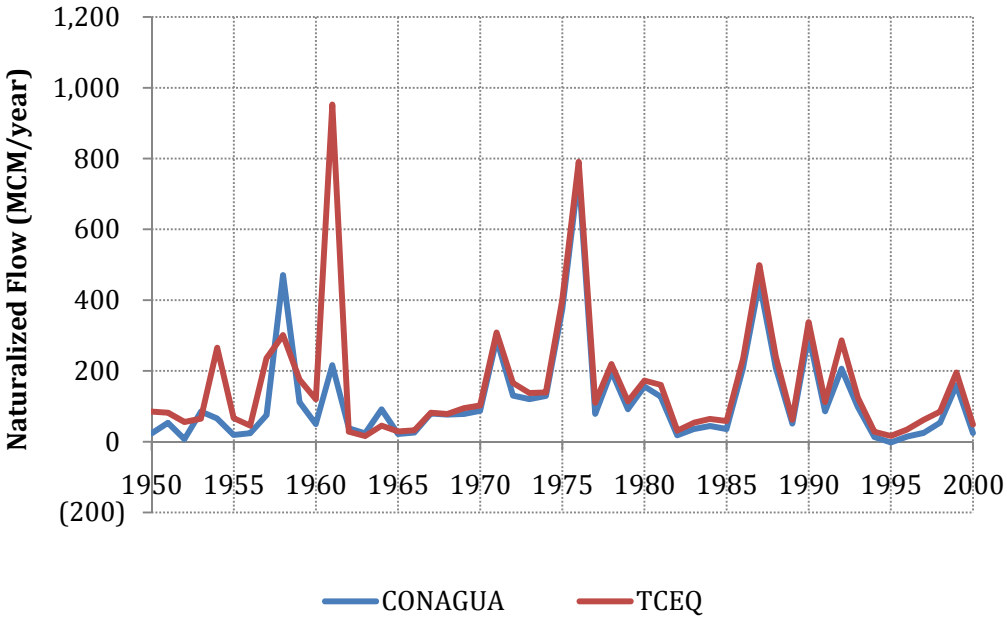

Figure A.18 - CONAGUA and TCEQ Naturalized flows; Rio San Rodrigo

A.3.4. Rio Escondido

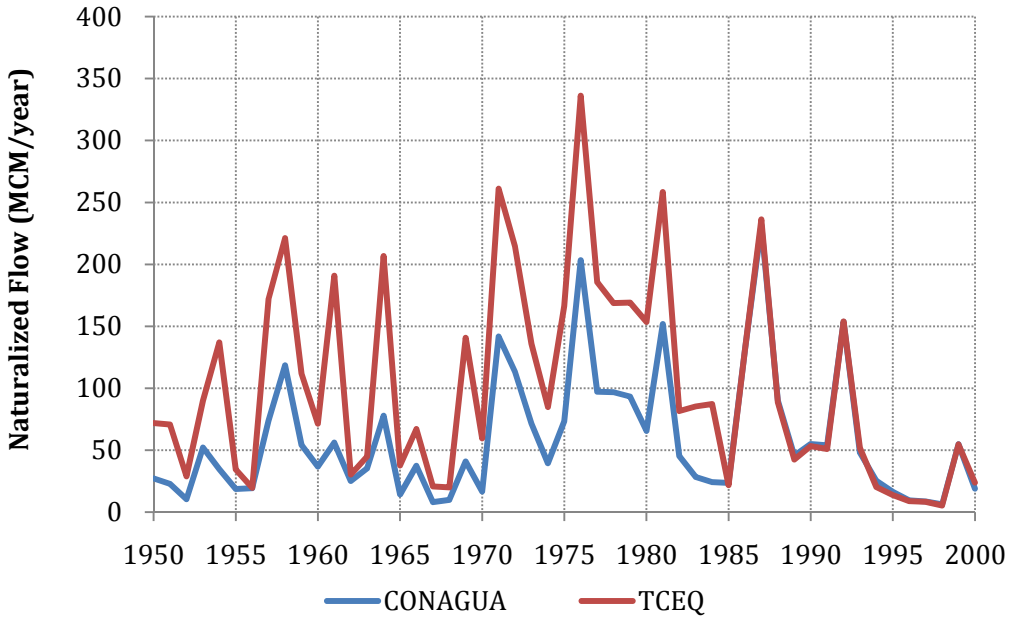

Figure A.19 - CONAGUA and TCEQ Naturalized flows; Rio Escondido

A.4. Rio Salado Basin

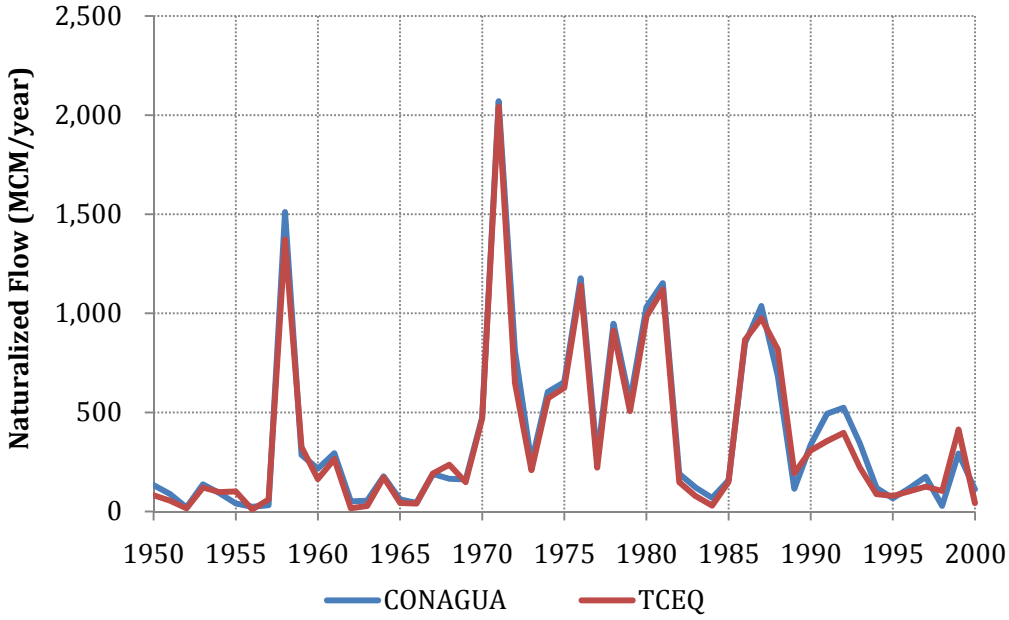

Figure A.20 - CONAGUA and TCEQ Naturalized flows; Arroyo Sabinas

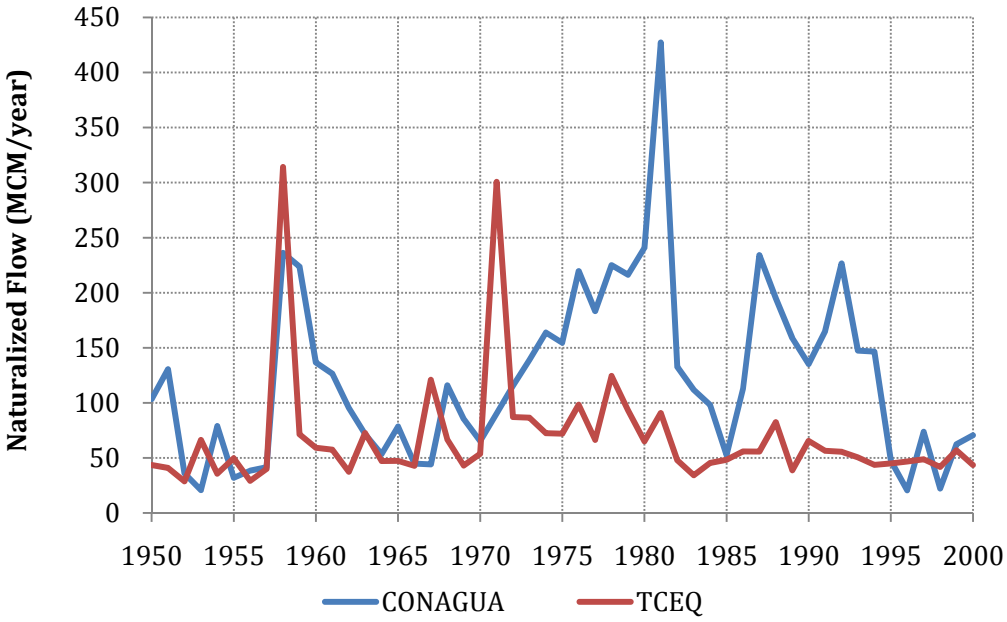

Figure A.21 - CONAGUA and TCEQ Naturalized flows; Rio Nadadores

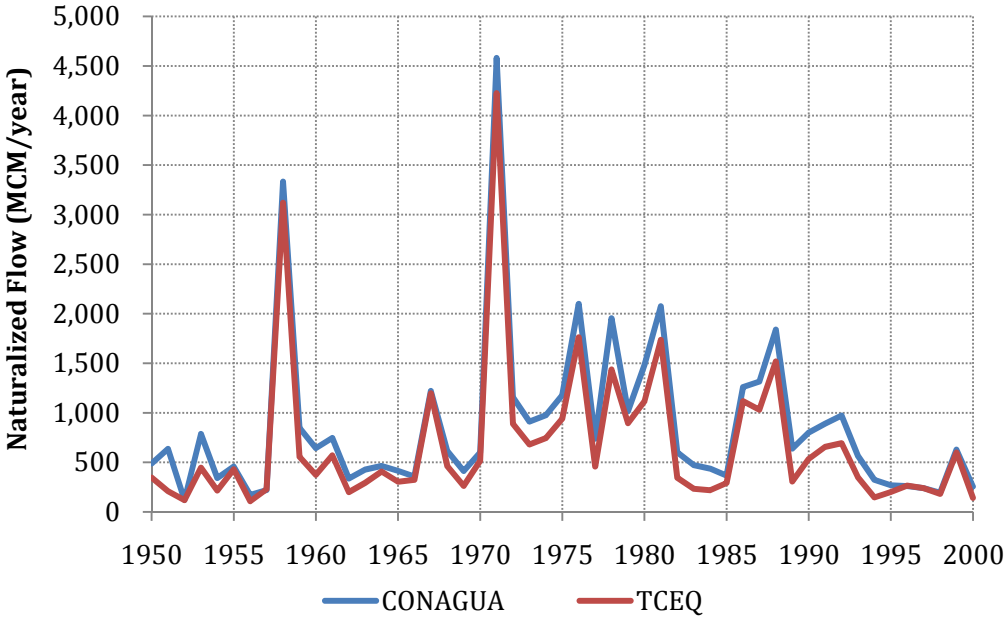

Figure A.22 - CONAGUA and TCEQ Naturalized flows; Rio Salado at Tortillas

A.5. RIO SAN JUAN BASIN

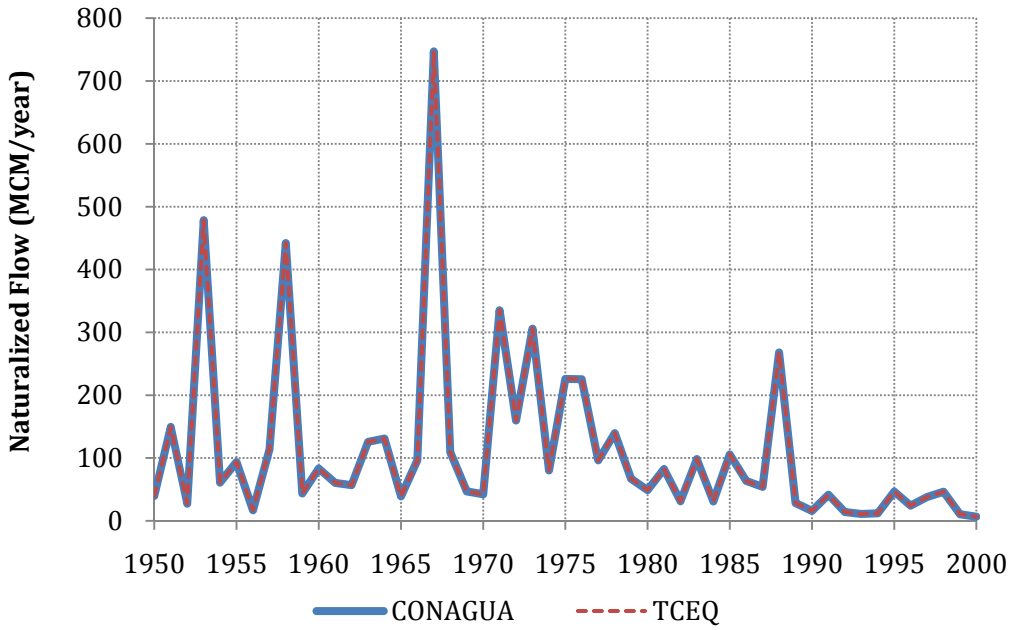

Figure A.23 - CONAGUA and TCEQ Naturalized flows; Rio Alamos

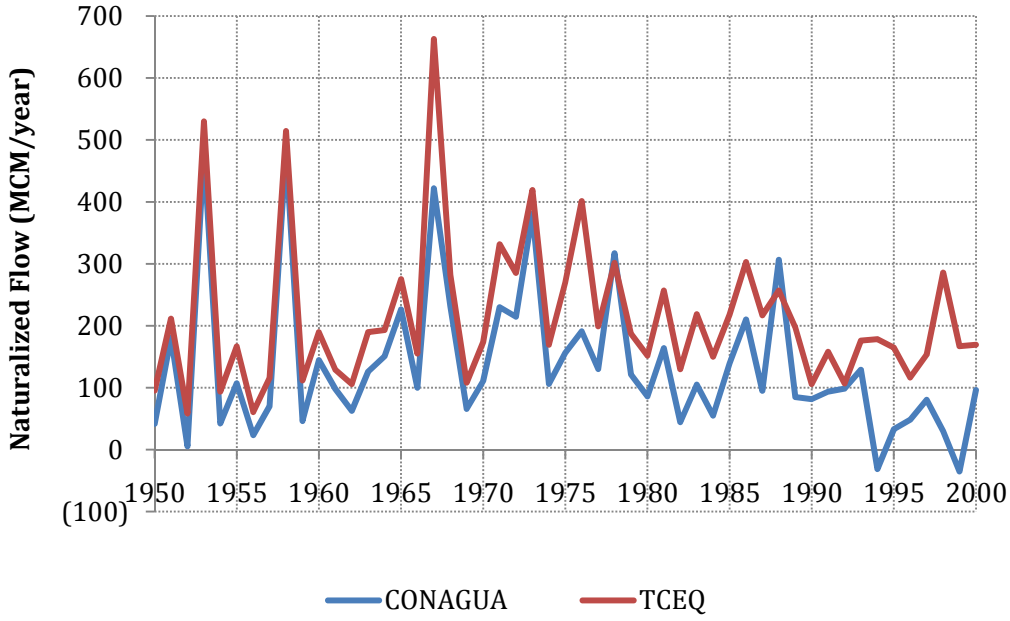

Figure A.24 - CONAGUA and TCEQ Naturalized flows; Rio Pesqueria at Los Herrera

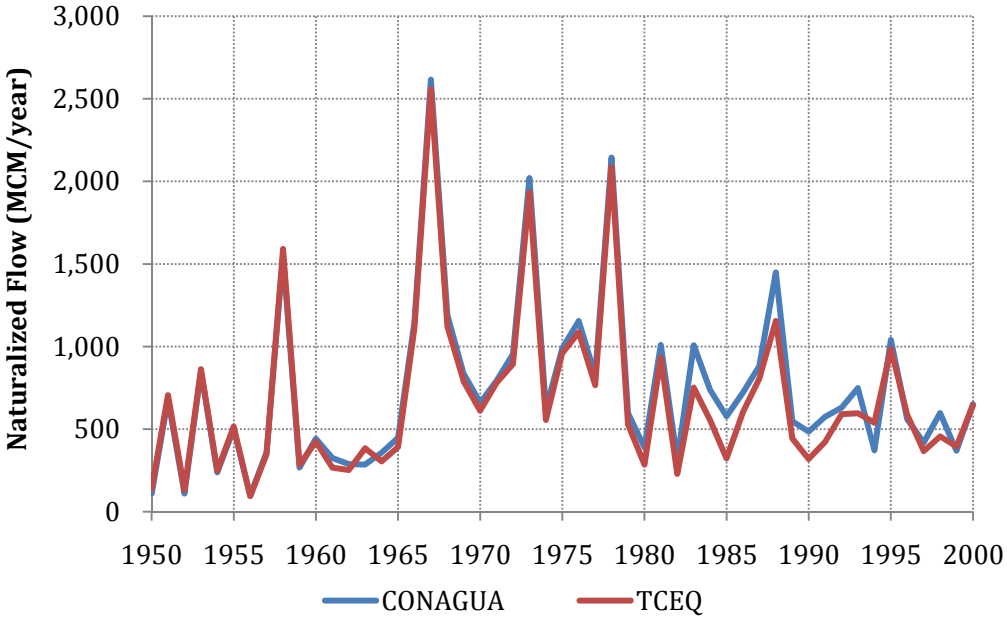

Figure A.25 - CONAGUA and TCEQ Naturalized flows; Rio San Juan at El Cuchillo

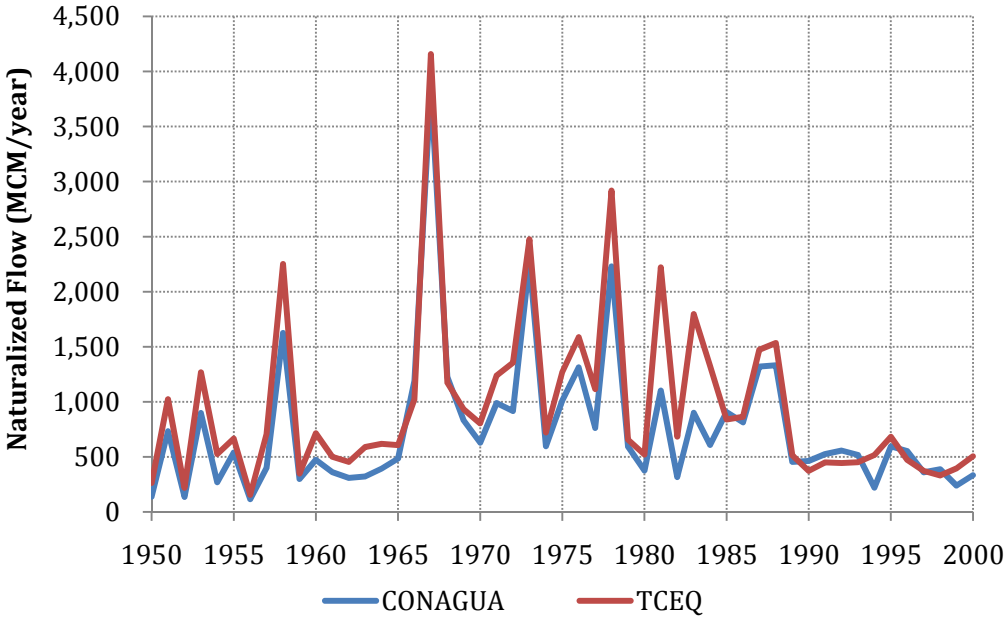

Figure A.26 - CONAGUA and TCEQ Naturalized flows; Rio San Juan at Los Aldama

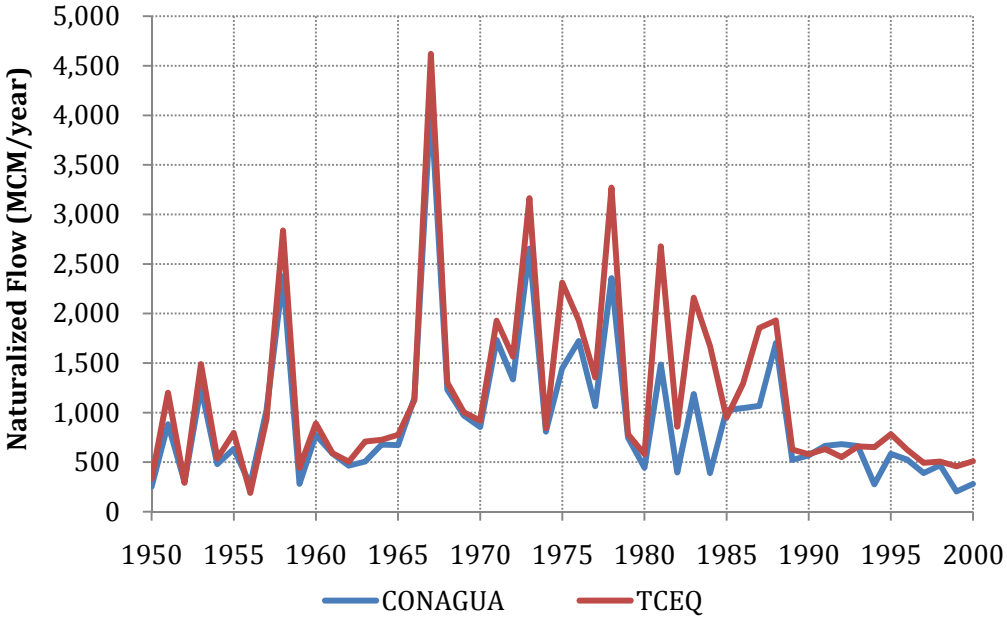

Figure A.27 - CONAGUA and TCEQ Naturalized flows; Rio San Juan at Camargo

Appendix B. TCEQ AND CONAGUA ANNUAL NATURALIZED FLOWS

B.1. TCEQ ANNUAL NATURALIZED FLOWS

Table B.1: TCEQ Control Points in the U.S. and along the Rio Grande/Rio Bravo

CRWR_ID	HydroID	Name
AT1000PCP110	1040100174	Rio Grande at Fort Quitman, TX
AT2000PCP120	1030100007	Rio Grande at El Paso, TX
BT1000PCP130	1040100175	Rio Grande abv Rio Conchos, TX
CT1000PCP140	1080100377	Rio Grande at Del Rio
CT2000PCP150	1040100182	Devils R at Pafford Crossing nr Comstock, TX
CT2100PCP160	1040100181	Devils R nr Juno, TX
CT3000PCP170	1040100180	Rio Grande at Foster Ranch nr Langtry, TX
CT4000PCP180	1040100179	Rio Grande at Johnson Ranch nr Castolon, TX
CT5000PCP190	1040100178	Terlingua Ck nr Terlingua, TX
CT6000PCP200	1040100177	Rio Grande blw Rio Conchos, TX
CT7000PCP210	1040100176	Alamito Creek nr Presidio, TX
DT1000PCP220	1080100382	Rio Grande blw Falcon Dam
DT3000PCP230	1080100381	Rio Grande at Laredo
DT5000PCP240	1080100380	Rio Grande at Piedras Negras
DT8000PCP250	1080100379	Pinto Creek near Del Rio
DT9000PCP260	1080100378	San Felipe Ck near Del Rio,TX
ET1000PCP270	1090100422	Rio Grande blw Anzalduas Dam
ET2000PCP280	1090100423	Rio Grande at Rio Grande City
GT1000PCP290	1070100119	Pecos R nr Langtry, TX
GT2000PCP300	1070100118	Pecos R nr Girvin, TX
GT3000PCP310	1070100117	Pecos River Nr Orla Tx
GT4000PCP320	1070100115	Delaware R nr Red Bluff, NM
GT5000PCP330	1070100116	Pecos R. at Red Bluff, NM

Table B.2: TCEQ Control Points in the Mexico

CRWR_ID	HydroID	NAME
EM4000PCP360	2060100002	Rio Alamo at Cd. Mier
EM3300PCP340	2060100003	Rio Salinas at Cienega de Flores
EM3200PCP330	2060100004	Rio Pesqueria at Los Herrera
EM3400PCP350	2060100005	Rio San Juan at El Cuchillo
EM3100PCP320	2060100006	Rio San Juan at Los Aldamas
EM3000PCP310	2060100007	Rio San Juan at Camargo
DM9500PCP280	2050100015	Arroyo de la Vacas at Cd. Acuna
DM7000PCP270	2050100016	Rio San Diego nr Jimenez
DM6000PCP260	2050100017	Rio San Rodrigo at El Moral
DM4000PCP240	2050100018	Rio Escondido at Villa de Fuente
DM2300PCP220	2040100009	Rio Sabinas at Sabinas
DM2200PCP210	2040100010	Rio Nadadores at Progreso
DM2100PCP200	2040100011	Rio Salado at Rodriguez
DM2000PCP190	2040100012	Rio Salado nr Las Tortillas
FM4000PCP400	2020100001	Rio San Pedro at Villalba
FM5000PCP410	2020100002	Rio Florido at Cd. Jimenez
FM3000PCP390	2020100003	Rio Conchos at Las Burras
FM2000PCP380	2020100004	Rio Conchos at El Granero
FM6000PCP420	2020100005	Rio Conchos at Presa La Boquilla
FM1000PCP370	2020100051	Rio Conchos at Ojinaga

Table B.3: TCEQ Annual Naturalized Flows (million m^3/year)

Year	Control Point												
	A2000	A1000	B1000	CT7000	C6000	CT5000	C4000	C3000	CT2100	CT2000	CT1000	DT1000	DT3000
1940	635	666	419	20	20	12	1,345	1,628	77	202	2,688	4,501	3,382
1941	701	936	860	50	50	46	4,574	4,998	76	204	7,578	9,008	7,875
1942	1,977	2,213	1,800	16	16	10	5,026	5,301	127	332	6,910	7,912	7,402
1943	859	1,020	677	8	8	5	2,068	2,370	102	258	3,352	3,785	3,722
1944	832	1,037	680	36	36	15	2,232	2,499	91	212	3,367	6,059	4,040
1945	784	923	595	12	12	15	1,858	2,199	116	309	3,175	4,086	3,519
1946	677	728	472	13	13	16	1,712	2,053	114	373	3,127	4,918	3,950
1947	640	643	357	10	10	11	1,708	1,960	63	173	2,835	3,486	3,285
1948	602	589	310	8	8	27	932	1,218	327	517	2,868	4,550	3,885
1949	643	685	417	9	9	43	2,450	2,702	189	362	4,695	6,468	6,094
1950	649	678	411	12	12	74	1,782	2,056	162	216	3,015	4,034	4,086
1951	383	335	187	4	4	37	731	1,004	83	81	1,659	3,999	2,894
1952	528	435	246	32	32	58	1,266	1,510	114	114	2,028	2,330	2,677
1953	373	318	172	8	8	22	721	977	116	123	1,479	3,335	2,553
1954	146	121	117	14	14	29	1,248	1,520	172	217	6,340	5,838	6,913
1955	110	85	75	21	21	44	1,951	2,248	129	174	3,405	4,406	4,137
1956	145	117	64	8	8	21	560	831	104	150	1,372	2,156	2,042
1957	233	184	105	16	16	33	930	1,213	211	293	3,264	5,272	5,423
1958	539	477	284	44	44	108	4,527	5,005	228	342	6,372	11,217	8,308
1959	539	458	250	19	19	45	1,619	1,879	297	454	3,421	5,107	4,971
1960	539	512	284	14	14	71	2,453	2,701	86	199	3,823	4,205	4,172
1961	444	378	216	19	19	39	1,574	1,832	98	234	3,071	4,346	3,953
1962	539	524	280	37	37	46	1,490	1,747	61	153	2,578	2,931	2,649
1963	373	326	186	14	14	59	1,627	1,852	52	118	2,539	2,907	2,618
1964	123	88	48	14	14	42	1,196	1,656	349	486	3,570	4,645	4,750
1965	367	294	163	14	14	28	1,230	1,658	84	234	2,662	3,246	3,022
1966	453	400	240	29	29	111	3,397	3,702	62	211	4,780	4,945	4,934
1967	328	256	142	23	23	36	1,727	2,040	33	103	2,784	4,480	3,199
1968	375	207	121	29	29	50	3,193	3,361	29	89	3,902	3,812	3,706
1969	539	496	248	12	12	31	1,466	1,698	35	159	2,355	2,887	2,787

Table B.3 (Cont): TCEQ Annual Naturalized Flows (million m^3/year)

Year	Control Point												
	A2000	A1000	B1000	CT7000	C6000	CT5000	C4000	C3000	CT2100	CT2000	CT1000	DT1000	DT3000
1970	539	565	301	16	16	68	2,032	2,318	35	106	2,892	3,330	3,139
1971	353	303	183	46	46	101	2,124	2,502	445	746	4,403	10,522	6,319
1972	206	198	185	24	24	48	2,197	2,392	358	596	3,410	4,172	3,674
1973	539	484	250	30	30	25	2,263	2,400	68	198	3,105	4,072	3,558
1974	539	601	361	87	87	128	3,119	3,603	647	872	6,621	6,651	6,662
1975	539	560	286	5	5	21	1,955	2,259	147	333	3,393	5,296	4,794
1976	557	584	325	10	10	53	2,286	2,550	343	598	4,180	7,192	6,120
1977	291	242	156	5	5	29	1,383	1,560	154	381	2,725	3,770	3,629
1978	220	194	193	9	9	75	4,044	4,494	128	309	5,516	6,605	5,717
1979	539	475	253	7	7	41	1,965	2,326	122	284	3,278	4,870	4,148
1980	539	514	271	15	15	59	2,302	2,666	156	297	3,908	5,196	4,402
1981	539	546	385	13	13	77	3,325	3,682	180	512	5,200	7,248	5,845
1982	539	502	268	3	3	27	1,452	1,734	134	314	2,754	3,456	3,098
1983	539	531	298	4	4	20	1,829	2,058	81	217	2,847	3,300	3,203
1984	539	592	425	18	18	55	3,095	3,270	59	145	3,983	4,070	4,118
1985	539	591	407	14	14	102	2,032	2,332	73	176	3,026	3,634	3,510
1986	1,344	1,404	1,164	23	23	114	4,396	4,637	149	482	5,865	6,620	6,394
1987	1,378	1,250	1,406	4	4	60	3,419	3,611	153	362	4,618	6,220	6,069
1988	758	992	647	6	6	22	3,066	3,446	181	359	4,426	5,775	4,898
1989	589	680	392	3	3	27	2,478	2,665	97	235	3,290	3,836	3,718
1990	545	323	396	34	34	135	4,788	5,247	345	558	6,199	6,691	6,988
1991	540	643	447	29	29	75	5,548	5,906	169	377	7,034	6,943	7,337
1992	644	802	527	2	2	15	2,778	3,107	193	439	4,146	5,614	5,609
1993	682	860	547	5	5	9	2,484	2,861	149	314	3,699	3,985	4,175
1994	690	795	446	1	1	3	1,249	1,522	100	234	2,365	3,099	3,101
1995	918	1,097	648	1	1	24	1,271	1,544	105	245	2,215	2,583	2,720
1996	611	652	423	33	33	37	2,409	2,641	69	161	3,269	3,356	3,465
1997	656	667	401	2	2	13	1,395	1,673	102	251	2,533	2,636	2,662
1998	624	647	367	2	2	14	1,052	1,286	278	455	2,591	2,881	3,024
1999	626	712	419	5	5	40	1,467	1,698	94	216	2,495	3,301	2,957
2000	596	651	412	4	4	36	1,212	1,410	101	288	2,300	2,469	2,466

Table B.3 (Cont): TCEQ Annual Naturalized Flows (million m^3/year)

Year	Control Point									
	DT5000	DT8000	DT9000	ET1000	ET2000	GT1000	GT2000	GT3000	GT4000	GT5000
1940	2,871	7	50	5,220	5,525	225	111	138	8	125
1941	7,802	16	41	9,861	10,824	1,553	1,646	2,082	33	2,001
1942	6,767	3	46	8,503	9,332	363	457	597	9	576
1943	3,461	12	64	4,384	4,592	249	174	212	5	183
1944	3,473	8	54	9,911	10,730	301	120	175	7	148
1945	3,150	2	33	4,646	4,952	218	104	141	4	113
1946	3,500	7	33	5,498	5,917	211	111	123	6	116
1947	3,014	14	39	4,781	5,098	196	106	83	1	88
1948	3,819	77	62	5,182	5,601	454	112	119	3	118
1949	5,986	18	94	8,200	8,731	300	146	175	12	190
1950	4,220	3	69	4,396	4,625	471	151	205	14	201
1951	2,771	4	26	4,546	4,861	302	81	91	2	88
1952	2,725	3	40	2,525	2,756	243	75	45	14	32
1953	2,272	9	30	4,605	5,092	230	55	52	6	48
1954	7,142	19	60	5,477	6,280	387	137	231	28	233
1955	4,103	12	56	4,454	5,179	299	70	148	62	94
1956	1,930	12	46	2,028	2,350	166	23	33	2	23
1957	4,918	85	95	5,352	6,122	255	67	79	17	51
1958	8,488	63	104	11,059	12,711	463	111	190	18	182
1959	4,849	60	140	4,775	5,345	205	47	71	4	77
1960	4,000	12	119	4,801	5,086	174	95	149	8	146
1961	3,953	15	112	4,703	4,982	182	61	88	2	88
1962	2,746	3	78	3,417	3,522	181	58	83	2	78
1963	2,609	3	52	3,537	3,735	209	54	89	11	75
1964	4,596	65	92	4,875	5,344	673	37	51	1	49
1965	2,916	11	100	3,920	4,042	174	69	88	11	75
1966	4,859	14	86	5,428	5,846	193	166	314	36	346
1967	3,053	4	76	6,093	6,783	149	21	43	6	25
1968	3,930	2	67	4,254	4,437	173	36	47	13	32
1969	2,727	16	90	3,771	3,968	226	100	168	28	119

Table B.3 (Cont): TCEQ Annual Naturalized Flows (million m^3/year)

Year	Control Point									
	DT5000	DT8000	DT9000	ET1000	ET2000	GT1000	GT2000	GT3000	GT4000	GT5000
1970	3,208	8	95	3,739	4,055	140	55	94	6	78
1971	5,021	34	87	10,415	11,281	456	56	101	6	62
1972	3,727	20	116	5,091	5,297	205	60	95	7	86
1973	3,496	18	128	5,523	5,398	173	68	144	2	134
1974	6,802	10	114	7,151	7,401	1,412	174	227	10	230
1975	4,488	9	128	7,174	7,223	306	44	57	4	59
1976	5,613	18	119	8,582	9,063	350	28	47	4	14
1977	3,344	18	128	5,057	5,139	222	25	36	2	26
1978	5,859	6	122	8,930	9,774	267	102	182	30	108
1979	3,792	5	116	5,464	5,555	245	43	84	9	62
1980	4,301	1	75	5,530	5,625	237	73	101	12	92
1981	5,581	8	100	9,351	9,495	423	54	72	7	55
1982	2,899	13	114	4,342	4,270	201	39	59	4	54
1983	3,278	12	123	5,195	5,536	166	35	54	4	57
1984	4,333	7	104	5,252	5,633	163	73	131	10	131
1985	3,477	6	92	4,330	4,453	157	43	91	5	97
1986	6,433	8	87	7,105	7,724	410	165	290	17	325
1987	6,008	79	115	7,182	7,818	292	152	186	8	183
1988	4,896	7	114	7,069	7,588	219	53	45	4	44
1989	3,599	2	102	4,195	4,373	141	40	57	2	40
1990	6,796	17	107	6,423	7,128	285	63	72	5	58
1991	7,519	7	113	6,731	7,343	246	91	145	4	153
1992	5,212	21	113	5,936	6,162	296	89	120	4	137
1993	4,048	5	104	4,372	4,616	139	35	83	1	74
1994	2,661	2	77	3,503	3,768	112	45	77	2	74
1995	2,472	3	72	3,441	3,726	127	54	91	2	103
1996	3,489	18	54	3,683	3,936	268	54	100	6	97
1997	2,918	19	96	2,836	3,150	243	55	117	3	114
1998	3,226	58	137	3,046	3,394	168	40	91	1	80
1999	2,948	19	114	3,391	3,573	129	56	102	8	91
2000	2,450	3	101	2,748	2,975	182	59	98	1	87

Table B.3 (Cont): TCEQ Annual Naturalized Flows (million m^3/year)

Year	Control Point												
	EM4000	**EM3300**	**EM3200**	**EM3400**	**EM3100**	**EM3000**	**DM9500**	**DM7000**	**DM6000**	**DM4000**	**DM2300**	**DM2200**	**DM2100**
1940	169	113	225	414	595	757	16	163	110	125	137	137	293
1941	112	84	265	1,077	1,499	1,791	23	374	185	88	488	488	591
1942	127	90	233	879	1,198	1,477	14	187	94	62	66	66	153
1943	81	33	85	363	503	655	29	154	310	89	86	86	165
1944	453	132	444	1,298	1,920	2,250	31	199	132	119	762	762	1,245
1945	76	41	119	672	976	1,103	14	158	88	67	128	128	192
1946	127	89	161	522	769	964	17	310	157	94	529	529	601
1947	111	99	204	521	712	817	21	193	120	74	287	287	531
1948	439	92	237	652	953	1,160	29	198	305	148	219	219	410
1949	105	20	99	223	537	525	34	353	206	198	304	304	408
1950	40	17	96	138	264	335	9	141	85	72	82	82	259
1951	149	84	212	706	1,023	1,201	12	151	82	71	54	54	171
1952	27	3	58	131	219	292	4	117	56	29	16	16	67
1953	479	176	530	863	1,268	1,489	11	144	65	90	121	121	347
1954	61	36	94	248	526	537	49	190	265	137	98	98	161
1955	94	106	167	516	667	795	8	127	67	34	101	101	355
1956	17	22	61	94	155	190	9	104	45	20	10	10	116
1957	114	28	116	348	711	937	43	255	236	172	61	61	210
1958	442	263	515	1,591	2,252	2,838	41	423	301	221	1,373	1,373	2,509
1959	44	90	112	285	349	444	20	309	176	112	326	326	466
1960	83	69	190	424	715	890	13	200	120	71	164	164	381
1961	60	36	129	267	501	593	98	365	953	191	264	264	496
1962	57	19	106	253	455	505	7	155	28	30	16	16	178
1963	126	144	190	384	589	708	5	120	16	45	28	28	219
1964	131	10	193	304	619	727	74	315	45	207	172	172	332
1965	39	34	275	392	606	776	10	150	29	38	43	43	232
1966	96	53	155	1,111	1,023	1,125	8	138	32	67	40	40	231
1967	747	360	663	2,558	4,158	4,620	7	165	82	21	192	192	732
1968	110	56	282	1,121	1,174	1,301	5	176	79	20	236	236	335
1969	47	44	108	789	932	1,006	53	199	95	141	148	148	225

Table B.3 (Cont): TCEQ Annual Naturalized Flows (million m^3/year)

Year	Control Point												
	EM4000	**EM3300**	**EM3200**	**EM3400**	**EM3100**	**EM3000**	**DM9500**	**DM7000**	**DM6000**	**DM4000**	**DM2300**	**DM2200**	**DM2100**
1970	42	54	174	612	805	920	18	240	102	59	468	468	524
1971	335	78	332	781	1,240	1,927	41	366	308	261	2,043	2,043	3,418
1972	160	15	285	894	1,355	1,566	19	252	166	215	648	648	753
1973	306	108	419	1,933	2,475	3,164	14	257	138	136	209	209	413
1974	80	41	169	556	722	844	22	243	139	85	571	571	668
1975	226	46	270	960	1,269	2,312	29	485	399	166	624	624	753
1976	225	147	401	1,087	1,587	1,930	34	621	791	336	1,140	1,140	1,727
1977	96	52	199	766	1,115	1,356	14	350	110	186	221	221	389
1978	140	85	301	2,086	2,919	3,271	14	270	219	169	913	913	1,298
1979	67	39	187	528	656	782	15	282	114	169	507	507	843
1980	49	33	152	285	521	581	30	321	173	153	983	983	1,042
1981	83	82	257	933	2,221	2,678	26	387	160	258	1,120	1,120	1,683
1982	31	24	130	229	684	858	8	136	31	82	148	148	279
1983	98	23	219	751	1,796	2,160	16	211	54	85	77	77	206
1984	31	29	150	555	1,326	1,671	13	235	64	87	29	29	180
1985	106	42	218	323	839	950	14	207	59	22	150	150	248
1986	63	58	303	604	864	1,293	22	343	235	132	867	867	1,007
1987	54	88	217	807	1,472	1,854	27	499	499	236	975	975	1,080
1988	268	201	257	1,156	1,534	1,930	10	288	239	89	817	817	1,343
1989	28	29	197	443	514	628	8	127	62	42	193	193	297
1990	16	7	106	320	372	581	24	350	338	53	308	308	463
1991	42	62	158	423	450	632	25	312	112	51	356	356	574
1992	14	19	107	591	444	551	26	422	286	154	397	397	648
1993	11	44	176	596	452	659	12	195	124	52	222	222	337
1994	12	33	179	539	517	651	11	119	28	20	87	87	138
1995	47	24	165	983	682	782	12	104	16	14	79	79	114
1996	24	383	116	588	473	625	12	119	34	9	102	102	258
1997	38	55	153	367	373	493	11	245	62	8	126	126	226
1998	46	43	286	455	331	507	38	222	85	5	104	104	152
1999	11	17	167	395	395	457	16	290	195	55	414	414	581
2000	6	42	169	645	505	509	10	156	49	24	43	43	115

Table B.3 (Cont): TCEQ Annual Naturalized Flows (million m^3/year)

Year	Control Point						
	DM2000	FM4000	F5000	FM3000	FM2000	FM6000	FM1000
1940	327	186	71	1,300	1,433	716	1,228
1941	694	676	390	2,991	2,972	1,943	2,686
1942	173	519	328	2,355	2,446	1,476	2,192
1943	213	271	185	2,315	2,398	1,357	2,173
1944	1,456	148	288	2,266	2,293	1,416	2,080
1945	336	315	96	1,935	2,060	1,074	1,880
1946	702	262	155	1,410	1,675	747	1,470
1947	595	248	247	2,078	2,166	1,323	1,911
1948	487	74	37	1,099	1,287	613	1,046
1949	459	411	138	2,203	2,199	2,024	1,982
1950	347	178	26	1,175	1,144	798	1,058
1951	210	38	2	564	535	275	499
1952	118	247	46	982	1,162	464	871
1953	447	173	94	782	756	602	701
1954	215	347	82	1,171	1,130	912	1,076
1955	431	414	338	2,105	2,038	1,508	1,808
1956	108	67	10	674	616	467	495
1957	229	110	15	906	850	574	797
1958	3,120	694	720	4,511	4,660	2,696	4,327
1959	557	280	54	1,522	1,442	851	1,369
1960	374	423	136	2,552	2,502	1,526	2,218
1961	570	146	30	1,584	1,512	913	1,347
1962	199	179	3	1,417	1,349	775	1,200
1963	293	269	44	1,709	1,629	977	1,438
1964	408	113	35	1,383	1,322	813	1,141
1965	305	169	2	1,334	1,305	727	1,108
1966	324	792	409	3,381	3,392	2,369	3,379
1967	1,197	230	204	1,840	1,777	1,227	1,622
1968	461	796	185	3,655	3,653	1,874	3,265
1969	263	123	1	1,213	1,331	578	1,285

Table B.3 (Cont): TCEQ Annual Naturalized Flows (million m^3year)

Year	Control Point						
	DM2000	FM4000	F5000	FM3000	FM2000	FM6000	FM1000
1970	516	260	103	1,993	1,999	1,168	1,792
1971	4,226	332	223	2,172	2,084	1,299	1,942
1972	888	516	138	2,206	2,219	1,238	2,098
1973	681	269	531	2,432	2,530	1,515	2,129
1974	745	656	189	2,574	2,757	1,315	2,614
1975	941	382	44	1,977	2,099	1,268	1,715
1976	1,762	395	233	2,358	2,396	1,299	2,029
1977	458	167	13	1,484	1,482	808	1,295
1978	1,438	438	789	3,741	4,164	2,033	4,060
1979	896	305	87	1,649	1,721	1,093	1,727
1980	1,117	341	123	2,224	2,197	1,449	2,033
1981	1,736	666	332	3,238	3,262	1,923	2,998
1982	345	65	18	1,321	1,286	659	1,212
1983	233	175	58	2,042	1,942	1,319	1,686
1984	220	625	200	3,346	3,199	2,273	2,858
1985	291	222	56	1,898	1,789	1,070	1,693
1986	1,118	662	329	3,656	3,476	2,515	3,316
1987	1,032	231	291	2,304	2,231	1,328	2,102
1988	1,519	368	270	3,061	2,853	2,188	2,562
1989	307	275	58	2,684	2,520	1,773	2,213
1990	533	1,138	524	4,175	4,073	2,101	4,288
1991	657	1,048	631	5,285	5,630	2,671	5,224
1992	694	83	52	2,356	2,359	960	2,273
1993	350	353	173	2,435	2,308	1,517	2,166
1994	146	112	8	1,013	1,007	476	877
1995	201	117	53	799	800	280	728
1996	266	492	210	2,447	2,304	1,763	2,031
1997	240	181	59	1,147	1,170	716	1,051
1998	182	134	60	880	866	394	741
1999	600	305	79	1,290	1,238	952	1,078
2000	142	189	61	944	946	555	828

B.2. CONAGUA ANNUAL NATURALIZED FLOWS

Table B.4: CONAGUA Control Points

CONAGUA_ID	HydroID	NAME
1	104070000	Rio Bravo at Fort Quitman
2	104070000	Rio Grande above Rio Conchos near Presidio Texas
3	202010003	Rio Florido at San Gabriel
4	202010004	Rio Florido at San Antonio
5	202010001	Rio Florido at Jimenez
6	202080004	Bufalo, V. de Allende
7	202010003	Rio Balleza at Llanitos
8	202010000	Rio Conchos at Presa La Boquilla
9	202010001	Rio San pedro at Presa Francisco I Madero
10	202090000	Rio Conchos at Las Burras
11	202080007	Rio Chuviscar
12	202010000	Rio Conchos at El Granero
13	202080009	Rio Conchos at Ojinaga
14	203010000	Rio Bravo at Johnson Ranch
15	203010000	Rio Bravo at Foster Ranch
16	203010000	Rio Bravo at Presa La Amistad
17	108070001	Rio Bravo Cd. Acuña
18	108070001	Arroyo las Vacas
19	205010001	Rio San Diego
20	108070002	Rio Bravo near Jimenez
21	108070002	Rio San Rodrigo at El Moral
22	108070002	Rio Bravo at Piedras Negras
23	108070002	Rio Escondido at Villa de Fuente
24	108070002	Rio Bravo near Villa Guerrero
25	108070002	Rio Bravo at Nuevo Laredo
26	204010000	Rio Sabinas at Sabinas
27	204010000	Rio Nadadores at Progreso
28	108070002	Rio Salado near Las Tortillas
29	108070003	Rio Bravo below Falcon
30	109070000	Rio Alamo at Cd. Mier
31	206090001	Rio Pesqueria at Icamole
32	206010004	Rio Pesqueria at Los Herrera
33	206010001	Rio San Juan at El Cuchillo
34	206010003	Rio San Juan at Los Aldamas
35	109070000	Rio San Juan at Camargo
36	207010001	Rio Bravo at Anzalduas
37	109070000	Rio Bravo at Matamoros

Table B.5: CONAGUA Annual Naturalized Flows, million m^3/year

Year	Control Point												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1950	76	89	44	100	59	83	44	605	180	1,372	6	1,450	1,584
1951	16	50	26	25	14	94	7	102	64	680	2	711	675
1952	7	60	65	42	60	56	28	384	299	1,019	6	1,103	1,221
1953	13	53	23	87	102	7	38	526	188	835	2	860	842
1954	9	91	73	128	93	22	60	830	339	1,328	5	1,399	1,482
1955	4	65	218	329	356	9	103	1,416	458	2,208	6	2,292	2,347
1956	4	37	61	87	63	17	23	316	82	743	2	776	680
1957	3	43	19	49	22	41	29	403	127	830	4	880	892
1958	22	71	257	542	731	105	189	2,602	893	4,735	6	4,821	5,255
1959	8	82	46	107	106	33	53	726	373	1,504	5	1,568	1,622
1960	32	50	141	170	148	81	99	1,357	546	2,551	6	2,647	2,647
1961	11	55	84	127	52	84	56	770	258	1,491	1	1,552	1,531
1962	46	50	19	31	23	60	44	600	203	1,331	0	1,375	1,372
1963	15	63	74	108	61	65	60	821	291	1,506	9	1,552	1,581
1964	2	39	37	86	62	62	47	650	161	1,206	-3	1,238	1,227
1965	1	40	26	53	29	78	24	555	223	1,156	-2	1,144	1,189
1966	20	62	238	343	432	3	114	2,277	956	3,568	8	3,806	4,212
1967	2	40	190	246	268	49	66	1,101	303	1,912	2	1,958	2,031
1968	12	56	284	382	273	167	111	1,984	819	4,019	8	4,221	4,282
1969	27	60	31	48	57	46	36	407	194	1,120	1	1,302	1,352
1970	58	63	68	97	124	44	75	988	305	1,797	3	1,956	2,008
1971	12	67	106	148	302	39	87	1,125	404	2,110	9	2,198	2,373
1972	21	111	91	128	225	69	103	1,098	555	2,298	15	2,460	2,587
1973	22	33	308	414	572	47	110	1,374	299	2,558	17	2,824	2,713
1974	86	96	149	204	243	56	49	1,154	802	2,664	34	3,022	3,195
1975	59	42	103	144	171	162	81	1,127	379	2,560	-5	2,422	2,236
1976	60	78	206	279	282	103	173	1,040	374	2,593	3	2,478	2,397
1977	6	69	59	85	105	57	53	647	146	1,675	-4	1,526	1,490
1978	16	128	457	611	825	27	184	1,979	759	3,720	28	4,323	4,669
1979	31	46	39	59	123	47	85	959	335	1,863	5	2,037	2,194
1980	39	52	119	207	270	50	112	1,287	402	2,475	2	2,536	2,639

Table B.5 (Cont): CONAGUA Annual Naturalized Flows, million m^3/year

	Control Point												
Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1981	54	151	232	371	355	76	194	2,191	500	3,863	13	3,665	3,745
1982	36	63	42	70	41	51	48	427	75	1,006	-5	1,020	1,031
1983	52	65	51	123	106	43	112	1,103	183	1,817	-3	1,846	1,820
1984	80	173	166	155	239	137	190	2,014	510	3,424	6	3,427	3,546
1985	76	156	29	59	89	47	100	856	144	1,628	0	1,548	1,652
1986	442	514	247	314	377	103	194	1,995	603	3,608	9	3,776	4,062
1987	344	834	204	269	269	85	145	1,055	268	2,208	3	2,231	2,368
1988	231	191	182	225	295	78	174	1,799	314	2,926	4	2,960	2,973
1989	104	104	64	123	84	105	138	1,399	237	2,350	7	2,433	2,387
1990	118	293	385	449	527	57	225	1,801	1,114	3,948	26	3,899	4,612
1991	114	164	415	495	587	113	167	2,691	1,117	5,026	13	5,355	5,626
1992	147	160	49	86	98	34	92	1,368	171	1,892	6	2,088	2,301
1993	159	157	136	184	245	114	115	1,356	186	2,376	3	2,599	2,556
1994	127	80	19	48	6	26	15	301	38	664	3	674	668
1995	253	147	34	63	62	3	11	284	235	603	8	662	682
1996	104	152	210	241	254	-24	107	1,776	650	2,403	12	2,657	2,790
1997	110	110	60	91	77	14	32	787	237	1,237	6	1,354	1,432
1998	108	96	51	100	98	18	29	455	114	781	4	825	849
1999	117	104	80	118	75	3	52	980	318	1,345	8	1,404	1,436
2000	86	121	64	134	118	20	57	606	158	934	4	986	1,113
2001	85	69	22	50	45	28	45	546	119	827	4	838	900
2002	99	88	69	148	110	1	38	662	273	1,017	4	1,069	1,176
2003	21	77	63	97	77	16	26	433	229	881	8	874	1,037
2004	39	137	120	183	100	26	60	903	344	1,586	9	1,588	2,023

Table B.5 (Cont): CONAGUA Annual Naturalized Flows, million m³/year

Year	Control Point											
	14	15	16	17	18	19	20	21	22	23	24	25
1950	1,829	2,354	2,486	2,493	5	83	2,613	24	2,664	27	2,795	2,743
1951	752	1,180	1,287	1,292	8	95	1,422	53	1,497	23	1,552	1,766
1952	1,345	1,671	1,753	1,757	3	57	1,837	7	1,861	10	1,903	2,008
1953	887	1,209	1,290	1,294	6	138	1,457	85	1,559	52	1,667	2,024
1954	1,710	2,986	3,306	3,322	39	146	3,584	65	3,716	35	3,786	3,623
1955	2,570	3,056	3,178	3,184	6	85	3,305	19	3,349	19	3,408	3,637
1956	733	1,026	1,099	1,103	7	94	1,222	24	1,261	19	1,295	1,381
1957	978	1,785	1,988	1,998	33	235	2,314	75	2,431	74	2,234	2,864
1958	5,356	6,077	6,259	6,268	30	422	6,763	471	7,272	119	7,059	7,270
1959	1,758	2,388	2,546	2,554	13	276	2,881	112	3,026	54	3,138	3,234
1960	2,754	3,267	3,395	3,402	8	163	3,604	50	3,681	37	3,829	4,009
1961	1,653	2,271	2,427	2,434	86	344	2,902	216	3,150	56	3,248	3,180
1962	1,465	1,924	2,039	2,045	6	142	2,220	38	2,282	25	2,358	2,337
1963	1,714	2,125	2,229	2,234	4	106	2,368	24	2,413	35	2,523	2,598
1964	1,312	2,149	2,359	2,369	70	286	2,776	91	2,911	78	3,198	3,080
1965	1,250	1,799	1,937	1,944	9	104	2,090	22	2,140	14	2,287	2,352
1966	4,172	4,707	4,841	4,848	8	105	4,993	26	5,047	37	5,111	5,379
1967	2,115	2,571	2,685	2,691	6	119	2,844	79	2,947	8	2,942	3,237
1968	4,325	4,537	4,862	4,866	4	127	5,004	76	5,138	10	5,164	5,260
1969	1,377	1,631	1,945	1,949	45	166	2,217	78	2,370	41	2,427	2,561
1970	2,094	2,414	2,804	2,807	15	188	3,058	87	3,172	17	3,153	3,277
1971	2,481	2,894	3,663	3,667	34	357	4,239	289	4,530	142	4,783	6,139
1972	2,690	2,917	3,231	3,235	11	215	3,563	130	3,720	113	3,821	3,968
1973	2,756	2,927	3,325	3,329	9	220	3,669	120	3,731	72	3,844	3,968
1974	3,415	3,939	4,693	4,697	16	221	5,073	130	4,997	39	4,997	5,115
1975	2,360	2,698	3,227	3,230	24	463	3,861	375	4,274	73	4,336	4,652
1976	2,542	2,847	3,564	3,567	29	602	4,302	757	5,033	203	5,358	5,663
1977	1,569	1,774	2,374	2,377	10	317	2,629	79	2,873	97	2,990	3,186
1978	4,762	5,261	5,866	5,870	10	252	6,091	200	6,421	97	6,561	6,599
1979	2,304	2,683	3,214	3,217	11	290	3,468	92	3,680	93	3,952	4,076
1980	2,804	3,198	3,970	3,974	28	274	4,179	156	4,417	66	4,636	4,655

Table B.5 (Cont): CONAGUA Annual Naturalized Flows, million m^3/year

Year	Control Point											
	14	15	16	17	18	19	20	21	22	23	24	25
1981	3,977	4,366	4,937	4,941	24	348	5,242	127	5,506	152	5,885	6,049
1982	1,145	1,442	2,005	2,009	5	95	2,060	18	2,005	45	2,269	2,233
1983	1,891	2,147	2,676	2,679	12	151	2,940	36	3,051	28	3,068	3,102
1984	3,734	3,949	4,622	4,626	8	151	4,889	44	5,027	24	5,026	5,042
1985	1,788	2,111	2,647	2,651	12	160	2,967	36	3,139	24	3,119	3,384
1986	4,675	4,964	5,532	5,536	16	285	6,076	208	6,308	131	6,335	6,657
1987	3,236	3,455	4,115	4,118	19	427	4,797	451	5,479	232	5,721	5,820
1988	3,250	3,666	4,305	4,309	7	252	4,733	209	4,866	90	5,013	5,168
1989	2,593	2,815	3,429	3,433	7	104	3,774	51	3,619	46	3,910	4,034
1990	5,122	5,622	6,119	6,123	21	293	6,859	302	6,842	55	7,135	7,386
1991	5,909	6,316	7,030	7,034	22	269	7,372	86	7,734	54	7,519	7,961
1992	2,564	2,910	3,514	3,518	22	418	4,295	206	4,471	154	4,663	5,001
1993	2,693	3,100	3,620	3,624	11	162	3,835	98	3,974	48	4,036	4,305
1994	783	1,071	1,609	1,613	11	95	1,834	13	1,722	25	1,803	2,135
1995	811	1,101	1,242	1,246	12	61	1,423	-2	1,429	16	1,558	1,762
1996	3,072	3,341	3,664	3,668	10	95	3,974	14	4,026	9	4,007	4,272
1997	1,622	1,920	2,287	2,291	10	193	2,544	25	2,650	9	2,520	2,591
1998	988	1,238	1,763	1,768	36	170	2,156	54	2,217	6	2,162	2,142
1999	1,620	1,872	2,303	2,308	15	262	2,630	160	2,715	55	2,740	2,917
2000	1,287	1,501	2,090	2,096	9	112	2,278	25	2,161	19	2,275	2,305
2001	975	1,168	1,716	1,727	7	39	1,868	-6	1,840	0	1,899	1,954
2002	1,351	1,559	2,036	2,049	29	174	2,519	137	2,682	0	2,705	2,787
2003	1,286	1,503	1,967	1,982	18	211	2,254	72	2,367	0	2,378	2,604
2004	2,157	2,584	3,070	3,085	24	317	3,446	259	3,879	0	3,985	3,920

Table B.5 (Cont): CONAGUA Annual Naturalized Flows, million m³/year

Year	Control Point											
	26	27	28	29	30	31	32	33	34	35	36	37
1950	133	103	489	3,277	40	38	42	110	140	253	3,643	3,453
1951	88	131	638	2,443	149	26	181	683	734	882	3,695	4,265
1952	21	36	121	2,171	27	18	5	110	136	302	2,667	2,965
1953	137	21	788	2,875	478	26	481	852	899	1,257	5,555	5,608
1954	94	79	342	3,122	61	19	42	239	270	481	3,689	3,411
1955	41	32	458	4,166	94	30	107	501	541	635	4,703	4,440
1956	24	39	172	1,502	17	2	23	96	115	272	1,722	1,696
1957	32	41	220	3,146	114	1	70	360	400	1,026	4,413	5,313
1958	1,511	236	3,333	11,425	442	53	483	1,551	1,625	2,374	15,180	14,730
1959	286	224	848	4,103	44	15	46	268	299	282	4,569	5,928
1960	216	137	644	4,796	83	35	144	441	473	775	5,891	6,132
1961	294	126	746	4,045	60	31	98	325	362	589	4,952	5,006
1962	52	95	336	2,782	57	16	63	289	309	465	3,528	3,572
1963	54	72	427	3,140	126	39	126	286	323	506	3,922	3,968
1964	177	53	465	3,601	131	18	151	357	394	677	4,520	4,569
1965	61	79	415	2,811	39	13	226	448	484	672	3,730	3,753
1966	43	45	358	6,009	96	18	100	1,147	1,188	1,148	7,422	7,440
1967	190	44	1,222	5,143	747	85	422	2,616	3,864	4,126	11,532	11,000
1968	165	116	615	6,087	109	44	231	1,193	1,226	1,229	7,652	8,640
1969	162	85	412	3,116	47	14	66	835	831	974	4,359	4,407
1970	476	65	600	3,954	42	13	111	659	629	855	4,929	5,026
1971	2,071	90	4,581	11,705	335	82	230	795	989	1,734	13,896	13,185
1972	810	115	1,156	5,258	160	29	215	955	916	1,337	7,262	7,458
1973	246	139	911	5,319	306	63	381	2,020	2,276	2,655	8,713	8,552
1974	604	164	976	5,928	80	23	106	623	596	809	7,164	7,132
1975	653	155	1,178	5,904	226	28	156	989	1,011	1,447	8,056	7,994
1976	1,176	220	2,100	7,728	225	46	191	1,155	1,313	1,723	9,931	9,817
1977	268	183	740	3,928	96	23	130	825	762	1,064	5,265	5,409
1978	947	225	1,954	8,732	140	33	317	2,145	2,230	2,357	11,405	11,535
1979	554	216	1,017	5,357	67	26	121	598	594	749	6,419	6,444
1980	1,032	241	1,483	6,298	49	32	86	389	376	445	7,100	7,082

Table B.5 (Cont): CONAGUA Annual Naturalized Flows, million m^3/year

Year	Control Point											
	26	27	28	29	30	31	32	33	34	35	36	37
1,981	1,153	427	2,076	8,596	83	63	164	1,010	1,103	1,484	10,518	10,308
1,982	191	133	602	3,067	31	40	44	313	316	396	3,791	3,888
1,983	121	112	472	3,725	98	39	105	1,009	901	1,188	5,157	5,204
1,984	69	98	438	5,591	31	31	55	738	608	391	6,101	6,163
1,985	158	52	367	4,002	106	36	139	578	908	1,026	5,334	5,395
1,986	850	113	1,260	7,717	63	35	210	723	814	1,045	8,973	9,043
1,987	1,037	234	1,315	7,007	54	72	95	883	1,320	1,068	8,229	8,311
1,988	686	195	1,841	6,963	268	39	307	1,449	1,331	1,701	8,945	8,894
1,989	115	159	640	4,795	28	41	85	548	454	523	5,340	5,543
1,990	336	135	800	8,030	16	41	82	485	463	567	8,647	8,779
1,991	494	165	891	8,564	42	40	94	575	526	665	9,357	9,511
1,992	524	227	973	5,828	14	40	99	630	557	682	6,795	6,813
1,993	343	147	567	4,705	11	49	129	749	519	663	5,522	5,752
1,994	120	147	324	2,474	12	43	-31	371	221	278	2,764	2,831
1,995	67	47	268	1,943	47	22	33	1,040	595	584	2,881	2,881
1,996	118	21	261	4,561	24	26	48	561	553	526	5,131	5,188
1,997	175	74	240	2,930	38	27	81	418	360	391	3,355	3,374
1,998	29	22	195	2,280	46	22	30	598	387	470	2,694	2,723
1,999	293	62	628	3,629	11	14	-35	369	239	204	3,825	3,739
2,000	113	71	256	2,583	7	43	96	651	334	280	2,808	2,706
2,001	53	41	282	2,248	21	26	85	702	685	770	2,986	2,929
2,002	28	8	92	2,862	53	52	137	1,019	1,268	1,414	4,381	4,210
2,003	297	91	819	3,728	111	43	154	1,494	1,896	1,873	5,985	5,935
2,004	641	93	914	4,890	107	55	147	1,184	1,561	2,148	7,334	7,392

Appendix C. WILCOXON RANK SUM TEST EXAMPLE: RIO SAN JUAN AT CAMARGO

Table C.1 : Annual Naturalized Flows, Rio San Juan at Camargo million m^3/year

	TCEQ		CONAGUA	
	Flow (MCM/Year)	Rank	Flow (MCM/Year)	Rank
1950	335	10	253	3
1951	1,201	73	882	58
1952	292	8	302	9
1953	1,489	82	1,257	75
1954	537	27	481	19
1955	795	53	635	38
1956	190	1	272	4
1957	937	61	1,026	65
1958	2,838	98	2,374	95
1959	444	14	282	7
1960	890	59	775	49
1961	593	34	589	33
1962	505	21	465	17
1963	708	46	506	22
1964	727	47	677	44
1965	776	50	672	43
1966	1,125	70	1,148	71
1967	4,620	102	4,126	101
1968	1,301	77	1,229	74
1969	1,006	64	974	63
1970	920	60	855	56
1971	1,927	89	1,734	87
1972	1,566	83	1,337	78
1973	3,164	99	2,655	96
1974	844	55	809	54
	Σ=	1,383	Σ=	1,261

	TCEQ		TCEQ	
	Flow (MCM/Year)	Rank	Flow (MCM/Year)	Rank
1975	2,312	93	1,447	80
1976	1,930	91	1,723	86
1977	1,356	79	1,064	68
1978	3,271	100	2,357	94
1979	782	51	749	48
1980	581	31	445	15
1981	2,678	97	1,484	81
1982	858	57	396	13
1983	2,160	92	1,188	72
1984	1,671	84	391	12
1985	950	62	1,026	66
1986	1,293	76	1,045	67
1987	1,854	88	1,068	69
1988	1,930	90	1,701	85
1989	628	36	523	25
1990	581	30	567	29
1991	632	37	665	42
1992	551	28	682	45
1993	659	40	663	41
1994	651	39	278	5
1995	782	52	584	32
1996	625	35	526	26
1997	493	20	391	11
1998	507	23	470	18
1999	457	16	204	2
2000	509	24	280	6
	Σ=	1,471	Σ=	1,138

n= Sample size of TCEQ sample = 51 year
n= 51
m= Sample size of CONAGUA sample = 51 years
m= 51
N= n+m=51+51
N= 102

W_{rs}= Sum of the ranks of TCEQ sample
W_{rs}= 1,383+1,471
W_{rs}= 2,854

μ_W= n*(N+1)/2

μ_W= 51*(102+1)/2

μ_W= 2627

σ_W= $(n*m*(N+1)/12)^{1/2}$

σ_W= $(51*51*(102+1)/12)^{1/2}$

σ_W= 149

d= Length of the time step = 1 year

d= 1

if: $W_{rs}>\mu_W$

Z_{rs}= $(W_{rs}-d/2-\mu_W)/\sigma_W$

Z_{rs}= (2,854-1/2-2627)/149

Z_{rs}= 1.5192

Two sided p-test

if Z_{rs} >0 (right side tail): $2*\Phi(1-Z_{rs})$

else (left side tail): $2*\Phi(Z_{rs})$

where $\Phi()$ is the standard normal distribution function (μ=0,σ=1)

p-value = $2* (1-\Phi(Z_{rs}))$

p-value = 2* (1-Φ(1.5192))

p-value = 2* (1-0.9356)

p-value = 0.1287

α= Standard value for p=0.05

α= 0.05

Reject H_0 if p<α

Result: Do not reject H0