Daily Water Availability Model
for the Nueces River Basin

Ralph A. Wurbs
Texas A&M University
College Station, Texas

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CHAPTER 1
INTRODUCTION

The Texas Commission on Environmental Quality (TCEQ) Water Availability Modeling (WAM) System consists of simulation input datasets for the Water Rights Analysis Package (WRAP) modeling system for all river basins of Texas and related information. The TCEQ WAM System WRAP input dataset for a particular river basin is called a water availability model (WAM). The term "Nueces WAM" refers to the WRAP simulation input dataset for the Nueces River Basin in the TCEQ WAM System and variations thereof. The original Nueces WAM is documented by a 1999 report prepared for the Texas Natural Resource Conservation Commission (TNRCC) by HDR Engineering [1]. [Numbers in brackets refer to the list of references.]

The WAM System was originally implemented by the TNRCC/TCEQ and its partner agencies and contractors during 1997-2003 pursuant to water management legislation enacted by the Texas Legislature in 1997 as Senate Bill 1 (SB1). The TNRCC was renamed the TCEQ effective September 2002. Capabilities provided by the WRAP/WAM system have been expanded over the years since its initial implementation. The WRAP/WAM modeling system is based on a monthly computational time step. Development of auxiliary daily modeling features was motivated by the need to improve capabilities for incorporating into the modeling system the environmental flow standards (EFS) established pursuant to the 2007 Senate Bill 3 (SB3).

WRAP software, manuals, other related publications, training courses, and a link to the TCEQ WAM website are available at the WRAP website (https://wrap.engr.tamu.edu/). The latest versions of the various components of the WRAP modeling system are documented by a set of manuals [2, 3, 4, 5, 6, 7]. New daily modeling capabilities were incorporated in the May 2019 version of WRAP and further improved in January 2021 and July 2022 modifications to the WRAP daily simulation model *SIMD* [8].

Nueces Daily and Modified Monthly WAMs with SB3 EFS

Environmental flow standards (EFS) have been adopted by the TCEQ through the process created by the 2007 Senate Bill 3 (SB3). A strategy for modeling the SB3 EFS is explored, adopted, and demonstrated with the Brazos, Trinity, Neches, Colorado, and Lavaca WAMs documented in May 2019, December 2019, June 2020, March 2022, and January 2023 reports [9, 10, 11, 12, 13]. This methodology consists of: (1) converting monthly WAMs to daily, (2) computing daily targets for environmental flow standards using the daily simulation model *SIMD*, and (3) incorporating monthly summations of the daily instream flow targets into the input datasets read by the monthly simulation model *SIM*. This general strategy is employed to develop the daily and modified monthly Nueces WAMs documented by this report. Daily SB3 EFS targets computed in daily full authorization and current use scenario Nueces WAM simulations are summed to monthly EFS targets and incorporated in the monthly WAM simulation input datasets.

SB3 EFS for the Nueces River and Corpus Christi and Baffin Bays adopted by the TCEQ in February 2014 are documented as Subchapter F of Chapter 298 of the Texas Administrative Code [14]. The SB3 EFS for seventeen sites on the Nueces River and its tributaries were incorporated in the daily *SIMD* input dataset for the Nueces WAM employing capabilities provided by sets of instream flow *IF*, environmental standard *ES*, and pulse flow *PF* records. Hydrologic condition *HC* and *PO* pulse options records used in modeling SB3 EFS in other daily WAMs are not needed for the SB3 EFS in the daily Nueces WAM. Daily flow targets computed by *SIMD* for each day of a 1934-2021 simulation were summed to 1934-2021 monthly targets for incorporation as target series *TS* records incorporated in the monthly *SIM* input dataset.

The primary component of the conversion of the monthly Nueces WAM to daily is the disaggregation of monthly naturalized flows to daily within the *SIMD* simulation based on input *DF* record daily flow pattern hydrographs. A *JT* record is added to the DAT file to activate daily computations. The negative incremental flow option activated on the *JO* record was changed from option 5 to option 6. The SB3 EFS are incorporated in the daily WAM using sets of *IF*, *ES*, and *PF* records. Target series *TS* records are used to incorporate the SB3 EFS in the monthly WAM. *SIM* and *SIMD* time series input data (*IN*, *EV*, *DF*, and *TS* records) are compiled in a single *SIM/SIMD* input DSS file. Modeling options adopted for the Brazos, Trinity, Neches, and Colorado WAMs for dealing with various complexities and issues also guided creation and application of the daily and modified monthly Lavaca and Nueces WAMs.

Forecasting is relevant only if routing is activated. Routing parameters are needed only if routing is activated. Lag and attenuation routing parameters were included in the daily WAM datasets for the Brazos, Trinity, Neches, and Colorado WAMs. Comparative simulations were performed with these previous daily WAMs with and without routing and forecasting [9, 10, 11, 12]. Routing and forecasting were determined to adversely affect accuracy in some cases and to generally not result in improvements in simulation results. The routing parameters were included in the datasets to allow comparative analyses but were generally not employed in final adopted simulations. The Lavaca and Nueces River Basins are smaller than these other river basins and most of the storage and diversion of stream flow occurs in the lower Lavaca and Nueces Basins, making routing and forecasting much less relevant. The Nueces WAM is complicated by extremely high channel losses in aquifer recharge zones. Routing and forecasting options are not activated in the Lavaca and Nueces WAMs, and routing parameters are considered unnecessary.

Various issues of integrated multiple-purpose water management can be investigated by directly applying daily WAMs. Capabilities for satisfying the instream flow requirements reflected in SB3 EFS can be assessed directly using a daily WAM. Effects of EFS on unappropriated flows available for municipal, industrial, and agricultural water use can be quantified either directly from daily *SIMD* simulations or using a monthly WAM with monthly EFS targets computed in a daily *SIMD* simulation.

Creation of the daily simulation *SIMD* input datasets for the full authorization and current use scenarios began with the monthly *SIM* datasets from the TCEQ WAM System. The original monthly full authorization and current use scenario versions of the Nueces WAM have a hydrologic period-of-analysis of 1934-1996 which was extended through 2021 in the new expanded version. Daily flow pattern (*DF* record) hydrographs for twenty control points are added to the simulation input dataset. Hydrology data include monthly naturalized flows (*IN* records) at forty-one primary control points and reservoir net evaporation-precipitation depths (*EV* records) for ten control points. A set of 1934-2021 sequences of *DF* record daily flows at twenty control points were developed based on combining observed daily flows downloaded from the U.S. Geological Survey (USGS) National Water Information System (NWIS) website with WAM naturalized monthly flows.

Nueces River Basin

The location and size of the 16,700 square mile Nueces River Basin relative to the other major river basins and coastal basins of Texas are shown in Figure 1.1. A basin map of the Nueces River Basin is provided as Figure 1.2 [1]. The Nueces River flows into Nueces Bay, which is a northwestern extension of Corpus Christi Bay.

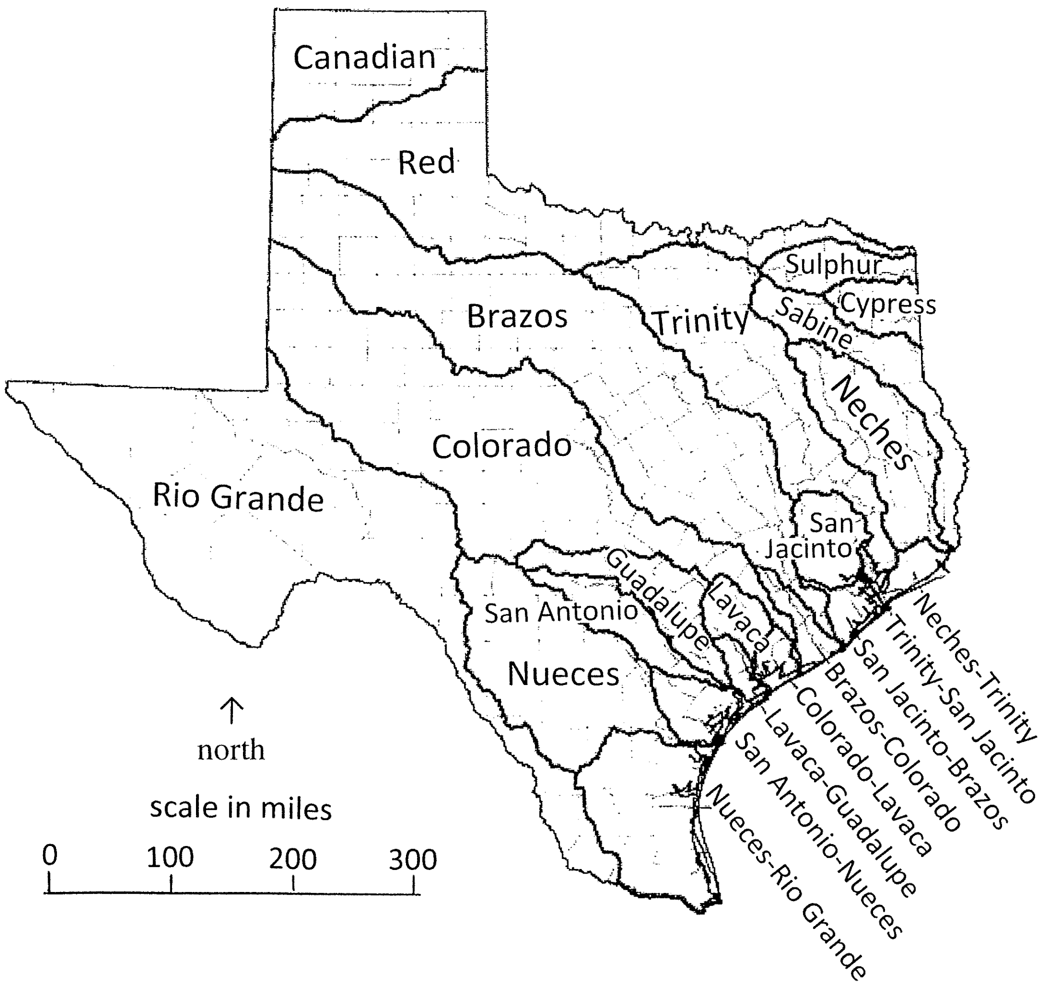

Figure 1.1 Fifteen Major River Basins and Eight Coastal Basins in Texas

The City of Corpus Christi is in Nueces County adjacent to the southwest side of Nueces Bay and Corpus Christi Bay, mostly in the Nueces-Rio Grande Coastal Basin. Most surface water use supplied from the Nueces River Basin is used by the City of Corpus Christi and its water customers for municipal and industrial use. The majority of water supplied by Corpus Christi from the city-owned and operated Choke Canyon Reservoir and Lake Corpus Christi is diverted downstream at the Calallen diversion dam and saltwater barrier located on the Nueces River about twelve miles upstream of the river outlet into Nueces Bay.

The 2020 census population of the City of Corpus Christi is 317,800. The 2020 census population of Nueces, San Patricio, and Jim Wells Counties are 353,200, 68,800, and 38,890, respectively. The City of Corpus Christi supplies water throughout these three counties.

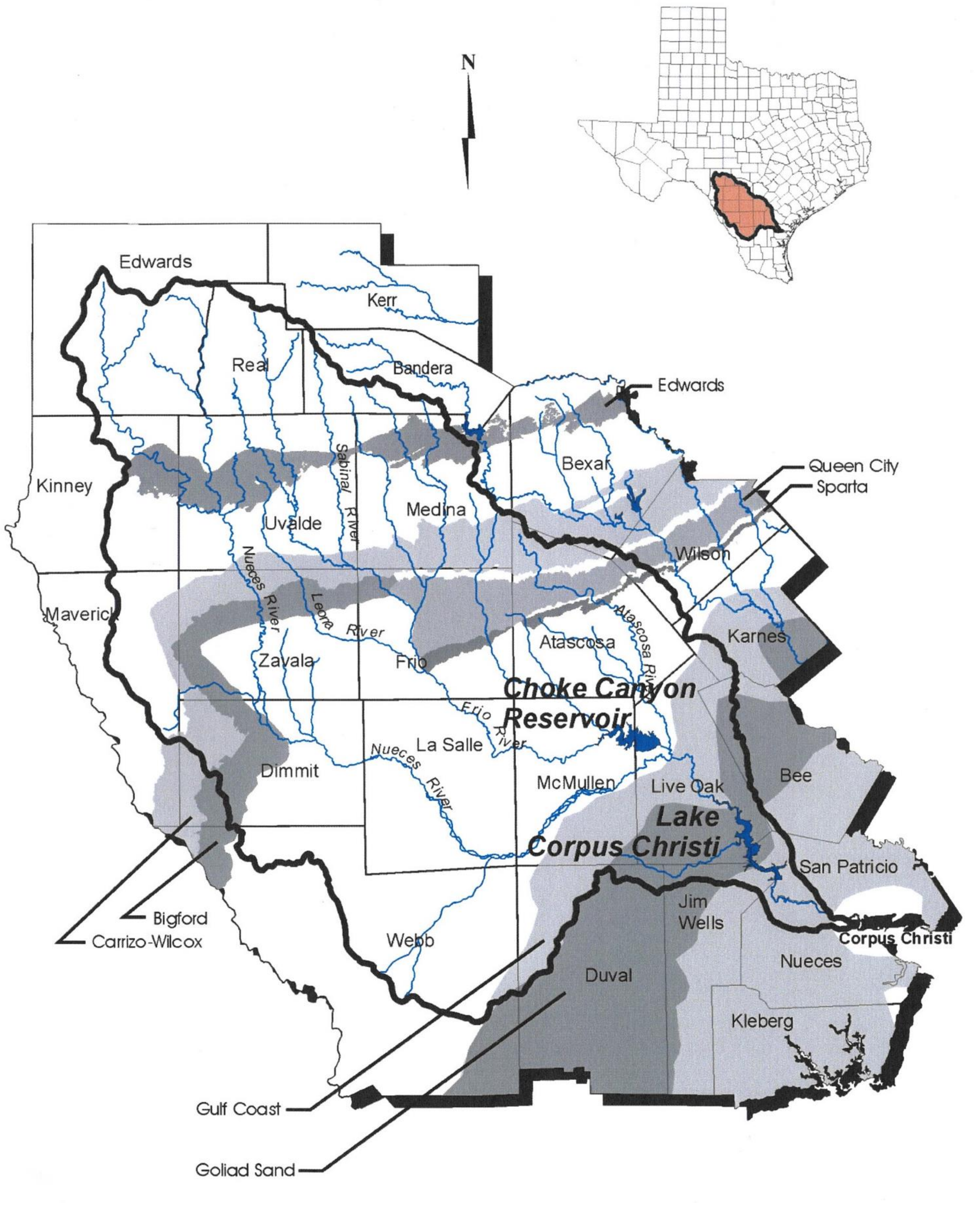

Figure 1.2 Nueces River Basin and Underlying Aquifers [1]

Most surface water use from the Nueces River Basin occurs in the Nueces-Rio Grande Coastal Basin. Most water use within the Nueces River Basin is supplied from groundwater. Groundwater supplies are declining. Uvalde, with a 2020 population of 24,560, is the largest city located within the Nueces Basin. The Edwards Aquifer is the primary source of supply for Uvalde.

Hydrologic Characteristics of the Nueces River Basin

Mean annual rainfall and reservoir evaporation rates in the Nueces River Basin are 25.0 inches and 58.4 inches, respectively. Most rainfall in the basin originates from localized convective thunderstorms or from tropical storms and hurricanes covering wider areas. The sporadic nature of rainfall in the basin results in intermittent, highly variable stream flows. Short periods of high flows in the streams and rivers are preceded and followed by long periods of low or zero flows.

The hydrology of the basin is complicated by interactions between surface and ground water. As indicated in Figure 1.2, the Nueces River and its tributaries cross major aquifer outcrop or recharge zones. The Edwards Aquifer recharge zone accounts for the largest volume of stream flow loss to groundwater. Stream flow recharge of the Carrizo-Wilcox, Bigford, Queen City, Sparta, Gulf Coast, and Goliad Sand groundwater formations is also significant.

The Edwards recharge zone extends across middle reaches of the Nueces River and tributaries that include the Frio River, Sabinal River, and other smaller streams. Flows from these streams flow into the underlying fractured limestone contributing to aquifer recharge. Most groundwater aquifers in Texas are comprised largely of sand and gravel. The unique Edwards Aquifer consists of caverns through limestone that are essentially underground rivers. The principal Edwards recharge zone is a 1,500 square mile area of fractured and cavernous limestone exposed on the surface allowing large quantities of water to enter the aquifer. This recharge zone extends across the upper portions of the Nueces, San Antonio, and Guadalupe River Basins in the Hill Country just north of the cities of Uvalde, Hondo, San Antonio, and New Braunfels.

Reservoirs in the Nueces River Basin

Choke Canyon Reservoir and Lake Corpus Christi are the only reservoirs in the Nueces WAM with authorized storage capacities of 5,000 acre-feet or greater. Information describing these two reservoirs is provided in Table 1.1.

Table 1.1
Choke Canyon Reservoir and Lake Corpus Christi

Reservoir	Choke Canyon	Corpus Christi
River	Frio River	Nueces River
Watershed Area (square miles)	4,667	16,660
Initial Impoundment Date	May 1982	April 1958
Storage Capacity (acre-feet)		
Full Authorization WAM	700,000	300,000
Current Use WAM	693,350	225,250
TWDB 2012 Surveys	662,820	254,730
Surface Area in 2012 (acres)	25,440	18,700

The two reservoirs have a total combined authorized storage capacity of 1,000,000 acre-feet, which accounts for 96.1% of the total authorized storage capacity of 1,040,446 acre-feet in the 121 reservoirs included in the full authorization Nueces WAM. Choke Canyon Reservoir and Lake Corpus Christi have a total storage capacity of 918,600 acre-feet accounting for 97.5% of the total capacity of 959,830 acre-feet of 125 reservoirs in the current use scenario WAM.

The storage capacities and surface areas in the last two lines of Table 1.1 are from a Texas Water Development Board (TWDB) website and are based on sediment surveys conducted by the TWDB in 2012. Observed historical storage plots in Figures 1.3 and 1.4 are also from the TWDB website. The storage capacity in each reservoir is shown by dashed lines in the storage plots.

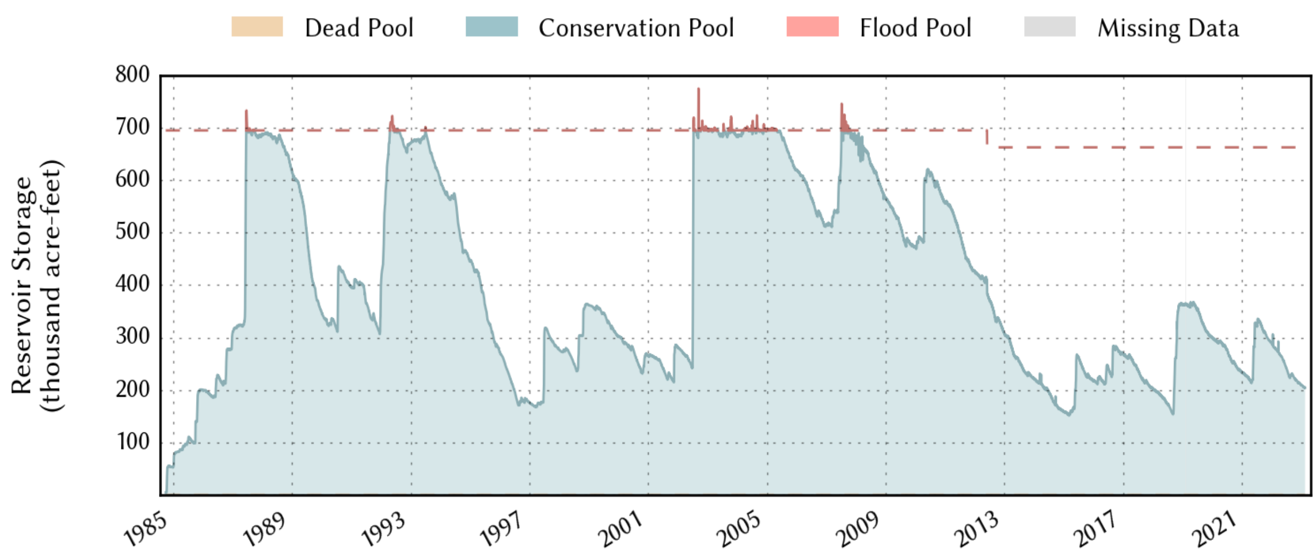

Figure 1.3 Historical Storage in Choke Canyon Reservoir
https://www.twdb.texas.gov/surfacewater/rivers/reservoirs/choke_canyon/index.asp

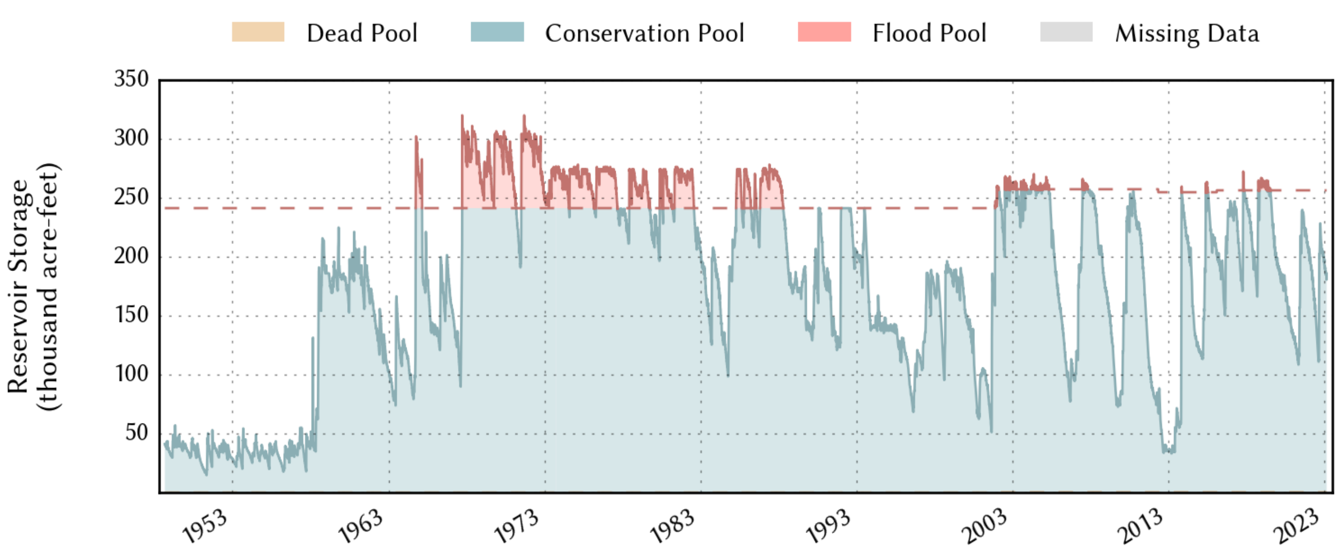

Figure 1.4 Historical Storage in Lake Corpus Christi
https://www.twdb.texas.gov/surfacewater/rivers/reservoirs/corpus_christi/index.asp

Choke Canyon Reservoir on the Frio River was constructed by the U.S. Bureau of Reclamation and is jointly owned by the Nueces River Authority (20%) and City of Corpus Christi (80%). Choke Canyon Dam is in Live Oak County about four miles west of the City of Three Rivers. The reservoir began to impound water in 1982. Choke Canyon Reservoir has an authorized storage capacity of 700,000 acre-feet, but a 2012 TWDB volumetric survey indicated that the capacity had been reduced by sedimentation to 662,820 acre-feet. The surface area at capacity is 25,440 acres. The watershed area above the dam is 4,667 square miles.

Lake Corpus Christi and Wesley E. Seale Dam are owned and operated by the City of Corpus Christi for water supply and recreation. Impoundment began in 1958. In addition to supplying its own residents, the City of Corpus Christi sells water to the San Patricio Municipal Water District, Alice Water Authority, and several cities and industries. Lake Corpus Christi has an authorized storage capacity of 300,000 acre-feet and according to a 2012 site survey by the TWDB a reduced capacity of 254,730 acre-feet with a surface area of 18,700 acres. The watershed area above the dam is 16,660 square miles.

Lake Corpus Christi and Wesley E. Seale Dam replaced the smaller Lake Lovenskiold and La Fruta Dam constructed in 1927-1929. A partial failure of La Fruta Dam occurred in 1930. Reconstruction of the failed dam at the same site was completed in 1934. Construction of Wesley E. Seale Dam just downstream of La Fruta Dam began in 1955 and was completed in April 1958.

Simulated storage contents of Choke Canyon Reservoir and Lake Corpus Christi computed in monthly full authorization and current use scenario simulations with a 1934-2021 hydrologic period-of-analysis are plotted in Figures 1.5 and 1.6 to illustrate the extent to which the water resources of the Nueces River Basin have been appropriated. Storage drawdowns are dramatic in the full authorization simulation. The reservoir storage plot of Figure 1.5 helps explain the motivation for the interbasin water transport projects discussed in the next section. The storage drawdowns from the current use WAM simulation of Figure 1.6 are also severe but much less than in the full authorization scenario. The current use scenario reflects estimates of water use in the 1990's and loss of storage capacity due to sedimentation.

The simulations generating the storage volumes plotted in Figures 1.5 and 1.6 were performed with the monthly full authorization and current use WAMs without SB3 environmental flow standards. The reservoirs were assumed to be full to capacity at the beginning of the simulation. Both reservoirs are empty in the full authority scenario from 31 January 1939 through 30 April 1939 and from 30 November 1939 through 31 March 1940. Setting the reservoirs full at the beginning of the simulation probably results in unrealistically high simulated storage contents during 1934-1938 in Figure 1.5 but has no effect on simulation results after 1938.

Interbasin Water Transport and Possible Future Seawater Desalination

Water supplies initially developed from sources in the Nueces River Basin have been supplemented since the 1990's by inter-basin transfer of water by pipeline from the Lavaca and Colorado River Basins. The City of Corpus Christi now operates a water supply system for the Coastal Bend Region that obtains water from Choke Canyon Reservoir on the Frio River, Lake Corpus Christi on the Nueces River, Lake Texana on the Navidad River, and the Colorado River. Growing water demands have motivated interbasin water transport projects.

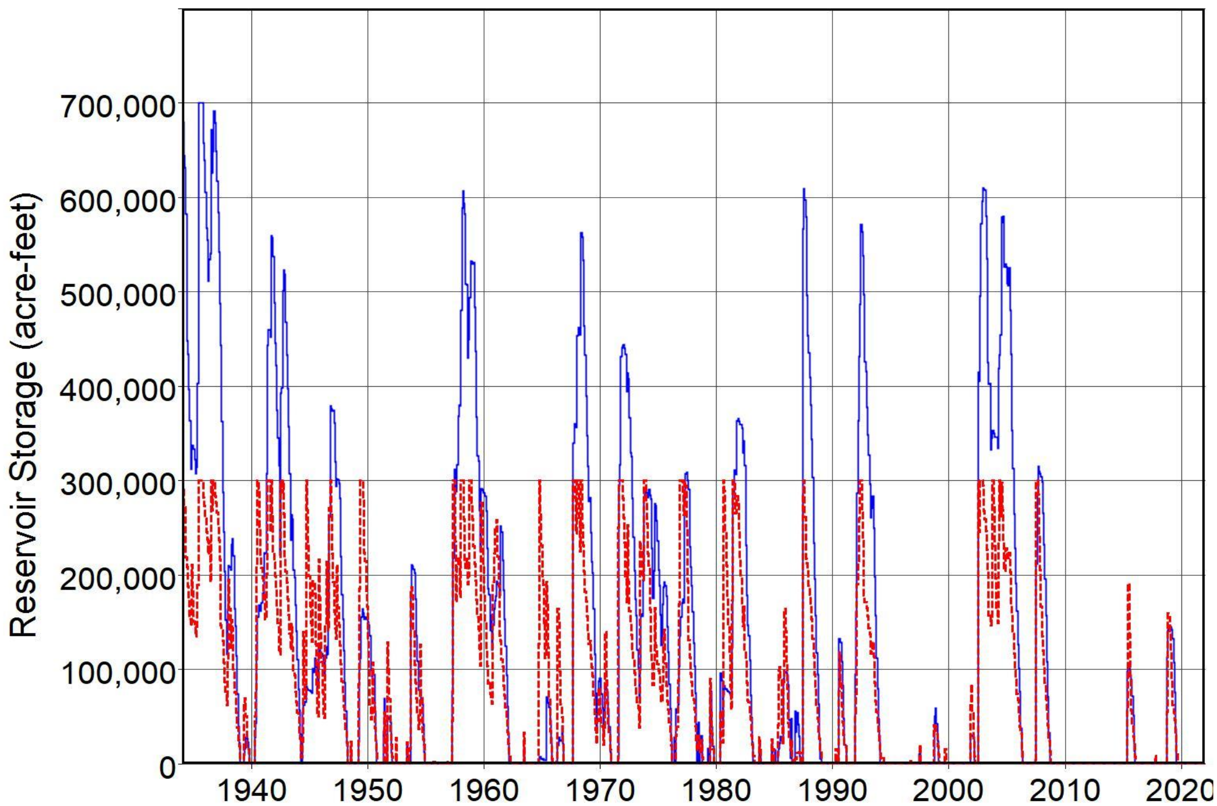

Figure 1.5 Full Authorization WAM storage in Lakes Choke Canyon and Corpus Christi

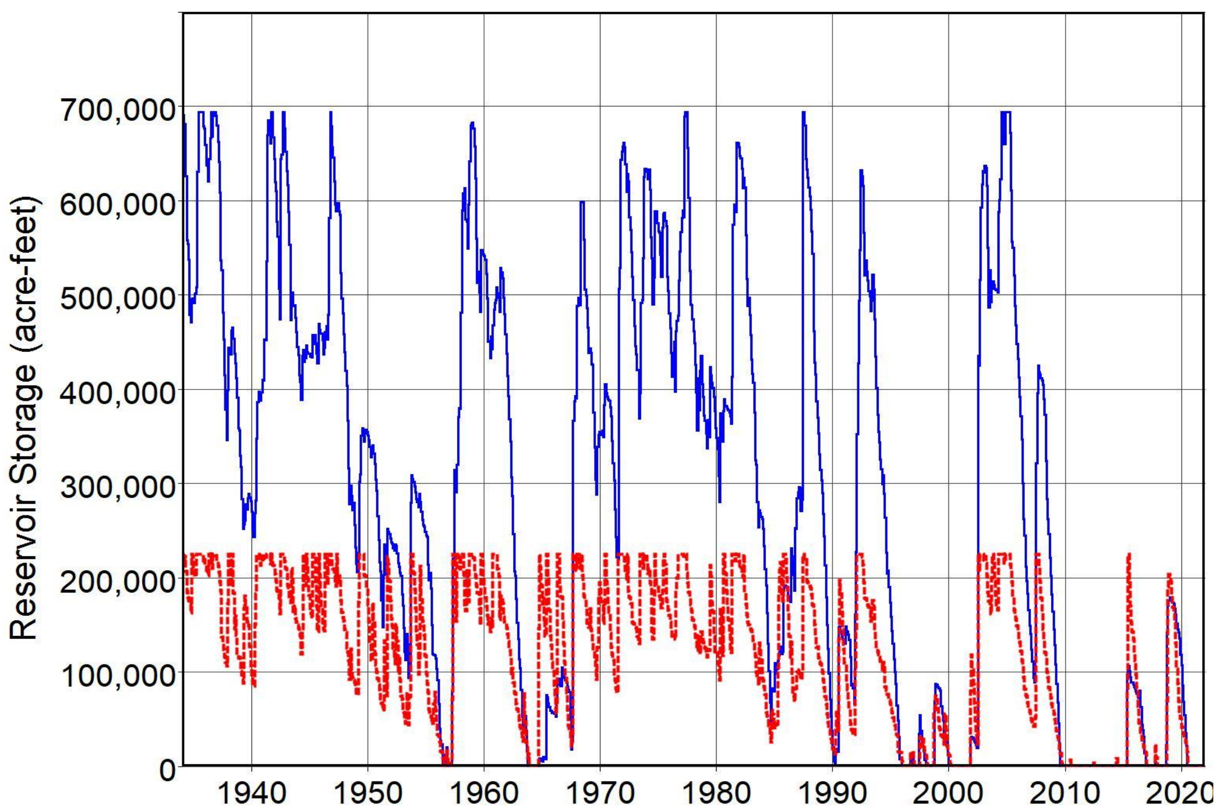

Figure 1.6 Current Use WAM storage in Lakes Choke Canyon and Corpus Christi

The City of Corpus Christi and Nueces River Authority completed the Mary Rhodes Pipeline Project in two phases at the locations shown in the map of Figure 1.7 available at the Nueces River Authority website. The first phase completed in 1999 transports water to Corpus Christi by pipeline from Lake Texana on the Navidad River in the Lavaca River Basin [13]. The second phase completed in 2016 added water from the Colorado River to the supply transported to Corpus Christi from Lake Texana. The City of Corpus Christi acquired water rights during the 1990's for the Navidad River and Colorado River water.

The first phase of the Mary Rhodes Pipeline Project consists of a 101-mile long, 64-inch diameter pipeline constructed of reinforced concrete in a steel cylinder and two pumping stations that connects Lake Texana and the O. N. Stevens Water Treatment Plant in Corpus Christi. The Texana pipeline was constructed during 1998-1999 and has been supplying a major portion of the water used in the Coastal Bend Region since 1999. The second phase of the interbasin water transport system completed in 2016 consists of a 42-mile-long pipeline from a pumping station on the Colorado River near Bay City that connects to the Texana pipeline.

The City of Corpus Christi, Port of Corpus Christi Authority, and private industrial companies have investigated the feasibility of seawater desalination over the past several decades. Multiple projects for construction of seawater desalination plants in the Corpus Christi area continue to be investigated. Currently, no seawater desalination plant supplying municipal or agricultural water use is in operation in Texas. The Corpus Christ region is perhaps the most likely candidate to become the first region of Texas to supplement its municipal water supplies by construction a seawater desalination plant.

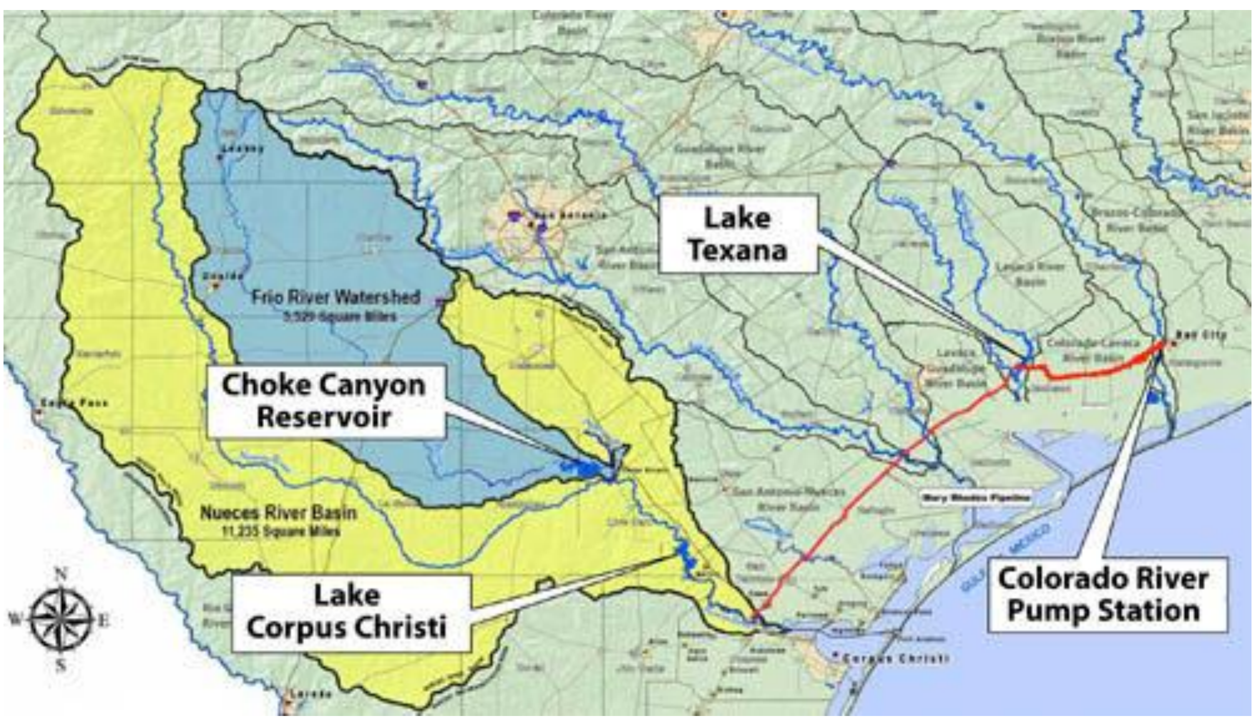

Figure 1.7 Water Supply System Owned and Operated by City of Corpus Christi and Nueces River Authority (source: Nueces River Authority website)

U.S. Environmental Protection Agency secondary drinking water standards include a maximum total dissolved solids (TDS) limit of 500 milligrams per liter (mg/l). Brackish water is defined as having TDS concentrations between 1,000 mg/l and 10,000 mg/l. Saline water has TDS concentrations greater than 10,000 mg/l. Seawater has concentrations of about 35,000 mg/l. The primary constraint to desalination is operation cost. Water treatment processes to remove salts are energy intensive and expensive. Another constraint is environmental and economic issues associated with disposal of the waste brine generated in the desalination process.

According to an online TWDB desalination database, Texas has thirty-six municipal desalination facilities with a total capacity of 100,769 acre-feet/year that treat brackish ground water and sixteen plants with a total capacity of 72,443 acre-feet/year that treat brackish surface water (https://www.twdb.texas.gov/innovativewater/desal/index.asp). None treat seawater. Industrial operations mainly in the electric power and semi-conductor industries are estimated by the TWDB to provide an additional 67,000 to 112,000 acre-feet/year of desalination. A desalination plant in El Paso is the largest municipal desalination plant in Texas. Its supply source is brackish groundwater. The two largest desalination plants for treating brackish surface water are a plant in Sherman that treats water from Lake Texoma and a plant in Granbury that treats water from Lake Granbury.

Scope and Organization of this Report

This report documents the development of full authorization and current use scenario versions of the Nueces WAM that employ a daily computational time step. The report also documents a specific application of the daily model in which the monthly full authorization and current use WAMs are modified by adopting monthly SB3 EFS instream flow targets stored in the monthly *SIM* input datasets that were computed by summing daily targets generated in daily *SIMD* simulations. Data storage system (DSS) files are employed for storing time series input data and simulation results. A single DSS file created in conjunction with this work contains all *SIM* and *SIMD* time series input datasets (*IN*, *EV*, *DF*, and *TS* records) for both daily and monthly simulations with both full authorization and current use scenario DAT files.

Relevant WAM datasets are listed and briefly described in the next section of the present Chapter 1. The alternative versions of the Nueces WAM are described in Chapter 2. River system hydrology as modeled in the monthly *SIM* and daily *SIMD* is discussed in Chapter 3, including extension of the hydrologic period-of-analysis from 1934-1996 to 1934-2021 and disaggregation of monthly naturalized flows to daily. Chapter 4 covers conversion of the monthly WAM to daily.

The preceding version of the monthly WAM and the new daily and revised monthly WAMs provide capabilities for simulating environmental flow standards (EFS) that have been established by the TCEQ and collaborating science and stakeholder committees through the 1997 Senate Bill 3 (SB3) process. Capabilities employing hydrologic condition *HC*, environmental standard *ES*, and pulse flow *PF* records with the WRAP daily simulation model *SIMD* are applied to incorporate the SB3 EFS at seventeen gage sites into the Nueces WAM.

Simulation results generated with the daily and revised monthly full authorization and current use WAMs are presented in Chapter 6. Simulation results from the alternative versions of the WAM are compared.

Nueces WAM Data Files

The initial datasets modified to create the June 2023 daily and monthly WAMs consist of the monthly full authorization and current use WAMs last updated by the TCEQ in January 2013 which are discussed in Chapter 2. Daily and monthly versions of the full authorization (run 3) and current use (run 8) WAMs developed as described in this report include the following DSS and DIS files common to monthly *SIM* and daily *SIMD* simulations and separate *SIM* and *SIMD* main input DAT files. A *SIMD* daily input DIF file provides flow disaggregation specifications.

The June 2023 daily and monthly WAMs consist of the following WRAP simulation *SIM* and *SIMD* input files.

NuecesHYD.DSS − The hydrology DSS file contains 1934-2021 monthly series of *IN* record naturalized flows, *EV* record net reservoir surface evaporation less precipitation depths, *TS* record monthly SB3 EFS instream flow targets, and 1934-2021 *DF* record daily flows. FLO and EVA files were converted to a DSS file and *DF* and *TS* records were added. The DSS input file contains 41 *IN*, 10 *EV*, 20 *DF*, and *34 TS* records, with each record containing data covering the 1934-2021 hydrologic period-of-analysis. The 34 TS records include 17 records for the full authorization scenario and 17 records for the current use scenario.

Nueces.DIS (N_RUN3.DIS and N_RUN8.DIS) − The flow distribution DIS file contains the flow distribution *FD* and watershed parameter *WP* records used to distribute monthly naturalized flows from 41 primary control points to over 500 secondary control points the same with the daily versus monthly and authorized versus current use versions of the WAM. The 465 *FD* and associated *WP* records and DIS file are not changed in the work reported here.

Nueces.DIF − The DIF file contains flow disaggregation specifications on a *DC* record. Optional routing *RT* records are not included. The same DIF file is employed with both the full authorization and current use scenario WAMs.

Nueces3D.DAT − The daily version of the full authorization scenario (run 3) DAT file with filename Nueces3D.DAT expands the monthly DAT file with filename N_RUN3.DAT.

Nueces3M.DAT − The Nueces3M version of the monthly full authorization DAT file with monthly SB3 EFS targets from a daily simulation replaces the monthly DAT file with filename N_RUN3.DAT.

Nueces8D.DAT − The daily version of the current use scenario (run 8) DAT file with filename Nueces8D.DAT expands the monthly DAT file with filename N_RUN8.DAT.

Nueces8M.DAT − The Nueces8M version of the monthly current use DAT file with monthly SB3 EFS targets from a daily simulation replaces the monthly DAT file with filename N_RUN8.DAT.

The daily and monthly WAMs created as described in this report are the first versions of the Nueces WAM to employ DSS (data storage system) files. The *SIM/SIMD* input file with filename NuecesHYD.DSS stores hydrology time series (*IN*, *EV*, *DF* records) and target time series (*TS* records) data. This DSS file can be called either the hydrology or the time series input file. The same single *SIM/SIMD* hydrology or time series input file with filename

NuecesHYD.DSS is read by both *SIM* and *SIMD* for use with either the full authorization or current use DAT files. Model users can read this DSS file, like all DSS files, with *HEC-DSSVue*.

SIM and *SIMD* time series simulation results are also written to a DSS file. The DSS pathname parts A, B, C, D, E, and F labeling conventions adopted for the *IN*, *EV*, *DF*, and *TS* records in the DSS input file and the simulation results variables in the DSS output file are defined in Chapter 6 of the *WRAP Users Manual* [3].

Any data storage system (DSS) files including *SIM* and *SIMD* input and output files are viewed, analyzed, and modified with *HEC-DSSVue*. All other WRAP input and output files are in normal text format read with Microsoft WordPad, NotePad, Word, Excel, or other editors. Program *TABLES* is used to organize and display the information in *SIM* and *SIMD* simulation input DAT and output OUT files.

CHAPTER 2
WATER AVAILABILITY MODEL FOR THE NUECES RIVER BASIN

The term *Nueces WAM* refers to the monthly WRAP simulation model *SIM* input dataset for the Nueces River Basin from the TCEQ WAM System and modified variations thereof. The original Nueces WAM was completed by HDR Engineering for the TNRCC (TCEQ) in 1999 [1]. The TCEQ has modified the monthly WAM in the past as new permits and amendments were added. Daily and revised monthly versions of the WAM datasets were developed during 2022-2023 as documented by this report.

Previous and Updated Versions of the WAM

The June 2023 daily and monthly WAMs were created by modifying the monthly full authorization and current use WAMs last updated by the TCEQ in January 2013. The January 2013 datasets do not include environmental flow standards (EFS) developed through the process created by the 2007 Senate Bill 3 (SB3). SB3 EFS have been added in the June 2023 daily and modified monthly WAM datasets. Versions of WAM datasets relevant to this chapter are listed as follows.

Full authorization run 3 dataset last modified by TCEQ in January 2013 comprised of the following files: N_RUN3.dat, N_RUN3.dis, N_RUN.eva, and N_RUN.inf

Current use run 8 dataset last modified by TCEQ in January 2013 comprised of the following files: N_RUN8.dat, N_RUN8.dis, N_RUN8.eva, and N_RUN8.inf

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Daily full authorization run 3 dataset developed as documented by this report comprised of the following files: Nueces3D.DAT, Nueces.DIS, Nueces.DIF, and NuecesHYD.DSS.

Monthly full authorization run 3 dataset developed as documented by this report comprised of the following files: Nueces3M.DAT, Nueces.DIS, NuecesHYD.DSS.

Daily current use run 8 dataset developed as documented by this report comprised of the following files: Nueces8D.DAT, Nueces.DIS, Nueces.DIF, and NuecesHYD.DSS.

Monthly current use run 8 dataset developed as documented by this report comprised of the following files: Nueces8M.DAT, Nueces.DIS, and NuecesHYD.DSS.

The hydrologic period-of-analysis is January 1934 through December 1996 for the original 1999 Nueces WAM and updated 2013 version of the WAM. The hydrologic period-of-analysis has been extended through December 2021 for the June 2023 versions of the WAM as discussed in Chapter 3 of this report.

Negative incremental flow ADJINC option 5 is activated on the *JD* record for monthly versions of the Nueces WAM. Daily standard ADJINC option 6 is activated for daily WAMs. INMETHOD option 6 is selected on control point *CP* records to apply the drainage area method for distributing flows to most secondary control points using watershed areas from watershed parameter *WP* records in the DIS file and channel loss coefficients from the *CP* records.

The WRAP simulation models *SIM* and *SIMD* print a listing in the message (MSS) file of the number of various system components. Program *TABLES* 1RCT, 1SUM, and 1RES records provide summaries of data in a DAT file. Several counts for the alternative WAM versions listed above are tabulated in Table 2.1 for comparison.

Table 2.1
Number of Model Components in Nueces WAM Datasets

Latest Update of Datasets	2013	2013	2023	2023	2023	2023
Monthly or Daily Time Step	Monthly	Monthly	Daily	Daily	Monthly	Monthly
Authorized (3) or Current Use (8)	Run 3	Run 8	Run 3	Run 8	Run 3	Run 8
Filename Root	N_Run3	N_Run 8	Nueces3D	Nueces8D	Nueces3M	Nueces8M
total number of control points	543	546	544	547	544	547
primary control points	41	41	41	41	41	41
evap-precip control points	10	10	10	10	10	10
number of reservoirs	121	125	121	125	121	125
WR record water rights	374	392	374	393	374	393
instream flow *IF* record rights	30	32	64	66	47	49
drought index *DI* records	3	3	3	3	3	3
FD records in DIS file	465	465	465	465	465	465

The January 2013 full authorization (run 3) and current use (run 8) WAMs are comprised of 1,677 and 1,788 records, respectively, that include following number of records (run3, run 8) by record type: T1 (1, 1), T2 (1, 1), T3 (1, 1), ** (369, 349), JD (1, 1), RO (1, 1), UC (48, 48), CI (1, 42), CP (543, 546), WR (374, 393), IF (30, 32), TO (8, 8), SO (3, 11), WS (229, 261), OR (50, 77), SV (3, 3), SA (3, 3), DI (3, 3), IP (3,3), and ED (1, 1).

Primary control points CP11, CP14, CP20, and CP23 are included on control point *CP* records in the original and later versions of the DAT file but not actually used in the simulation. Naturalized flow *IN* records are also included for these four control points in the hydrology dataset though not actually used in the simulation. Only thirty primary control points are actually used in computations performed in the *SIM* or *SIMD* simulation.

Twenty daily flow *DF* and thirty-four or seventeen instream flow *IF*, environmental standard *ES*, and pulse flow *PF* records for seventeen control points were added in the June 2023 daily WAM to convert from monthly to daily and to add SB3 EFS. Instream flow *IF* and target series *TS* are added in the June 2023 monthly WAM to model the SB3 EFS at seventeen sites. These additional records added to the daily and modified monthly WAMs are described in Chapters 4 and 5.

Reservoirs and Water Rights

Choke Canyon Reservoir and Lake Corpus Christi are the only reservoirs in the Nueces WAM with authorized storage capacities equaling or exceeding 5,000 acre-feet. The two reservoirs are discussed in Chapter 1. Pertinent metrics describing the two reservoirs are tabulated in Table 1.1. Choke Canyon Reservoir and Lake Corpus Christi have a total combined authorized storage capacity of 1,000,000 acre-feet, which accounts for 96.1 percent of the total authorized storage capacity of 1,040,446 acre-feet in the 121 reservoirs included in the full authorization Nueces WAM. The two reservoirs have a total storage capacity of 918,600 acre-feet in the current use scenario WAM which is 97.5 percent of the total capacity of 959,830 acre-feet of 125 reservoirs.

The 374 water right *WR* records in the full authorization WAM simulate diversion and storage rights with priority dates ranging from December 31, 1885 to November 9, 1999. The thirty instream flow *IF* records in the full authorization WAM have priority dates ranging from February 2, 1924 to April 23, 1997. Several "dummy" accounting *WR* and *IF* records are assigned priorities of 99999999. The diversion amounts on the *WR* and *IF* records in the DAT file sum to greater than the total actual water right amounts due to "dummy" water rights employed in water accounting schemes to model complexities of system operations.

Total authorized diversion and annual consumptive use amounts are tabulated in Tables 2.2 and 2.3 by type of use and location within basin segments, respectively. The basin segments delineated in Figure 2.1 are defined as follows (1) upstream of downstream edge of the Edwards Aquifer outcrop, (2) from segment 1 to subwatershed boundaries near Interstate Highway 35, (3) from segment 2 to the confluence of the Nueces, Frio, and Atascosa Rivers at the City of Three Rivers, and (4) from segment 3 to the Nueces Estuary [1].

Table 2.2
Authorized Annual Diversion Amounts by Type of Use [1]

Type of Water Use	Total of Authorized Annual Diversions	Total of Authorized Annual Consumptive Use
	(acre-feet/year)	(acre-feet/year)
Municipal	221,588	221,588
Industrial	229,640	229,640
Irrigation	79,565	79,705
Mining	262	262
Recreation	44	44
Other	28	28
Aquifer Recharge	2,290	2,290
Total	533,416	531,512

Table 2.3
Authorized Annual Diversion Amounts by Location [1]

Basin Segment (Figure 2.1)	Total of Authorized Annual Diversions	Total of Authorized Annual Consumptive Use
	(acre-feet/year)	(acre-feet/year)
1	22,019	20,115
2	42,320	42,320
3	152,074	152,074
4	317,003	317,003
Total	533,416	531,512

The larger water rights with annual diversion amounts of 2,000 acre-feet or greater are listed in Table 2.4 by owner, with their locations shown in Figure 2.1. These water rights with annual diversion amounts of at least 2,000 acre-feet account for 91.8% of the total authorized annual diversion volume and 96.9% of the authorized storage capacity in the full authorization WAM. The authorized diversion and authorized consumptive use are the same for the water rights listed in Table 2.4, but different for some smaller rights. The water right labels are numbers from permits or certificates of adjudication [1].

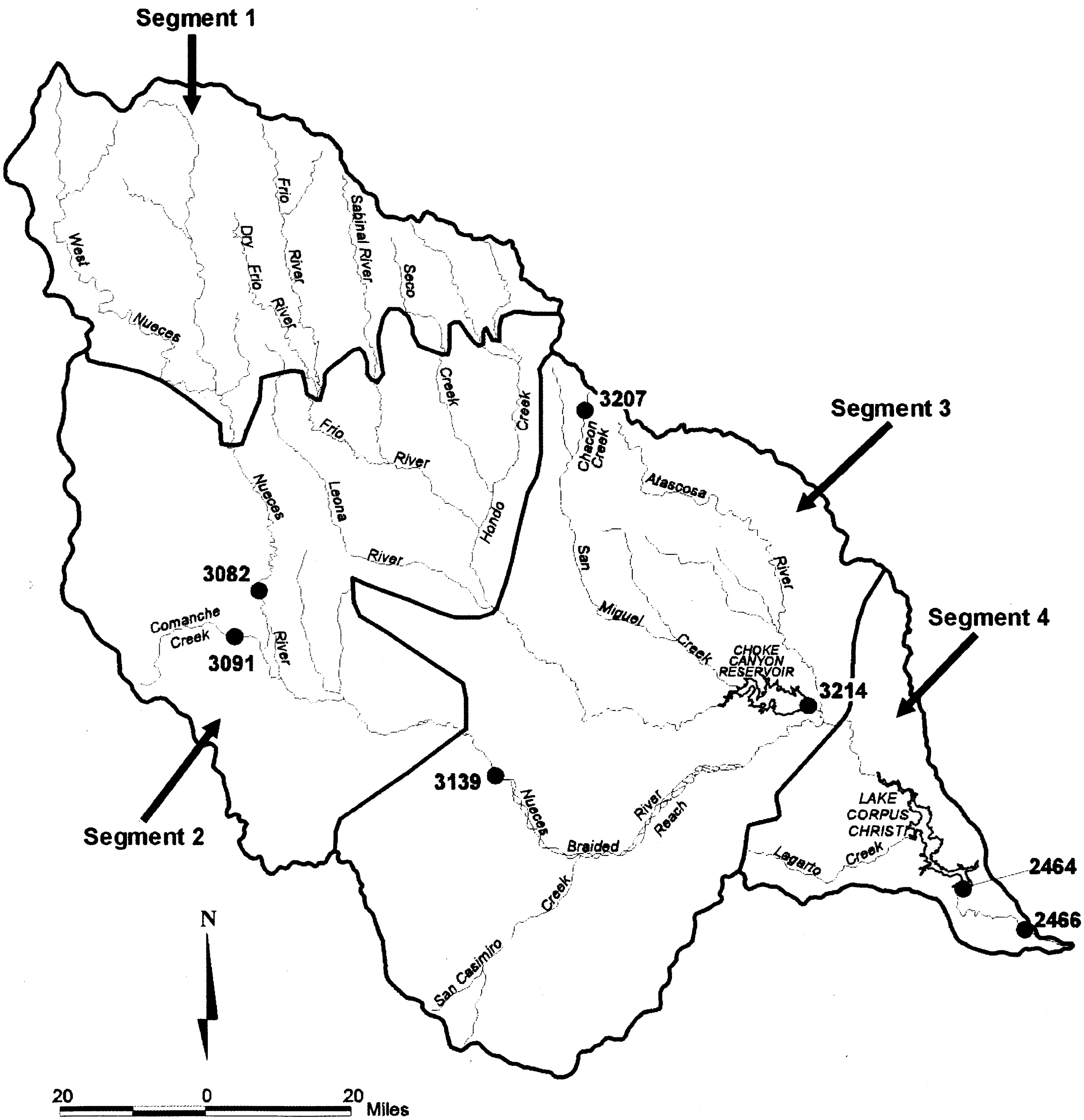

Figure 2.1 Location of Water Rights in Nueces River Basin [1]

Table 2.4
Largest Water Rights

Water Right	Owner	Diversions (ac-ft/year)	Storage (acre-feet)	Reservoir
2464	City of Corpus Christi	304,898	300,000	Lake Corpus Christi
			1,175	Calallen Reservoir
3214	City of Corpus Christi & Nueces River Authority	139,000	700,000	Choke Canyon Reservoir
3082	Zavala-Dimmitt Co. WCID	28,000	5,633	Upper Nueces and others
2466	Nueces County WCID #3	11,546	0	
3091	Turkey Creek Ranches	2,098	0	
3239	Holland Dam & Irrigation	2,023	700	
3207	Bexar-Medina-Atascosa County WCID #1	2,000	730	
Total		489,565	1,008,238	

Operations of the Choke Canyon Reservoir (CCR) and Lake Corpus Christi (LCC) System and the Nueces WAM reflect special conditions in the certificate of adjudication for CCR that provide for maintenance of freshwater inflows to the Nueces Estuary. The special conditions include a monthly schedule of minimum desired freshwater inflows to Nueces Bay totaling between 97,000 and 138,000 acre-feet/year to be provided by spills, return flows, and runoff below Lake Corpus Christi, and/or dedicated passage of inflows through the CCR/LLC System. Provisions for temporary reduction or suspension of freshwater inflow requirements are based on CCR/LLC storage, monthly inflow banking, salinity variations in upper Nueces Bay, and implementation of drought contingency measures [1].

Control Points

The Nueces WAM has 41 primary control points defined by *CP* records with naturalized flows provided as *IN* records in a *SIM/SIMD* hydrology input file. However, primary control points CP11, CP14, CP20, and CP23 serve no purpose in the simulation model. Each of these four control points have OUT entered for the next downstream control point in the second field of the *CP* record. No other records in the DAT file refer to these four controls point. Naturalized flow *IN* records are included in the hydrology dataset for the four unused control points. This report refers to a total of 37 rather than 41 primary control points, omitting control points CP11, CP14, CP20, and CP23. The control point count in Table 2.1 also includes several extra secondary control points used for water accounting computations rather than representing actual physical locations.

The 22 primary control points listed in Table 2.5 are at USGS gage sites. The 15 primary control points listed in Table 2.6 represent ungaged locations. The locations of these 37 primary control points are shown in the basin map of Figure 2.3. Six other USGS gage sites not used in the WAM due in inadequate periods of record are also included in Figure 2.3. Control points CP27 and CP30 are gage sites just downstream of Choke Canyon Reservoir and Lake Corpus Christi. The two reservoirs are assigned secondary control point identifiers CP2731 and CP3031.

Table 2.5
Primary Control Points at USGS Gage Sites

Control Point	USGS Gage No.	Location (Stream, Town)	Drainage Area	Period-of-Record	Missing Data
			(sq miles)		(days)
CP01	08190000	Nueces River, Laguna	737	1Oct1923-present	0
CP02	08190500	W. Nueces R., Brackettville	694	28Sep1939-present	2,010
CP03	08192000	Nueces River, Uvalde	1,861	1Oct1927-present	0
CP04	08193000	Nueces River, Asherton	4,082	1Oct1939-present	366
CP05	08194000	Nueces River, Cotulla	5,171	1Oct1926-present	14
CP06	08194500	Nueces River, Tilden	8,093	1Dec1942-present	43
CP07	08195000	Frio River, Concan	389	30Sep1924-present	366
CP08	08196000	Dry Frio Riv. Reagan Wells	126	1Sep1952-present	0
CP09	08197500	Frio River, Uvalde	631	1Oct1953-present	2
CP12	08198000	Sabinal River, Sabinal	206	1Oct1942-present	0
CP13	08198500	Sabinal River, Sabinal	241	30Sep1986-present	0
CP16	08201500	Seco Creek, Utopia	45.0	1Aug1952-29Sep1961	0
CP17	08202700	Seco Creek, D'Hanis	168	1Nov1960-present	0
CP18	08200000	Hondo Creek, Tarpley	95.6	20Aug1952-present	0
CP19	08200700	Hondo Creek, Hondo	149	1Oct1960-23Jul2006	0
CP24	08204000	Leona River, Uvalde	Spring	Jan1939-Sep1965	-
CP25	08205500	Frio River, Derby	3,429	1Aug1915-present	1,462
CP26	08206700	San Miguel Creek, Tilden	783	25Jan1964-present	9,199
CP27	08207000	Frio River, Calliham	5,491	1Oct1924-23Mar1981	2,192
CP28	08208000	Atascosa River, Whitsett	1,171	22May1932-present	273
CP29	08210000	Nueces River, Three Rivers	15,427	1Jul,1915-present	0
CP30	08212000	Nueces River, Mathis	16,660	5Aug1939-present	3

Control point CP24 on the Leona River near Uvalde is the gage site for spring flow measured between January 1939 and September 1965. This gage is no longer found in the National Water Information System (NWIS) online database maintained by the U.S. Geological Survey (USGS). Gage 08204005 on the Leona River near Uvalde, with a period-of-record of March 2003 to the present, is near the site of the discontinued 08204000 spring flow gage.

Daily flows at the gage sites represented by the control points listed in Table 2.5 were downloaded from the USGS NWIS in early February 2023. The gage periods-of-record are shown in the next-to-last column of the table. The number of days of missing measured flows during the period-of-record is tabulated in the last column. The watershed drainage area above each gage from the NWIS is shown in the fourth column of Table 2.5.

Environmental flow standards (EFS) established through the process created by the 2007 Senate Bill 3 (SB3) at nineteen USGS gate sites in the Nueces River Basin are discussed in Chapter 5. Sixteen of the nineteen gage sites with SB3 EFS are included in Table 2.3. The other three SB3 EFS sites are other UGAS gages not included in Table 2.3.

Table 2.6
Primary Control Points at Ungaged Sites

Control Point	Stream	Drainage Area (sq miles)
CP10	Leona River	34
CP111	Hackberry Creek	9
CP112	Blanco Creek	23
CP141	Little Blanco Creek	16
CP142	Nolton Creek	2
CP15	Ranchero Creek	5
CP201	Live Oak Creek	2
CP202	Parkers Creek	10
CP21	Verde Creek Above Recharge Zone	57
CP22	Verde Creek In Recharge Zone	105
CP231	Elm Creek	33
CP232	Quihi Creek	14
CP31	Calallen Diversion Dam	16,721
CPBAY	Upper Nueces Bay	16,850
CPEST	Nueces Bay and Estuary	17,147

The naturalized flows input on *IN* records for the fifteen primary control points listed in Table 2.6 were synthesized from flows at gaged primary control points. The control points in Table 2.6 are not located at gage sites.

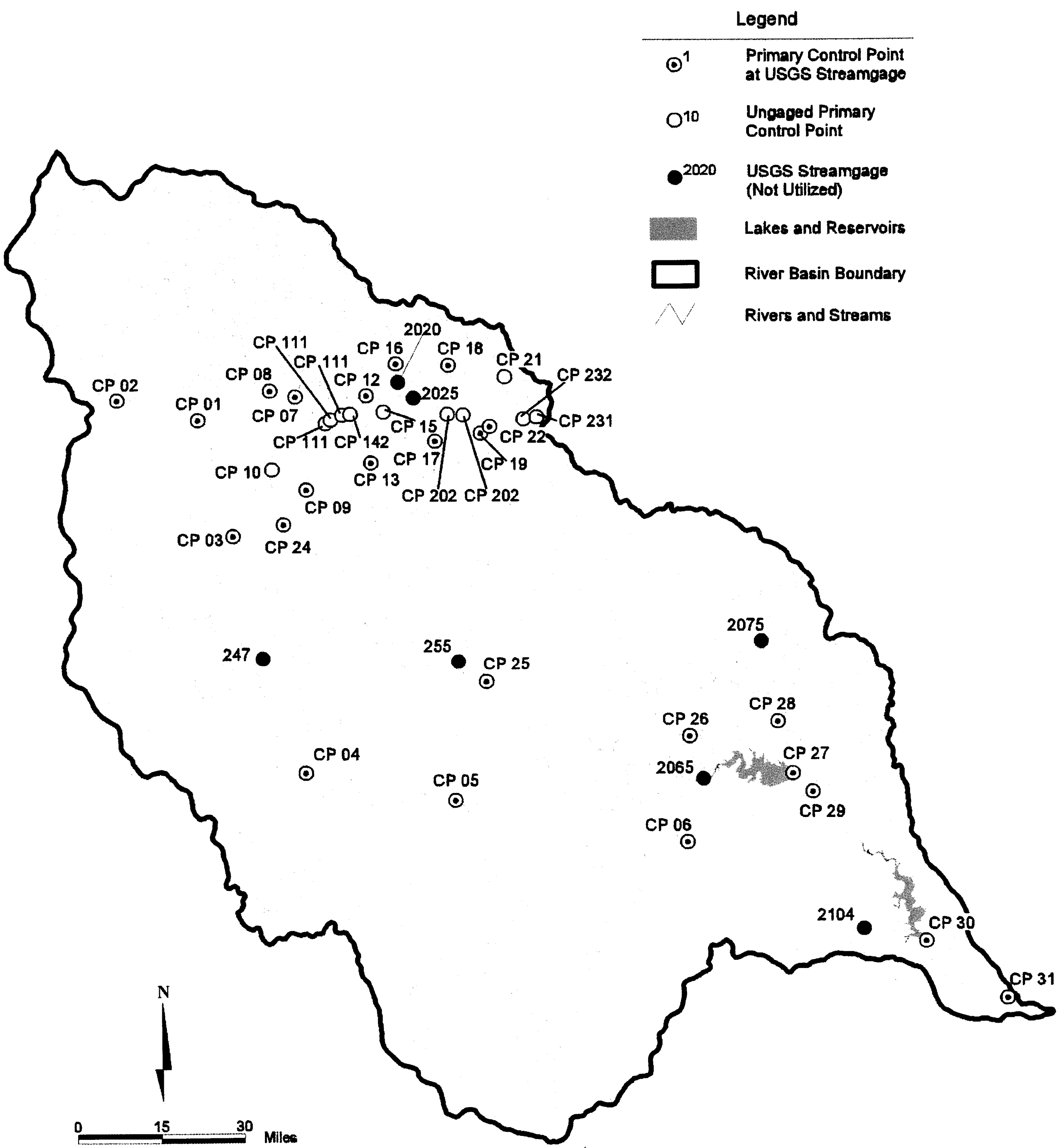

Figure 2.2 Primary Control Points with Monthly Naturalized Flows (*IN* records) in WAM Dataset and USGS Gage Sites [1]

CHAPTER 3
RIVER SYSTEM HYDROLOGY

Chapter 3 describes the general hydrologic characteristics of the Nueces River Basin and the WAM hydrology input data. The monthly and daily versions of the Nueces WAM include the same channel loss factors (*CP* records), flow distribution parameters (*FD* and *WP* records), and 1934-2021 hydrologic period-of-analysis (originally 1934-1996) monthly naturalized stream flows (*IN* records), and net evaporation-precipitation depths (*EV* records). The daily WAM also includes 1934-2021 sequences of daily stream flows on *DF* records that serve as pattern hydrographs in converting monthly naturalized flow volumes to daily quantities in the *SIMD* simulation.

Primary control points are sites at which monthly naturalized stream flows are provided as input on *IN* records. Monthly naturalized flows at secondary control points are computed during a *SIM* or *SIMD* simulation based on the monthly naturalized stream flows read from *IN* records and watershed parameters read from flow distribution *FD* and watershed parameter *WP* records in the DIS file and channel loss factors and INMETHOD(cp) option selections from the *CP* records in the DAT file. Monthly naturalized flows at most secondary control points in the Nueces WAM are synthesized with INMETHOD(cp) option 6 based on channel loss factors and watershed areas.

Hydrologic Characteristics of the Nueces River Basin

The location and size of the Nueces River Basin in comparison to the other major river basins and coastal basins of Texas are illustrated in Figure 1.1 on page 3. The general configuration of the river basin and underlying groundwater formations are shown in Figure 1.2 on page 4. The locations of relevant USGS stream gage stations and WAM primary control points are shown in Figure 2.2 on the preceding page 20. The gaging stations serving as WAM control points are listed in Table 2.5 with their watershed drainage areas.

Mean annual rainfall and reservoir evaporation rates in the Nueces River Basin are 25.0 inches and 58.4 inches, respectively. Rainfall is sporadic. Stream flow throughout the basin is generally characterized as being intermittent and highly variable with short periods of high flows preceded and followed by long periods of low or zero flows.

The following two aspects of the Nueces River Basin combine to make the basin unusual compared to other river basins of Texas.

1. The hydrology of the Nueces River Basin is greatly affected by interactions between stream flow and groundwater, much more than typically in other river basins. Effects are primarily through stream flow recharge of groundwater systems but also through spring flows to streams. Although stream flow in all river basins is affected by interactions between surface and groundwater, the interactions in the Nueces River Basin are much greater than typically occurring in other river basins.

2. Only minimal use of surface water occurs within the Nueces Basin. Most use of surface water from the Nueces River and tributaries occurs in the adjoining coastal basins from diversions near the basin outlet. Reservoir storage is dominated by the two-reservoir Choke Canyon Reservoir and Lake Corpus Christi System located in the lower basin. The population of the basin is small. Most water use within the basin is supplied by groundwater.

The Nueces River and its tributaries cross aquifer outcrop recharge zones of the Edwards, Carrizo-Wilcox, Bigford, Queen City, Sparta, Gulf Coast, and Goliad Sand groundwater formations as shown in Figure 1.2. The streams contribute to recharge of all these aquifers. However, the Edwards Aquifer recharge zone accounts for the largest volume of stream flow loss to groundwater. HDR Engineering, Inc. [1, 15] estimated the 1934-1996 average annual recharge to the Edwards Aquifer to be 333,400 acre-feet/year. For comparison, this quantity of stream flow volume recharging the Edwards Aquifer is 62.5 percent as large as the 533,416 acre-feet/year total of all authorized diversions from the Nueces River and tributaries shown in Tables 2.2 and 2.3.

The estimated 333,400 acre-feet/year recharge of the Edwards Aquifer and additional quantities of recharge to the several other groundwater systems occur in the upper and middle regions of the basin. Most of the 533,416 acre-feet/year of authorized water supply diversions are from the lower reach of the Nueces River. Spring flow also contributes to stream flow in the upper basin. The authorized use of stream flow includes groundwater recharge enhancement projects sponsored by the Edwards Aquifer Authority.

Table 3.1
Channel Loss Factors (C_L) and Delivery Factors (DF=1.0-C_L)

	Control Points		Loss	Delivery
Stream	From	To	Factor	Factor
Nueces River	CP01	CP03	0.05	0.95
West Nueces River	CP02	CP03	0.03	0.97
Nueces River	CP03	CP04	0.47	0.53
Nueces River	CP04	CP05	0.26	0.74
Nueces River	CP05	CP06	0.35	0.65
Nueces River	CP06	CP20	0.18	0.82
Frio River	CP07	CP09	0.49	0.51
Dry Frio River	CP08	CP09	0.22	0.78
Frio River	CP09	CP25	0.49	0.51
Sabinal River	CP12	CP13	0.26	0.84
Sabinal River	CP13	CP25	0.49	0.51
Seco Creek	CP16	CP17	0.49	0.51
Seco Creek	CP17	CP25	0.49	0.51
Hondo Creek	CP18	CP19	0.23	0.77
Hondo Creek	CP19	CP25	0.49	0.51
Verde Creek	CP21	CP22	0.23	0.77
Verde Creek	CP22	CP25	0.49	0.51
Leona River	CP10	CP24	0.49	0.51
Leona River	CP24	CP25	0.49	0.51
Frio River	CP25	CP27	0.34	0.66
San Miguel Creek	CP26	CP27	0.47	0.53
Frio River	CP27	CP29	0.05	0.95
Atascosa River	CP28	CP29	0.10	0.90
Nueces River	CP29	CP30	0.26	0.74
Nueces River	CP30	CP31	0.07	0.93

Channel loss factors employed in the WAM to estimate channel losses between primary control points at USGS gages are tabulated in Table 3.1 [1]. A channel loss factor (C_L) is the fraction of the flow at an upstream control point lost through seepage, evapotranspiration, aquifer recharge, and other unaccounted for reasons before reaching a downstream site.

The following example illustrates application of the delivery factors (DF = 1.0 – C_L). The reach of the Nueces River from control point CP03 through control points CP04 and CP05 to control point CP06 has a delivery factor (DF) of 0.2549 computed as (0.53)(0.74)(0.65)=0.2549. For each 100 acre-feet of water entering the Nueces River at CP3, an estimated 25.49 acre-feet reaches CP06 under natural conditions and the other 74.51 acre-feet is loss. Likewise, for each 100 acre-feet of water diverted from the Nueces River at CP3, an estimated 25.49 acre-feet reduction in flow occurs at CP06. The other 74.51 acre-feet would not have reached CP06 even without the 100 acre-feet diversion at CP03. Control point CP03 and this entire example reach are located well below the Edwards recharge zone. Thus, this reach does not cross the Edwards recharge zone.

Channel losses affect aspects of WRAP/WAM modeling in which stream flow changes at upstream locations are relevant further downstream. Channel loss factors affect both conversion of observed flows to monthly naturalized flows for incorporation in the WAM simulation input dataset and the results of *SIM* and *SIMD* simulation computations. Delivery factors are applied to changes in flow volumes resulting from diversions, return flows, refilling reservoirs, releases from storage, and other flow changes as the flow changes propagate downstream. Loss factors for the Nueces River and tributaries are very high compared to other river systems. However, effects of the large loss factors on *SIM* and *SIMD* simulation computations are reduced by the occurrence of most of the simulated diversions, return flows, and reservoir storage changes in the lower basin downstream of the stream reaches with high channel losses.

Daily Observed Flows

Daily mean stream flows in cubic feet per second (cfs) were downloaded in early February 2023 from the National Water Information System (NWIS) online database maintained by the U.S. Geological Survey (USGS) to a DSS file using HEC-DSSVue. The last three columns of Table 3.2 are comprised of the median (50% exceedance), mean, and maximum of the available observed mean daily flows during the 1934-2021 WAM hydrologic period-of-analysis. The minimum mean daily flow at gage 08190000 on the Nueces River near Laguna (control point CP01) during 1934-2021 is 3.0 cfs. The other gages listed in Table 3.2 all have multiple days with zero observed flow.

The twenty-two primary control points located at USGS gaging stations are listed in both Tables 2.5 and 3.2 with their periods-of-analysis and drainage areas in square miles from the USGS NWIS. The days of missing data tabulated in the last column of Table 2.5 of the preceding Chapter 2 refers to daily flow data missing from the USGS database during the entire period-of-analysis shown in the preceding column of the table. The days of missing data tabulated in the fifth column of Table 3.2 refers to daily flow data missing during the 1934-2021 WAM hydrologic period-of-analysis, which consists of a total of 88 years, 1,056 months, or 32,142 days.

Control point CP24 on the Leona River near Uvalde includes monthly naturalized flows determined from spring flow measured between January 1939 and September 1965 [1]. The spring flow gage is no longer found in the USGS NWIS. USGS gage 08204005 on the Leona River near

Uvalde, with a period-of-record of March 2003 to the present and drainage area of 132 square miles, is near the site of the discontinued USGS 08204000 spring flow gage.

Table 3.2
Primary Control Points at USGS Gage Sites with Daily Observed Flow Statistics

Control Point	Location (Stream, Town)	DA (sm)	Period-of-Record	Missing Days	50% (cfs)	Mean (cfs)	Max (cfs)
CP01	Nueces River, Laguna	737	1Oct1923-present	0	78.0	164.9	107,000
CP02	W. Nueces R., Brackettville	694	28Sep1939-present	4,106	0.90	32.84	42,500
CP03	Nueces River, Uvalde	1,861	1Oct1927-present	0	25.0	146.4	171,000
CP04	Nueces River, Asherton	4,082	1Oct1939-present	2,465	0.07	178.3	24,800
CP05	Nueces River, Cotulla	5,171	1Oct1926-present	0	0.490	236.5	79,000
CP06	Nueces River, Tilden	8,093	1Dec1942-present	3,299	4.60	363.3	70,000
CP07	Frio River, Concan	389	30Sep1924-present	0	66.0	119.6	35,000
CP08	Dry Frio Riv. Reagan Wells	126	1Sep1952-present	6,818	13.0	34.83	12,200
CP09	Frio River, Uvalde	631	1Oct1953-present	7,215	0.00	36.70	32,300
CP12	Sabinal River, Sabinal	206	1Oct1942-present	3,195	5.50	46.50	22,900
CP13	Sabinal River, Sabinal	241	30Sep1986-present	19,265	1.40	35.06	22,900
CP16	Seco Creek, Utopia	45.0	1Aug1952-29Sep1961	28,795	1.40	15.40	5,800
CP17	Seco Creek, D'Hanis	168	1Nov1960-present	9,801	0.00	7.928	16,100
CP18	Hondo Creek, Tarpley	95.6	20Aug1952-present	6,806	9.60	40.23	30,000
CP19	Hondo Creek, Hondo	149	1Oct1960-23Jul2006	15,410	0.00	16.75	24,000
CP24	Leona River, Uvalde	spring	Jan1939-Sep1965	-	-	-	-
CP25	Frio River, Derby	3,429	1Aug1915-present	1,462	6.80	132.1	65,300
CP26	San Miguel Creek, Tilden	783	25Jan1964-present	20,180	0.00	36.29	22,400
CP27	Frio River, Calliham	5,491	1Oct1924-23Mar1981	14,893	20.00	254.4	40,200
CP28	Atascosa River, Whitsett	1,171	22May1932-present	273	9.80	114.7	65,000
CP29	Nueces River, Three Rivers	15,427	1Jul,1915-present	0	74.50	707.3	128,000
CP30	Nueces River, Mathis	16,660	5Aug1939-present	2,042	123.0	650.0	125,000

A comparison of observed flow at control points CP01 and CP03 on the Nueces River near Laguna and Uvalde illustrates the effects of the Edwards outcrop on stream flow. The river reach between control points CP01 and CP03 crosses the recharge zone of the Edwards Aquifer. Watershed drainage areas are 737 and 1,961 at the upstream and downstream gage sites. The median daily flows exceeded 50% of the time at CP01 and CP03 are 78.0 cfs and 25.0 cfs, respectively. The upstream and downstream mean flows are 164.9 and 146.4 cfs, respectively. Mean and lesser flows are smaller at the downstream gage site that at the upstream gage site. The maximum observed flows are 107,000 cfs and 171,000 cfs at the upstream (CP01) and downstream (CP3) gage sites. Flood flows greatly exceed the recharge capacity of the Edwards Aquifer recharge zone and thus are not affected as much as low flows by groundwater recharge.

The hydrologic characteristics of the Nueces River Basin are further explored in Tables 3.3 and 3.4. The 1934-2021 means of the observed daily flows at the USGS gages are tabulated in cubic feet per second (cfs) and as an annual volume equivalent to covering the watershed above the gage to a depth in inches. The days of missing data during 1934-2021 analysis period are shown in the fourth column of Table 3.3. The mean annual precipitation varies a little across the Nueces River Basin with a basin-wide average of about 25 inches. The mean annual stream flow quantities in the last column of Table 3.3 are much smaller than the mean 25 inches/year mean annual rainfall. Most of the rainfall never reaches the stream flow gage sites.

Table 3.3
Observed Stream Flows at USGS Gage Sites in Annual Volume Equivalents in Inches

Control Point	Location (Stream, Town)	Area (sq miles)	Missing Days	Mean Flow (cfs)	Mean Flow (inches/yr)
CP01	Nueces River, Laguna	737	0	164.9	3.04
CP02	W. Nueces R., Brackettville	694	4,106	32.84	0.64
CP03	Nueces River, Uvalde	1,861	0	146.4	1.07
CP04	Nueces River, Asherton	4,082	2,465	178.3	0.59
CP05	Nueces River, Cotulla	5,171	0	236.5	0.62
CP06	Nueces River, Tilden	8,093	3,299	363.3	0.61
CP07	Frio River, Concan	389	0	119.6	4.18
CP08	Dry Frio Riv. Reagan Wells	126	6,818	34.83	3.75
CP09	Frio River, Uvalde	631	7,215	36.70	0.79
CP12	Sabinal River, Sabinal	206	3,195	46.50	3.07
CP13	Sabinal River, Sabinal	241	19,265	35.06	1.98
CP16	Seco Creek, Utopia	45.0	28,795	15.40	4.65
CP17	Seco Creek, D’Hanis	168	9,801	7.928	0.64
CP18	Hondo Creek, Tarpley	95.6	6,806	40.23	5.72
CP19	Hondo Creek, Hondo	149	15,410	16.75	1.53
CP25	Frio River, Derby	3,429	1,462	132.1	0.52
CP26	San Miguel Creek, Tilden	783	20,180	36.29	0.63
CP27	Frio River, Calliham	5,491	14,893	254.4	0.63
CP28	Atascosa River, Whitsett	1,171	273	114.7	1.33
CP29	Nueces River, Three Rivers	15,427	0	707.3	0.62
CP30	Nueces River, Mathis	16,660	2,042	650.0	0.53

Table 3.4
Comparison of Precipitation and Observed Stream Flow at Sites Throughout Texas

USGS Gage Location	Drainage Area	Mean Precip	Mean Flow	Mean Flow
	(sq miles)	(inches/yr)	(inches/yr)	(% Precip)
Nueces River at Three Rivers	15,427	24.8	0.662	2.67%
Nueces River at Mathis	16,503	24.8	0.574	2.31%
Canadian River near Amarillo	19,445	19.5	0.218	1.12%
Canadian River near Canadian	22,866	19.5	0.189	0.97%
Guadalupe River at Victoria	5,198	32.7	5.079	15.53%
Colorado River near Bay City	30,837	23.5	1.085	4.62%
Brazos River at Richmond	35,541	28.9	2.807	9.71%
Trinity River at Romayor	17,186	39.4	6.126	15.55%
Neches River at Evadale	7,951	48.7	10.46	21.48%
Sabine River near Ruliff	9,329	47.8	11.81	24.71%

The quantities in Table 3.4 comparing the Nueces River Basin with other locations throughout Texas are from a 2014 Texas Water Resources Institute technical report [16]. Means of observed stream flow at USGS gages with long gage records located near basin outlets are compared with long-term means of precipitation averaged over the river basins. For example, Table 3.4 indicates that the 1938-2016 mean observed flow of the Nueces River at Mathis is an estimated 2.3% of the precipitation falling on the basin above this site. This long-term mean observed flow as a percentage of precipitation can be compared with quantities for other locations in Texas ranging from mean flows of 0.97% of precipitation on the Canadian River near the City of Canadian to mean flows of 24.7% of precipitation on the Sabine River near the City of Ruliff. Stream flow as a percentage of precipitation is small in the Nueces River Basin. Groundwater recharge contributes significantly to reductions in stream flow in the Nueces River Basin.

Plots of Daily Observed Flows and Monthly Naturalized Flows

Daily observed flows in cfs and monthly naturalized flows in acre-feet at eleven primary control points at USGS gage sites with periods-of-record covering all or most of the WAM January 1934 through December 2021 hydrologic period-of-analysis are plotted in Figures 3.1 through 3.22. These time series plots illustrate stationarity (or departure therefrom) and variability characteristics of flows of the Nueces River and its tributaries. Observed daily versus naturalized monthly stream flows are graphically displayed for comparison. Drainage areas of the gage sites range from 95.6 to 16,660 square miles. Site locations are shown in Figure 2.2. Monthly naturalized flows are discussed later in the present Chapter 3. Daily pattern hydrographs used in monthly flow disaggregation and daily naturalized flows are covered in Chapter 4.

The twenty-two WAM primary control points located at USGS gage sites are listed in Tables 2.5 and 3.2 with relevant information. The number of days of missing data shown in the last column of Table 2.5 refers to the gage period-of-record shown in the preceding column of the table. The number of days of missing data in the fifth column of Table 3.2 refers to daily flow data missing during the 32,142 days of the 1934-2021 WAM hydrologic period-of-analysis.

Plots are included in Figures 3.1 through 3.22 for eleven of the twenty-two WAM primary control points representing USGS gage sites as follows.

- Five of the selected gage sites have complete records covering 1934-2021 with no missing data. CP01, CP03, CP05, and CP29 are on the Nueces River. CP07 is on the Frio River.
- The gage at CP28 on the Atascosa River has only 273 days of missing data, consisting of the 273 days extending from December 31, 2006 through September 29, 2007.
- The periods-of-record for the gages at CP08, CP09, CP12, CP18, CP28, and CP30 begins later than 1934. The periods-of-record for gages at CP08, CP12, CP18, and CP28, though beginning several years after 1934, have no missing data. CP09 and CP30 gages have two and three days, respectively, of missing data during their periods-of-record which begin in 1953 and 1939. The two and three days of missing data are filled in by interpolation.

The other eleven gage sites are not selected for inclusion in Figures 3.1 through 3.22 due to their larger gaps of missing observed daily flows. The numbers of days of missing data during the WAM 1934-2021 period-of-analysis range from 1,462 days at CP25 to 28,795 days at CP16.

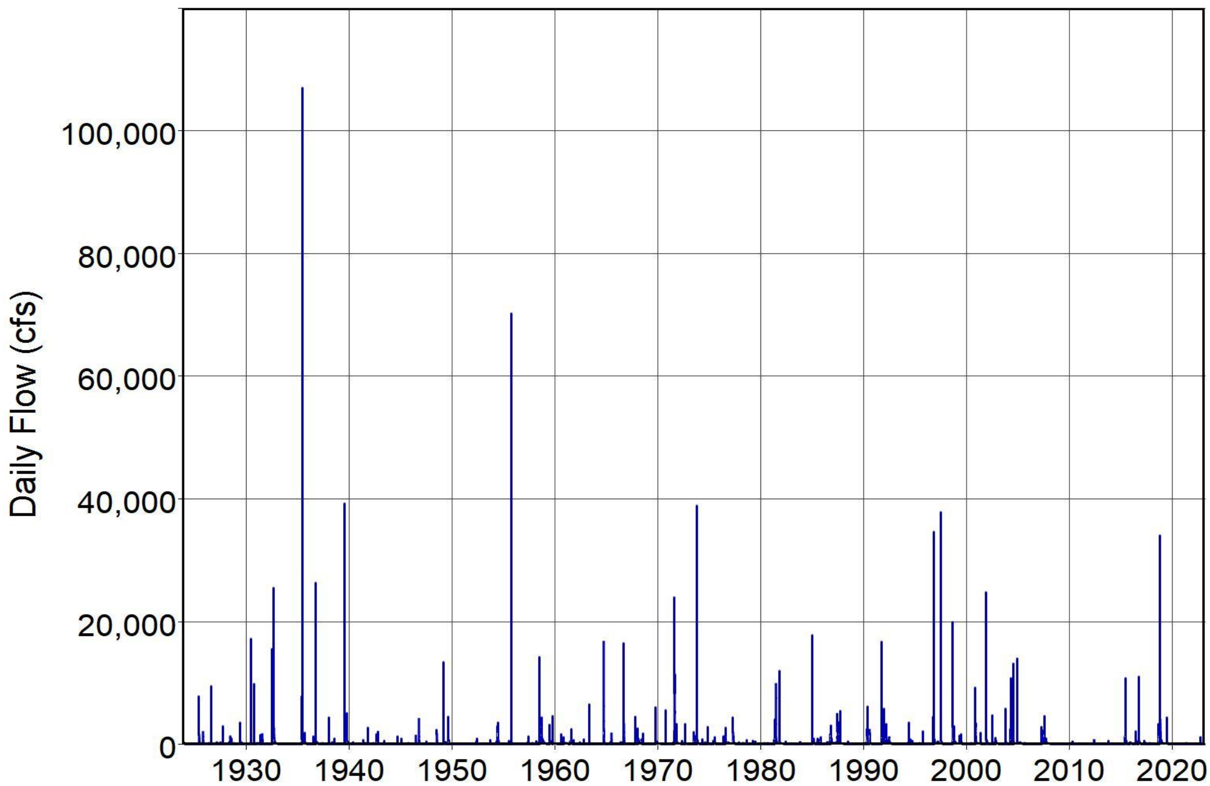

Figure 3.1 Daily Observed Flows of Nueces River, Laguna, CP01

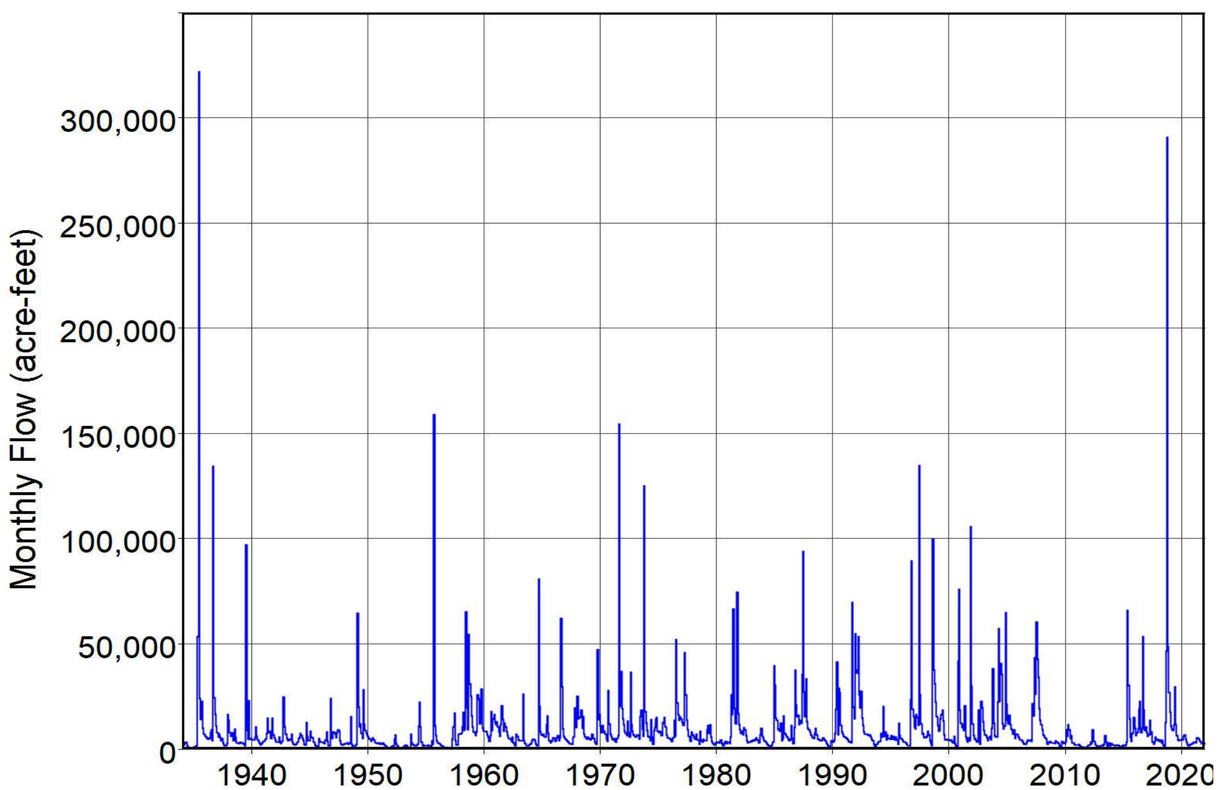

Figure 3.2 Monthly Naturalized Flows of Nueces River, Laguna, CP01

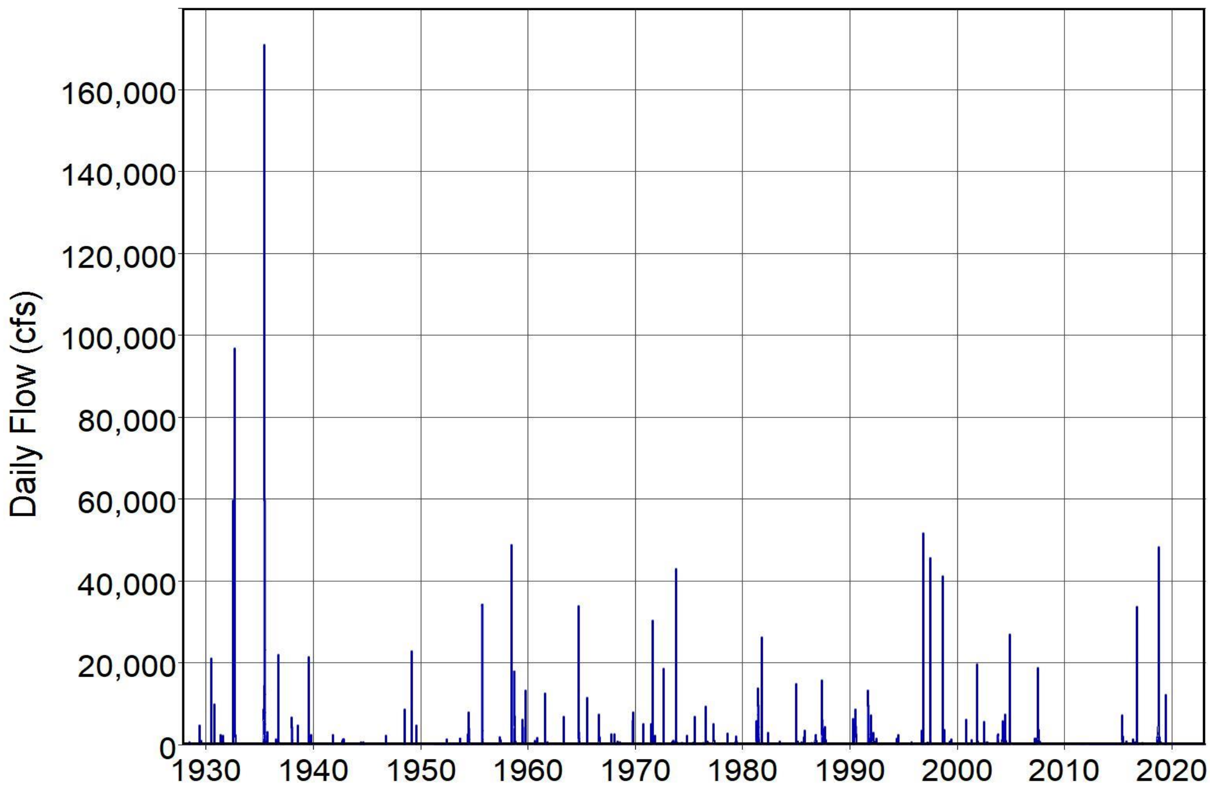

Figure 3.3 Daily Observed Flows of Nueces River, Uvalde, CP03

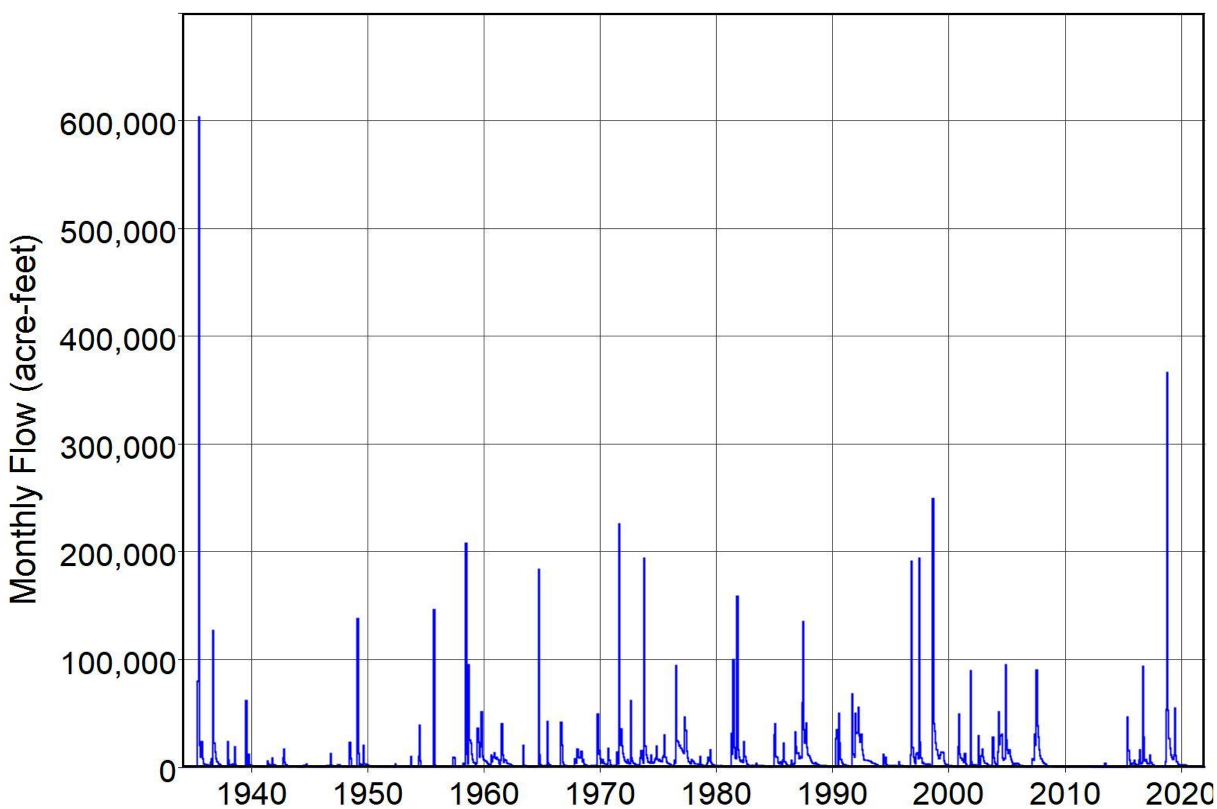

Figure 3.4 Monthly Naturalized Flows of Nueces River, Uvalde, CP03

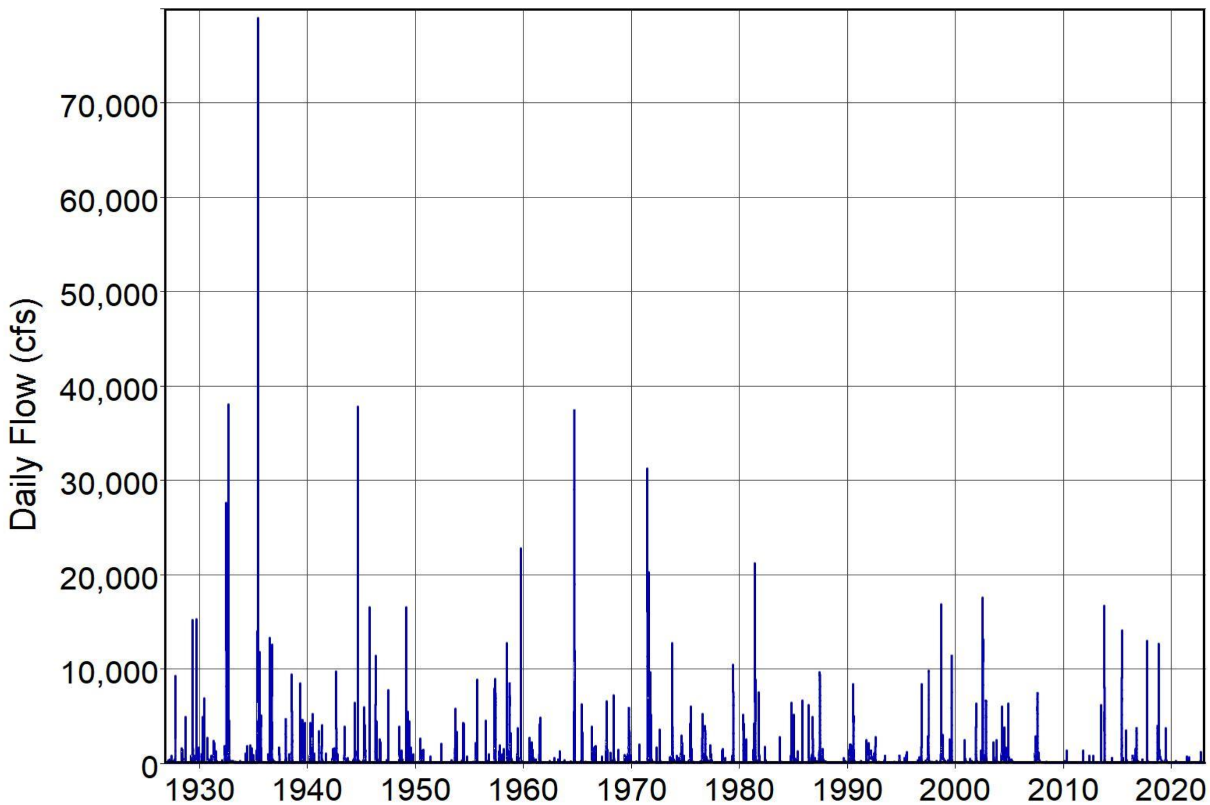

Figure 3.5 Daily Observed Flows of Nueces River, Cotulla, CP05

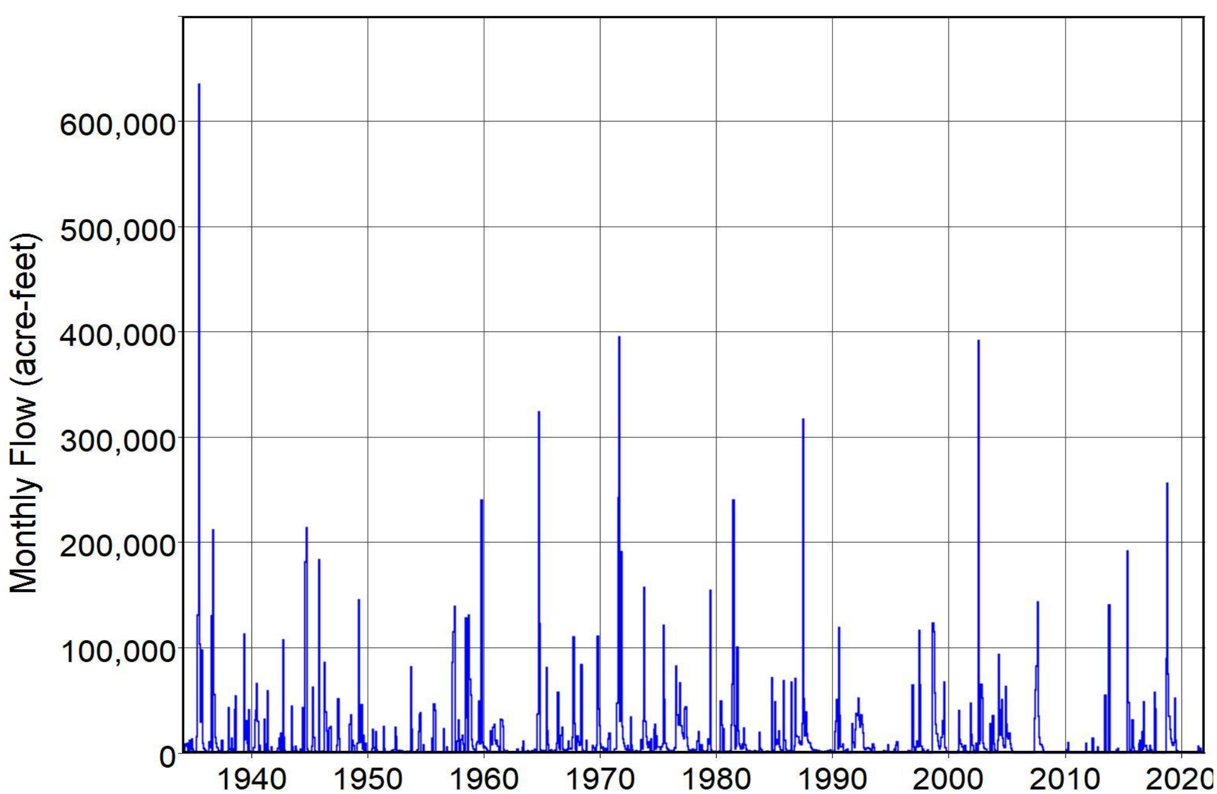

Figure 3.6 Monthly Naturalized Flows of Nueces River, Cotulla, CP05

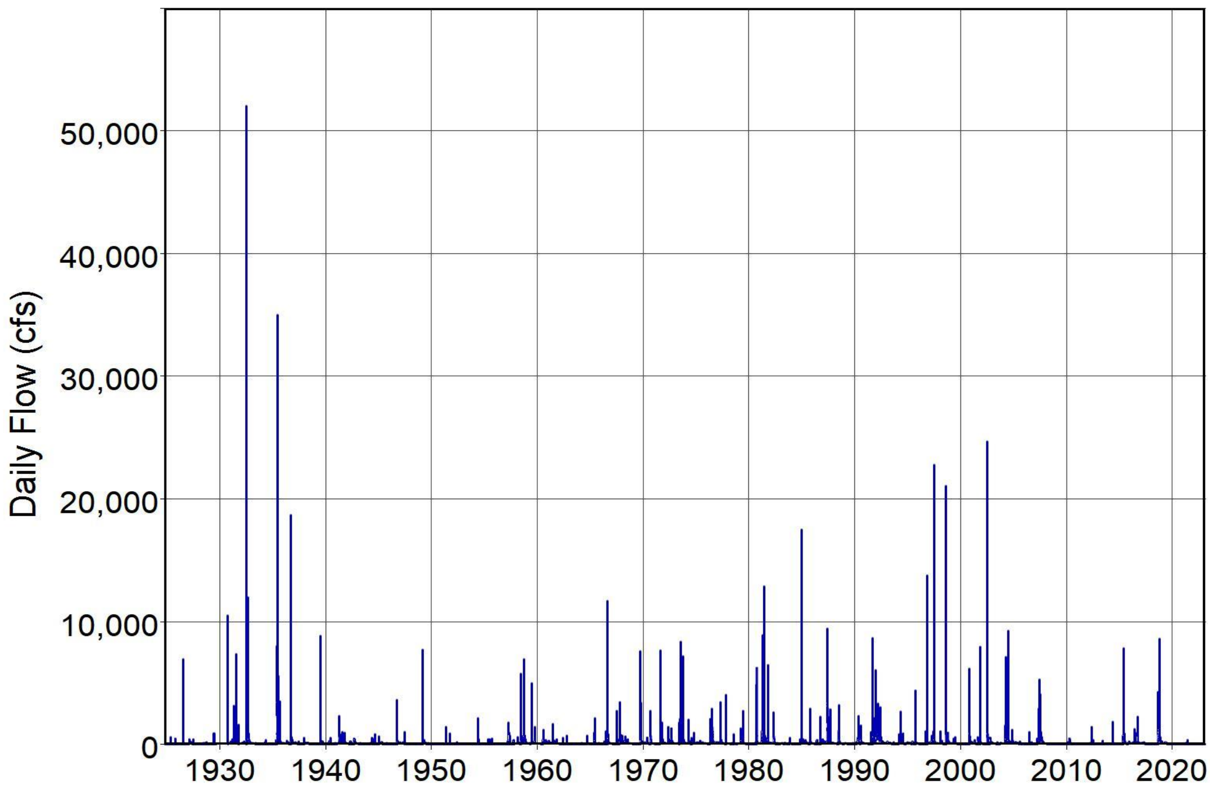

Figure 3.7 Daily Observed Flows of Frio River, Concan, CP07

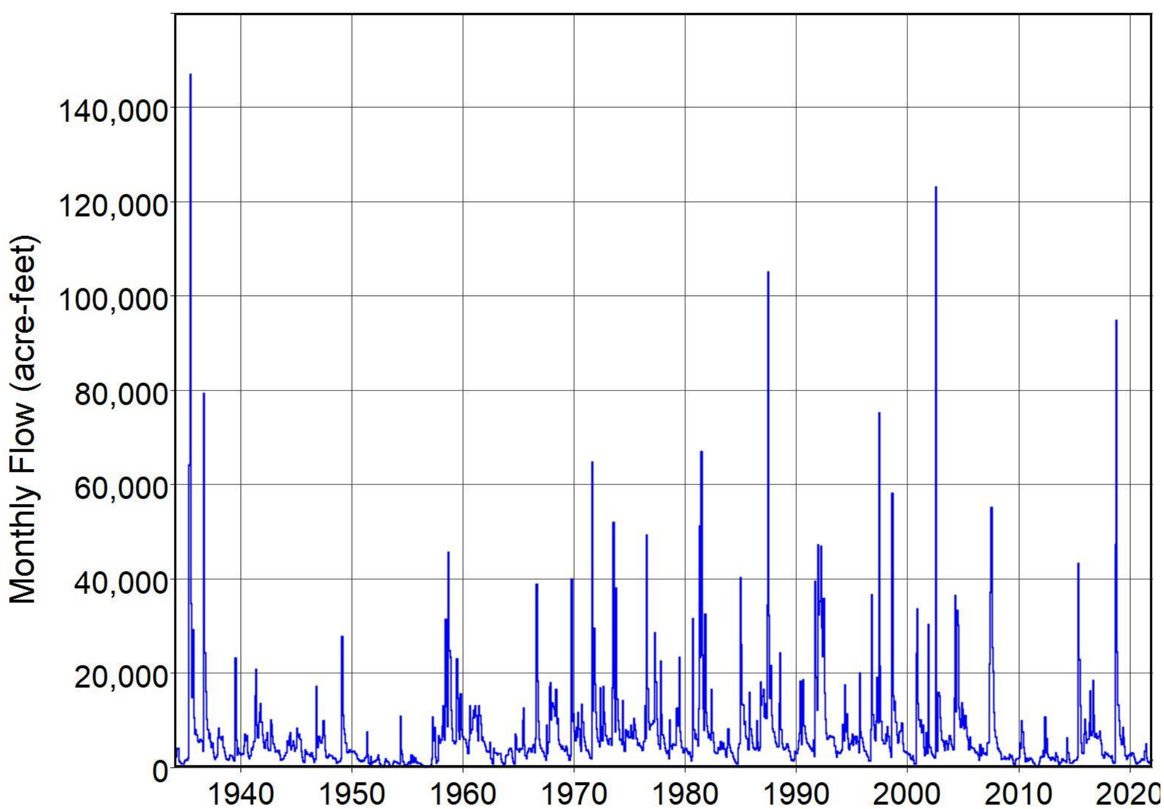

Figure 3.8 Monthly Naturalized Flows of Frio River, Concan, CP07

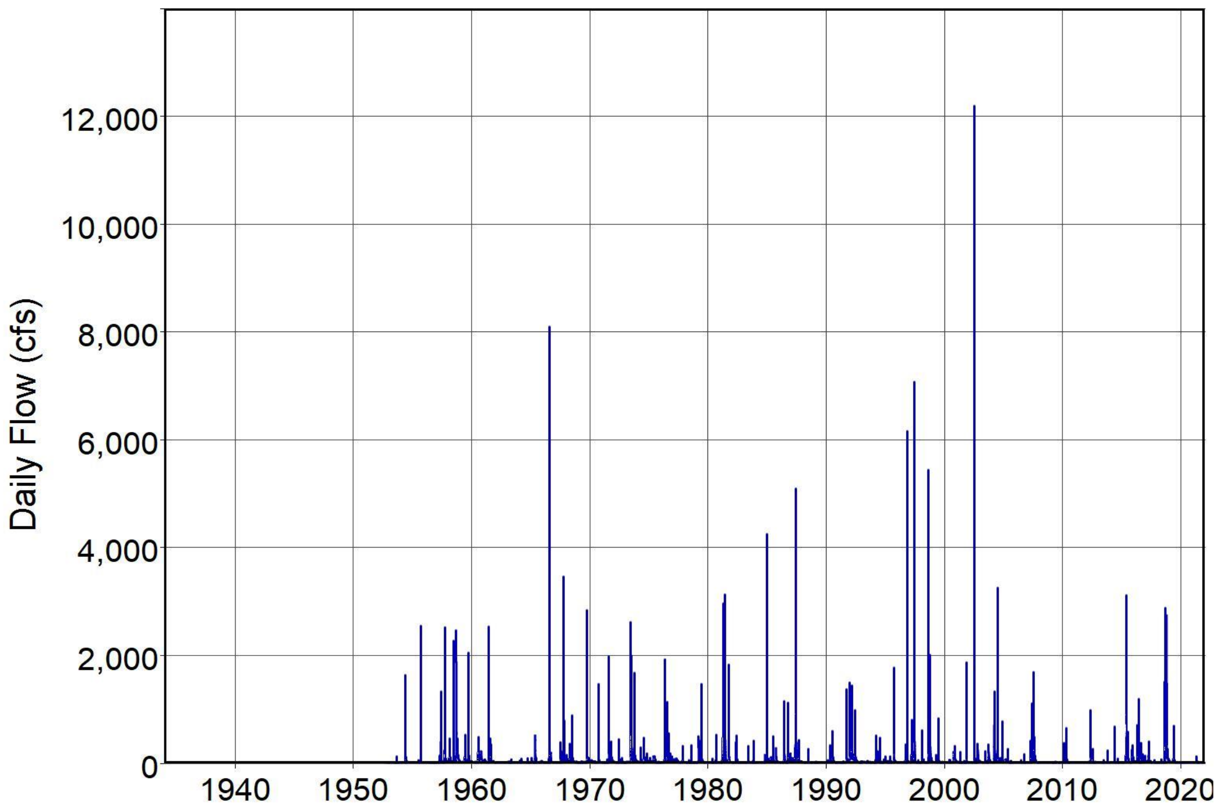

Figure 3.9 Daily Observed Flows of Dry Frio River, Reagan Wells, CP08

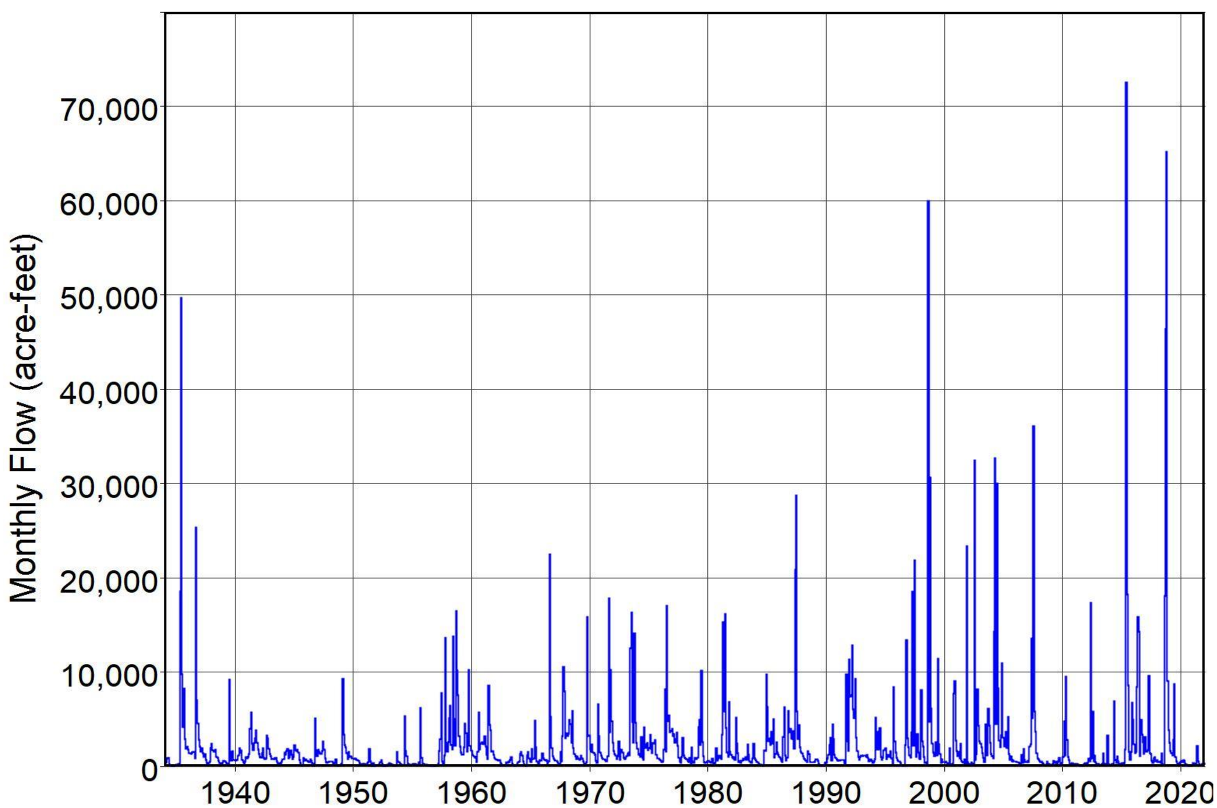

Figure 3.10 Monthly Naturalized Flows of Dry Frio River, Reagan Wells, CP08

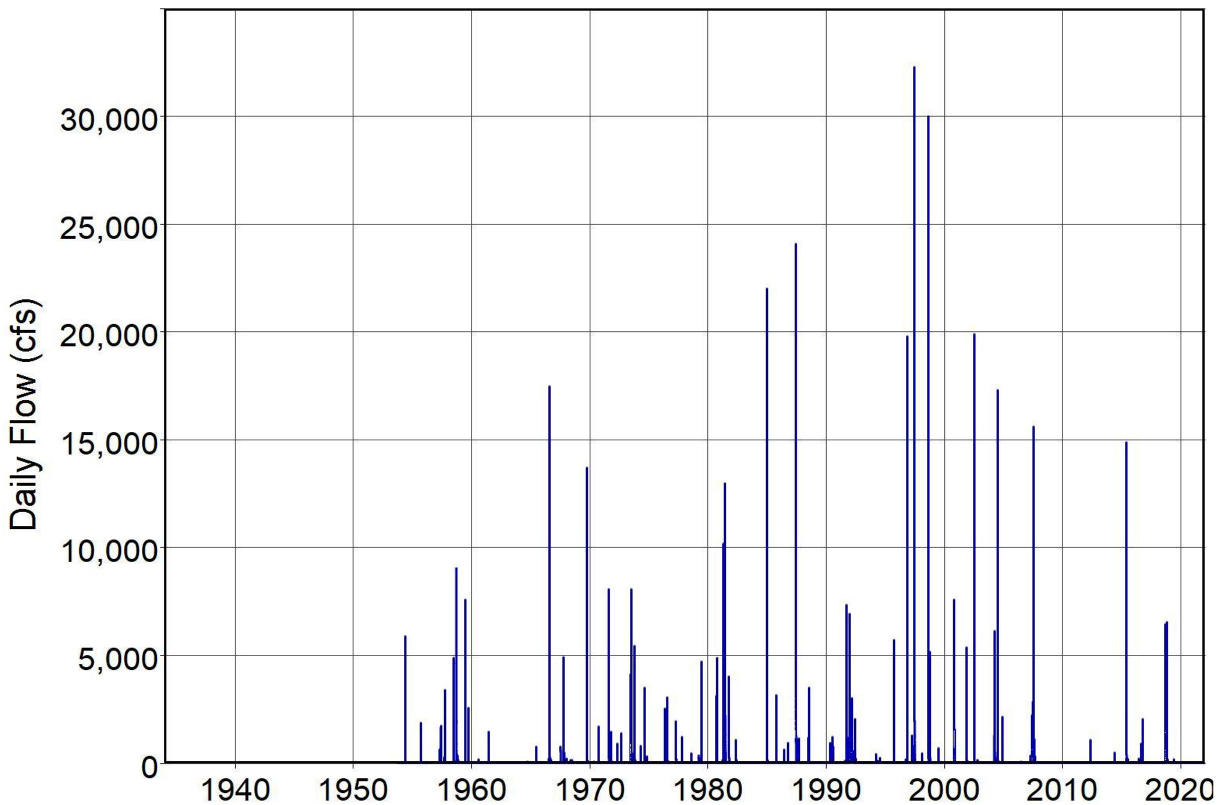

Figure 3.11 Daily Observed Flows of Frio River, Uvalde, CP09

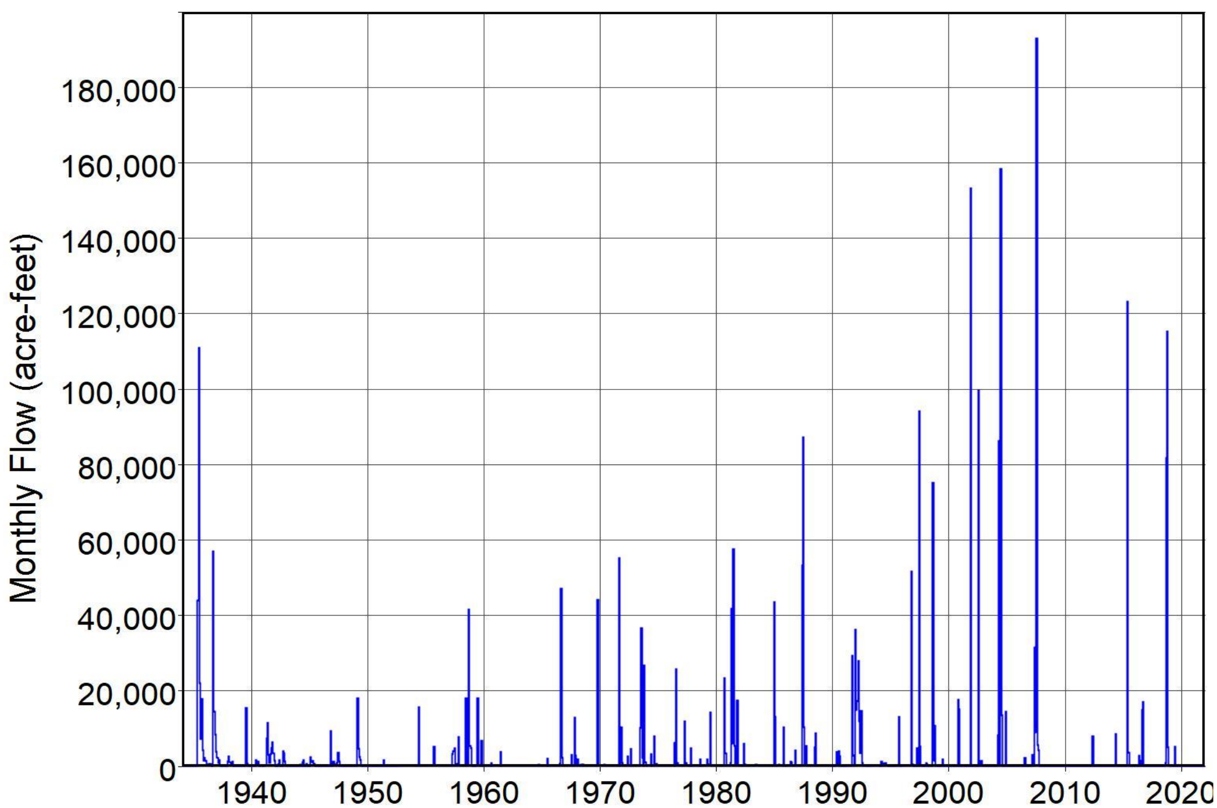

Figure 3.12 Monthly Naturalized Flows of Frio River, Uvalde, CP09

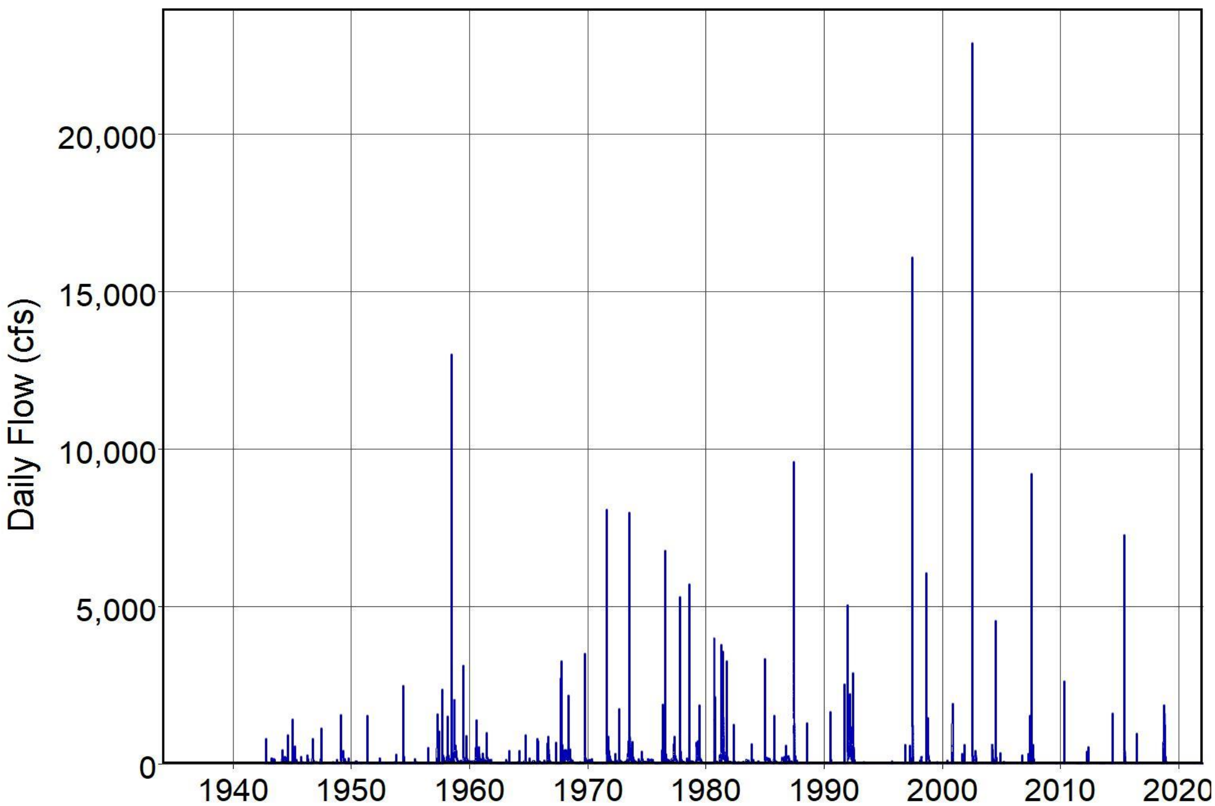

Figure 3.13 Daily Observed Flows of Sabinal River, Sabinal, CP12

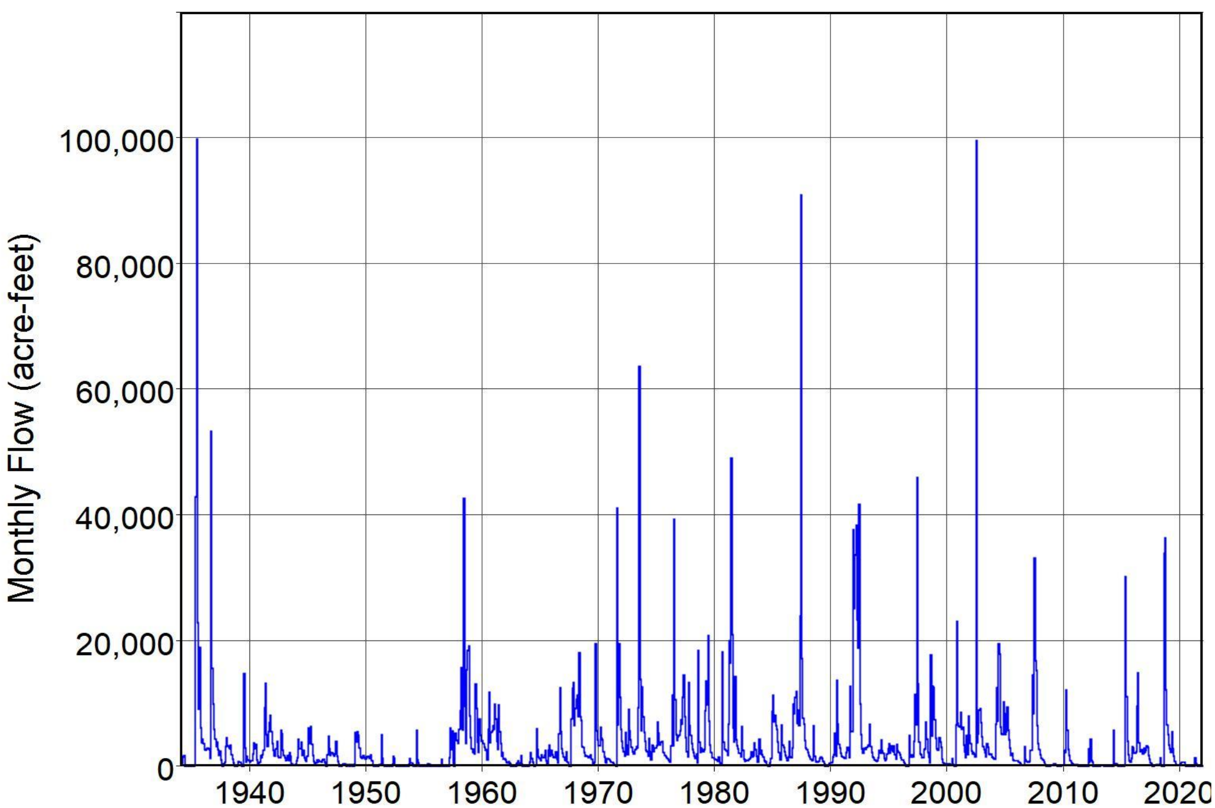

Figure 3.14 Monthly Naturalized Flows of Sabinal River, Sabinal, CP12

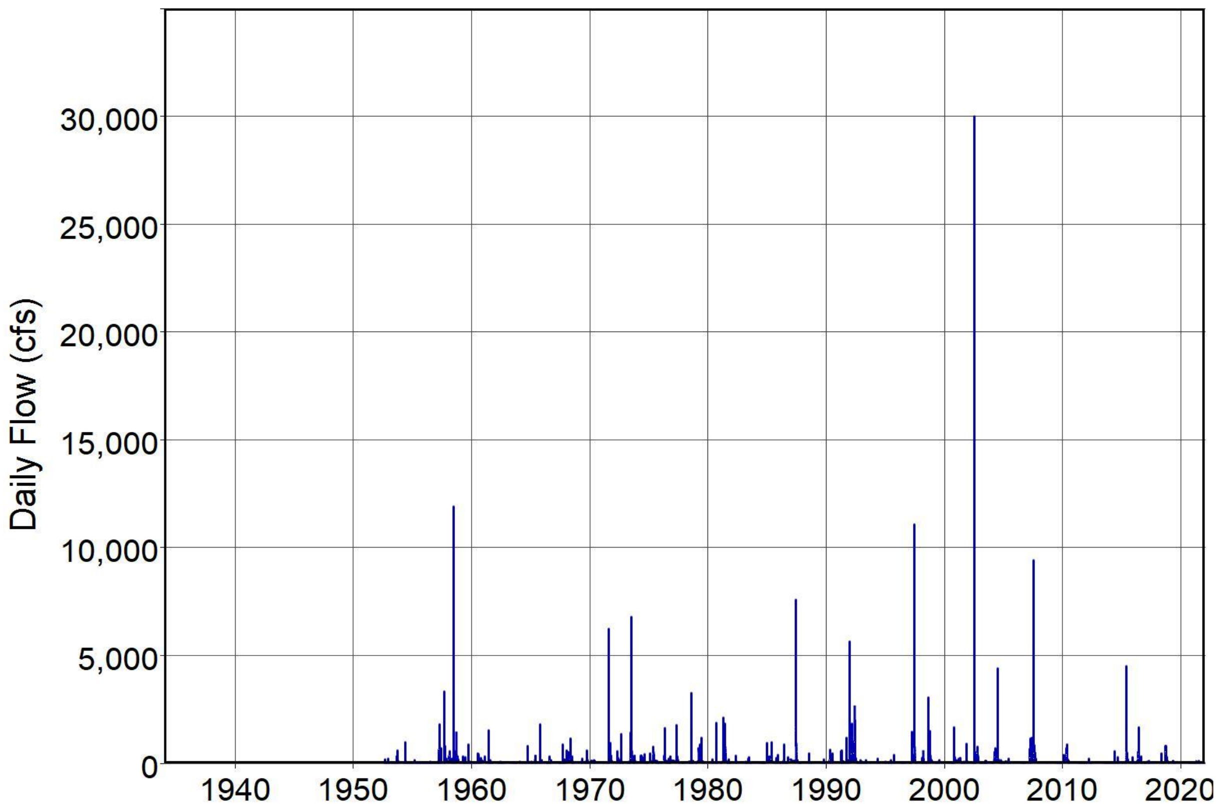

Figure 3.15 Daily Observed Flows of Hondo Creek, Tarpley, CP18

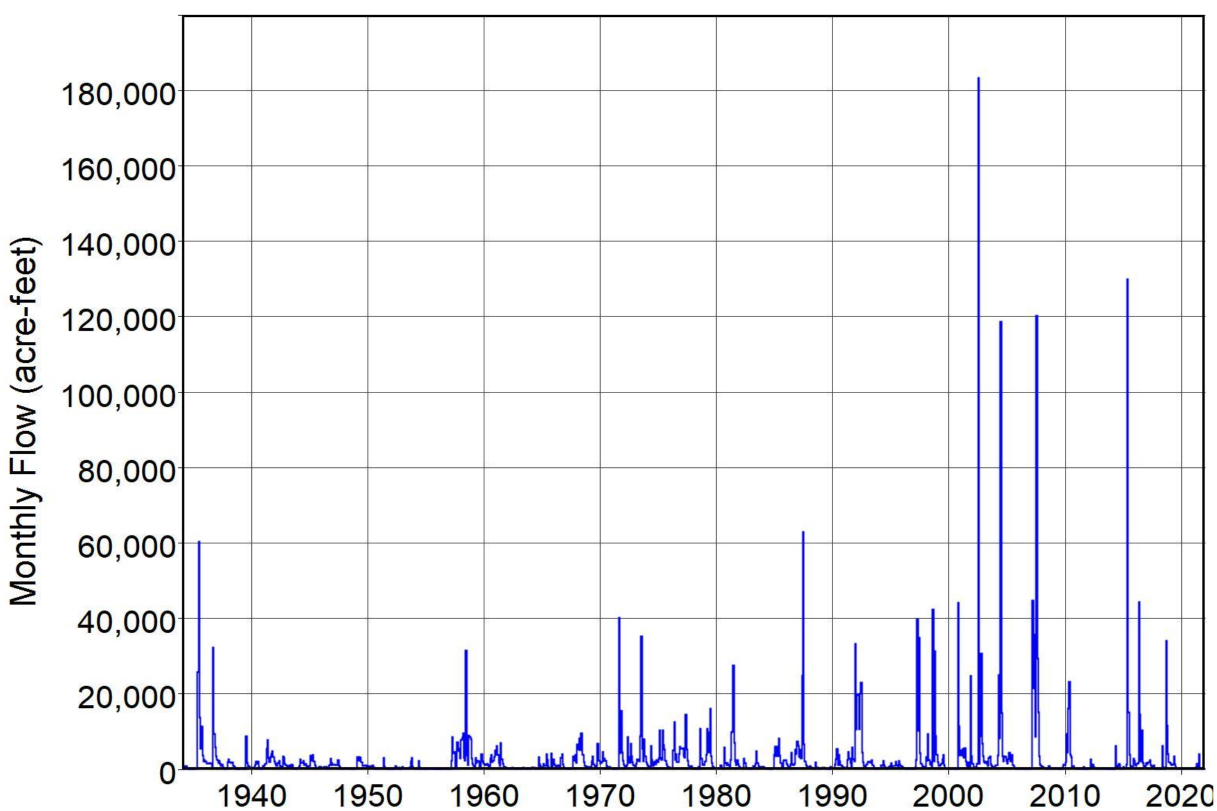

Figure 3.16 Monthly Naturalized Flows of Hondo Creek, Tarpley, CP18

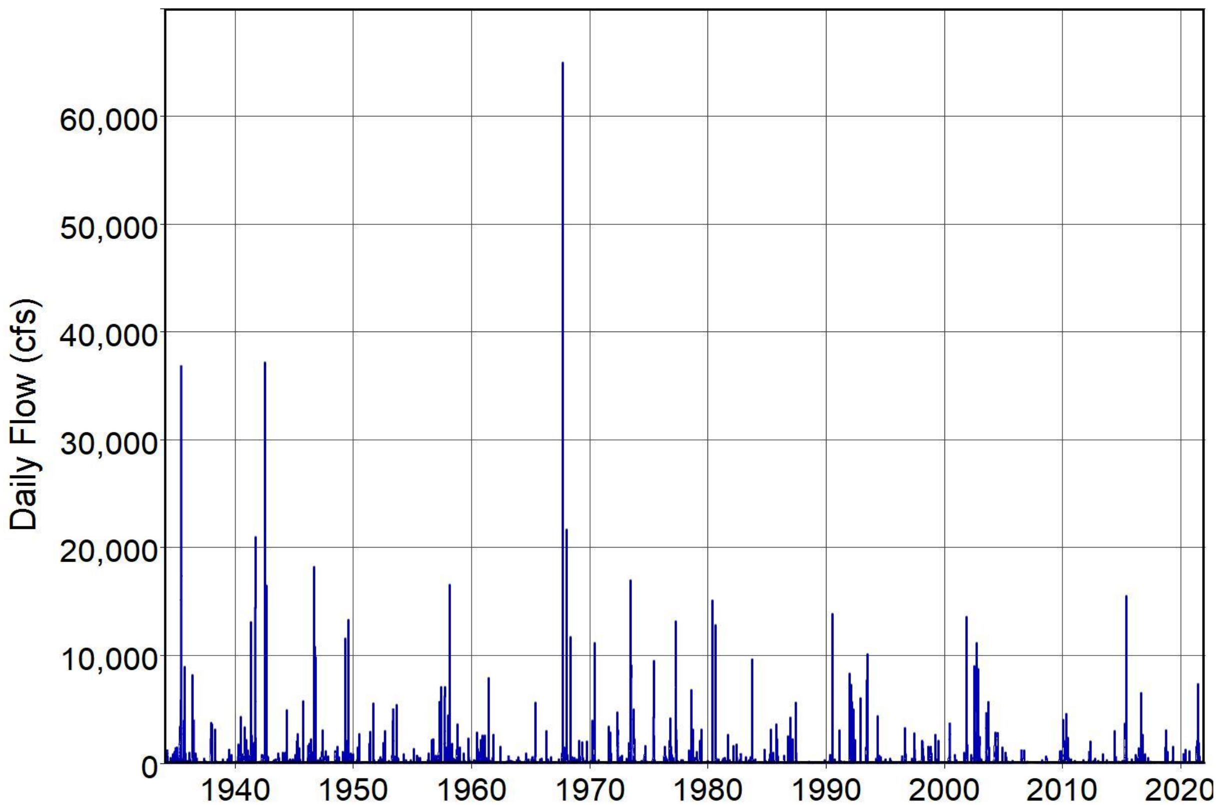

Figure 3.17 Daily Observed Flows of Atascosa River, Whitsett, CP28

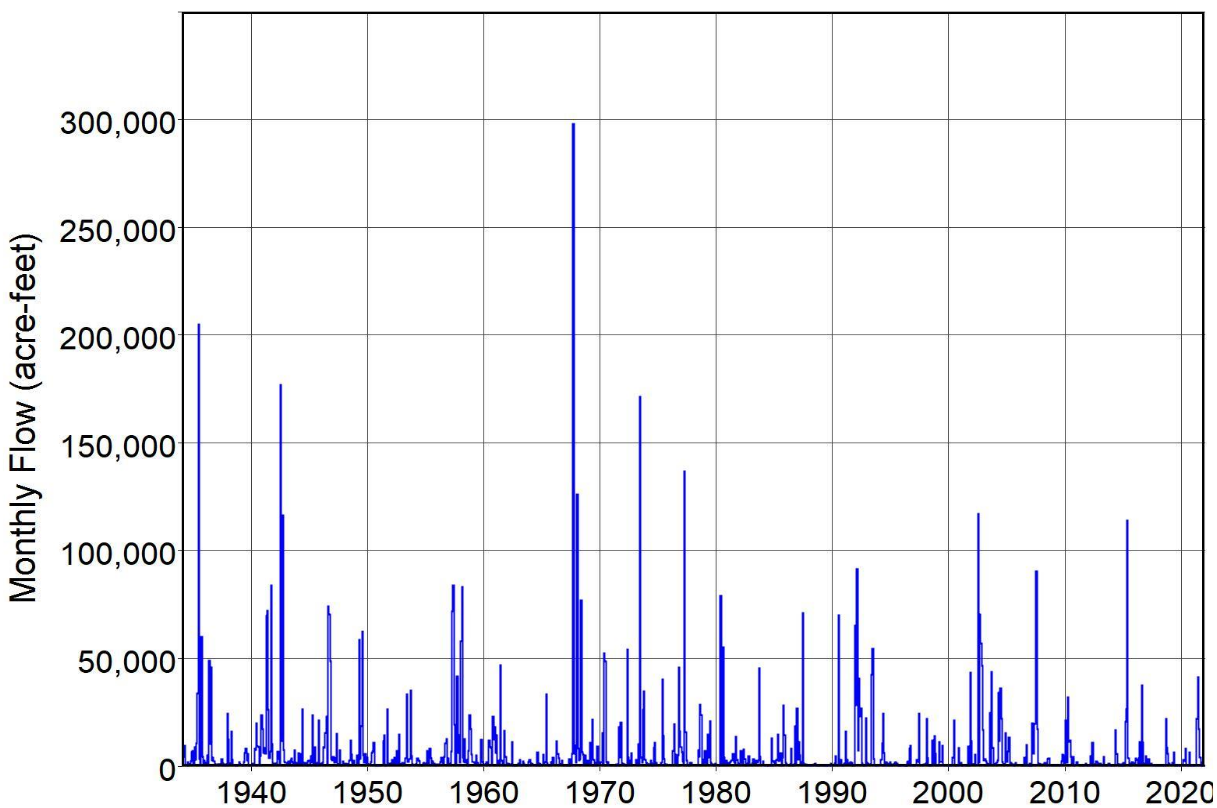

Figure 3.18 Monthly Naturalized Flows of Atascosa River, Whitsett, CP28

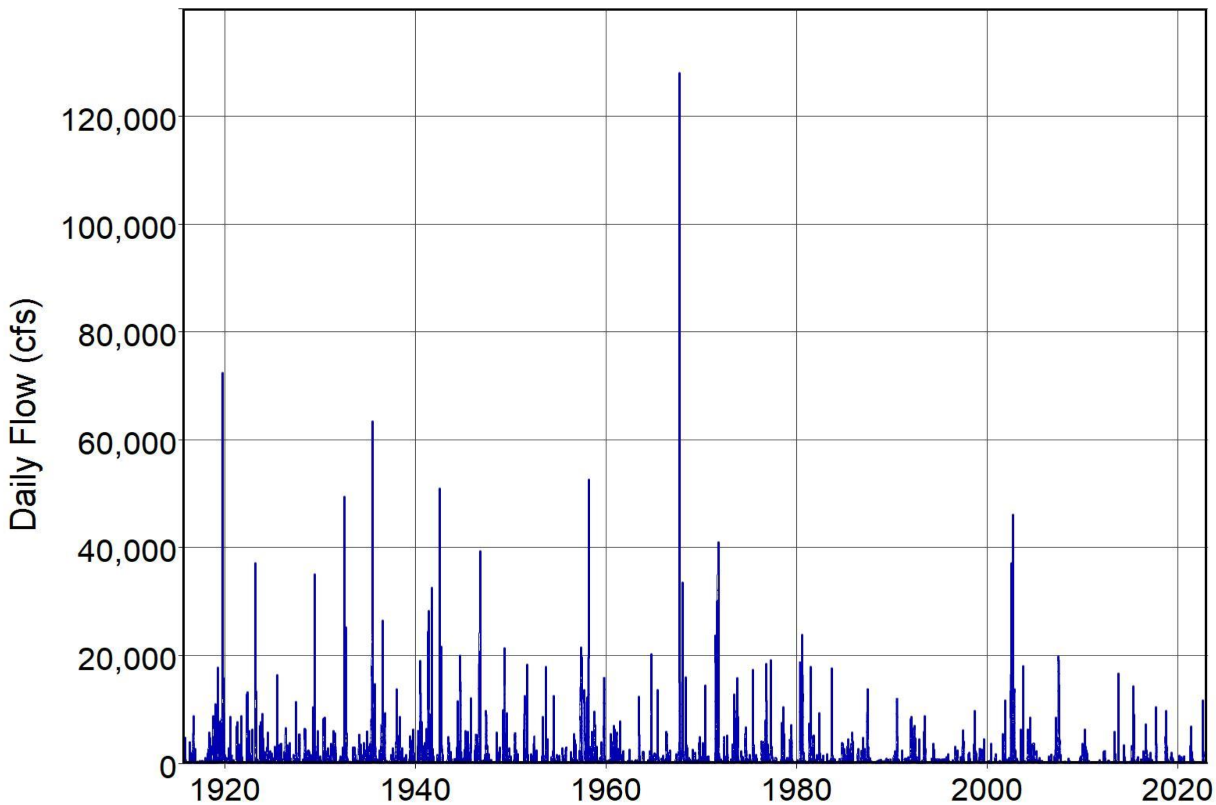

Figure 3.19 Daily Observed Flows of Nueces River, Three Rivers, CP29

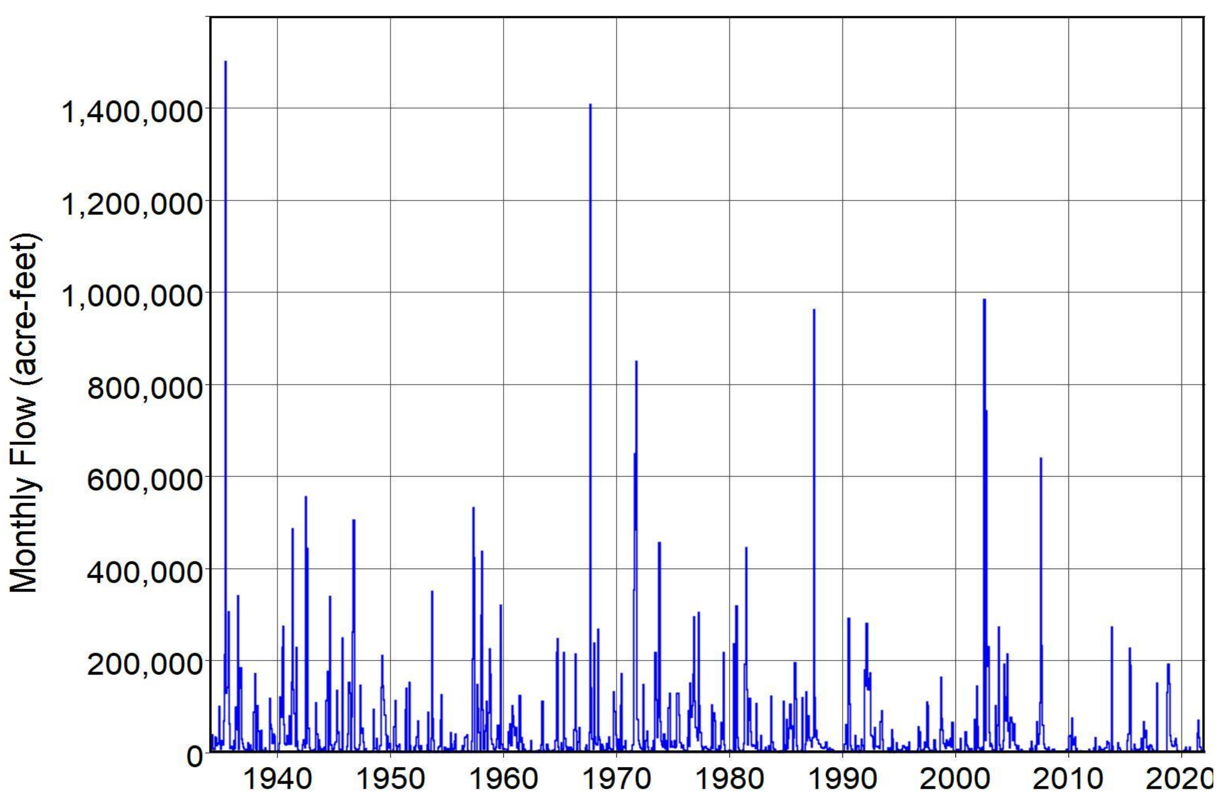

Figure 3.20 Monthly Naturalized Flows of Nueces River, Three Rivers, CP29

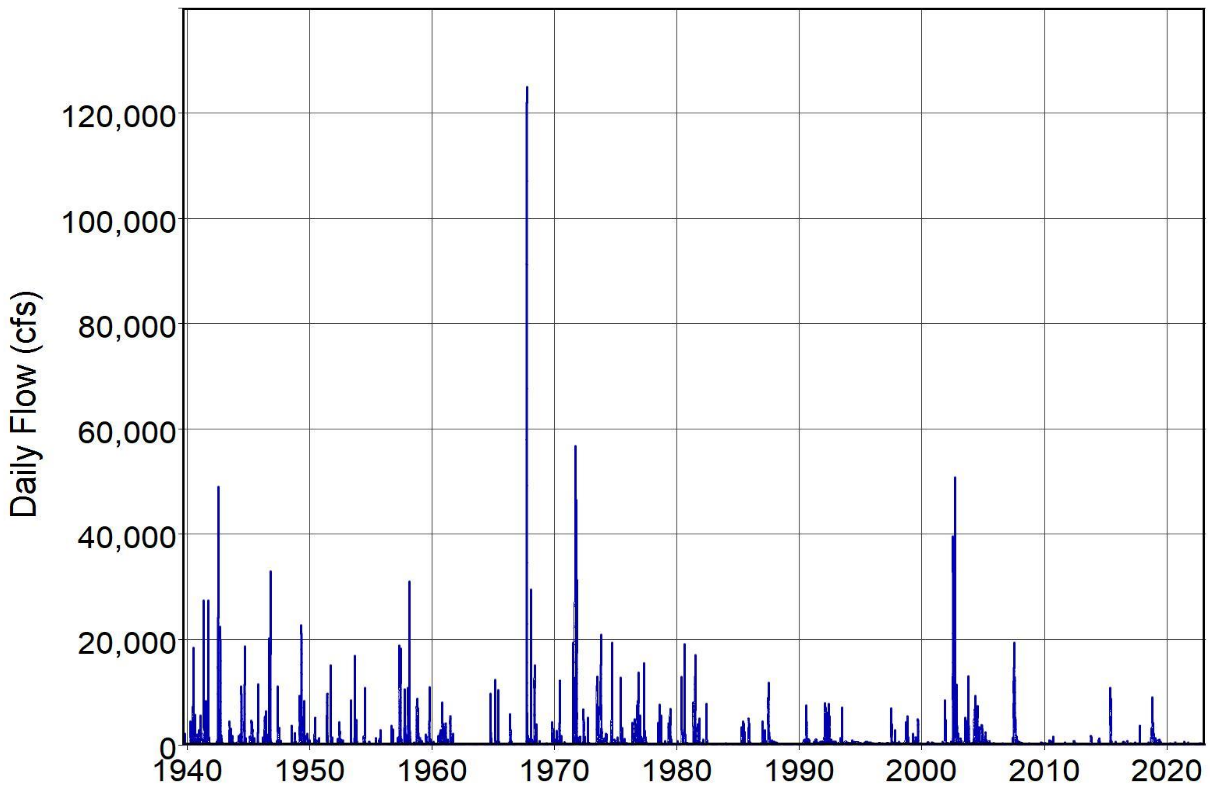

Figure 3.21 Daily Observed Flows of Nueces River, Mathis, CP30

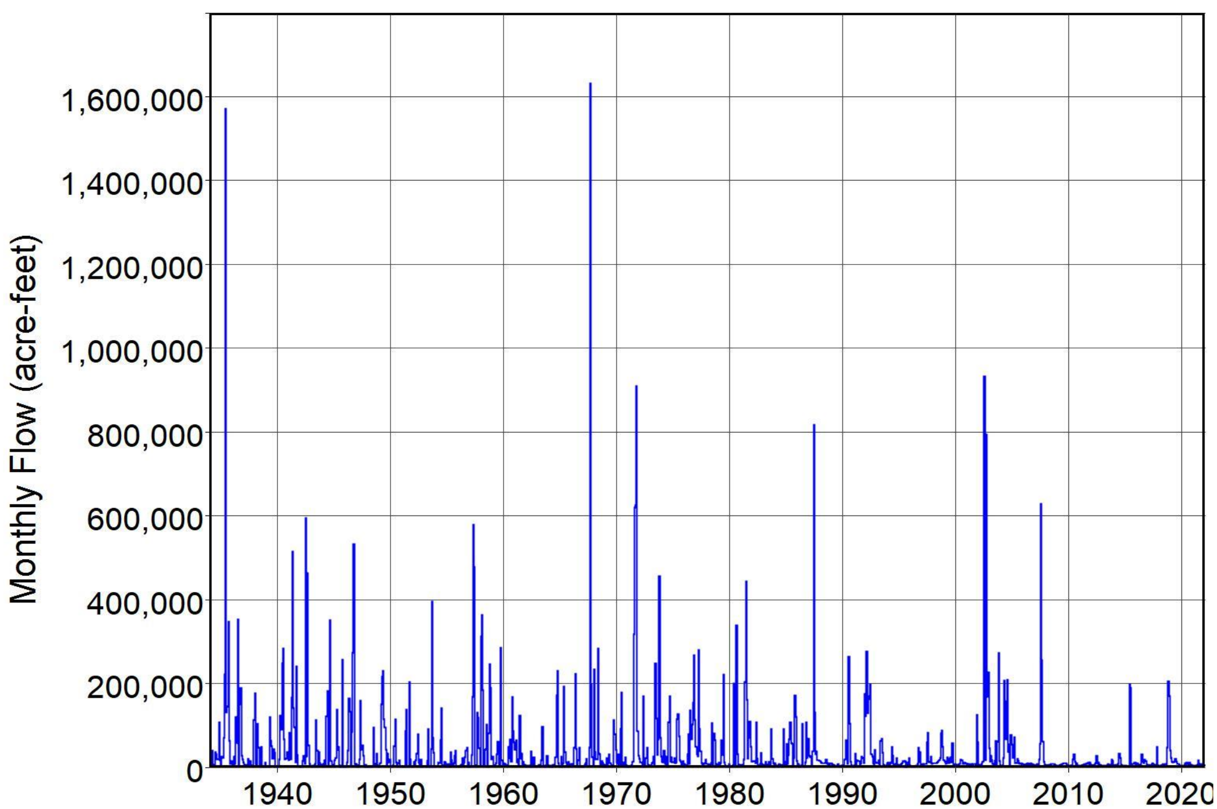

Figure 3.22 Monthly Naturalized Flows of Nueces River, Mathis, CP30

Monthly Naturalized Flows

The hydrologic period-of-analysis for the original Nueces WAM extends from January 1934 through December 1996. The period-of-analysis was extended for the 2023 WAM by appending 1997-2021 sequences of *IN* and *EV* records available online from the TWDB that were developed by the TWDB for use in SB3 regional and statewide planning studies.

(https://www.twdb.texas.gov/surfacewater/data/ExtendedNatFlow/index.asp).

TWDB applies the latest extended monthly naturalized flows (*IN* records) and evaporation-precipitation rates (*EV* records) updated by the TCEQ and its contractors for the WAMs that have recently updated periods-of-analysis. TWDB staff have updated for use in SB1 planning studies the *IN* and *EV* records for nine WAMs including the Nueces WAM that have not been recently updated by the TCEQ. The extended *IN* record naturalized flow datasets at the TWDB website were generated by TWDB staff using linear regression between historical gaged flow and available existing naturalized flow and between naturalized flows at different locations [17].

Naturalized flows may be extended by adjusting observed flows to remove effects of water development in the same or similar manner as employed in developing the original naturalized flows. This approach requires significant data and effort. A hydrologic model for extending monthly naturalized flows based on monthly precipitation and evaporation is described in the WRAP Hydrology Manual [6]. However, the relationship between rainfall and stream flow in the Nueces River Basin is greatly complicated by interactions between surface and groundwater. Naturalized flow extensions at a site should be based on observed flows at that site or similar sites to the extent feasible. The TWDB applied regression analyses using the original 1934-1996 naturalized flows and period-of-record observed flows to develop the 1997-2021 flow extensions for the Nueces WAM that were adopted for the work presented in this report.

As previously discussed, water management and WAM simulation results are dominated by water needs supplied by the two-reservoir system in the lower basin operated by the City of Corpus Christi and Nueces River Authority. This system consists of Choke Canyon Reservoir and Lake Corpus operated for bay and estuary instream flow requirements and water supply diversion from the lower Nueces River. In general, from a water supply perspective, simulation results are dependent mainly on stream flow in the lower Frio and lower Nueces River. The simulation studies reported in Chapters 5 and 6 of this report focus on modeling SB3 EFS at seventeen control points. Thus, stream flows at these seventeen gage sites have particular significance.

The scope of the present work does not include a detailed conclusive investigation of all 1934-1996 naturalized flows in the original WAM and the TWDB 1997-2021 flow extensions. However, cursory analyses support general observations found in the following subsections of this section. A new replacement set of 1934-2021 monthly naturalized flows was developed for control point CP26 as discussed in a later subsection. The adopted monthly naturalized flows at all other control points consist of the original 1934-1996 flows with TWDB 1997-2021 extensions.

The monthly naturalized flows at gage sites are realistic. Issues with 1934-1996 naturalized flows at ungagged sites in upper watersheds with small drainage areas are highlighted. However, the flows from these small ungaged upper-basin watersheds are not replaced.

Naturalized Monthly Flows at Thirty-Seven Primary Control Points

WAM primary control points are defined as sites for which monthly naturalized stream flows are provided as *IN* records in a *SIM* or *SIMD* simulation input dataset. Monthly naturalized flows at secondary control points are synthesized within an execution of *SIM* or *SIMD* based on the *IN* record flows at primary control points and watershed parameters provided on control point *CP*, flow distribution *FD*, and watershed parameter *WP* records.

The Nueces WAM has a total of forty-one primary control points. However, data on the *CP* and *IN* records for control points CP11, CP14, CP20, and CP23 are not actually used in the *SIM/SIMD* simulation. These four control points are retained in the input files but not included in the tables and discussions of this report. Only a few of the 756 months of the original 1934-1996 period-of-analysis have non-zero flows on the *IN* records of these four control points. The 1934-1996 naturalized flow data for these control points appear to be incomplete and incorrect. The unused control points CP11, CP14, CP20, and CP23 are located at sites without UGSG gages.

Control points at twenty-two USGS gages and fifteen ungaged locations are listed in Table 3.5 and also in Tables 2.5 and 2.6 of Chapter 2. These thirty-seven primary control points do not include the four unused control points noted in the preceding paragraph. The locations of the gaged and ungaged primary control points are shown in Figure 2.2. The periods-of-record of the USGS gages are tabulated in Tables 2.5 and 3.2. The seventeen control points (16 primary and one secondary) with SB3 environmental flow standards (EFS) are listed in Table 5.1 of Chapter 5.

The 37 primary control points are listed in Table 3.5 with their drainage area in square miles and monthly naturalized flow statistics in acre-feet/month that include the minimum, median (50% exceedance), mean, and maximum flow during the 88 months of the 1934-2021 hydrologic period-of-analysis. The 1934-2021 mean flow in inches per year is shown in the last column of Table 3.5. This is the mean annual naturalized flow expressed as a volume equivalent to covering the river basin area above the control point location to the depth shown in inches. Similarly, the mean annual observed flow in inches/year is tabulated in the last column of Table 3.3 for the control points at gage sites based on available daily observed flow measurements. The statistical metrics in the tables were computed using *HEC-DSSVue*.

Daily observed flows and monthly naturalized flow plots from *HEC-DSSVue* are replicated as the preceding Figures 3.1-3.22 for twenty-two primary control points at gage sites with observed flow records covering all or most of the 1934-2021 WAM period-of-analysis. The other gage sites have significant gaps of missing observed data.

Time series data are conveniently plotted and analyzed within *HEC-DSSVue*. Plots of the monthly naturalized flows at all the primary control points have been reviewed within *HEC-DSSVue* to obtain general insight into the characteristics of the flow data during the original 1934-1996 period-of-analysis, 1997-2021 extension, and entire 1934-2021 updated period-of-analysis. In general, with the exception of control point CP26, the naturalized monthly flows at gage sites appear to be reasonably realistic. As discussed later in this chapter, the original 1934-1996 monthly naturalized flows at the ten ungaged sites with drainage areas of thirty-four square miles or less are not realistic. The monthly naturalized flows at the ungaged control points with larger watershed areas appear to be realistic.

Table 3.5
Primary Control Points at USGS Gage Sites with Monthly Naturalized Flow Statistics

Control Point	Location (Stream, Town)	DA (sm)	Min (ac-ft)	50% (ac-ft)	Mean (ac-ft)	Max (ac-ft)	Mean (inch/yr)
	Control Points at USGS Gages						
CP01	Nueces River, Laguna	737	310.0	5,068	10,026	321,807	3.06
CP02	W. Nueces R., Brackettville	694	0.0	9.0	3,032	196,510	0.98
CP03	Nueces River, Uvalde	1,861	0.0	1,820	8,960	603,207	1.08
CP04	Nueces River, Asherton	4,082	0.0	2,628	12,902	538,220	0.71
CP05	Nueces River, Cotulla	5,171	0.0	2,168	15,111	635,303	0.66
CP06	Nueces River, Tilden	8,093	0.0	3,292	23,996	763,190	0.67
CP07	Frio River, Concan	389	2.0	4,204	7,253	146,900	4.20
CP08	Dry Frio Riv. Reagan Wells	126	0.0	861.0	2,362	72,500	4.22
CP09	Frio River, Uvalde	631	0.0	8.5	2,841	192,939	1.01
CP12	Sabinal River, Sabinal	206	0.0	1,594	3,759	99,746	4.11
CP13	Sabinal River, Sabinal	241	0.0	89.5	1,907	143,481	1.78
CP16	Seco Creek, Utopia	45.0	0.0	622.5	2,029	59,274	10.15
CP17	Seco Creek, D'Hanis	168	0.0	0.0	519.3	53,031	0.70
CP18	Hondo Creek, Tarpley	95.6	0.0	771.5	3,023	183,263	7.11
CP19	Hondo Creek, Hondo	149	0.0	0.0	1,112	127,113	1.68
CP24	Leona River, Uvalde	sprg flw	0.0	1,024	1,620	73,927	2.62
CP25	Frio River, Derby	3,429	0.0	1,109	8,143	480,100	0.53
CP26	San Miguel Creek, Tilden	783	0.0	19.0	711.0	112,377	0.20
CP26	(Revised Flows Adopted)	783	0.0	390.4	3,002	122,760	0.86
CP27	Frio River, Calliham	5,491	0.0	2,398	13,703	591,589	0.56
CP28	Atascosa River, Whitsett	1,171	0.0	1,073	7,038	297,942	1.35
CP29	Nueces River, Three Rivers	15,427	0.0	9,241	44,383	1,501,017	0.65
CP30	Nueces River, Mathis	16,660	0.0	8,983	44,181	1,632,553	0.60
	Control Points Not Located at Gages						
CP10	Leona River	34	0.0	0.0	168.9	19,221	1.12
CP111	Hackberry Creek	9	0.0	0.0	27.65	980.0	0.69
CP112	Blanco Creek	23	0.0	0.0	71.73	2,676	0.70
CP141	Little Blanco Creek	16	0.0	0.0	61.02	5,534	0.86
CP142	Nolton Creek	2	0.0	0.0	8.339	851.0	0.94
CP15	Ranchero Creek	5	0.0	0.0	18.47	1,937	0.83
CP201	Live Oak Creek	2	0.0	0.0	7.837	2,079	0.88
CP202	Parkers Creek	10	0.0	0.0	7.969	367.0	0.18
CP21	Verde Creek above Recharge	57	0.0	210.5	1,276	72,195	5.04
CP22	Verde Ck in Recharge Zone	105	0.0	0.0	773.5	62,767	1.66
CP231	Elm Creek	33	0.0	0.0	139.9	3,809	0.95
CP232	Quihi Creek	14	0.0	0.0	58.57	1,540	0.94
CP31	Calallen Diversion Dam	16,721	0.0	8,526	41,987	1,577,485	0.56
CPBAY	Upper Nueces Bay	16,850	0.0	8,924	42,606	1,630,103	0.57
CPEST	Nueces Bay and Estuary	17,147	92.0	11,088	47,416	1,775,739	0.62

A new 1934-2021 series of monthly naturalized flows at control point CP26 on San Miquel Creek near Tilden was adopted to replace the original 1934-1996 flows and 1997-2021 extended flows as discussed in the next subsection. Statistics for both the initial and final adopted naturalized flows for CP26 are included in Table 3.5.

Monthly Naturalized Flows at CP26 on San Miquel Creek near Tilden

CP26 is one of the 17 USGS gage locations listed in Table 5.1 with SB3 environmental flow standards (EFS). Thus, monthly and daily naturalized flows at CP26 are particularly important for the work documented by this report. Developing a new 1934-2021 series of monthly naturalized flows for this control point was determined to be warranted.

New 1934-2021 series of daily and monthly naturalized flows at CP26 were developed based on daily observed flows at CP26 and CP28. Daily observed flows at these sites are assumed to be adequately representative of daily naturalized flows. Observed flows are adopted as naturalized flows at CP26. The major gaps of missing daily observed flows at CP26 are filled in by regression with observed flows at CP28.

Missing data at CP26 are synthesized by regression with flows at CP28. Monthly observed flows are computed by summing daily observed flows. Observed flows are adopted without further adjustment as being naturalized flows representative of natural undeveloped conditions.

Quantities descriptive of CP26 on San Miquel Creek near Tilden and CP28 on the Atascosa River at Whitsett are found in Tables 2.5 and 3.2. Their locations are shown in Figure 2.2. The USGS gage at CP26 has a period-of-record of January 25, 1964 to the present, with 9,199 days of missing flow data during this period-of-record (Tables 2.5 and 3.2). Observed daily flows are available at CP28 for most though not all the days of missing data at CP26. Quantities for both the initial 1934-2021 naturalized monthly flows for CP26 and the new set of flows are included in Table 3.5. The final adopted and initially considered monthly naturalized flows at CP 26 are plotted in Figures 3.23 and 3.24.

The 1934-2021 monthly flows plotted in Figure 3.23 are adopted as the *IN* record naturalized flows incorporated in the 2023 WAM dataset. The 1934-2021 monthly flows plotted in Figure 3.24 are the original 1934-1996 naturalized flows extended by the TWDB to include 1997-2021. The original 1934-1996 monthly naturalized flows at CP26 documented by the 1999 report [1] are so small as to be not detectable with the plot scale of Figure 3.24. The 1934-1996 segment of the 1934-2021 time series of Figure 3.24 is replotted as Figure 3.25 for better clarity. These original 1934-1996 monthly flows were judged to not to be reasonable and thus were replaced with the flows shown in Figure 3.23.

The 1997-2021 segment of the monthly naturalized flows in Figures 3.23 and 3.24 are identically the same though computed at different times by different people. The flows in Figure 3.23 were computed at TAMU as discussed here in conjunction with the work documented by this report without knowledge of the data selection and details of the regression computations adopted by the TWDB in their earlier flow extension for CP26.

The subsequent observation that the TAMU and TWDB results are identical indicates that the same methodologies and data sets must have been employed. The only difference is that the TAMU work replaced the 1934-1996 monthly naturalized flow data series for control point CP26 along with extending the flows through 2021. The TWDB update for all the primary control points including CP26 consisted of appending 1997-2021 flows to the original 1934-1996 flows.

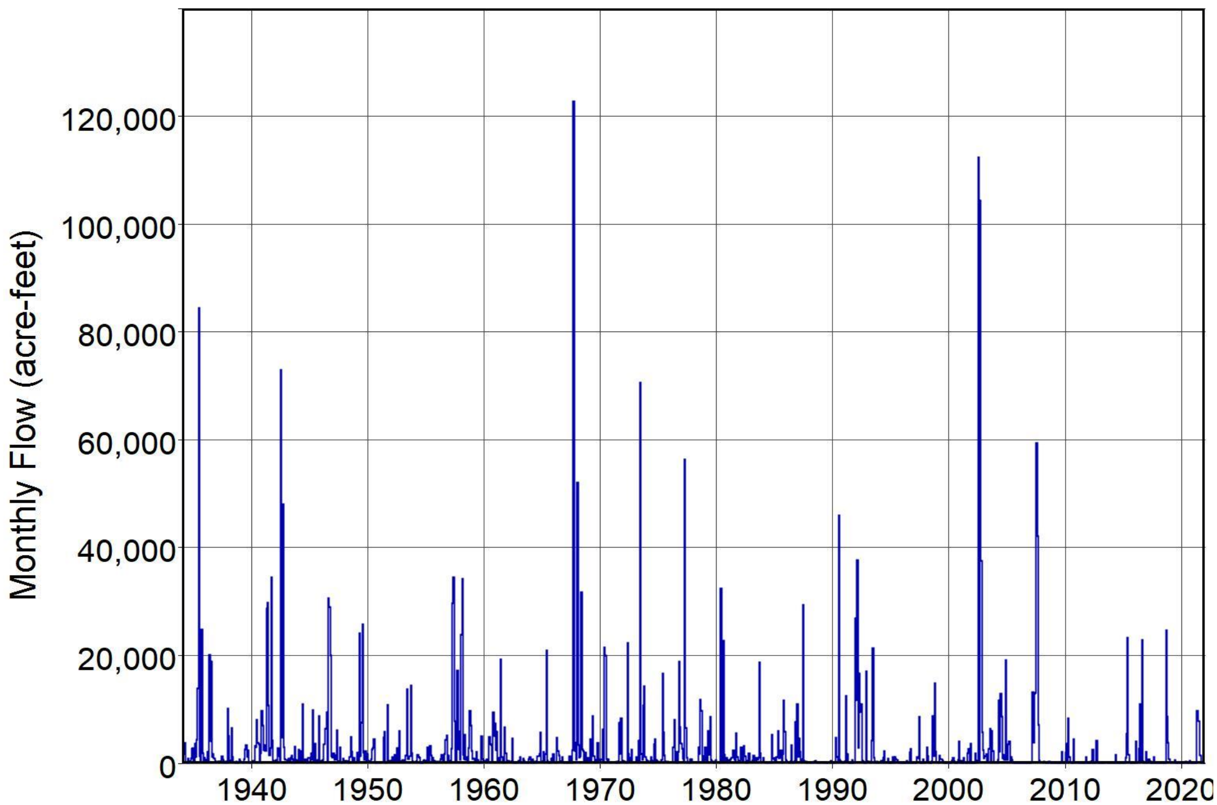

Figure 3.23 Adopted Monthly Naturalized Flows of San Miguel Creek near Tilden (CP26)

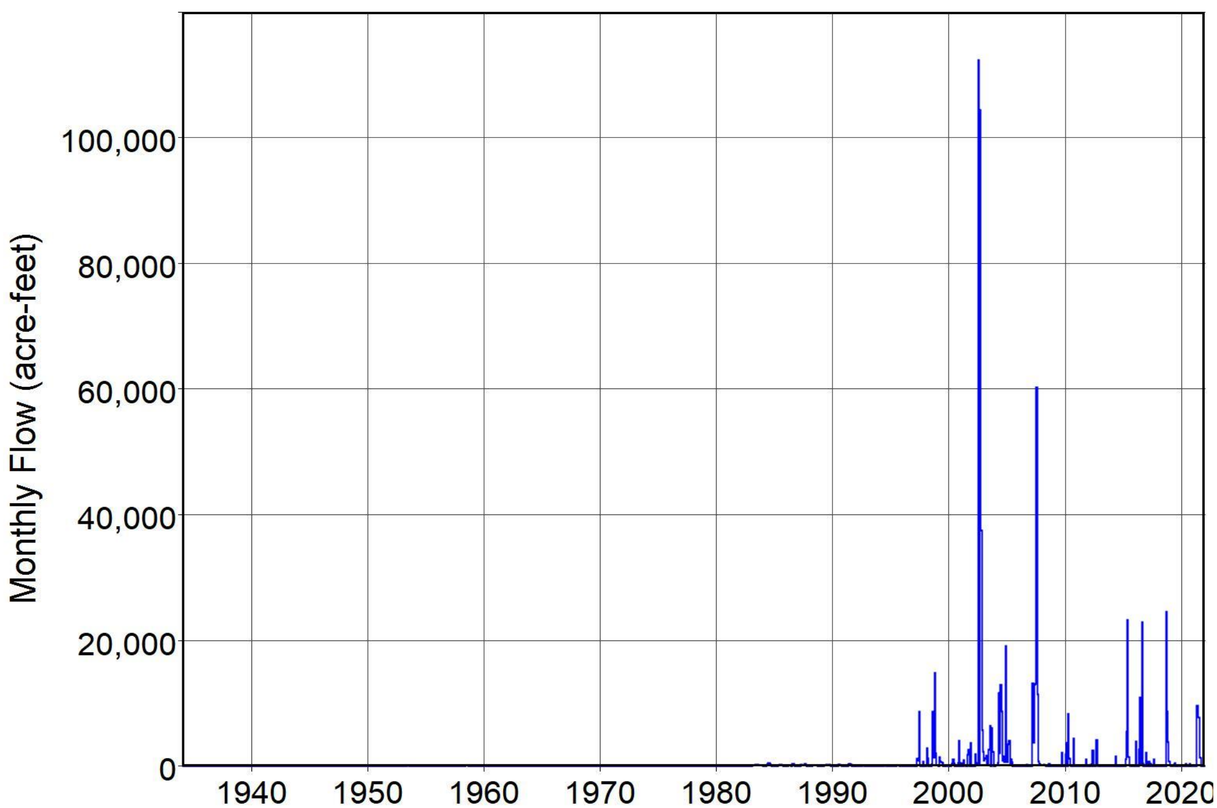

Figure 3.24 Initial Monthly Naturalized Flows of San Miguel Creek near Tilden (CP26)

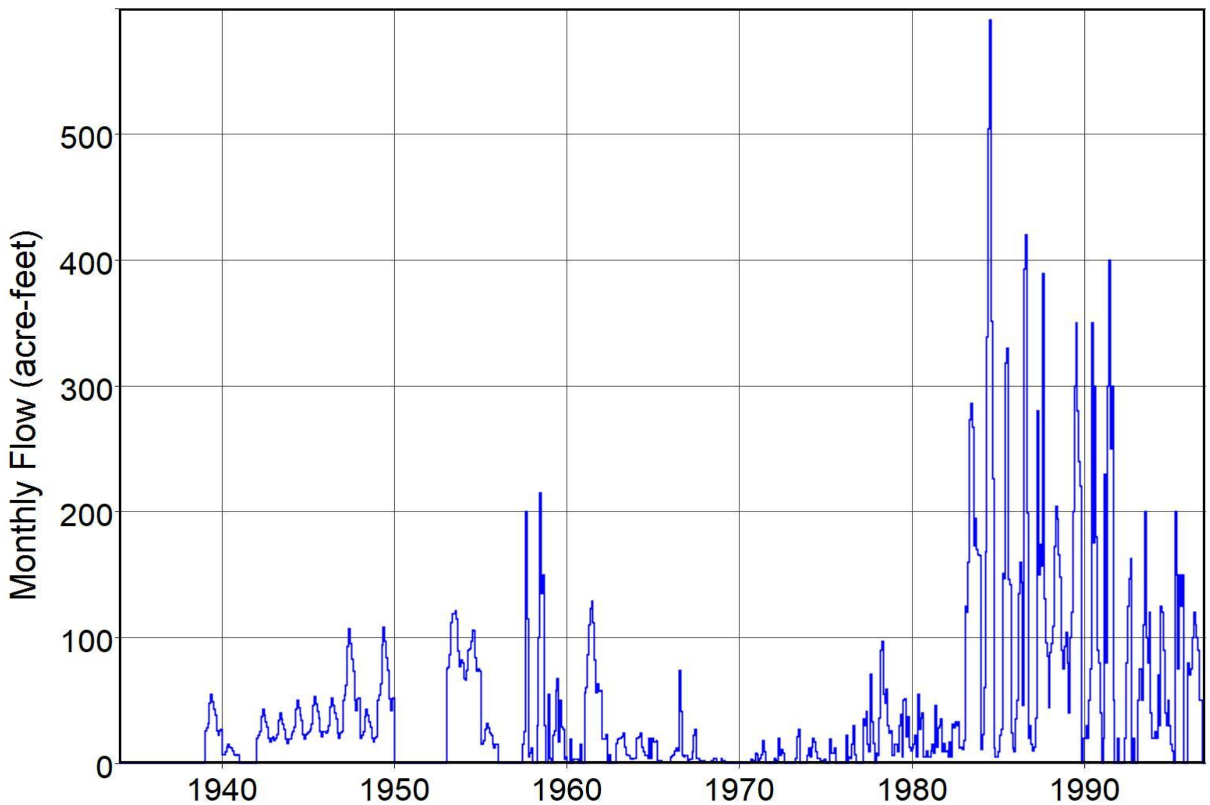

Figure 3.25 Initial Monthly Naturalized Flows of San Miguel Creek near Tilden (CP26)

Monthly Naturalized Flows at Ungaged Primary Control Points

The monthly naturalized flows at primary control points are comprised of the original 1934-1996 flows documented by the 1999 report [1] and the TWDB 1997-2021 flow extension [17]. Except for control point CP26 monthly flows discussed on the preceding pages, the monthly naturalized flows have not been further revised in the work documented by this report.

The fifteen primary control points at locations with no stream gages are listed in the bottom portion of Table 3.5. Analysis and resulting discussion of monthly naturalized flows at these locations are organized by dividing the 15 ungaged control points into the following three groups: (1) ten control points with drainage areas ranging from two to thirty-four square miles; (2) CP21 and CP22 with drainage areas of 57 and 105 square miles; and (3) control points CP31, CPBAY, and CPEST with drainage areas of 16,721, 16,850, and 17,147 square miles.

The 1934-1996 monthly naturalized flows at the ten ungaged control points with watershed areas of 34 square miles or less appear unrealistic. The flows at CP10 are plotted in Figure 3.26 for illustration. Flows at CP111, CP112, CP141, CP142, CP15, CP202, CP231, and CP232 exhibit similar patterns. Monthly naturalized flows at CP10 are zero for 740 months and non-zero for only 16 months of the 756-month of 1934-1996. The maximum monthly naturalized flow during 1934-1996 is 3,049 acre-feet. The 1997-2021 monthly naturalized flows are more realistic. The monthly naturalized flow sequences of the other nine ungagged upper watershed sites are characterized as having flow (or no-flow) patterns similar to the CP10 flows of Figure 3.26.

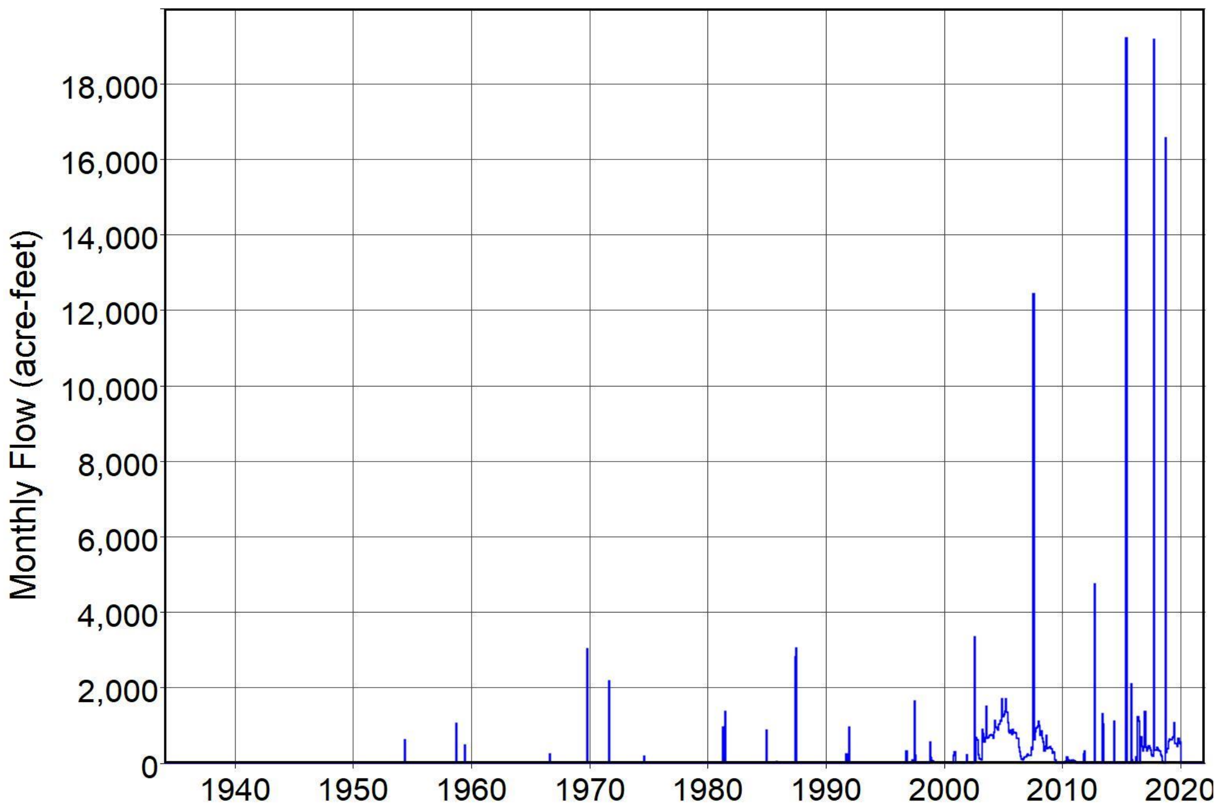

Figure 3.26 Monthly Naturalized Flow of the Leona River at Control Point CP10

Control point CP30 on the Nueces River near Mathis represents the USGS gage nearest the basin outlet. Daily observed and monthly naturalized at CP30 are plotted in Figures 3.21 and 3.22. Most of the stream flow appropriated for water supply is diverted at the Calallen Diversion Dam represented by ungaged control point CP31. Ungaged control point CPEST representing inflow to the Nueces Bay and Estuary is the most downstream control point in the WAM.

Monthly naturalized flows at ungagged control points CP31, CPBAY, and CPEST were computed from the corresponding flows at gaged control point CP30 and thus have the same general pattern. The plots of flows at CP31 and CPEST in Figure 3.27 are close to each other. Though not included in Figure 3.27, flows at CPBAY fall between the flows at CP31 and CPEST. As indicated in Table 3.5, the watershed drainage areas for CP30, CP31, CPBAY, and CPEST are 16,660 square miles, 16,721, 16,850, and 17,147 square miles, respectively.

Monthly Net Reservoir Evaporation-Precipitation Rates

Monthly precipitation depths extending from January 1940 and monthly reservoir evaporation depths from January 1954 to near the present for 92 one-degree latitude by one-degree longitude quadrangles that encompass Texas are accessible at the following TWDB website: https://waterdatafortexas.org/lake-evaporation-rainfall. The TWDB updates the databases each year to extend through the preceding year. Observed monthly precipitation and evaporation depths are spatially averaged by the TWDB over each of the 92 one-degree quadrangles as explained at the website. Each quadrangle covers an area of about 4,000 square miles.

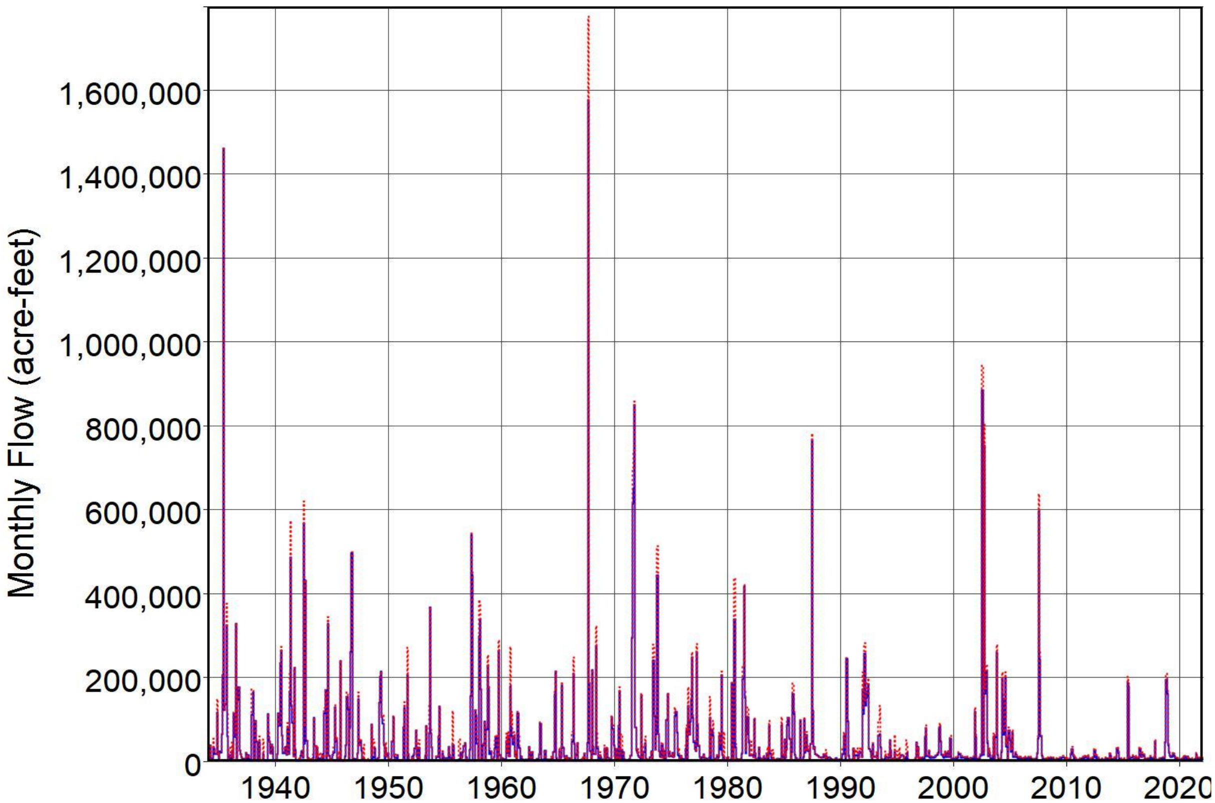

Figure 3.27 Monthly Naturalized Flows at Control Points
CP31 (blue solid line) and CPEST (red dotted line)

The Nueces WAM hydrology dataset includes ten hydrologic period-of-analysis sequences of net reservoir surface evaporation less precipitation rates on *EV* records. The small reservoirs are assigned evaporation-precipitation from the TWDB database which has been modified over the initial 1934-1996 period-of-analysis. Net evaporation-precipitation data from the TWDB database for quadrangles 910, 807, 808, 908, 907, 909, and 809 are used with the many small reservoirs. The WAM dataset reflects a compilation of 1934-1996 data from multiple TWDB and other sources employed to develop *EV* records for Choke Canyon Reservoir and Lake Corpus Christi. The original January 1934 through December 1996 hydrologic period-of-analysis for the original Nueces WAM was extended through December 2021 for the 2023 WAM by appending 1997-2021 sequences of *IN* and *EV* records available online from the TWDB as discussed earlier.

SIM and *SIMD* include an evaporation-precipitation adjustment option activated by *JD* record parameter EPADJ or *CP* record EWA(cp) designed to prevent double-counting the precipitation runoff from the land area covered by a reservoir that is reflected in the naturalized stream flows. This option is activated for all the reservoirs in the Nueces WAM except Lake Corpus Christi. The naturalized flows representing inflows to Lake Corpus Christi were computed differently in the original WAM than the naturalized flows at the other control points.

Monthly net evaporation-precipitation depths in feet on *EV* records assigned control point identifiers CP27 and CP30 are plotted as Figures 3.28 and 3.29. These monthly net evaporation-precipitation depths are for Choke Canyon Reservoir and Lake Corpus Christi.

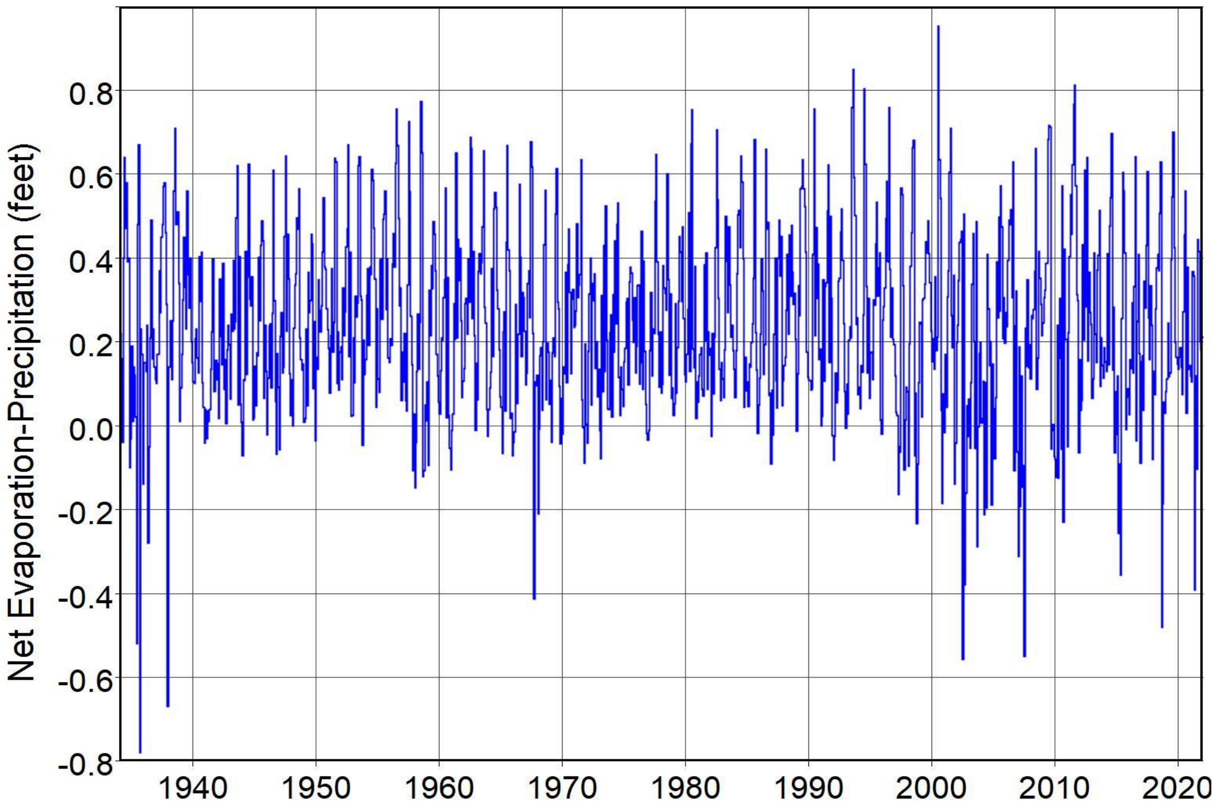

Figure 3.28 Net Evaporation-Precipitation Depths for Choke Canyon Reservoir (CP27)

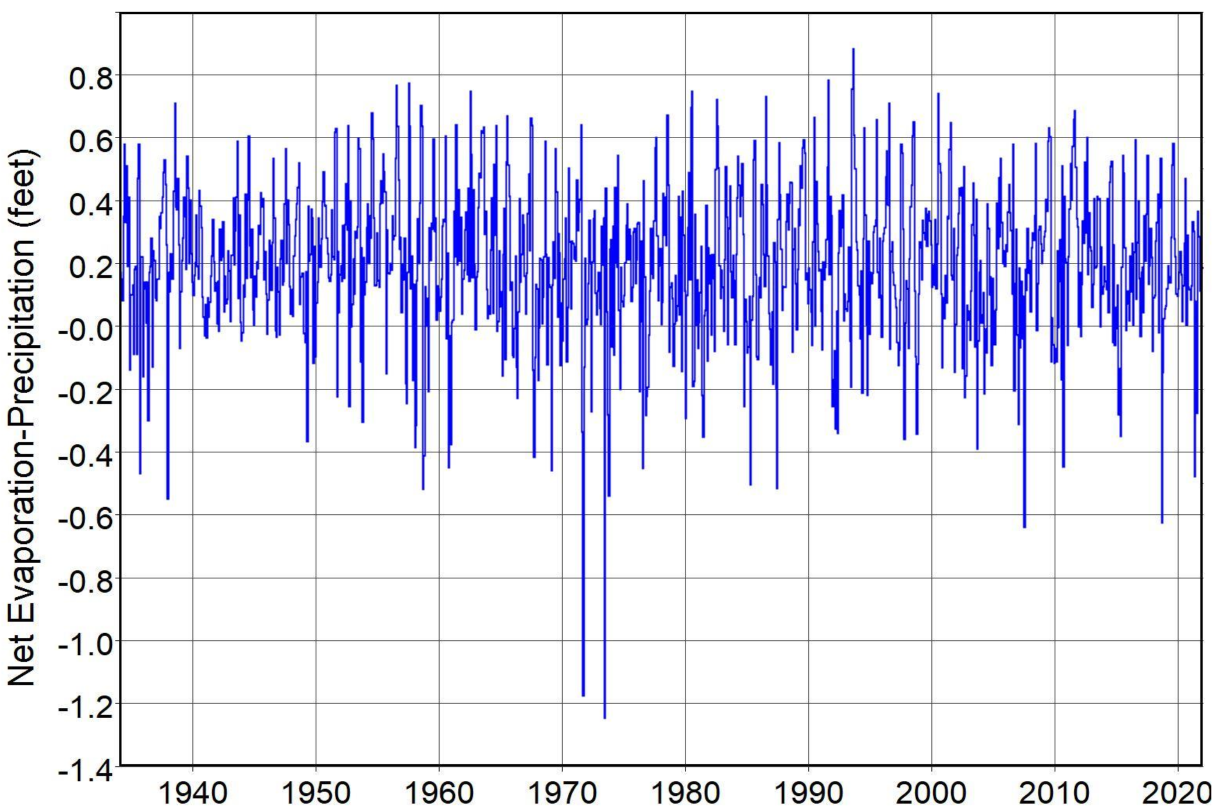

Figure 3.29 Net Evaporation-Precipitation Depths for Lake Corpus Christi (CP30)

CHAPTER 4
CONVERSION OF MONTHLY NUECES WAM TO DAILY

Actual real-world stream flow and other variables simulated in water availability modeling fluctuate continuously over time. Simulation computations dealing with continually varying variables are necessarily performed based on a fixed computational time interval. The monthly *SIM* employs a monthly computational time step, ignoring within-month variability. The daily *SIMD* employs a daily computational time step, ignoring within-day variability. The effects of computational time step choice on simulation results vary with different water management modeling situations and applications. Due to the extreme variability characteristic of stream flow, daily models are particularly relevant for modeling both the high flow pulse components of environmental flow standards and reservoir operations during floods [5].

Chapter 4 explains the conversion of the Nueces WAM described in Chapter 2 from a monthly to daily time step. Chapter 5 describes the addition of environmental flow standards (EFS) adopted by the TCEQ in 2014 following procedures established by the 2007 Senate Bill 3 (SB3). Daily and monthly WAM simulation results are presented in Chapter 6.

The completed daily WAM is used to compute daily instream flow targets for SB3 EFS that are summed to monthly targets within the *SIMD* simulation. The monthly instream flow targets are stored in the shared DSS input file as time series *TS* records that are used by *IF* record instream flow rights in the monthly *SIM* simulation model as described in Chapters 5 and 6.

Daily *SIMD* Simulation Input Dataset

All *SIM* input records in the monthly Nueces WAM dataset are also included in the daily Nueces WAM dataset to be read by *SIMD*. Additional "*daily-only*" input records are added in the conversion of the monthly WAM to daily. Daily-only *SIMD* input records are explained in Chapter 4 of the *Users Manual* [3]. The only record required to switch a monthly WAM to daily is the *JT* record. All other records are optional, with defaults activated for blank fields or missing records.

The following daily records are included in the daily Nueces WAM: *JT* and *JU* (daily options), *DC* (flow disaggregation), *DF* (daily flows), and *PF* (pulse flow component of environmental flow standards). Environmental standard *ES* records are also used in modeling SB3 EFS in the daily Nueces WAM. However, though not applied in the monthly Nueces WAM, *ES* records along with hydrologic condition *HC* records can also be included in monthly *SIM* simulations and thus are covered in Chapter 3 rather than Chapter 4 of the WRAP *Users Manual*. The output file options *OF* record applicable to both monthly *SIM* and daily *SIMD* simulations includes options applicable to only daily simulations.

Flood control operations (*FR*, *FF*, *FV*, and *FQ* records) are not included in the daily Nueces WAM since there is no designated flood control storage pool in Choke Canyon Reservoir, Lake Corpus Christi, or any other reservoirs in the Nueces River Basin.

Based on experience with daily WAMs for other river basins [9, 10, 11, 12, 13] and the characteristics of the Nueces River Basin, lag and attenuation routing and forecasting are not activated in the Nueces WAM. The purpose of routing is to adjust flow changes for the lag and attenuation effects of stream reaches with lag times that are significantly long relative to the computational time interval of one day. The stream reaches between key locations in the Nueces River Basin are not excessively long. Forecasting is relevant only if routing is activated. Routing was concluded to not contribute positively, though possibly adversely, to model accuracy for the Nueces River system and was not adopted.

Disaggregation of monthly naturalized flows to daily is mentioned in the next paragraph and further explained later in this chapter. Flow disaggregation is based on daily flow pattern hydrographs that, for many sites, combine daily flows at two or three sites. The combination of daily observed flows at multiple sites invalidates the forecasting and routing computations. This is one of the multiple significant reasons for not using the optional forecasting and routing features. Complexities of negative incremental flow adjustment options is another reason for not activating forecasting and routing options.

Stream flow is extremely variable. Capturing within-month daily variability in the monthly-to-daily disaggregation of naturalized stream flow is the key central component of converting a monthly WAM to daily. The monthly-to-daily naturalized flow disaggregation is highly non-uniform reflecting the great natural variability of stream flow.

All other monthly time series input data in the daily Nueces WAM are uniformly disaggregated from monthly to daily. *SIMD* includes no alternative other than a uniform distribution for monthly-to-daily disaggregation of *EV* record net evaporation-precipitation depths or *CI* record constant inflows. These quantities are uniformly disaggregated by *SIMD* in proportion to the number of days (28, 29, 30, or 31) in each month.

Monthly water supply diversion targets are uniformly disaggregated to daily. Daily diversion targets in acre-feet/day are computed by *SIMD* by dividing monthly diversion target volumes by the number of days in each month. Likewise, with the exception of the instream flow targets for the SB3 EFS added as discussed in Chapter 5, *IF* record instream flow targets are uniformly distributed from monthly to daily. *SIMD* includes options for non-uniformly disaggregating monthly diversion and instream flow targets to daily, activated by input parameters on *JU*, *DW*, and *DO* records, but these options are not employed in the daily Nueces WAM.

The daily Nueces WAM *SIMD* input dataset is composed of DAT, DIS, DIF, and DSS files. The original flow distribution DIS file (*FD* and *WP* records) is used without modification in both the daily and expanded monthly versions of the WAM. The same DSS hydrology input file is shared by both the daily and expanded monthly versions of the WAM. The only differences between the current use and full authorization versions of the Nueces WAM are reflected in the different DAT files.

A monthly simulation can be performed with *SIM* with a DAT file containing input records for a daily simulation. *SIM* skips over daily input records in the DAT file, does not read the DIF file, and ignores the *DF* records in the DSS time series input file. However, the daily *SIMD* has no option for skipping over the daily-only records in the DAT file, other than manually commenting (**) them out. *SIMD* can perform a monthly simulation if and only if no daily-only records are included in the input dataset.

Simulation Input DAT File Records

The records replicated as Table 4.1 are found at the beginning of the daily DAT file. The *JT*, *JU*, and *OF* records control daily simulation input, output, and computation options. The *SIMD JT* and *JU* records are analogous to the *SIM/SIMD JD* and *JO* records. *SIM/SIMD* input records applicable in both monthly and daily simulations are covered in Chapter 3 of the *Users Manual* [3]. *SIMD* input records applicable only in a daily *SIMD* simulation are explained in Chapter 4 of the *Users Manual*. Although *OF* record field 4 entry DSS(3) has some options that are relevant only to a daily simulation, the file options *OF* record is described in Chapter 3 of the *Users Manual*.

Table 4.1
SIMD DAT File Input Records for Controlling Daily Simulation Options

```
**       1         2         3         4         5         6         7         8
**345678901234567890123456789012345678901234567890123456789012345678901234567890
JD    88    1934       1       0       0               6
JO     6
JT                                                 0
JU     1   1
CO          CP01    CP02    CP03    CP05    CP06    CP07    CP08    CP12    CP13
CO          CP16    CP18    CP25  320603    CP26    CP28    CP29    CP30
DF          CP01    CP02    CP03    CP04    CP05    CP06    CP07    CP08    CP09
DF          CP12    CP13    CP17    CP18    CP19    CP25    CP26    CP27    CP28
DF          CP29    CP30
OF     0   0   2   1                                         Nueces
OFV   15
```

The following options activated on the records shown in Table 4.1 contribute to the conversion of the monthly WAM to daily.

- *JO* record *ADJINC* options 4 or 6 (column 56) are the recommended standards for monthly simulations or daily simulations without forecasting. Option 6 was adopted for the daily Nueces WAM. Option 5 was adopted in the original monthly Nueces WAMs. *ADJINC* option 7 is the recommended standard negative incremental flow adjustment option for daily simulations with forecasting as explained in *Daily Manual* Chapter 3 [5].
- INEV option 6 in *JO* record field 2 (column 8) instructs *SIM* and *SIMD* to read *IN* and *EV* records from the hydrology DSS input file.
- The *JT* record is required for a daily simulation. The *JU* record activates certain daily options. Defaults are activated for blank fields or entries of zero on the *JT* and *JU* records.
- All fields of the *JT* record in Table 4.1 are blank. Several of these fields allow optional output tables to be created in the annual flood frequency AFF file and daily message SMM file. An entry of 1 for SUBFILE in field 11 (column 44) would activate the daily output SUB file.
- Flow disaggregation DFMETH option 1 (uniform) is set as the global default in *JU* record field 2 used for computational control points that do not reflect actual real stream flow sites. A *DC* record placed in the DIF file with REPEAT and DFMETHOD options 2 and 4 activate disaggregation option 4 based on *DF* record pattern hydrographs for all control points on the Nueces River and its tributaries that have actual monthly naturalized stream flows.

- DFFILE option 1 is selected in *JU* record field 3 (column 12), meaning daily flow *DF* records are read from the hydrology input DSS file for the twenty control points listed on the DAT file *DF* record in Table 4.1.
- DSS(3) option 2 is selected in *OF* record field 4 (column 16) to instruct *SIMD* to record both daily and monthly simulation results in a DSS output file. A one in *OF* record field 4 (column 20, DSS(4)=1) and variable 15 (instream flow target) on the accompanying *OFV* record results in instream flow targets for the seventeen control points with SB3 EFS listed on the *CO* record being included in the simulation results DSS file.
- The DSS input filename root Nueces in *OF* record field 12 connects to the hydrology time series input file with filename NuecesHYD.DSS. With field 12 blank, by default, the filename of the DSS input file is the same as the DIS file which by default is the same as the DAT file.

Environmental flow standards (EFS) at seventeen sites established by the TCEQ in collaboration with a science team and stakeholder committee through a process created by the 2007 Senate Bill 3 are modeled by adding *IF*, *ES*, and *PF* records to the DAT file as described in Chapter 5. The control points with SB3 EFS may optionally be listed on *CO* records, as shown in Table 4.1, to have their instream flow targets output as option 15 on the *OFV* record.

Daily flows for the control points listed on *DF* records in Table 4.1 are stored on *DF* records in the time series DSS input file along with the *IN* and *EV* records. The *DF* record daily flows are used by *SIMD* for disaggregating monthly naturalized stream flows to daily. Naturalized flow volumes in acre-feet/month are distributed to daily volumes in acre-feet/day in proportion to the daily flow pattern hydrographs recorded on *DF* records in the DSS file as explained in the next section.

Disaggregation of Monthly Naturalized Stream Flow to Daily

SIM and *SIMD* read monthly naturalized stream flow volumes from inflow *IN* records for 37 primary control points (Tables 2.5 and 2.6). Both monthly *SIM* and daily *SIMD* simulations synthesize monthly naturalized flows at over 500 other secondary control points based on the monthly naturalized flows at the 37 primary control points and parameters read from control point *CP*, flow distribution *FD*, and watershed parameter *WP* records. *SIMD* distributes the monthly naturalized flow volumes at each of the over 540 control points to the 28, 29 (February of leap years), 30, or 31 days in each of the 1,056 months of the 1934-2021 hydrologic period-of-analysis.

Control point CPEST represents the outlet of the Nueces River at Nueces Bay. CP30 is the most downstream control point with daily flows on *DF* records. DFMETHOD option 4 employing daily flows from *DF* records is applied to all control points upstream of the outlet at control point CPEST and at control point CPEST. *JU* record DFMETH option 1 (uniform) applies to all other control points including disconnected "dummy" accounting control points. The procedure described in the next paragraph is activated by the following DIF input file *DC* record which activates REPEAT and DFMETHOD options 2 and 4 and assigns CP30 daily flows to CPEST.

```
DC   CPEST    2    4     CP30
```

Monthly naturalized stream flows at control point CPEST and all other control points located upstream of CPEST are disaggregated to daily using 1934-2021 daily flows at twenty control points stored as *DF* records in the hydrology input DSS file. Monthly volumes are distributed to daily volumes in proportion to daily flows while maintaining the monthly volumes. The automated procedure in *SIMD* for repeating daily flows at multiple control points is described on page 28 of Chapter 2 of the *Daily Manual* [5]. The automated procedure consists of using flows at the nearest downstream control point if available, otherwise finding flows at the nearest upstream control point, and lastly if necessary using flows from another tributary.

DFMETH option 1 is selected in *JU* record field 2 (column 8 in Table 4.1) to apply the uniform monthly-to-daily naturalized flow disaggregation option for all of the other control points not located upstream of control point CPEST. Thus, the selected default uniform disaggregation option (DFMETH=1) is applied to dummy control points employed in computational water accounting schemes that are not actually physically connected in the model to the actual outlet.

Daily Flow Pattern Hydrographs

The dataset of *DF* records of daily 1934-2021 naturalized flow volumes in acre-feet at 20 control points stored in the *SIMD* hydrology DSS input file with filename NuecesHYD.DSS are developed from daily means in cubic feet per second (cfs) of observed flow rates at USGS gages. The daily quantities on *DF* records are used in the *SIMD* simulation to determine the proportion of monthly naturalized flow volume to distribute to each of the 28, 29, 30, or 31 days in each of the 1,056 months of the 1934-2021 hydrologic period-of-analysis at all relevant control points.

The daily flow *DF* records are employed in the *SIMD* simulation for the sole purpose of serving as pattern hydrographs used in disaggregating monthly naturalized flows to daily. Therefore, only the pattern of the quantities on the *DF* records within each of the 1,056 months, not the actual magnitude of the individual quantities for each day, affect *SIMD* simulation results. The *DF* record daily flows can be in any units and are not required to reflect a specific single site. However, the *DF* records for the Nueces WAM contain daily naturalized flows in acre-feet/day. The *DF* records of daily naturalized flows can be easily tabulated or plotted in *HEC-DSSVue*.

The following tasks were performed in developing the dataset of *DF* records of 1934-2021 daily flows at twenty control points.

1. Available daily observed flow data were explored to select control points for inclusion in the dataset of *DF* records. A determination was made to develop *DF* records for each of the twenty primary control points listed in Table 4.2, which are USGS gage sites with adequately long periods-of-records. These sites are also included in Tables 2.5 and 3.2 and Figure 2.2.

2. Observed flows at relevant USGS gages as daily means in cfs were compiled as a DSS file from the USGS NWIS website using the data import feature of *HEC-DSSVue*.

3. Periods-of-record for each of the USGS gages are listed in Table 4.2. Fifteen of the twenty gage sites do not have periods-of-record covering the entire WAM 1934-2021 hydrologic period-of-analysis. Gage records at two or more sites were combined as necessary to develop complete 1934-2021 sequences of observed daily flows in cfs.

4. The 1934-2021 daily flows in cfs at the twenty control points were converted within *HEC-DSSVue* to a *SIMD* input dataset of *DF* records with flows in cfs. *SIMD* was executed with this dataset. The *SIMD* simulation results included naturalized daily flows in acre-feet/day.

5. The daily naturalized flows recorded by *SIMD* in its simulation results DSS file were converted within *HEC-DSSVue* to a dataset of *DF* records. This final dataset of *SIMD* input *DF* records consists of 1934-2021 daily naturalized flows in acre-feet/day at twenty control points.

Observed Daily Flows at USGS Gages

DF record daily flows are developed from observed flows at the USGS gages listed in Table 4.2. The observed daily flow records were downloaded from the U.S. Geological Survey (USGS) National Water Information System (NWIS) website using the data import feature of *HEC-DSSVue* Version 7. The NWIS import feature no longer works in the old version 6 of *HEC-DSSVue* due to USGS modifications to the NWIS website. Data manipulations in developing the *DF* records of daily pattern hydrographs were performed using *HEC-DSSVue*. The data are stored in a DSS file. Daily observed flows at control points CP01, CP03, CP05, CP07, CP25, CP27, CP29, and CP30 are plotted in Figures 3.1, 3.3, 3.5, 3.7, 3.9, 3.11, 3.13, and 3.15 of Chapter 3.

Table 4.2
Primary Control Points at USGS Gage Sites Used
in Developing the *DF* Record Daily Flows

Control Point	Location (Stream, Town)	Drainage Area	Period-of-Record	Missing Days	Fill-In CP
		(sq miles)			
CP01	Nueces River, Laguna	737	1Oct1923-present	0	complete
CP02	W. Nueces R., Brackettville	694	28Sep1939-present	4,106	CP01
CP03	Nueces River, Uvalde	1,861	1Oct1927-present	0	complete
CP04	Nueces River, Asherton	4,082	1Oct1939-present	2,465	CP05
CP05	Nueces River, Cotulla	5,171	1Oct1926-present	0	complete
CP06	Nueces River, Tilden	8,093	1Dec1942-present	3,299	CP04
CP07	Frio River, Concan	389	30Sep1924-present	0	complete
CP08	Dry Frio Riv. Reagan Wells	126	1Sep1952-present	6,818	CP07
CP09	Frio River, Uvalde	631	1Oct1953-present	7,215	CP07
CP12	Sabinal River, Sabinal	206	1Oct1942-present	3,195	CP05
CP13	Sabinal River, Sabinal	241	30Sep1986-present	19,265	CP12
CP17	Seco Creek, D'Hanis	168	1Nov1960-present	9,801	CP29
CP18	Hondo Creek, Tarpley	95.6	20Aug1952-present	6,806	CP29
CP19	Hondo Creek, Hondo	149	1Oct1960-23Jul2006	15,410	CP29
CP25	Frio River, Derby	3,429	1Aug1915-present	1,462	CP05
CP26	San Miguel Creek, Tilden	783	25Jan1964-present	20,180	CP28
CP27	Frio River, Calliham	5,491	1Oct1924-23Mar1981	14,893	CP25
CP28	Atascosa River, Whitsett	1,171	22May1932-present	273	CP26
CP29	Nueces River, Three Rivers	15,427	1Jul,1915-present	0	complete
CP30	Nueces River, Mathis	16,660	5Aug1939-present	2,042	CP29

Periods-of-record are tabulated in the fourth column of Table 4.2. The number of days of missing data during the WAM 1934-2021 hydrologic period-of-analysis is shown in the next-to-last column of Table 4.2.

WAM Daily Pattern Hydrographs on *DF* Records

The January 1, 1934 through December 31, 2021 hydrologic period-of-analysis consists of 32,142 days. The five gages at CP01, CP03, CP05, CP07, and CP29 have a complete record covering the 32,142 days of the 1934-2021 period-of-analysis with no missing data. The fifteen other gages have multiple days of missing data during 1934-2021 ranging from 273 days to 20,180 days. In cases of gaps of missing data for one to several days, the missing data were filled-in using linear interpolation of preceding and subsequent daily flows. For larger gaps of missing data, daily flows at the control points listed in the last column of Table 4.2 are used to fill-in gaps of missing data. Daily flows at a single control point are used for all days of a particular month. In some cases, the fill-in source control point has had gaps filled in from another source control point.

The first column of Table 4.2 is the WAM identifier for each control point. The last column shows the selected control point of the USGS gage site for which observed daily flows were adopted for use in filling in gaps of missing data. All flows in a particular month are from the same source site in order to maintain within-month consistency.

The resulting dataset of 1934-2021 observed daily flows in cfs at twenty control points were converted to *DF* records within *HEC-DSSVue*. The flows in cfs provide patterns for disaggregating monthly naturalized flows in acre-feet/month to daily naturalized flows in acre-feet/day. The flow pattern within each month is the same regardless of units. However, for convenience, the *DF* record flow pattern hydrographs were converted to daily naturalized flows in acre-feet/day as described in the next paragraph.

SIMD was executed with the dataset described in the preceding paragraph. The *SIMD* simulation results include naturalized daily flows in acre-feet/day. The daily naturalized flows recorded by *SIMD* in the *SIMD* simulation results DSS file were converted within *HEC-DSSVue* to a dataset of *DF* records consisting of 1934-2021 daily naturalized flows in acre-feet/day at twenty control points.

Monthly naturalized flows are compiled differently for CP26 than for the other primary control points. However, development of daily naturalized flows is conceptually the same for CP26 as the other primary control points. Compilation of daily and monthly naturalized flows at control point CP26 is described in Chapter 3. Daily naturalized flows are summed to obtain monthly naturalized flows at CP26.

The final adopted dataset of *DF* records consists of January 1934 through December 2021 daily naturalized stream flow volumes in acre-feet at the twenty control points that serve as pattern hydrographs in disaggregating monthly naturalized flows to daily in a *SIMD* simulation. The *DF* record daily flows are plotted as Figures 4.1 through 4.20.

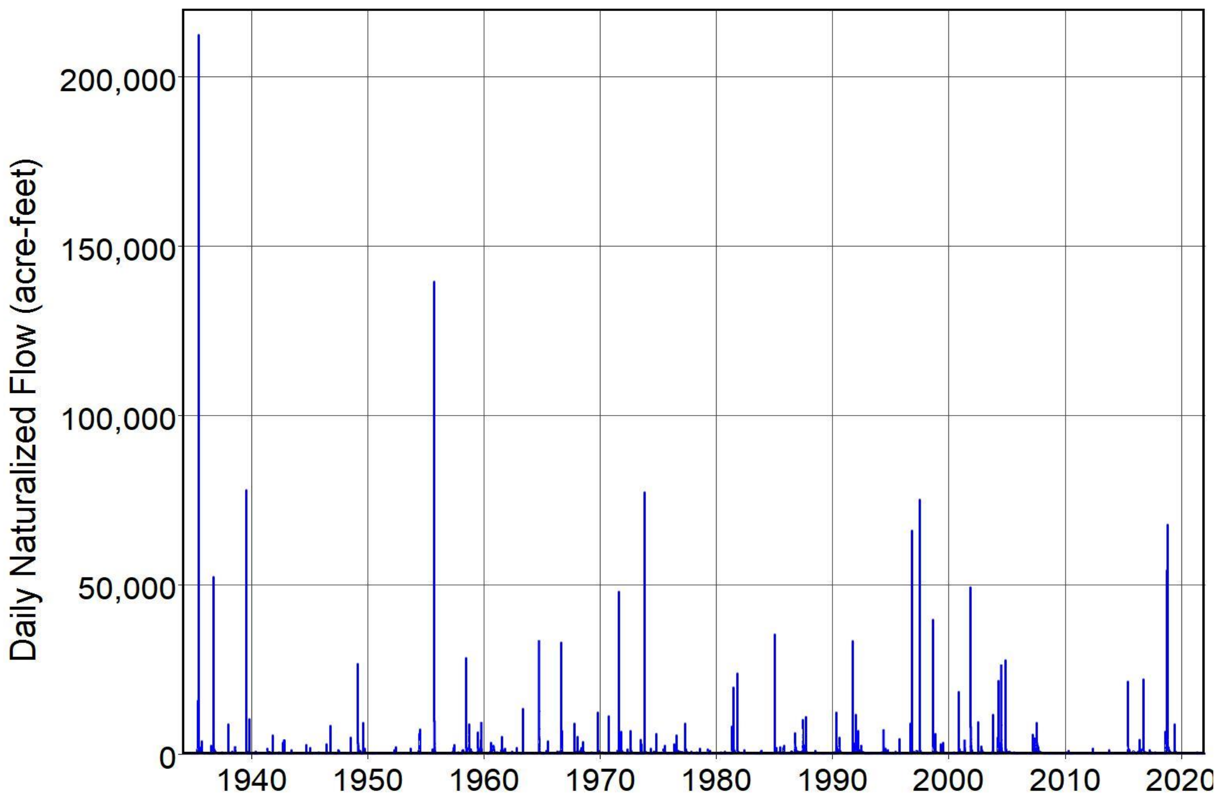

Figure 4.1 Daily Naturalized Flows of Nueces River at Laguna (CP01)

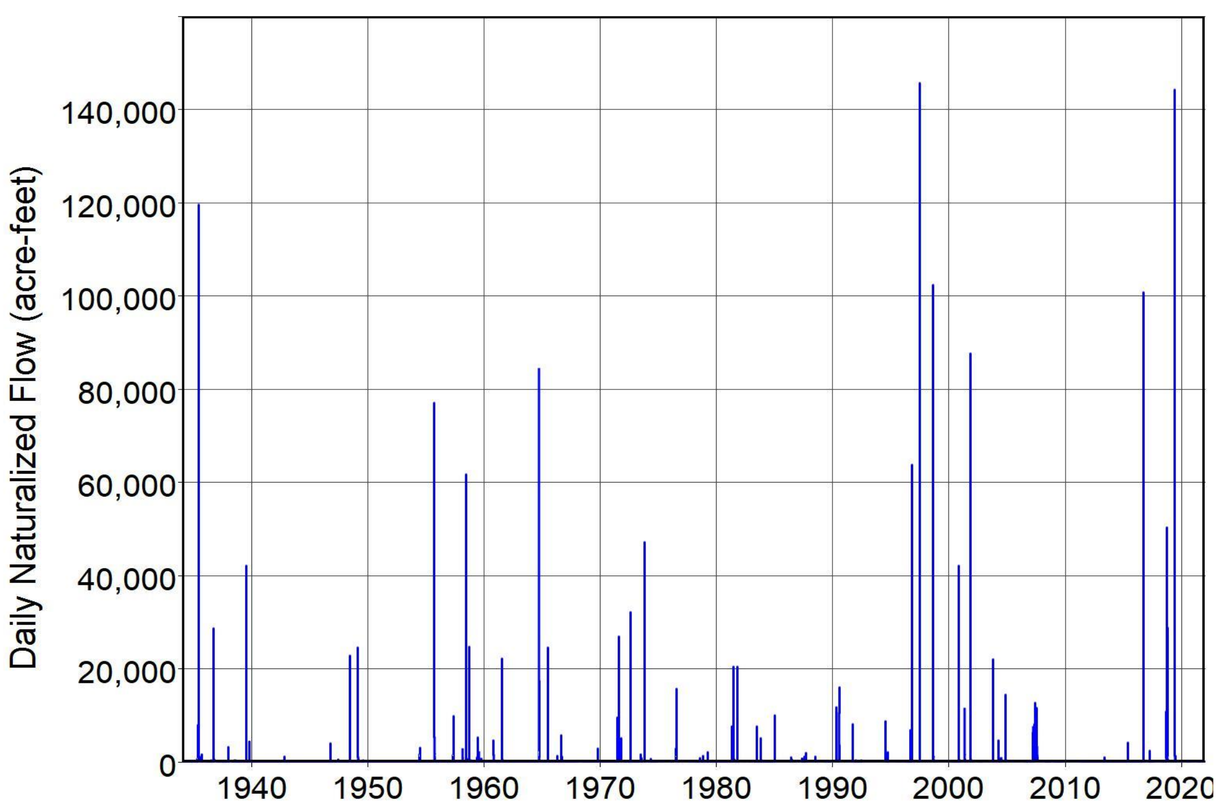

Figure 4.2 Daily Naturalized Flows of Nueces River at Brackettville (CP02)

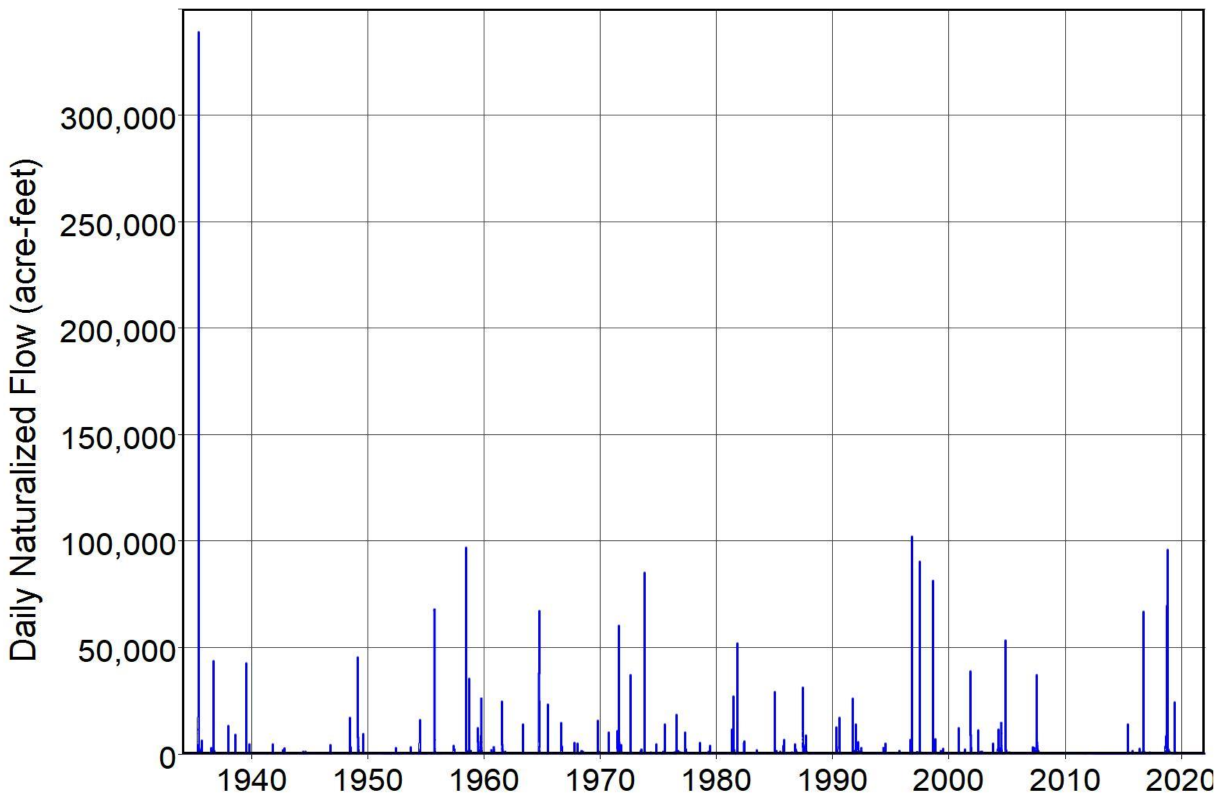

Figure 4.3 Daily Naturalized Flows of Nueces River at Uvalde (CP03)

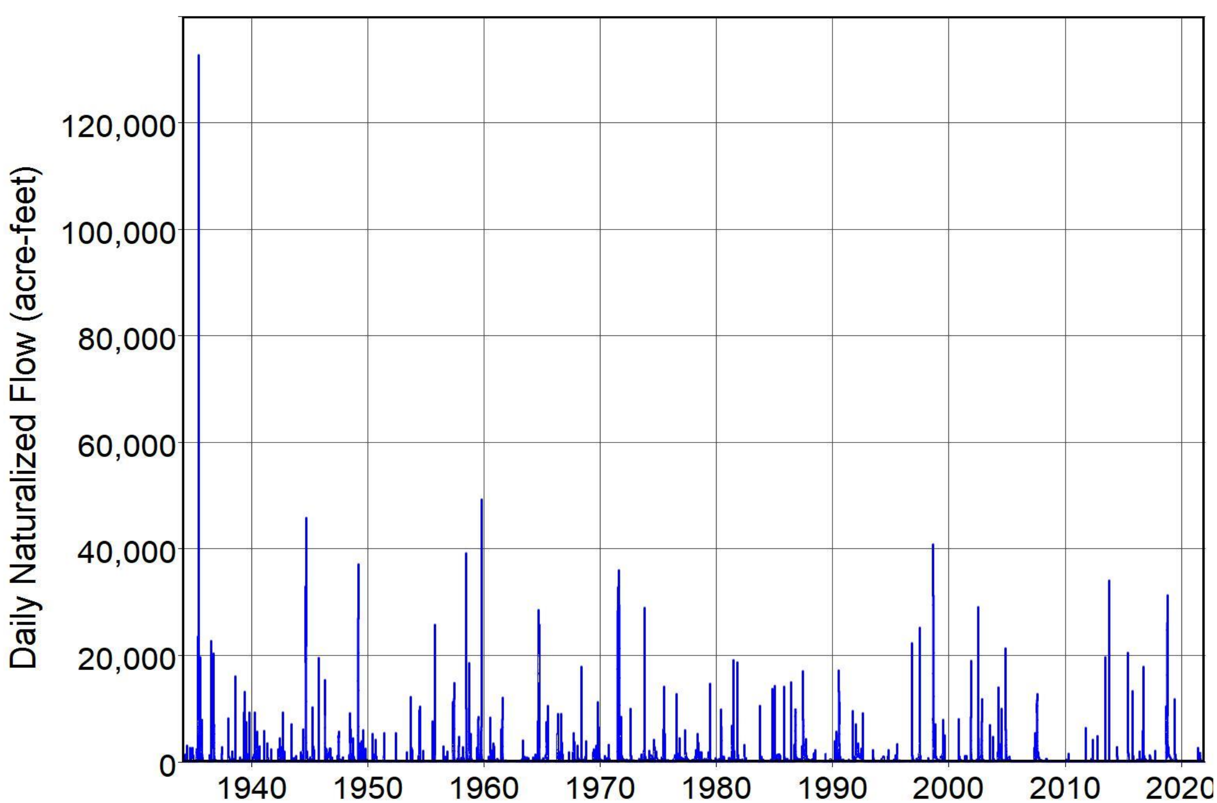

Figure 4.4 Daily Naturalized Flows of Nueces River at Asherton (CP04)

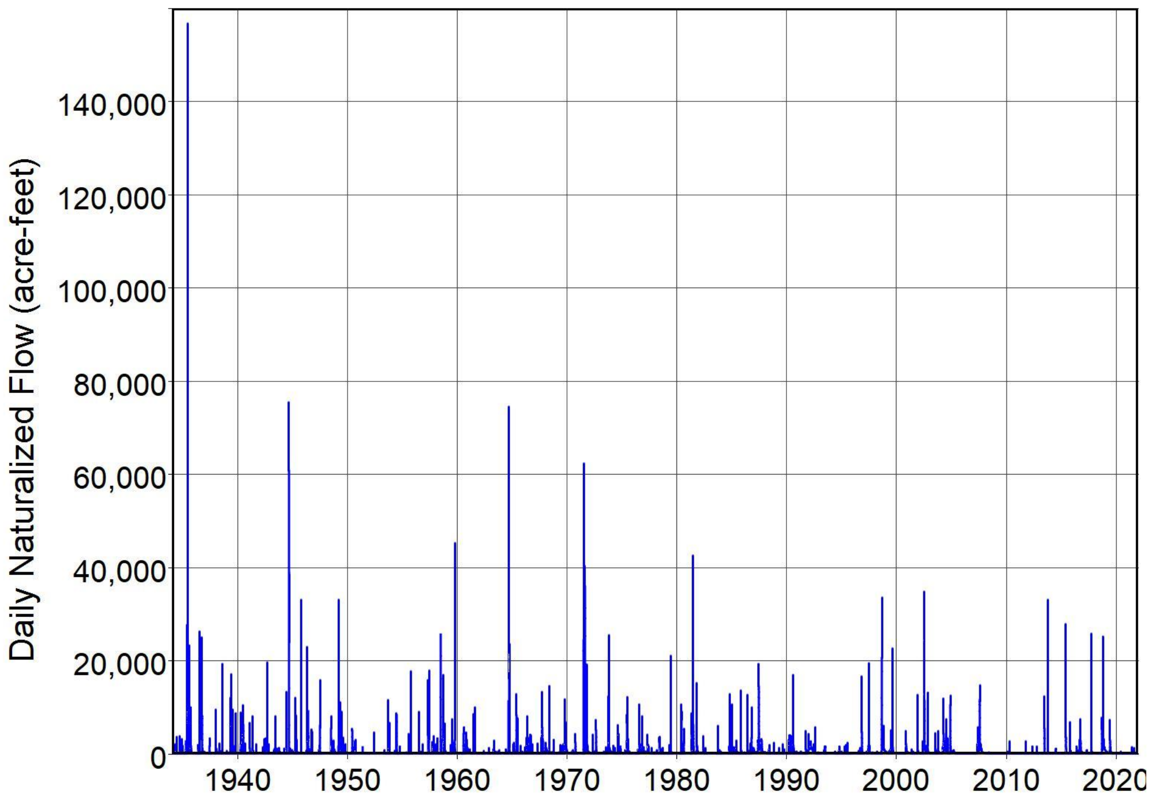

Figure 4.5 Daily Naturalized Flows of Nueces River at Cotulla (CP05)

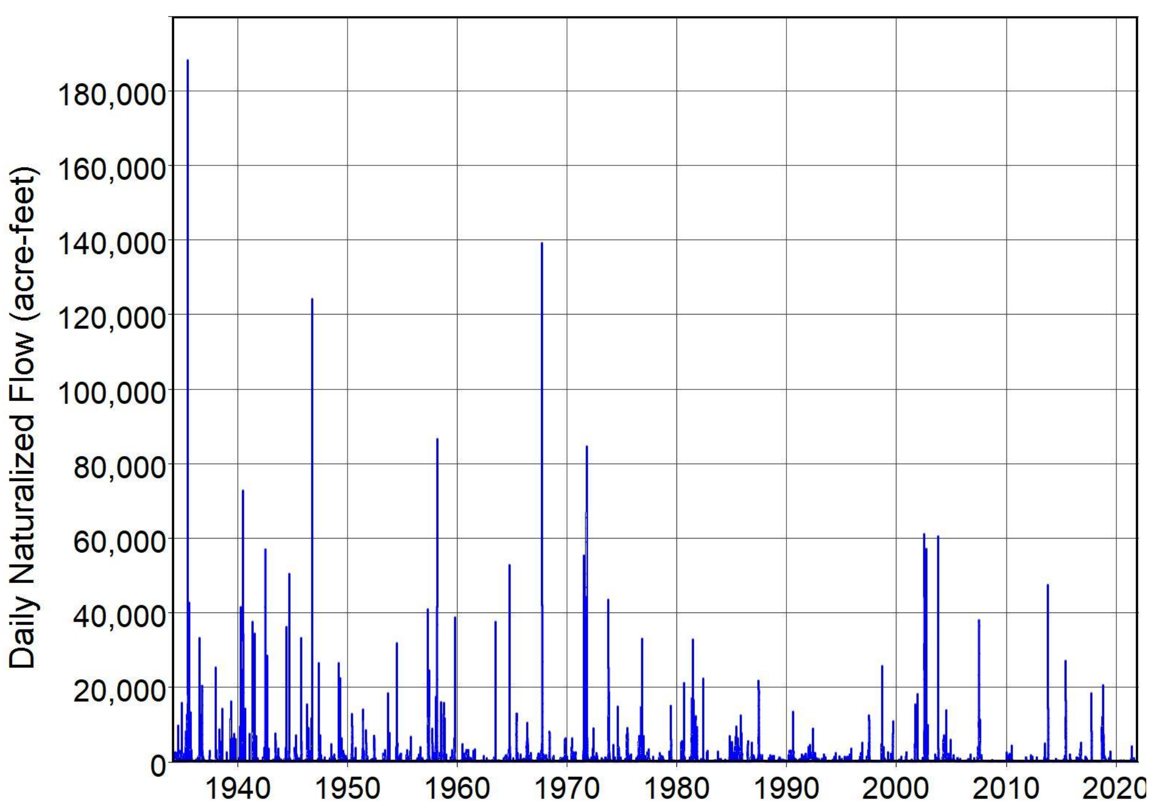

Figure 4.6 Daily Naturalized Flows of Nueces River at Tilden (CP06)

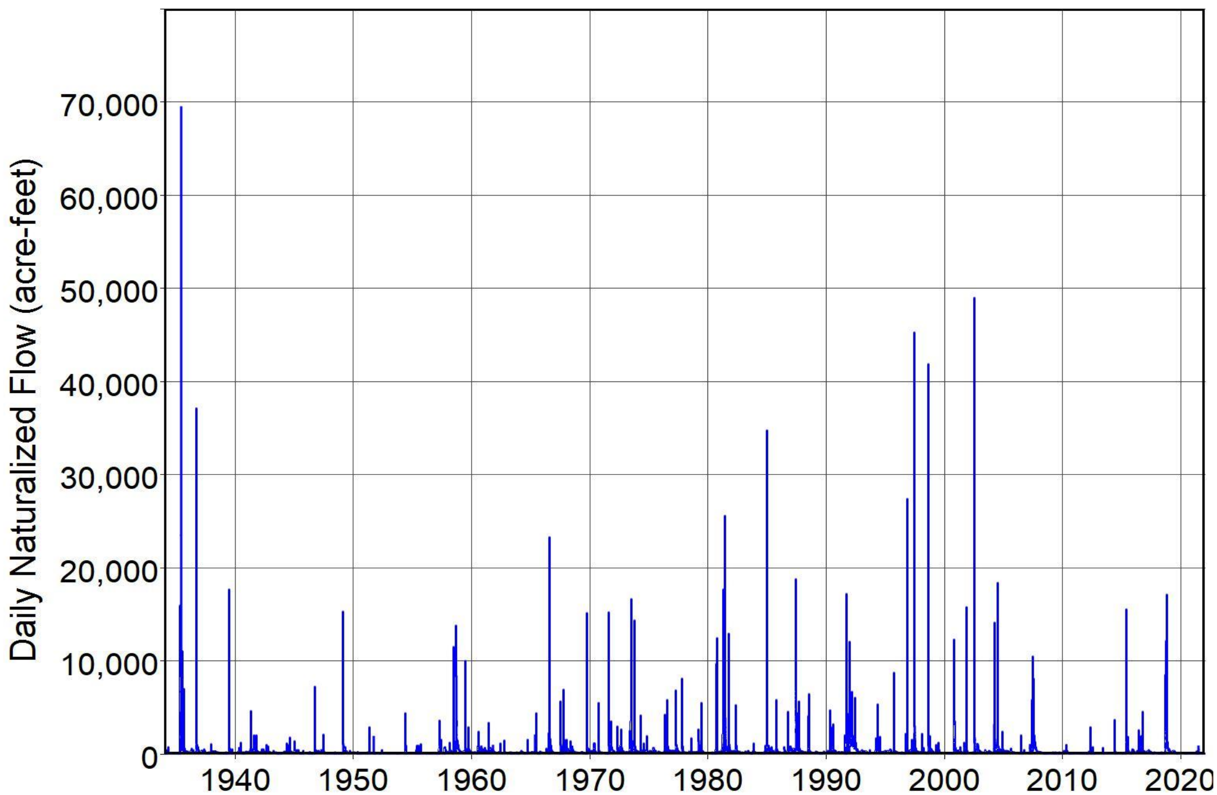

Figure 4.7 Daily Naturalized Flows of Frio River at Concan (CP07)

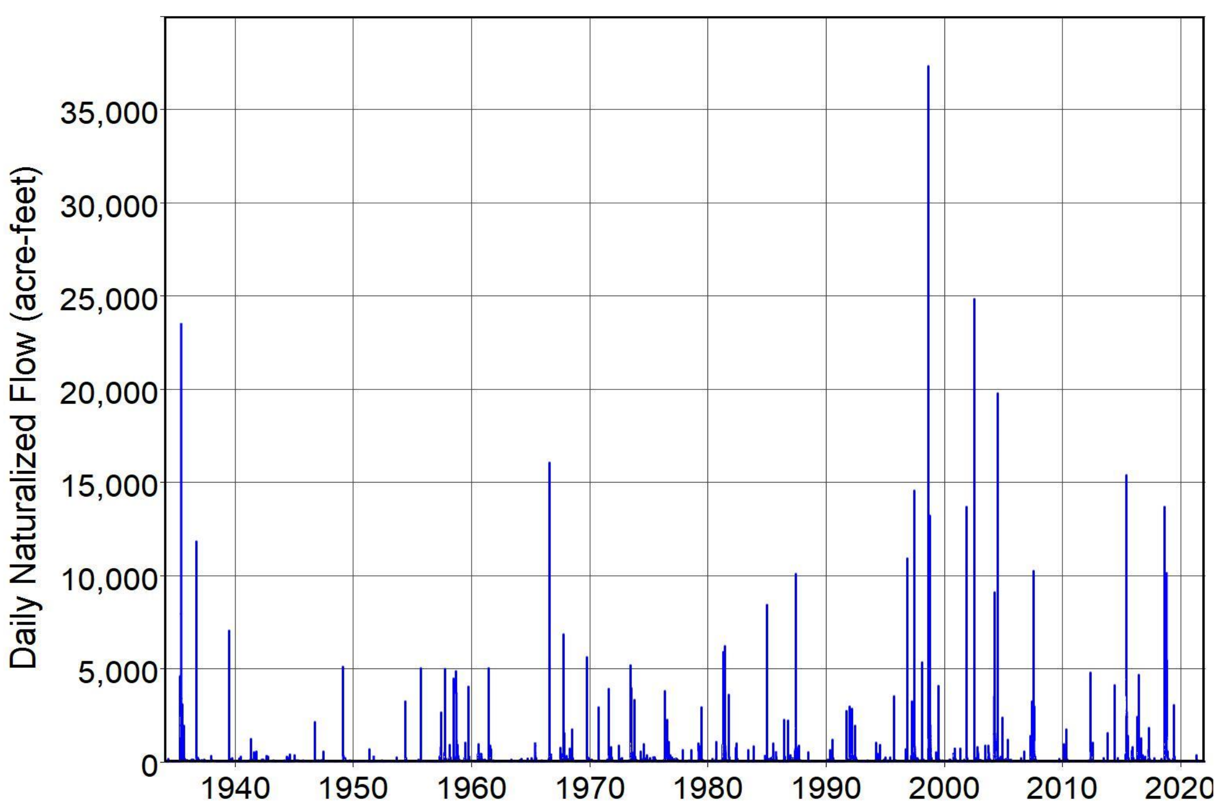

Figure 4.8 Daily Naturalized Flows of Dry Frio River at Reagan Wells (CP08)

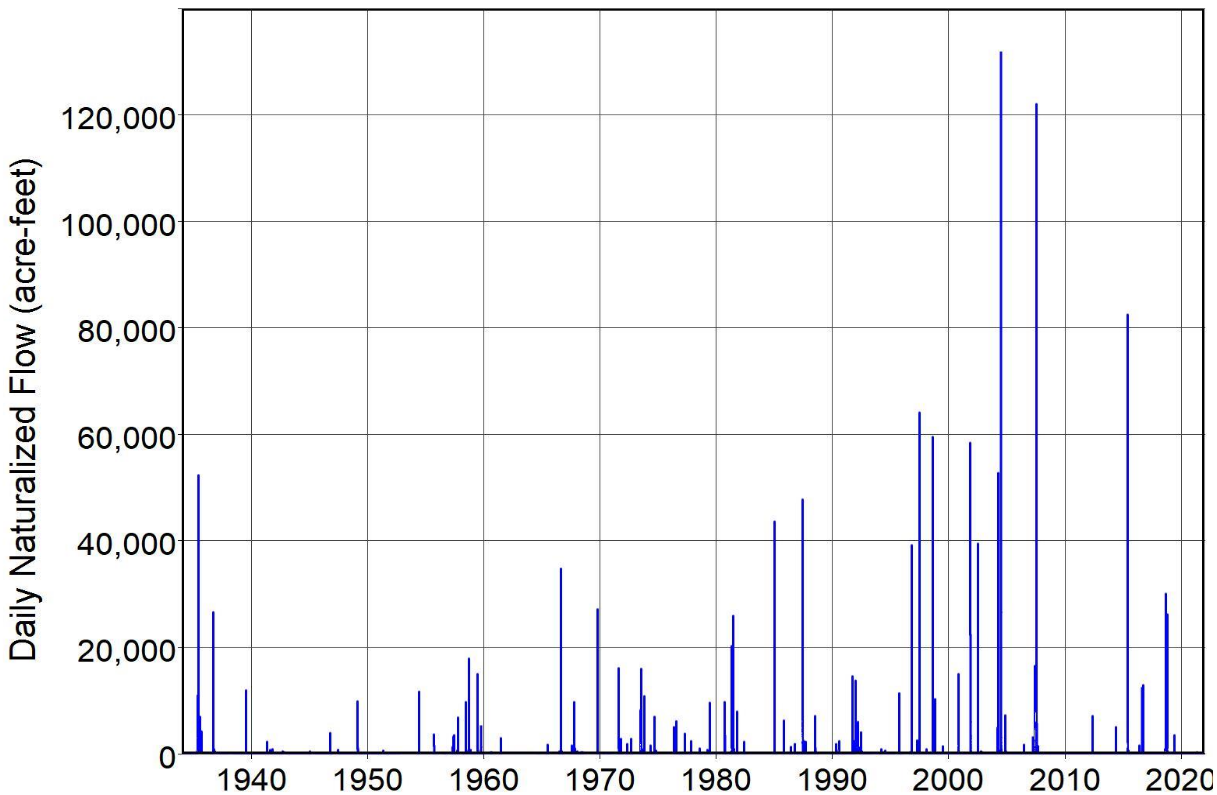

Figure 4.9 Daily Naturalized Flows of Frio River at Uvalde (CP09)

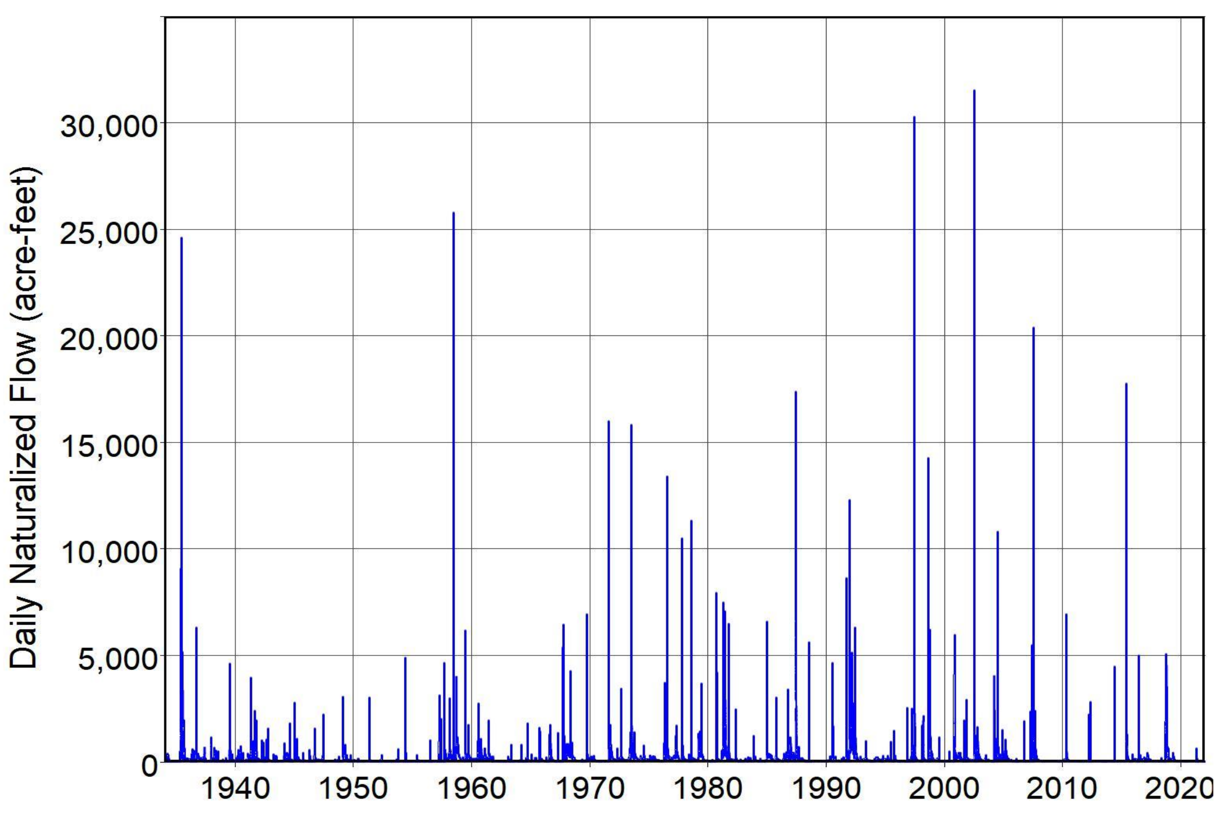

Figure 4.10 Daily Naturalized Flows of Sabinal River near Sabinal (CP12)

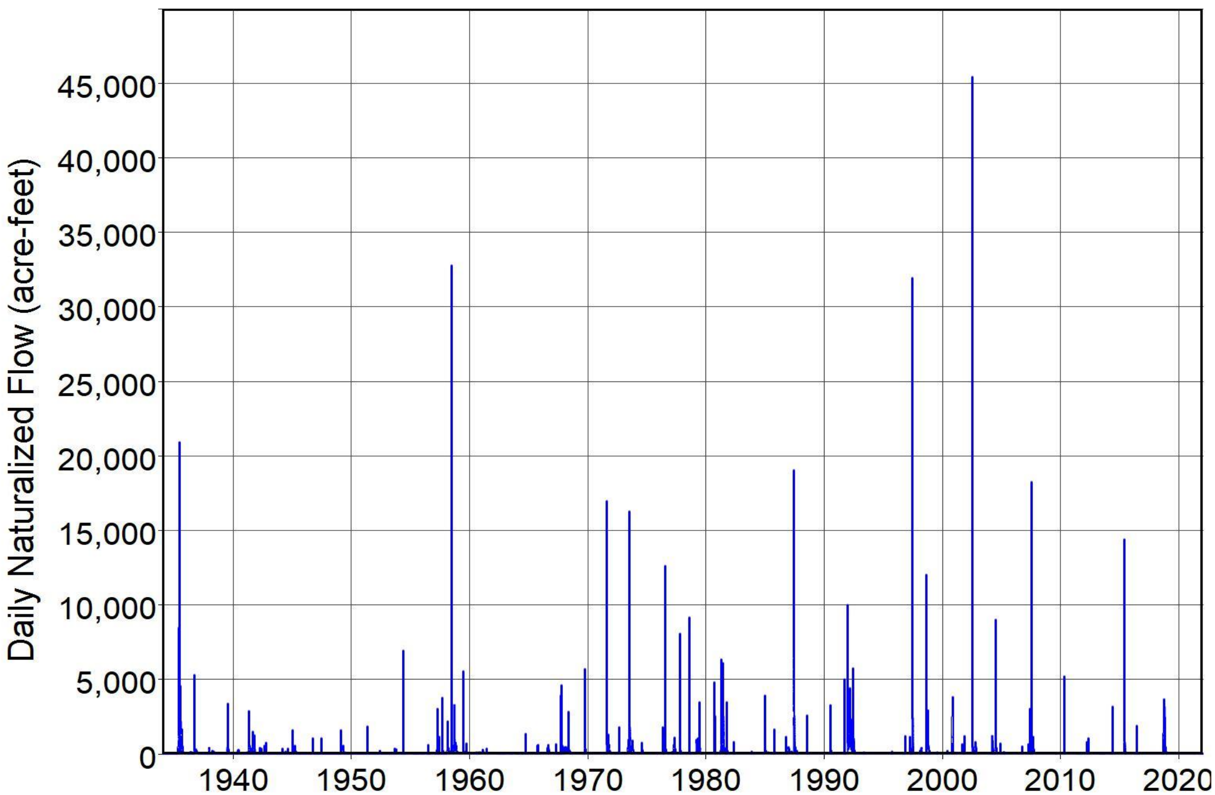

Figure 4.11 Daily Naturalized Flows of Sabinal River near Sabinal (CP13)

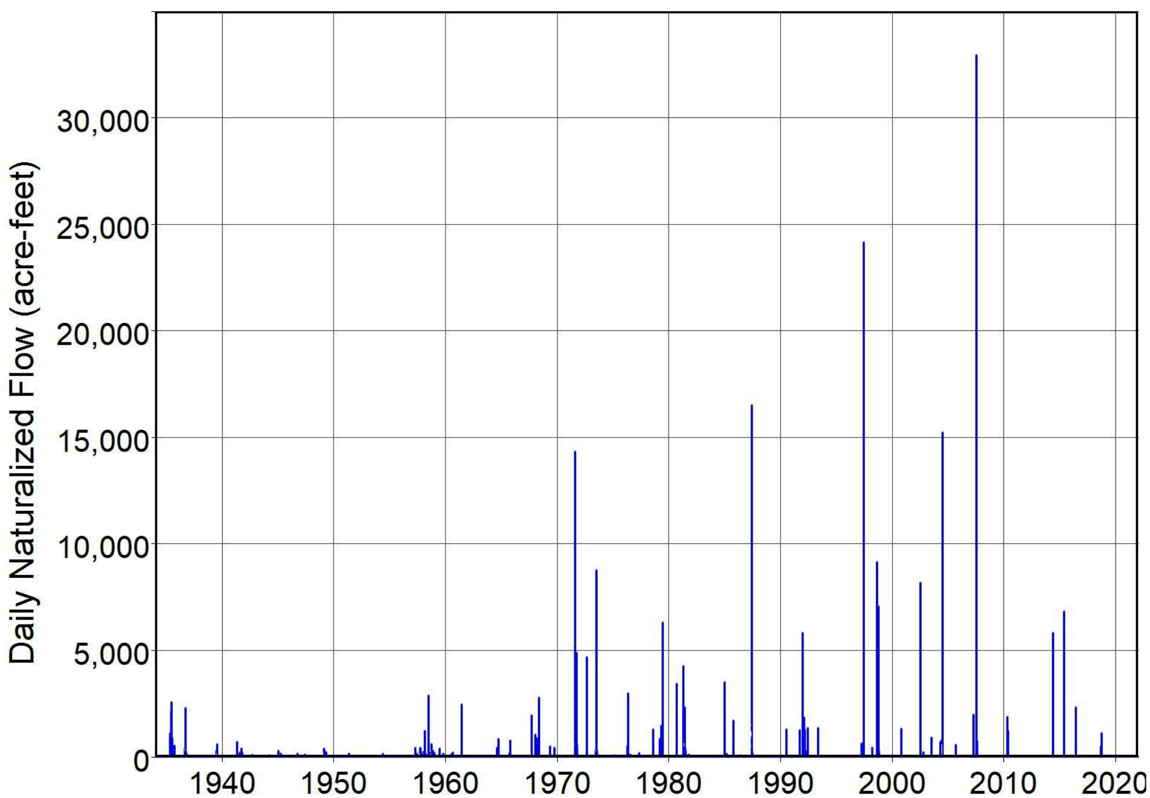

Figure 4.12 Daily Naturalized Flows of Seco Creek at D'Hanis (CP17)

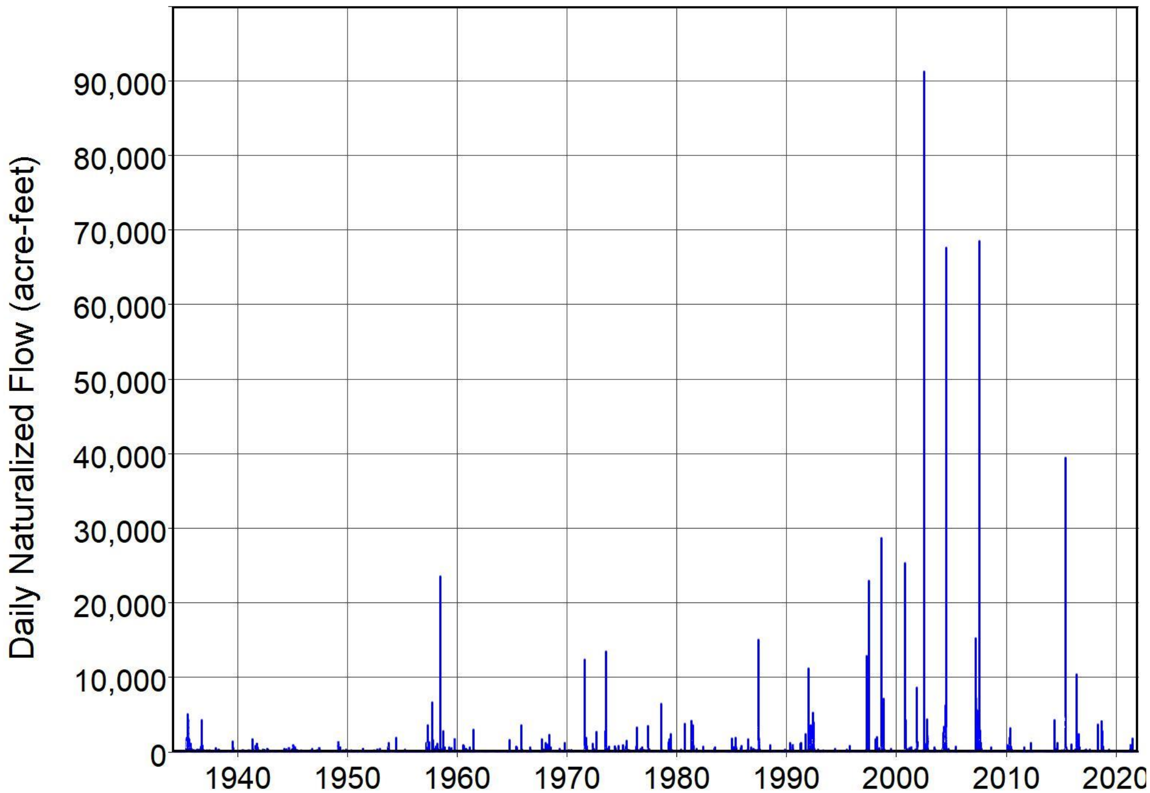

Figure 4.13 Daily Naturalized Flows of Hondo Creek at Tarpley (CP18)

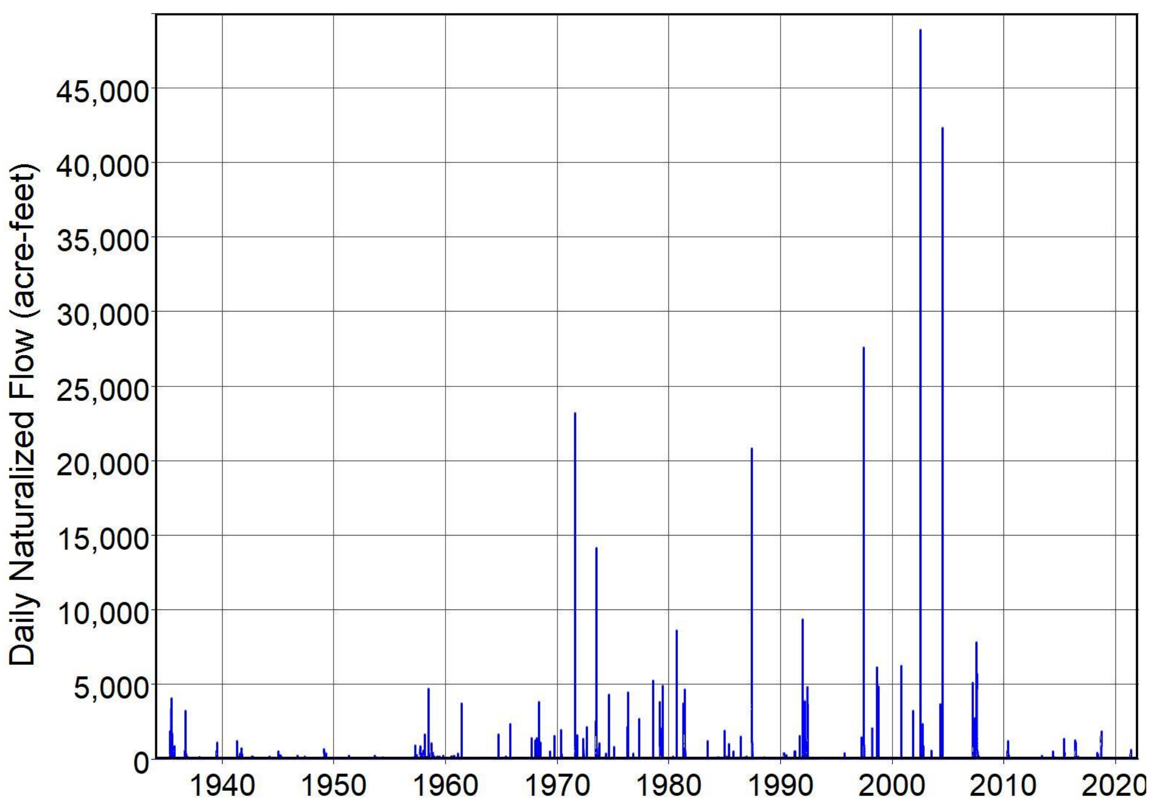

Figure 4.14 Daily Naturalized Flows of Hondo Creek at Hondo (CP19)

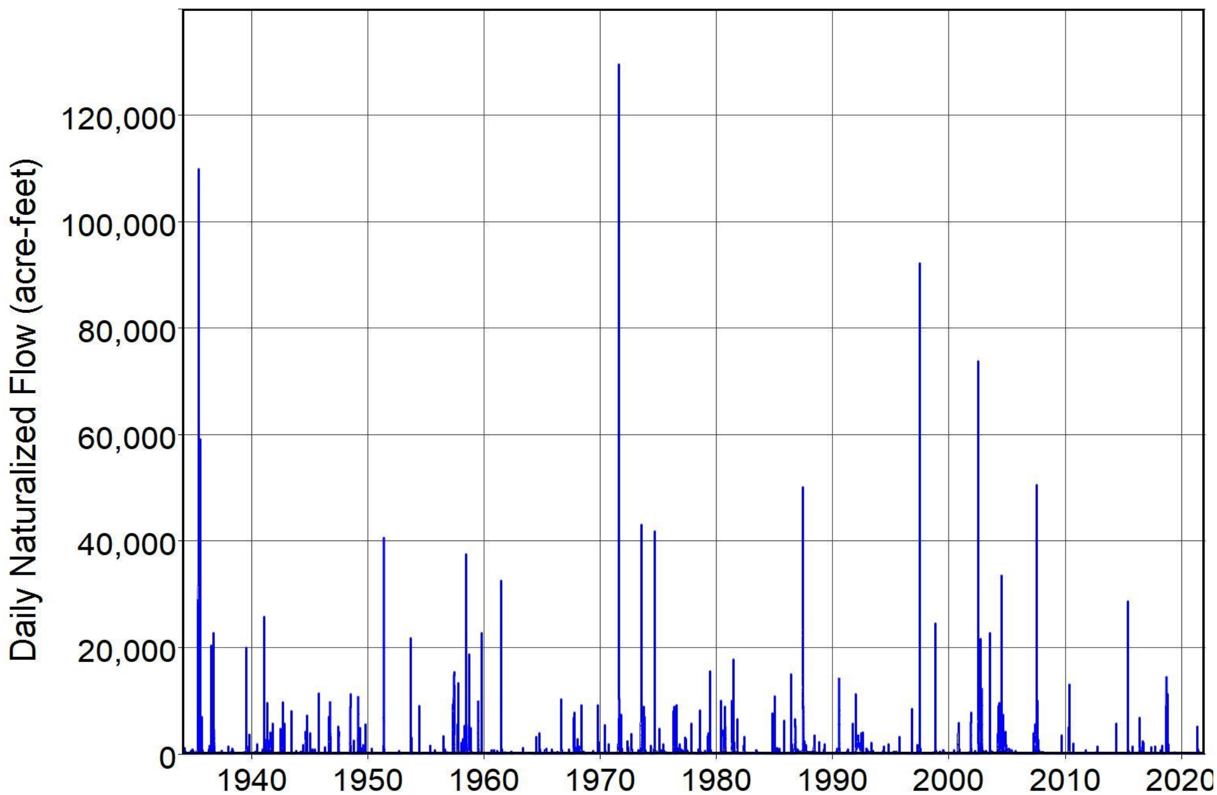

Figure 4.15 Daily Naturalized Flows of Frio River at Derby (CP25)

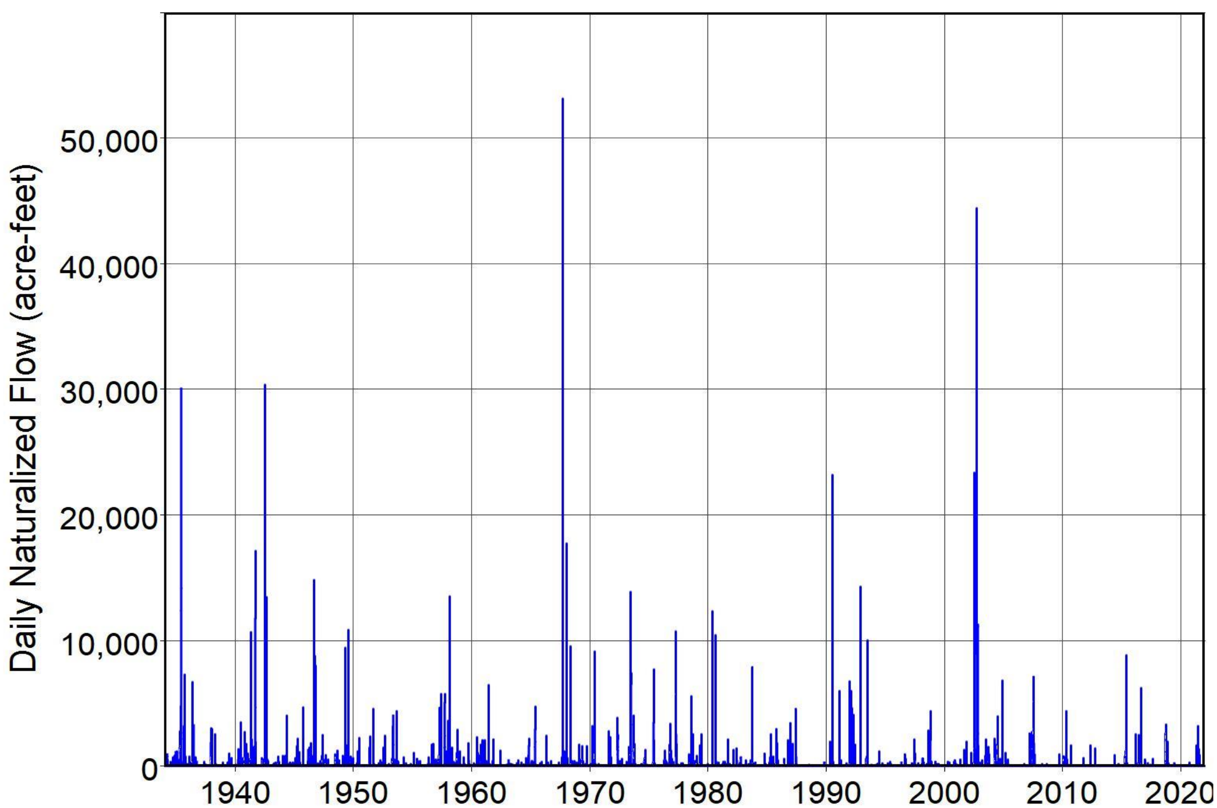

Figure 4.16 Daily Naturalized Flows of San Miguel Creek at Tilden (CP26)

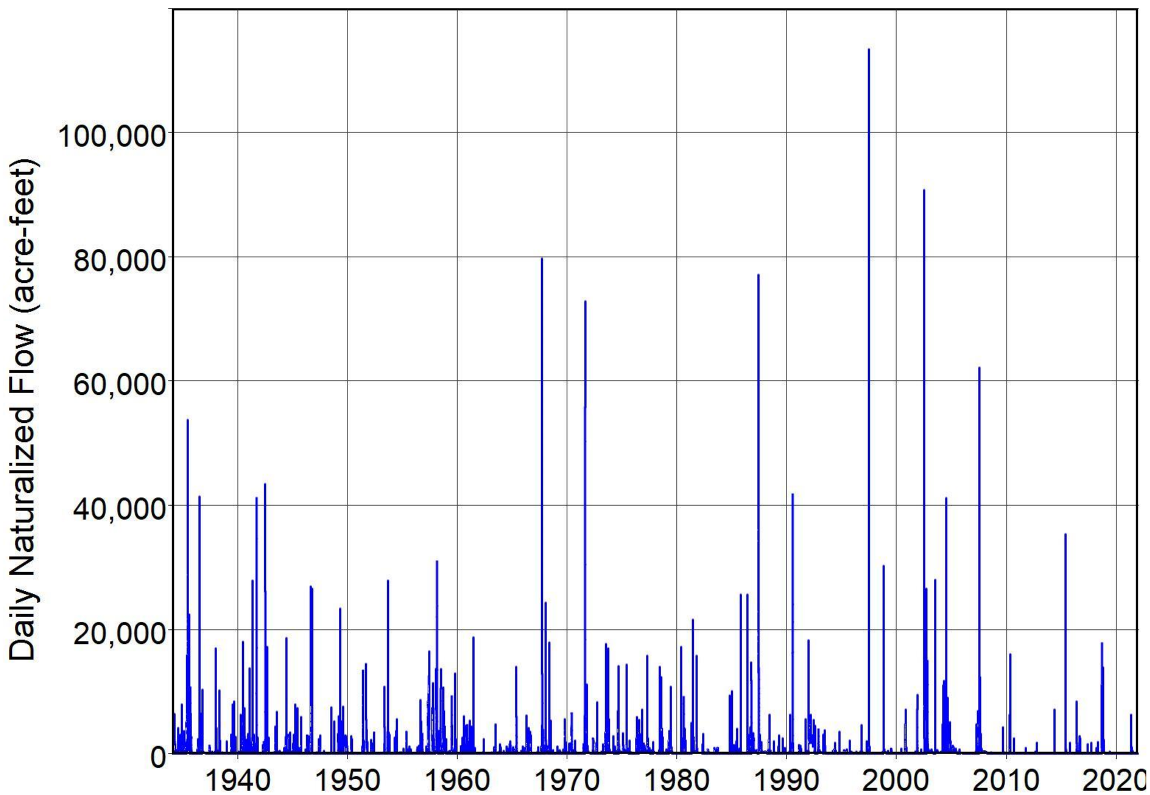

Figure 4.17 Daily Naturalized Flows of Frio River at Calliham (CP27)

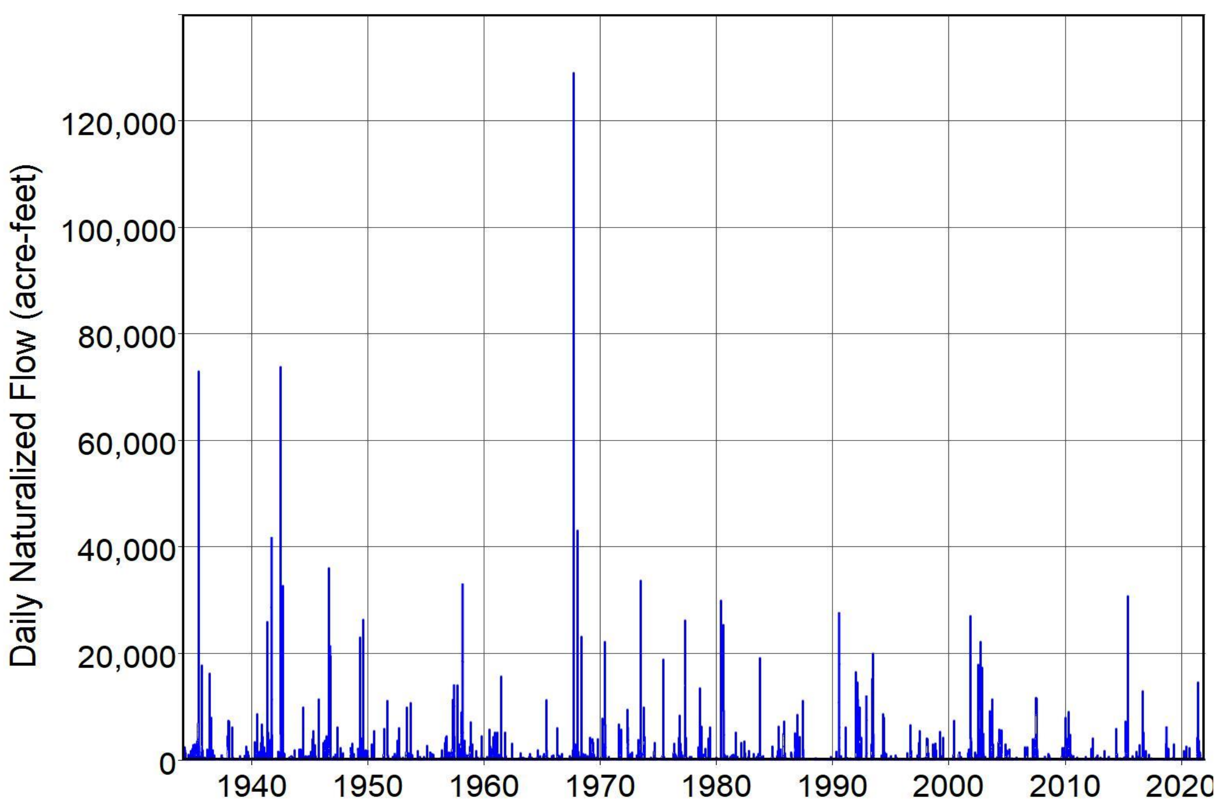

Figure 4.18 Daily Naturalized Flows of Atascosa River at Whitsett (CP28)

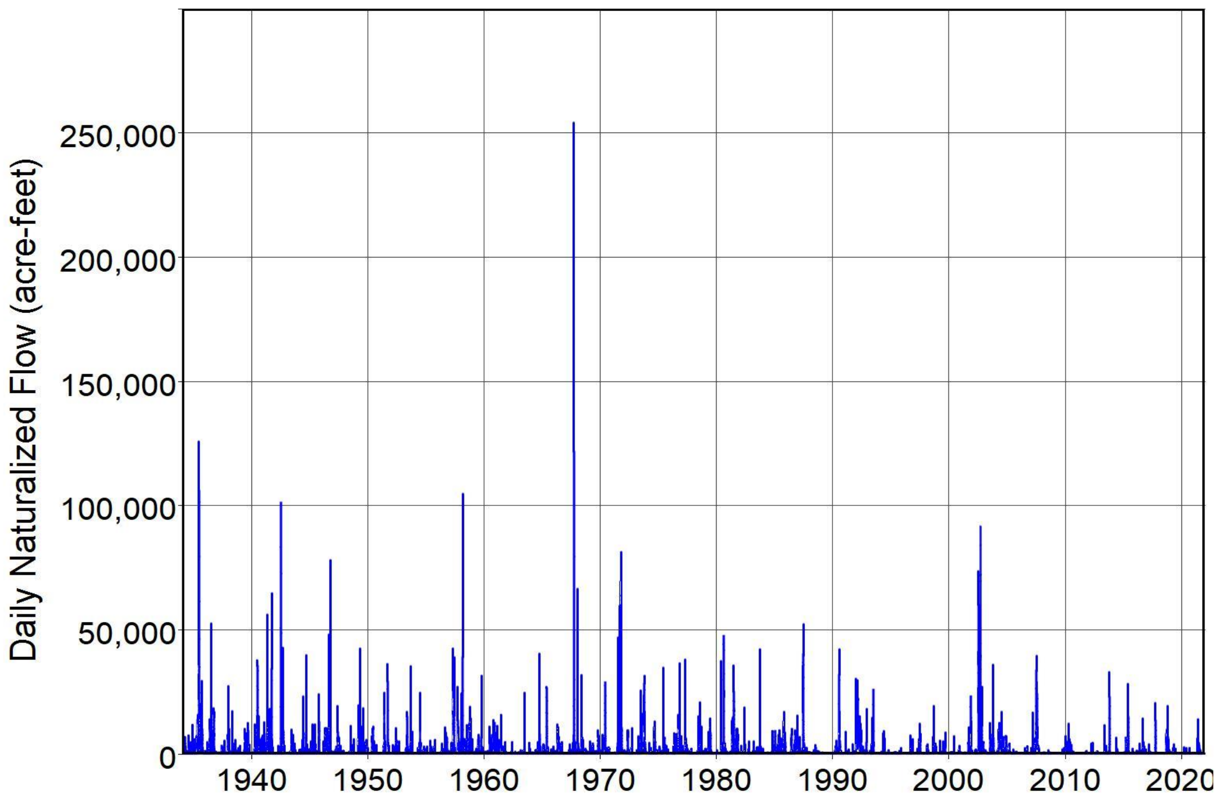

Figure 4.19 Daily Naturalized Flows of Nueces River at Three Rivers (CP29)

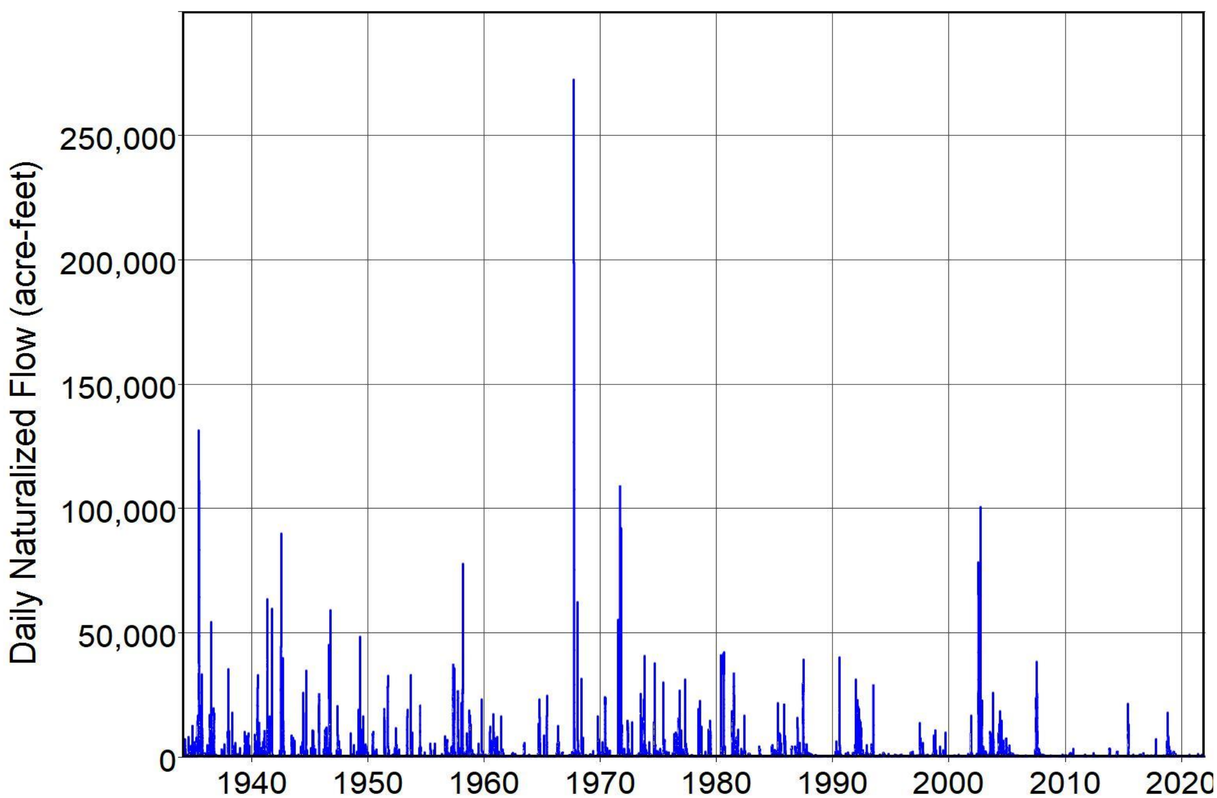

Figure 4.20 Daily Naturalized Flows of Nueces River at Mathis (CP30)

CHAPTER 5
ENVIRONMENTAL FLOW STANDARDS

The following topics are covered in this chapter.

1. Environmental flow standards (EFS) at seventeen gage sites in the Nueces River Basin established by the TCEQ in collaboration with a science team and stakeholder committee following procedures created by the 2007 Senate Bill 3 (SB3) are described.
2. Modeling of the SB3 EFS in the daily Nueces WAM using *IF*, *ES*, and *PF* input records inserted in the *SIMD* input DAT file is explained.
3. A procedure is outlined in which daily *IF* record instream flow targets for the SB3 EFS computed in a daily *SIMD* simulation are summed to monthly totals and incorporated in the monthly *SIM* input dataset for the Nueces WAM. This procedure is applied in Chapter 6.

Environmental Flow Standards Established Pursuant to Senate Bill 3 Process

Senate Bill 3 enacted by the 80th Texas Legislature in 2007 established a new regulatory approach to provide for environmental needs for certain stream flow conditions through the use of standards developed through a stakeholder process culminating in TCEQ rulemaking. Water right permits in effect prior to the effective date of September 1, 2007 are not impacted. Only new water rights and water right amendments that are submitted after this date are subject to the new requirements established pursuant to the 2007 Senate Bill 3. Information regarding the process created by the 2007 Senate Bill 3 (SB3) for establishing environmental instream flow standards (EFS) and the EFS that have been adopted to date can be found at the following TCEQ website.

https://www.tceq.texas.gov/permitting/water_rights/wr_technical-resources/eflows

The SB3 EFS established to date are published as Subchapters B through F of Chapter 298 of Title 30 of the Texas Administrative Code. EFS for different river systems are published as subsections of Chapter 298. Modifications to existing standards and establishment of standards for additional regions and river reaches are expected in the future. The SB3 EFS for the Nueces River Basin are found in "*Subchapter F: Nueces River and Corpus Christi and Baffin Bays*" which was adopted February 12, 2014 and became effective on March 6, 2014 [14]. The priority date for these EFS and the associated set-asides to be incorporated in the water availability modeling system is October 28, 2011.

The expanded regulatory process created by the 2007 SB3 results in determination of environmental flow needs and establishment of set-asides to satisfy the environmental flow needs. *Set-asides* refer to commitment of previously unappropriated water in the TCEQ WAM System to meet specified environmental flow standards. Environmental flow standards (requirements, needs, or targets) for particular locations in particular stream systems are defined in terms of flow regimes. SB3 defines an environmental flow regime as: *A schedule of flow quantities that reflects seasonal and yearly fluctuations that typically would vary geographically, by specific location in a watershed, and that are shown to be adequate to support a sound ecological environment and to maintain the productivity, extent, and persistence of key aquatic habitats in and along the affected water bodies.* Environmental flow standards (EFS) established through the Senate Bill 3 (SB3) process are based on flow regimes that include subsistence flows, base flows, and high flow pulses.

The geographic area covered by "*Subchapter F* of Chapter 298 of Title 30 of the Texas Administrative Code [14] consists of the Nueces River and its tributaries and Corpus Christi and Baffin Bays and associated tributary streams and estuaries. SB3 EFS have been established at the locations of nineteen USGS stream flow gages. The TCEQ established the EFS based on recommendations submitted by an expert science team and stakeholder committee in reports [18, 19] available at the TCEQ website shown below. The priority date for the EFS is October 28, 2011, the date the Basin and Bay Expert Science Team submitted its recommendations [18].

https://www.tceq.texas.gov/permitting/water_rights/wr_technical-resources/eflows/nueces-bbasc-bbest

SB3 EFS at Seventeen USGS Gages in the Nueces River Basin

The EFS at nineteen sites presented in the documents [14, 18, 19] cited in the preceding paragraph include seventeen locations in the Nueces River Basin and two other gage sites in the Nueces-Rio Grande Coastal Basin. The EFS at the 17 gage sites listed in Table 5.1 are incorporated in the daily Nueces WAM as described later in this chapter. Watershed areas in Table 5.1 in square miles are from the USGS NWIS website and WAM DIS file. Sixteen of the 17 gage sites in the Nueces River Basin with SB3 EFS are WAM primary control points included in Table 2.2 with locations shown in Figure 2.1 of Chapter 2. The two SB3 EFS sites in the coastal basin are:

USGS gage 08211520 on Oso Creek at Corpus Christi (drainage area = 90.3 square miles)
USGS gage 08211900 on San Fernando Creek at Alice (drainage area = 507 square miles)

Table 5.1
Seventeen SB3 EFS Sites in the Nueces River Basin

Control Point	USGS Gage	Location	Watershed Area USGS (sq miles)	Watershed Area WAM (sq miles)
CP01	08190000	Nueces River at Laguna	737	757.35
CP02	08190500	West Nueces River near Bracketville	694	687.1
CP03	08192000	Nueces River below Uvalde	1,861	1,863.16
CP05	08194000	Nueces River at Cotulla	5,171	5,193.11
CP06	08194500	Nueces River near Tilden	8,093	8,144.2
CP07	08195000	Frio River at Concan	389	393.18
CP08	08196000	Dry Frio River near Reagan Wells	126	124.32
CP12	08198000	Sabinal River near Sabinal	206	208.49
CP13	08198500	Sabinal River at Sabinal	241	246.82
CP16	08201500	Seco Creek at Miller Ranch near Utopia	45.0	45.19
CP18	08200000	Hondo Creek near Tarpley	95.6	97.42
CP25	08205500	Frio River near Derby	3,429	3,428.13
320603	08206600	Frio River at Tilden	4,493	4,469.81
CP26	08206700	San Miguel Creek near Tilden	783	784.26
CP28	08208000	Atascosa River at Whitsett	1,171	1,148.67
CP29	08210000	Nueces River near Three Rivers	15,427	15,460.6
CP30	08211000	Nueces River near Mathis	16,660	16,542.1

EFS established through the process created by the 2007 SB3 consist of subsistence flow, base flow, and high flow pulse components that may vary seasonally and with hydrologic conditions. Seasons are defined in Table 5.2 for the EFS in the Nueces Basin. Seasons for the EFS at the gage sites represented by the five control points CP01, CP02, CP06, CP07, CP08 are defined differently than for the EFS at the other gage sites. Unlike the EFS established in other river basins, the EFS in the Nueces River Basin are not varied as a function of hydrologic condition.

Table 5.2
Seasons Defined in the EFS

Season	Control Points CP01, CP02, CP06, CP07, CP08	All Other Control Points
Winter	December through March	November through March
Spring	April, May, and June	April, May, and June
Summer	July, August, September	July and August
Fall	October and November	September and October

Subsistence and Base Flow Standards

Subsistence and base flow limits in cubic feet per second (cfs) are tabulated in Table 5.3. The flow quantities specified in the EFS for the 17 USGS gage sites vary seasonally. The subsistence standards with flow limits tabulated in Table 5.3 are applicable during severe hydrologic conditions when flow at a gage site is less than the base flow limits in Table 5.3.

For a water right holder to which an environmental flow standard applies, at a measurement point that applies to the water right, the water right holder may not store or divert water, unless the flow at the measurement point is above the applicable subsistence flow standard for that point [14].

If the flow at the measurement point is above the subsistence flow standard but below the base flow standard, then the water right holder must allow the applicable subsistence flow plus 50% of the difference between measured streamflow and the applicable subsistence flow limit to flow pass the measurement point. Any remaining available flow may be diverted or stored in accordance with the water right permit, subject to senior water rights [14].

For a water right holder to which an environmental flow standard applies, at a measurement point that applies to the water right, when the flow at the measurement point is above the applicable base flow standard but below any applicable high flow pulse trigger levels, the water right holder may store or divert water according to its permit, subject to senior water rights [14].

High Flow Pulse Standards

Quantities defining the high flow pulse components of the SB3 EFS are tabulated in Table 5.4. High flow pulse standards are applicable only if actual flows are higher than the subsistence and base flow quantities in Table 5.3. When the high flow pulse trigger level is reached, that flow level is protected by curtailing junior water rights until either the specified volume or duration criteria in Table 5.4 is met. Junior rights can appropriate excess stream flow exceeding the trigger level but cannot reduce flow to below the trigger level. The high pulse criteria include specification of minimum numbers of events per season and events per year.

Table 5.3
Stream Flow Limits for EFS Subsistence and Base Flow Components

Control	Winter		Spring		Summer		Fall	
Point	Subsist	Base	Subsist	Base	Subsist	Base	Subsist	Base
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
CP01	14	65	18	65	16	48	14	65
CP02	1	1	1	1	1	1	1	1
CP03	1	21	1	21	1	17	1	19
CP05	1	6	1	10	1	7	1	15
CP06	1	1	1	3	1	1	1	12
CP07	11	61	10	61	10	47	10	55
CP08	1	12	1	9	1	8	1	12
CP12	1	21	1	21	1	13	1	21
CP13	1	2	1	1	1	1	1	2
CP16	1	4	1	3	1	3	1	4
CP18	1	6	1	5	1	9	1	8
CP25	1	17	1	11	1	7	1	12
320603	1	12	1	7	1	2	1	3
CP26	1	2	1	2	1	1	1	2
CP28	1	9	1	5	1	4	1	4
CP29	1	37	1	37	1	30	1	37
CP30	37	96	37	120	37	140	37	110

The first column of Table 5.4 lists the seventeen WAM control points that represent the USGS gage sites of the SB3 EFS. All of the control points except control point 320603 are primary control points with monthly naturalized flows provided in the WAM simulation input dataset.

The second column of Table 5.4 shows the number of high flow pulses per season or year that are protected by the EFS. The frequency of a defined pulse event is either one, two, or three in each of the four defined seasons (Table 5.2) of the year or one or two pulse events each year.

The quantities defining the individual high flow pulses are provided in the last four columns of Table 5.4. Seasonal events have sets of three parameters for each of the four seasons for which high flow pulses are protected. Some seasons at some sites have no high pulse standards. Annual events have a single set of three parameters applicable for the entire year. The three parameters are the (1) flow trigger in cfs that defines a high flow pulse event, (2) volume termination criterion in acre-feet, and (3) duration termination criterion in days. A high flow pulse event begins when the trigger flow level is exceeded and continues as long as the trigger flow level is exceeded or until either of the two termination criterion is met. The termination criteria limits are the cumulative volume of flow in acre-feet and the duration in days of the high flow pulse.

Table 5.4
High Flow Pulse Components of Environmental Flow Standards

Control Point	Frequency	Winter cfs/ac-ft/days	Spring cfs/ac-ft/days	Summer cfs/ac-ft/days	Fall cfs/ac-ft/days
CP01	2/season	none	99/1,560/9	none	None
	1/season	none	390/6,070/17	170/3,100/14	None
	2/year	trigger 590 cfs; volume 11,300 ac-ft; duration 26 days			
CP02	1/season	none	5/76/10	5/84/13	None
	2/year	trigger 25 cfs; volume 360 ac-ft; duration 16 days			
CP03	1/season	none	110/1,280/11	none	50/690/11
	2/year	trigger 510 cfs; volume 8,240 ac-ft; duration 26 days			
CP05	2/season	none	190/2,370/17	none	35/360/14
	1/season	96/1,570/20	none	100/1,030/16	none
CP06	3/season	none	89/930/14	none	29/250/10
	2/season	87/1,260/18	280/3,360/18	11/96/10	220/2,390/16
	1/season	300/4,610/22	880/12,200/22	320/4,390/21	840/10,900/23
CP07	2/season	none	120/1,320/8	none	none
	1/season	89/2,100/12	300/3,550/12	240/2,990/13	79/900/5
	2/year	trigger 540 cfs; volume 9,430 ac-ft; duration 24 days			
CP08	2/season	none	30/370/9	none	None
	1/season	32/650/13	120/1,470/16	81/1,100/15	35/620/13
	2/year	trigger 210 cfs; volume 3,500 ac-ft; duration 26 days			
CP12	2/season	none	64/750/10	none	none
	1/season	62/1,530,17	180/2,210/15	100/1,180/12	53/840/12
	2/year	trigger 330 cfs; volume 5,420 ac-ft; duration 24 days			
CP13	1/season	21/310/11	56/430/9	none	20/150/6
	2/year	trigger 230 cfs; volume: 2,680 ac-ft; duration 17 days			
	1/year	trigger 1,070; volume: 6,690 ac-ft; duration 29 days			
CP16	2/season	none	33/360/12	none	none
	1/season	21/290/12	91/1,140/17	38/360/11	23/270/11
	2/year	trigger 120 cfs; volume 1,710 ac-ft; duration 21 days			
CP18	2/season	16/200/8	91/950/12	24/220/7	None
	1/season	61/1,020/15	290/3,360/18	90/890/12	50/580/11
	2/year	trigger 330 cfs; volume 4,530 ac-ft; duration 22 days			
CP25	2/season	none	210/1,810/14	none	none
	1/season	87/1,450/20	900/7,940/17	58/510/13	350/4,340/24
	2/year	trigger 1,670; volume 18,800 ac-ft; duration 25 days			
320603	2/season	86/1,070/13	460/4,470/14	36/280/9	120/1,080/12
	1/season	390/5,320/20	none	270/2,440/14	960/10,400/20
CP26	2/season	45/470/16	220/1,560/14	16/110/10	44/310/12
	1/season	160/1,580/19	690/4,940/16	160/1,040/13	300/2,010/15
	2/year	trigger 990 cfs; volume 7,310 ac-ft; duration 18 days			

CP28	2/season	230/1,960/14	600/4,280/13	37/280/7	100/720/9
	1/season	730/5,720/18	1,770/12,500/16	250/1,960/12	620/4,320/14
	2/year	trigger 1,990 cfs; volume 14,800 ac-ft; duration 19 days			
CP29	2/season	720/8,460/13	1,600/22,200/16	280/2,520/9	710/7,920/13
	1/season	2,050/26,800/18	4,090/64,600/22	1,100/13,600/15	2,420/34,200/19
CP30	2/season	590/6,270/9	420/5,090/9	none	240/2,670/7
	1/season	1,120/14,200/12	2,540/49,400/19	370/4,970/10	1,550/24,700/15

High flow pulses in each season are independent of other seasons. If a requirement for a pulse event is satisfied during a season, a high flow pulse requirement is considered to be satisfied for each smaller event in that season.

Water right holders are not required to cease diverting water or release stored water to produce a high flow pulse event if the trigger criterion is not met during a season. High flow pulses are preserved but not created. Water that was previously stored as authorized by a water right may be diverted or released regardless of applicable environmental flow requirements.

Applicability of Instream Flow Requirements (EFS) Established Pursuant to Senate Bill 3 (SB3)

The priority date for the SB3 EFS for the Nueces River Basin and the associated set-asides to be incorporated by the TCEQ in the water availability modeling system is October 28, 2011. Existing water rights with priorities senior to October 28, 2011 are not regulated to protect the SB3 EFS. The SB3 EFS may constrain water availability for diversions and storage authorized by permits with priority dates junior to October 28, 2011. The SB3 EFS may constrain curtailment of stream flow appropriations for diversions and refilling depleted storage capacity, but do not require releases of water already in storage.

Administrative Code Chapter 298, Subchapter F, Section §298.335 entitled "*Water Right Permit Conditions*" requires that water right permits or amendments issued after the effective date of the EFS to store or divert water from the Nueces River Basin and the Nueces-Rio Grande Coastal Basin, to which the EFS apply, shall contain flow restriction special conditions that are adequate to protect the EFS of Subchapter F.

Other *IF* Record Instream Flow Requirements

The 2013 full authorization and current use versions of the WAM have 30 and 32 *IF* record instream flow rights, respectively, with priority dates ranging from 19140224 (February 15, 1914) to 19970423 (April 23, 1997). A *IF* record used for accounting computations in modeling the Choke Canyon Reservoir and Lake Corpus Christi System is assigned a priority of 99999999. These *IF* records were in the WAMs before the SB3 EFS were created. The only *IF* record right located at the same control point as a SB3 EFS was at control point CP07, which has now been assigned a new identifier CP07A. The old *IF* record now at CP07A has an annual amount of 28,266 acre-feet/year (77.4 cfs), the largest of any old *IF* record, and priority of 19940811. The existing *IF* record water rights are not otherwise altered in the conversion to a daily WAM other than uniformly distributing the monthly targets to the 28, 29, 30, or 31 days in each month.

Modeling SB3 Environmental Flow Standards

Environmental flow standards (EFS) established pursuant to the 2007 Senate Bill 3 (SB3) are based on a flow regime that includes subsistence, base, and high pulse flows as explained in Chapter 4 of the *WRAP Reference Manual* [2] and Chapter 6 of the *Daily Manual* [5] and illustrated by the SB3 EFS for the Nueces River Basin as described in this chapter.

Environmental standard *ES*, hydrologic condition *HC*, pulse flow *PF*, and pulse flow supplemental options *PO* records are designed specifically to model *IF* record instream flow rights in the format of SB3 EFS. Chapter 3 of the *Users Manual* [3] defines the input parameters entered on the types of input records that are applicable to both the monthly *SIM* and daily *SIMD*, which includes the *ES* and *HC* records. Chapter 4 of the *Users Manual* covers additional daily *SIMD* input records that are not applicable to the monthly *SIM*, including the *PF* and *PO* records.

An example of modeling SB3 EFS is presented in Chapter 8 of the *Daily Manual* [5]. SB3 EFS have been previously added to the Brazos, Trinity, Neches, Colorado, and Lavaca daily WAMs [9, 10, 11, 12, 13] using the same methodologies applied with the daily Nueces WAM described here in Chapter 5. Daily and monthly instream flow targets for *IF* record rights representing SB3 EFS computed in *SIMD* simulations are presented in Chapter 6 of this report.

The *SIMD* DAT file input records reproduced as Table 5.5 control the computation of daily instream flow targets at the seventeen control points in the Nueces WAM representing the SB3 EFS gage sites. These *IF* record instream flow targets are minimum flow limits that may constrain appropriation of stream flow by *WR* record water rights with junior priorities. The DAT file input records replicated in Table 5.5 are identically the same for both the full authorization and current use scenario DAT files.

Table 5.5
Instream Flow Rights that Model the SB3 EFS in the Daily Nueces WAM DAT File

```
**       1         2         3         4         5         6         7         8         9        10
**34567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234
**     !       !       !       !       !       !       !       !       !       !       !       !       !
**
IF  CP01     -9.        20111028   2            IF-CP01-ES
ES SF50      14.     14.     14.     18.     18.     18.     16.     16.     16.     14.     14.     14.
ES BASE      65.     65.     65.     65.     65.     65.     48.     48.     48.     65.     65.     65.
IF  CP01     -9.        20111028   2            IF-CP01-PF
ES PFES
PF   1 0     99.   1560.   9   2       4   6           2
PF   1 0    390.   6070.  17   1       4   6           2
PF   1 0    170.   3100.  14   1       7   9           2
PF   1 0    590.  11300.  26   2       1  12           2
**
IF  CP02     -9.        20111028   2            IF-CP02-ES
ES SF50       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
IF  CP02     -9.        20111028   2            IF-CP02-PF
ES PFES
PF   1 0      5.     76.  10   1       4   6           2
PF   1 0      5.     84.  13   1       7   9           2
PF   1 0     25.    360.  16   2       1  12           2
**
```

```
IF  CP03     -9.        20111028   2           IF-CP03-ES
ES SF50       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE      21.     21.     21.     21.     21.     21.     17.     17.     19.     19.     21.     21.
IF  CP03     -9.        20111028   2           IF-CP03-PF
ES PFES
PF   1 0    110.   1280.  11   1       4   6           2
PF   1 0     50.    690.  11   1      10  11           2
PF   1 0    510.   8240.  26   2       1  12           2
**
IF  CP05     -9.        20111028   2           IF-CP05-ES
ES SF50       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE       6.      6.      6.     10.     10.     10.      7.      7.     15.     15.      6.      6.
IF  CP05     -9.        20111028   2           IF-CP05-PF
ES PFES
PF   1 0    190.   2370.  17   2       4   6           2
PF   1 0     35.    360.  14   2       9  10           2
PF   1 0     96.   1570.  20   1      11   3           2
PF   1 0    100.   1030.  16   1       7   8           2
**
IF  CP06     -9.        20111028   2           IF-CP06-ES
ES SF50       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE       1.      1.      1.      3.      3.      3.      1.      1.      1.     12.     12.      1.
IF  CP06     -9.        20111028   2           IF-CP06-PF
ES PFES
PF   1 0     89.    930.  14   3       4   6           2
PF   1 0     29.    250.  10   3       9  10           2
PF   1 0     87.   1260.  18   2      12   3           2
PF   1 0    280.   3360.  18   2       4   6           2
PF   1 0     11.     96.  10   2       7   9           2
PF   1 0    220.   2390.  16   2      10  11           2
PF   1 0    300.   4610.  22   1      12   3           2
PF   1 0    880.  12200.  22   1       4   6           2
PF   1 0    320.   4390.  21   1       7   9           2
PF   1 0    840.  10900.  23   1      10  11           2
**
IF  CP07     -9.        20111028   2           IF-CP07-ES
ES SF50      11.     11.     11.     10.     10.     10.     10.     10.     10.     10.     10.     11.
ES BASE      61.     61.     61.     61.     61.     61.     47.     47.     47.     55.     55.     61.
IF  CP07     -9.        20111028   2           IF-CP07-PF
ES PFES
PF   1 0    120.   1320.   8   2       4   6           2
PF   1 0     89.   2100.  12   1      12   3           2
PF   1 0    300.   3550.  12   1       4   6           2
PF   1 0    240.   2990.  13   1       7   9           2
PF   1 0     79.    900.   5   1      10  11           2
PF   1 0    540.   9430.  24   2       1  12           2
**
IF  CP08     -9.        20111028   2           IF-CP08-ES
ES SF50       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE      12.     12.     12.      9.      9.      9.      8.      8.      8.     35.     35.     12.
IF  CP08     -9.        20111028   2           IF-CP08-PF
ES PFES
PF   1 0     30.    370.   9   2       4   6           2
PF   1 0     32.    650.  13   1      12   3           2
PF   1 0    120.   1470.  16   1       4   6           2
PF   1 0     81.   1100.  15   1       7   9           2
PF   1 0     35.    620.  13   1      10  11           2
PF   1 0    210.   3500.  26   2       1  12           2
**
IF  CP12     -9.        20111028   2           IF-CP12-ES
ES SF50       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE      21.     21.     21.     21.     21.     21.     13.     13.     21.     21.     21.     21.
IF  CP12     -9.        20111028   2           IF-CP12-PF
ES PFES
```

```
PF   1 0     64.    750.  10   2       4   6           2
PF   1 0     62.   1530.  17   1      11   3           2
PF   1 0    180.   2210.  15   1       4   6           2
PF   1 0    100.   1180.  12   1       7   8           2
PF   1 0     53.    840.  12   1       9  10           2
PF   1 0    330.   5420.  24   2       1  12           2
**
IF  CP13     -9.        20111028   2           IF-CP13-ES
ES SF50       1.      1.       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE       2.      2.       2.      1.      1.      1.      1.      1.      2.      2.      2.      2.
IF  CP13     -9.        20111028   2           IF-CP13-PF
ES PFES
PF   1 0     21.    310.  11   1      11   3           2
PF   1 0     56.    430.   9   1       4   6           2
PF   1 0     20.    150.   6   1       9  10           2
PF   1 0    230.   2680.  17   2       1  12           2
PF   1 0   1070.   6690.  29   1       1  12           2
**
IF  CP16     -9.        20111028   2           IF-CP16-ES
ES SF50       1.      1.       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE       4.      4.       4.      3.      3.      3.      3.      3.      4.      4.      4.      4.
IF  CP16     -9.        20111028   2           IF-CP16-PF
ES PFES
PF   1 0     33.    360.  12   2       4   6           2
PF   1 0     21.    290.  12   1      11   3           2
PF   1 0     91.   1140.  17   1       4   6           2
PF   1 0     38.    360.  11   1       7   8           2
PF   1 0     23.    270.  11   1       9  10           2
PF   1 0    120.   1710.  21   2       1  12           2
**
IF  CP18     -9.        20111028   2           IF-CP18-ES
ES SF50       1.      1.       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE       6.      6.       6.      5.      5.      5.      9.      9.      8.      8.      6.      6.
IF  CP18     -9.        20111028   2           IF-CP18-PF
ES PFES
PF   1 0     16.    200.   8   2      11   3           2
PF   1 0     91.    950.  12   2       4   6           2
PF   1 0     24.    220.   7   2       7   8           2
PF   1 0     61.   1020.  15   1      11   3           2
PF   1 0    290.   3360.  18   1       4   6           2
PF   1 0     90.    890.  12   1       7   8           2
PF   1 0     50.    580.  11   1       9  10           2
PF   1 0    330.   4530.  22   2       1  12           2
**
IF  CP25     -9.        20111028   2           IF-CP25-ES
ES SF50       1.      1.       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE      17.     17.      17.     11.     11.     11.      7.      7.     12.     12.     17.     17.
IF  CP25     -9.        20111028   2           IF-CP25-PF
ES PFES
PF   1 0    210.   1810.  14   2       4   6           2
PF   1 0     87.   1450.  20   1      11   3           2
PF   1 0    900.   7040.  17   1       4   6           2
PF   1 0     58.    510.  13   1       7   8           2
PF   1 0    350.   4340.  24   1       9  10           2
PF   1 0   1670.  18800.  25   2       1  12           2
**
IF320603     -9.        20111028   2           IF-320603-ES
ES SF50       1.      1.       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE      12.     12.      12.      7.      7.      7.      2.      2.      3.      3.     12.     12.
IF320603     -9.        20111028   2           IF-320603-PF
ES PFES
PF   1 0     86.   1070.  13   2      11   3           2
PF   1 0    460.   4470.  14   2       4   6           2
PF   1 0     36.    280.   9   2       7   8           2
```

```
PF   1 0    120.   1080.  12   2       9  10           2
PF   1 0    390.   5320.  20   1      11   3           2
PF   1 0    270.   2440.  14   1       7   8           2
PF   1 0    960.  10400.  20   1       9  10           2
**
IF  CP26     -9.         20111028   2            IF-CP26-ES
ES SF50       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE       2.      2.      2.      2.      2.      2.      1.      1.      2.      2.      2.      2.
IF  CP26     -9.         20111028   2            IF-CP26-PF
ES PFES
PF   1 0     45.    470.  16   2      11   3           2
PF   1 0    220.   1560.  14   2       4   6           2
PF   1 0     16.    110.  10   2       7   8           2
PF   1 0     44.    310.  12   2       9  10           2
PF   1 0    160.   1580.  19   1      11   3           2
PF   1 0    690.   4940.  16   1       4   6           2
PF   1 0    160.   1040.  13   1       7   8           2
PF   1 0    300.   2010.  15   1       9  10           2
PF   1 0    990.   7310.  18   2       1  12           2
**
IF  CP28     -9.         20111028   2            IF-CP28-ES
ES SF50       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE       9.      9.      9.      5.      5.      5.      4.      4.      4.      4.      9.      9.
IF  CP28     -9.         20111028   2            IF-CP28-PF
ES PFES
PF   1 0    230.   1960.  14   2      11   3           2
PF   1 0    600.   4280.  13   2       4   6           2
PF   1 0     37.    280.   7   2       7   8           2
PF   1 0    100.    720.   9   2       9  10           2
PF   1 0    730.   5720.  18   1      11   3           2
PF   1 0   1770.  12500.  16   1       4   6           2
PF   1 0    250.   1960.  12   1       7   8           2
PF   1 0    620.   4320.  14   1       9  10           2
PF   1 0   1990.  14800.  19   2       1  12           2
**
IF  CP29     -9.         20111028   2            IF-CP29-ES
ES SF50       1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
ES BASE      37.     37.     37.     37.     37.     37.     30.     30.     37.     37.     37.     37.
IF  CP29     -9.         20111028   2            IF-CP29-PF
ES PFES
PF   1 0    720.   8460.  18   2      11   3           2
PF   1 0   1660.  22200.  16   2       4   6           2
PF   1 0    280.   2520.   9   2       7   8           2
PF   1 0    710.   7920.  13   2       9  10           2
PF   1 0   2050.  26800.  18   1      11   3           2
PF   1 0   4090.  64600.  22   1       4   6           2
PF   1 0   1100.  13600.  15   1       7   8           2
PF   1 0   2420.  34320.  19   1       9  10           2
**
IF  CP30     -9.         20111028   2            IF-CP30-ES
ES SF50      37.     37.     37.     37.     37.     37.     37.     37.     37.     37.     37.     37.
ES BASE      96.     96.     96.    120.    120.    120.    140.    140.    110.    110.     96.     96.
IF  CP30     -9.         20111028   2            IF-CP30-PF
ES PFES
PF   1 0    590.   6270.   9   2      11   3           2
PF   1 0    420.   5090.   9   2       4   6           2
PF   1 0    240.   2670.   7   2       9  10           2
PF   1 0   1120.  14200.  12   1      11   3           2
PF   1 0   2540.  49700.  19   1       4   6           2
PF   1 0    370.   4970.  10   1       7   8           2
PF   1 0   1550.  24700.  15   1       9  10           2
**
```

The *IF* record targets are managed in the same manner as all water right targets within the *SIMD* simulation computations and output files. Options controlled by *IF* record field 3 and *PF* record field 15 create tables in the MSS and SMM message files that provide supplemental information that facilitates tracking the *ES* and *PF* record computations. These message file options are not activated in the dataset of Table 5.5 but can be easily activated whenever needed.

The set of input records replicated in Table 5.5 are inserted with the other sets of *WR* and *IF* record water rights in the *SIMD* input DAT file. Each *IF* record instream flow right in Table 5.5 has a set of *ES* and *PF* records that provide the metrics found in Tables 5.2, 5.3, and 5.4. The subsistence and base flows are combined in a single *IF* record water right, and the set of pulse flow requirements are organized as a separate water right in Table 5.5. Alternatively, all three EFS components but can be combined as a single *IF* record water right as discussed in the next section.

Multiple Instream Flow Targets or Target Components at the Same Control Point

The sets of *IF*, *ES*, and *PF* records replicated in Table 5.5 are inserted in the DAT file employed in the daily *SIMD* simulations presented in Chapter 6. In the dataset of Table 5.5 and simulation studies of Chapter 6, the pulse flow components are modeled as separate *IF* record rights to facilitate recording pulse flow targets in the simulation results separately from the subsistence and base flow targets. This does not affect the total target quantities but rather allows the components of each target to be recorded separately in output files [3, 5].

Other *IF* Record Water Rights in 2013 Version of WAM

As noted earlier in this chapter, the 2013 versions of the full authorization and current use WAMS have 30 and 32 *IF* record instream flow rights, respectively. Only one of these original *IF* record rights is located at the same control point as an *IF* record right added in the June 2023 version to model SB3 EFS. The original *IF* record with water right identifier 5497_IF1 is located at control point CP07 which is also the gage site of a set of SB3 EFS. None of the other original *IF* record rights were modified in conjunction with adding the SB3 EFS. However, *IF* record right 5497_IF1 at CP07 was reassigned to a new control point CP07A representing the same physical location as CP07 created specifically for this *IF* record water right. The addition of a new control point CP07A to separate the original existing *IF* record right from the new *IF* record rights for the SB3 EFS served only one purpose. The instream flow targets at CP07 for the SB3 EFS can thus be recorded separately in the simulation results. Simulation results are not otherwise affected.

IF Record Rights for SB3 Environmental Flow Standards

Table 5.5 includes 34 *IF* record water rights since the pulse flow components of the 17 EFS are separated from the subsistence/base flow components. However, subsidence flows, base flows, and high flow pulses can be combined reducing the SB3 EFS to 17 *IF* record water rights simply by removing the *IF* and *ES* records for each of the high flow pulse components. For example, the first two water rights in Table 5.5 labeled with water right identifiers IF-CP01-ES and IF-CP01-PF are instream flow requirements at control point CP01. These two water rights are combined into a single water right in Table 5.6. With this format, all components of the SB3 EFS at a site can be modeled as a single *IF* record water right, with the only difference in simulation results being that combined rather that separate water right targets and target shortages are recorded in the *SIMD* output OUT and DSS files.

Table 5.6
Instream Flow Right that Models the SB3 EFS at Control Point CP01
with *ES* and *PF* Record Components Combined as a Single *IF* Record Right

```
IF  CP01     -9.         20111028   2           IF-CP01-ES
ES SF50      14.      14.      14.      18.      18.      18.      16.      16.      16.      14.      14.      14.
ES BASE      65.      65.      65.      65.      65.      65.      48.      48.      48.      65.      65.      65.
PF   1 0     99.   1560.   9   2       4   6           2
PF   1 0    390.   6070.  17   1       4   6           2
PF   1 0    170.   3100.  14   1       7   9           2
PF   1 0    590.  11300.  26   2       1  12           2
```

<u>*Simulation Results Variables*</u>

The table on page 47 of the WRAP *Users Manual* [3] lists 43 time series variables that may be included in *SIM* and *SIMD* simulation results output files. Five of these variables are forms of instream flow targets or shortages in meeting instream flow targets. These five instream flow targets and shortage quantities are listed in the first column of Table 5.7. The second column refers to the *OF* record labels listed on page 47 of the *Users Manual* used to select variables for inclusion in the *SIM/SIMD* output DSS file. The labels in DSS pathname part C of the output records are listed in the third column. The corresponding *TABLES* monthly and daily time series input records are listed in the last two columns of Table 5.7. The DSS pathname part C labels in the third column are adopted in the following discussion for referring to the quantities listed in Table 5.7.

Table 5.7
Instream Flow Targets and Shortages in *SIM/SIMD* Simulation Results

Instream Flow Target or Shortage	*SIM/SIMD* *OR* Record	DSS Record Part C	*TABLES* Monthly	*TABLES* Daily
final target at control point	15. IFT	IFT-CP	2IFT	6IFT
shortage for final control point target	16. IFS	IFS-CP	2IFS	6IFS
combined target for IF water right	27. IFT	IFT-WR	2IFT	6IFT
shortage for IF water right	28. IFS	IFS-WR	2IFS	6IFS
individual target for IF water right	29. TIF	TIF-WR	2TIF	6TIF

With only one *IF* record instream flow water right located at a control point, the IFT-CP, IFT-WR, and TIF-WR targets are the same. IFT-CP, IFT-WR, and TIF-WR instream flow targets are different only in the case of two or more *IF* record rights located at the same control point. An IFT-CP target refers to the final target at the control point at the completion of the priority sequenced simulation computations. TIF-WR refers to the instream flow target computed for an individual *IF* record right without consideration of any other *IF* record rights located at the same control point. IFT-WR refers to the instream flow target for an *IF* record right after combining with the target for the preceding *IF* record right in the water rights priority sequence.

Any number of instream flow *IF* record water rights can be located at the same WAM control point regardless of the various records used with the *IF* records for computing instream flow targets. Various options can be employed to combine targets computed for multiple *IF* records. With two or more *IF* record rights at the same control point, the target for a junior right is combined with the target from the preceding senior right as specified by IFM(IF,2) in *IF* record field 7. The *IF* record IFM(IF,2) target combining options are listed in Table 5.8.

Table 5.8
Options for Combining Targets for Instream Flow Rights at the Same Control Point

IF record field 7	*PF* record field 14	Method for combining junior and senior targets.
1 (default)	1	The junior target replaces the senior target.
2	2 (default)	The largest target is adopted.
3	3	The smallest target is adopted.
–	4	The two targets are added together.

The computation of a SB3 target consists of computing a subsistence and base flow target as specified by *ES* records and a pulse flow target as specified by *PF* records. Pulse flow *PF* and subsistence/base flow *ES* records can be defined separately or alternatively combined as a single *IF* record instream flow water right at a control point as discussed in the preceding paragraphs. With pulse flow *PF* and subsistence/base flow *ES* records for the same *IF* record right, the instream flow targets are combined as specified in *PF* record field 14 as indicated in Table 5.8. The options for combining consecutive *PF* record targets for a single *IF* record right are also listed in Table 5.8. Multiple instream flow targets at the same control point are combined in the Nueces WAM always using the option of adopting the largest target.

Monthly WAM with Instream Flow Targets from the Daily WAM

A strategy for incorporating monthly instream flow targets computed in a daily *SIMD* simulation into the *SIM* input for a monthly WAM is introduced in the last section of Chapter 6 of the *Daily Manual* [5]. The methodology is illustrated in an example in *Daily Manual Chapter 8* and has been employed with the Brazos, Trinity, Neches, Colorado, and Lavaca daily WAMs [9, 10, 11, 12, 13]. The methodology is applied with the Nueces WAM as described in Chapter 6 of this report.

Daily instream flow targets in acre-feet/day for the SB3 EFS computed in the daily *SIMD* simulation are summed by *SIMD* to monthly totals in acre-feet/month that are included in the *SIMD* simulation results. These time series of monthly targets are converted to target series *TS* records within *HEC-DSSVue* and incorporated in the input DSS file read in a monthly *SIM* simulation.

The target series *TS* records of monthly instream flow targets in acre-feet/month stored in the DSS file have the pathname identifiers listed in Table 5.9. The target series *TS* records in the DSS file are referenced by *TS* records in the DAT file which are replicated in Table 5.10.

A daily *SIMD* simulation is performed with the set of *IF*, *ES*, and *PF* records in Table 5.5 inserted in the DAT file to control computation of IFT and TIF (Table 5.7) daily instream flow targets for the SB3 EFS at the seventeen USGS gaging stations (WAM control points). The daily TIF instream flow targets in acre-feet/day are summed to monthly quantities in acre-feet/month, which are included in the simulation results DSS file. The DSS records of monthly targets are copied from the daily *SIMD* simulation results DSS output file to the *SIM/SIM* hydrology input DSS file and the pathnames are revised using *HEC-DSSVue*.

The DSS file pathnames for the target series *TS* records are listed in Table 5.9. The *TS* records in the monthly *SIM* DAT file replicated in Table 5.10 reference the DSS file target series employed by the *IF* record water rights. IFM(if,2) option 2 in *IF* record field 7 activates the option to combine multiple *IF* record instream flow targets at the same control point by selecting the largest. With only one *IF* record at a control point, the IFM(if,2) option is not relevant. The results for daily and monthly simulations presented in Chapter 6 include daily and aggregated monthly instream flow targets for the SB3 EFS.

Parameter DSSTS on the *JO* record activates reading of *TS* records from the DSS input file. Control point identifiers can be included on the *TS* records. However, blank control point fields on the *TS* records of Table 5.10 default to assigning the control points from the *IF* records.

Table 5.9
Pathnames for *TS* Records for the SB3 EFS in the Hydrology Input DSS File

Part A	Part B	Part C	Part D	Part E
Nueces	CP01	TS	01Jan1934-31Dec2021	1Month
Nueces	CP02	TS	01Jan1934-31Dec2021	1Month
Nueces	CP03	TS	01Jan1934-31Dec2021	1Month
Nueces	CP04	TS	01Jan1934-31Dec2021	1Month
Nueces	CP05	TS	01Jan1934-31Dec2021	1Month
Nueces	CP06	TS	01Jan1934-31Dec2021	1Month
Nueces	CP07	TS	01Jan1934-31Dec2021	1Month
Nueces	CP08	TS	01Jan1934-31Dec2021	1Month
Nueces	CP12	TS	01Jan1934-31Dec2021	1Month
Nueces	CP13	TS	01Jan1934-31Dec2021	1Month
Nueces	CP16	TS	01Jan1934-31Dec2021	1Month
Nueces	CP18	TS	01Jan1934-31Dec2021	1Month
Nueces	CP25	TS	01Jan1934-31Dec2021	1Month
Nueces	320603	TS	01Jan1934-31Dec2021	1Month
Nueces	CP28	TS	01Jan1934-31Dec2021	1Month
Nueces	CP29	TS	01Jan1934-31Dec2021	1Month
Nueces	CP30	TS	01Jan1934-31Dec2021	1Month

Table 5.10
Instream Flow Rights that Model the SB3 EFS in the DAT File of the Monthly WAM

```
IF  CP01                20111028   2            CP01ES
TS       DSS
IF  CP02                20111028   2            CP02ES
TS       DSS
IF  CP03                20111028   2            CP03ES
TS       DSS
IF  CP05                20111028   2            CP05ES
TS       DSS
IF  CP06                20111028   2            CP06ES
TS       DSS
IF  CP07                20111028   2            CP07ES
TS       DSS
IF  CP08                20111028   2            CP08ES
TS       DSS
IF  CP12                20111028   2            CP12ES
TS       DSS
IF  CP13                20111028   2            CP13ES
TS       DSS
IF  CP16                20111028   2            CP16ES
TS       DSS
IF  CP18                20111028   2            CP18ES
TS       DSS
IF  CP25                20111028   2            CP25ES
TS       DSS
IF320603                20111028   2            CP320603ES
TS       DSS
IF  CP26                20111028   2            CP26ES
TS       DSS
IF  CP28                20111028   2            CP28ES
TS       DSS
IF  CP29                20111028   2            CP29ES
TS       DSS
IF  CP30                20111028   2            CP30ES
TS       DSS
```

CHAPTER 6
SIMULATION RESULTS

Results from simulations with daily and monthly full authorization and current use scenario water availability models (WAMs) are presented in this chapter. Daily SB3 environmental flow standard (EFS) instream flow targets are summed to monthly quantities within the daily *SIMD* simulation for incorporation in the monthly *SIM* simulation time series input dataset.

Full authorization scenario WAMs are based on the premise that all water right holders store and divert the full amounts of stream flow for which they are legally entitled subject to water availability. The current use scenario replicates water use quantities that are representative of water use during recent years. The terms run 3 and run 8 have been applied since the beginning of WAM development in the late 1990's to the full authorization and current use, respectively, simulation datasets maintained at the TCEQ WAM website that reflect specified sets of premises.

The June 2023 daily and monthly full authorization (run 3) and current use (run 8) Nueces WAMs employed in the simulations discussed in this chapter are comprised of simulation input files with the filenames listed in Table 6.1. Selected results from multiple simulations are compiled in a DSS file with filename NuecesSimulationResults.DSS. The Hydrologic Engineering Center (HEC) Data Storage System (DSS) pathname labeling conventions are described in Chapter 6 of the WRAP Users Manual [3].

Table 6.1
WAM Simulation Input Data Files

Full Authorization Scenario		Current Use Scenario	
Daily *SIMD*	Monthly *SIM*	Daily *SIMD*	Monthly *SIM*
Nueces3D.DAT	Nueces3M.DAT	Nueces8D.DAT	Nueces8M.DAT
Nueces.DIS	Nueces.DIS	Nueces.DIS	Nueces.DIS
NuecesHYD.DSS	NuecesHYD.DSS	NuecesHYD.DSS	NuecesHYD.DSS
Nueces.DIF		Nueces.DIF	

All plots and statistical metrics in this chapter were developed with *HEC-DSSVue* from the results of *SIMD* and *SIM* simulations. Daily and monthly time series quantities for selected simulation results are presented in this chapter. The January 1934 through December 2021 hydrologic period-of-analysis has a length spanning 88 years, 1,056 months, or 32,142 days.

Daily Full Authorization WAM

The following summary of simulation results from a daily *SIMD* simulation with the full authorization WAM begins with storage plots for the two large reservoirs and stream flow plots and statistics for selected control points. The presentation then focuses on daily instream flow targets for the SB3 EFS. Monthly summations of daily instream flow targets computed with *SIMD* are converted to an input dataset for the monthly WAM discussed later in the chapter.

Storage in Choke Canyon Reservoir and Lake Corpus Christi

Choke Canyon Reservoir and Lake Corpus Christi are the only reservoirs in the Nueces WAM with authorized storage capacities equaling or exceeding 5,000 acre-feet. The two reservoirs are discussed in Chapter 1 with descriptive information tabulated in Table 1.1. Choke Canyon Reservoir and Lake Corpus Christi have a total combined authorized storage capacity of 1,000,000 acre-feet, which accounts for 96.1 percent of the total authorized storage capacity of 1,040,446 acre-feet in the 121 reservoirs included in the full authorization Nueces WAM. Full authorization *SIM* simulated monthly storage in Choke Canyon Reservoir and Lake Corpus Christi is plotted in Figure 1.5. The 2013 WAM with extended hydrology is employed in the Figure 1.5 simulation.

Figures 6.1 and 6.2 compare storage plots for Choke Canyon Reservoir and Lake Corpus Christi from simulations with the June 2023 daily WAM incorporating the SB3 EFS and a monthly version of the WAM without the SB3 EFS. The monthly *SIM* and daily *SIMD* versions of the WAM simulations reflected in Figures 6.1 and 6.2 activate negative incremental flow options 5 and 6, respectively. The choice of negative incremental flow option as well as computational time step significantly affects simulation results.

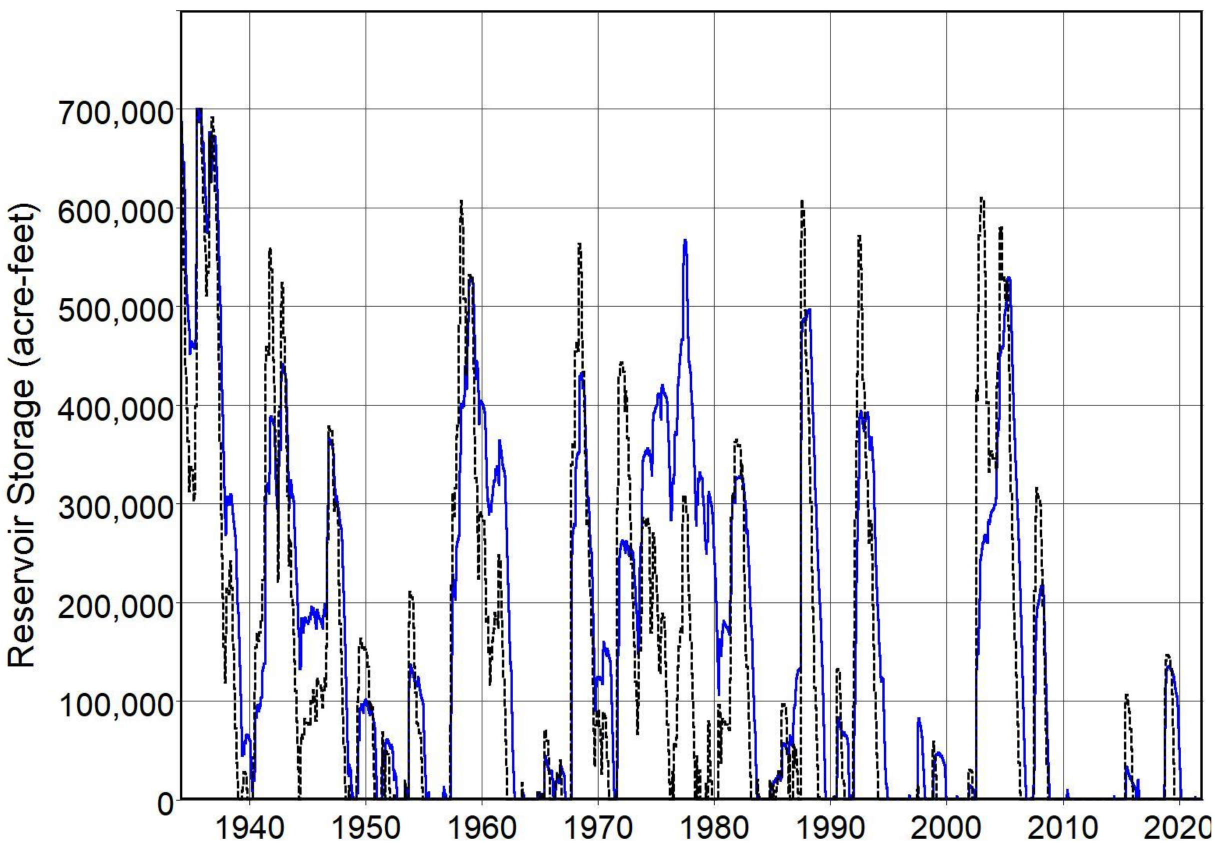

Figure 6.1 Choke Canyon Reservoir Storage from Daily (blue solid line)
and Monthly (black dashed line) Full Authorization Simulations

As previously discussed in Chapter 1, the dramatic storage depletions in Figures 6.1 and 6.1 show that the water resources of the Nueces River Basin are over-appropriated. The City of Corpus Christi imports water from Lake Texana in the Lavaca Basin and from the Colorado River.

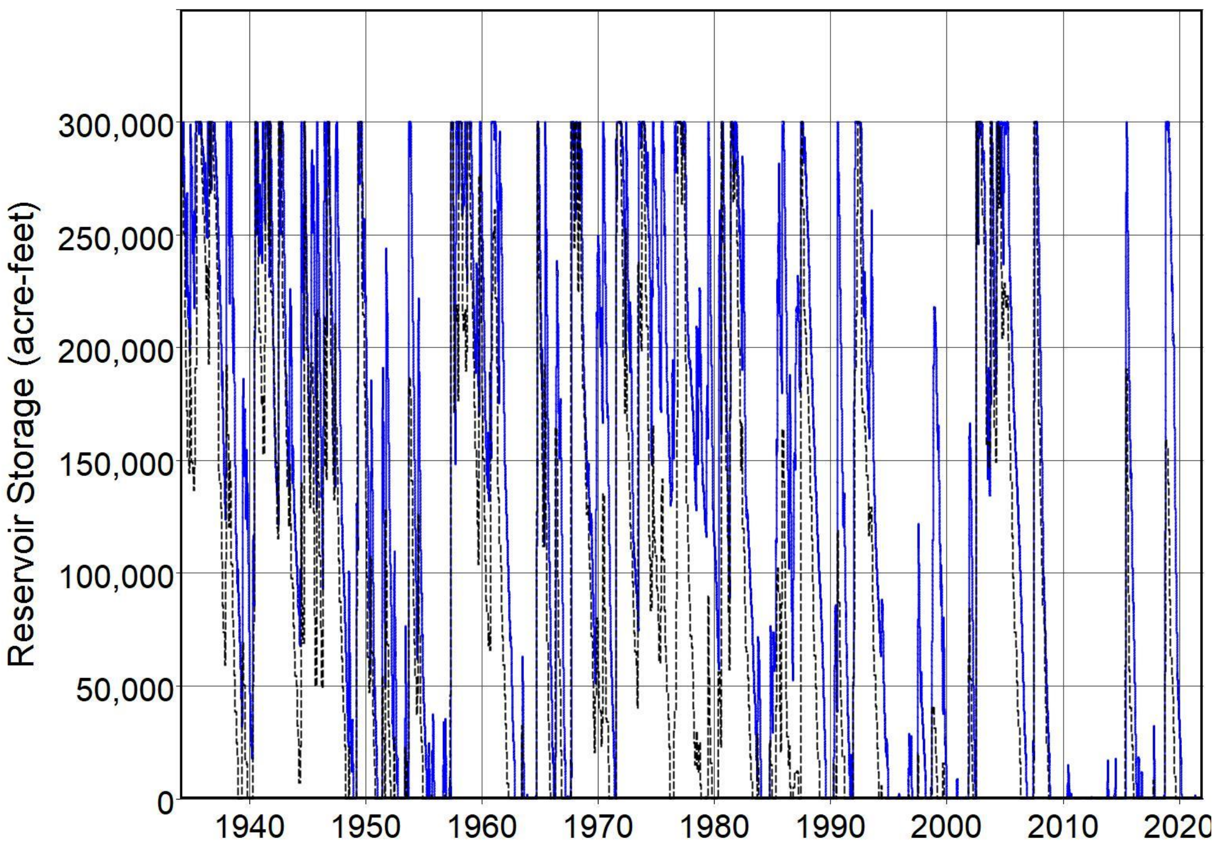

Figure 6.2 Lake Corpus Christi Storage from Daily (blue solid line) and Monthly (black dashed line) Full Authorization Simulations

River Flows at the Outlet

Control point CPEST represents the outlet of the river basin where the Nueces River flows into Nueces Bay and estuary. Simulated daily regulated flows of the Nueces River at control point CPEST are plotted in Figure 6.3. Frequency statistics for daily naturalized, regulated, and unappropriated flows in cfs at control point CPEST are tabulated in Table 6.1. The regulated and unappropriated flows at control point CPEST are the same since no *WR* or *IF* record water rights are located at or downstream of control point CPEST.

The *IF* record rights for the SB3 EFS are the most junior water rights in the WAM and thus have no effect on other more senior water rights. The reservoir storage volumes of Figures 6.1 and 6.2 and stream flow metrics of Table 6.1 are the same with or without inclusion of the SB3 EFS *IF* record instream flow requirements in the WAM. Without the SB3 EFS *IF* record water rights, the *WR* and *IF* record water right priorities range from December 31, 1885, to November 9, 1999. Several "dummy" accounting *WR* and *IF* records are assigned priorities of 99999999 employed in water accounting schemes to model complexities of system operations of Choke Canyon Reservoir and Lake Corpus Christi. The *IF* record rights for the SB3 EFS are added with a priority of 20111028 (October 28, 2011).

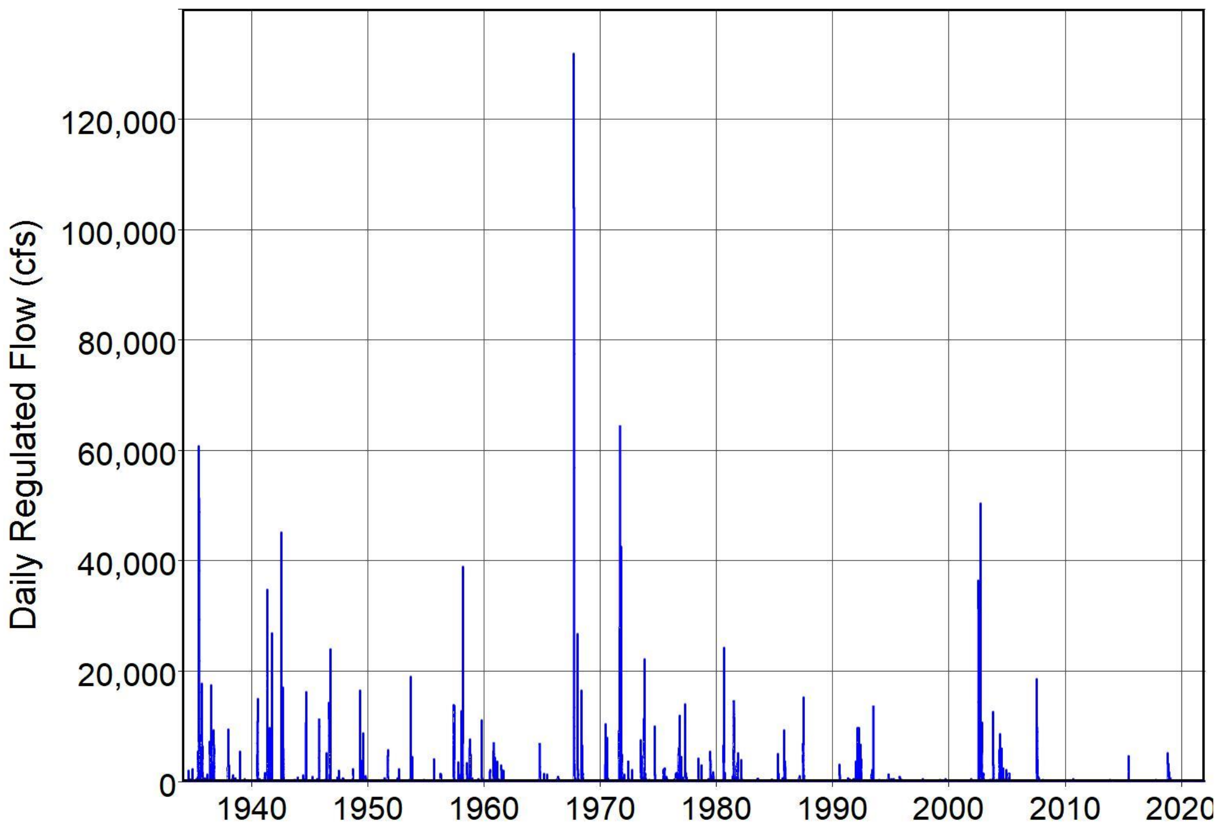

Figure 6.3 Daily Regulated Flow at Outlet (CPEST) for Daily Full Authorization Simulation

Table 6.1
Naturalized, Regulated, Unappropriated Flows at the Outlet (Control Point CPEST)

	Naturalized	Regulated	Unappropriated
Mean Flow (cfs)	785.4	318.3	318.3
Standard Deviation	3,076	2,457	2,457
Minimum (cfs)	0.0	0.0	0.0
Maximum (cfs)	149,530	131,962	131,962
	Daily Flows (cfs) with Specified Exceedance Frequencies		
0.1%	34,688	31,412	31,412
1%	12,248	8,290	8,290
5%	3,432	765.7	765.7
10%	1,435	126.4	126.4
20%	496.2	32.1	32.1
30%	274.7	0.0	0.0
40%	274.7	0.0	0.0
50%	148.0	0.0	0.0
60%	119.4	0.0	0.0
70%	92.7	0.0	0.0
80%	60.2	0.0	0.0
90%	26.0	0.0	0.0
95%	12.3	0.0	0.0

Simulated Regulated Flows at the SB3 EFS Sites

SB3 EFS flow rate metrics are input on *ES* and PF records in units of cubic feet per second (cfs). All simulation result variables related to flow rates, including regulated flows and instream flow targets, are computed in a *SIMD* daily simulation in acre-feet/day. Both daily and monthly summations of daily flow volumes in acre-feet/day and acre-feet/month, respectively, can be optionally included in the *SIMD* simulation results. *SIMD* daily computations and simulation results are in units of acre-feet/day which may be converted to cfs within *HEC-DSSVue*. A flow rate of 1.0 cubic feet per second (cfs) is equivalent to a flow rate of 1.98347 acre-feet per day.

The USGS gage site locations of environmental flow standards (EFS) established following the process created by the 2007 Senate Bill 3 (SB3) are represented in the WAM by the control points listed in Tables 6.2 and 6.3. Watershed drainage areas above the gage sites from the USGS NWIS are tabulated in the third column of the tables. The USGS gage identifiers are included in Table 5.1 of Chapter 5. Locations of the sites are shown in Figure 2.1.

Table 6.2
Statistics for Daily Regulated Flows in cfs at the Control Points of the SB3 EFS

Control Point	USGS Gage Location of SB3 EFS	Drainage Area (square miles)	Regulated Flow (cfs) Mean	Median	90%
CP01	Nueces River at Laguna	737	162.1	75.81	23.05
CP02	West Nueces River near Bracketville	694	50.07	0.044	0.000
CP03	Nueces River below Uvalde	1,861	142.3	21.41	0.000
CP05	Nueces River at Cotulla	5,171	226.0	0.000	0.000
CP06	Nueces River near Tilden	8,093	375.5	0.045	0.000
CP07	Frio River at Concan	389	115.1	61.55	13.35
CP08	Dry Frio River near Reagan Wells	126	39.08	12.94	2.196
CP12	Sabinal River near Sabinal	206	61.85	20.54	0.092
CP13	Sabinal River at Sabinal	241	31.27	1.081	0.000
CP16	Seco Creek, Miller Ranch near Utopia	45.0	33.60	6.798	0.000
CP18	Hondo Creek near Tarpley	95.6	49.50	8.403	0.033
CP25	Frio River near Derby	3,429	131.8	4.542	0.000
320603	Frio River at Tilden	4,493	170.6	10.82	0.000
CP26	San Miguel Creek near Tilden	783	48.05	2.692	0.000
CP28	Atascosa River at Whitsett	1,171	116.4	9.769	0.714
CP29	Nueces River near Three Rivers	15,427	638.3	128.9	14.21
CP30	Nueces River near Mathis	16,660	685.4	487.7	23.07

The mean and median (50% exceedance) of the regulated flows and the regulated flow quantities equaled or exceeded during 90 percent of the 32,142 days of the *SIMD* simulation are tabulated in the last three columns of Tables 6.2 and 6.3 in units of cfs and acre-feet/day, respectively. The median is the flow quantity equaled or exceeded during 50 percent of the 32,142 days of the *SIMD* simulation.

Table 6.3
Statistics for Daily Regulated Flow in acre-feet/day at the Control Points of the SB3 EFS

Control Point	USGS Gage Location of SB3 EFS	Drainage Area (square miles)	Regulated Flow (acre-feet/day) Mean	Median	90%
CP01	Nueces River at Laguna	737	321.5	150.4	45.72
CP02	West Nueces River near Bracketville	694	99.31	0.087	0.000
CP03	Nueces River below Uvalde	1,861	282.2	42.47	0.000
CP05	Nueces River at Cotulla	5,171	448.3	0.000	0.000
CP06	Nueces River near Tilden	8,093	744.8	0.089	0.000
CP07	Frio River at Concan	389	228.3	122.1	26.48
CP08	Dry Frio River near Reagan Wells	126	77.51	25.67	4.356
CP12	Sabinal River near Sabinal	206	122.7	40.74	0.182
CP13	Sabinal River at Sabinal	241	62.02	2.144	0.000
CP16	Seco Creek, Miller Ranch near Utopia	45.0	66.64	13.48	0.000
CP18	Hondo Creek near Tarpley	95.6	98.18	16.67	0.065
CP25	Frio River near Derby	3,429	261.4	9.009	0.000
320603	Frio River at Tilden	4,493	338.4	21.46	0.000
CP26	San Miguel Creek near Tilden	783	95.31	5.340	0.000
CP28	Atascosa River at Whitsett	1,171	230.9	19.38	1.416
CP29	Nueces River near Three Rivers	15,427	1,266	255.7	28.19
CP30	Nueces River near Mathis	16,660	1,359	967.3	45.76

Table 6.4
Statistics for Monthly Regulated Flow in acre-feet/month at the Control Points of the SB3 EFS

Control Point	USGS Gage Location of SB3 EFS	Regulated Flow (acre-feet/month) Mean	Median	90%
CP01	Nueces River at Laguna	9,788	4,942	1,499
CP02	West Nueces River near Bracketville	3,023	7.92	0.00
CP03	Nueces River below Uvalde	8,592	1,513	1.73
CP05	Nueces River at Cotulla	13,643	923.3	0.00
CP06	Nueces River near Tilden	22,669	2,175	0.00
CP07	Frio River at Concan	6,947	3,954	971.6
CP08	Dry Frio River near Reagan Wells	2,359	860.2	167.7
CP12	Sabinal River near Sabinal	3,734	1,571	18.91
CP13	Sabinal River at Sabinal	1,888	75.14	0.00
CP16	Seco Creek, Miller Ranch near Utopia	2,028	622.5	3.69
CP18	Hondo Creek near Tarpley	2,988	737.5	14.29
CP25	Frio River near Derby	7,955	911.6	0.00
320603	Frio River at Tilden	10,298	1,612	0.00
CP26	San Miguel Creek near Tilden	2,901	344.1	0.00
CP28	Atascosa River at Whitsett	7,027	1,064	137.1
CP29	Nueces River near Three Rivers	41,250	16,946	1,537
CP30	Nueces River near Mathis	41,381	29,166	4,446

The mean, median, and regulated flow quantities equaled or exceeded during 90 percent of the 1,056 months of the *SIMD* daily simulation are tabulated in the last three columns of Table 6.4. *SIMD* summed the daily regulated flow volumes in acre-feet/day for the 28, 29, 30, or 31 days of each month to monthly totals in acre-feet/month. The metrics in Table 6.4 are in acre-feet/month.

On average, a month is 30.4375 days. A flow rate of 1.0 cubic feet per second (cfs) is equivalent to 1.98347 acre-feet/day or 60.3719 acre-feet/month. A mean flow rate of 1.0 acre-feet/month is equivalent to a mean flow rate of 0.016564 cfs.

<u>SB3 EFS Instream Flow Targets from a *SIMD* Daily Simulation</u>

The SB3 EFS are modeled as shown in Table 5.5. The subsistence and base flow components of the EFS are modeled as an *IF* record water right. The high pulse flow components are modeled as a separate *IF* record water right. Instream flow targets for the subsistence and base flow components of the EFS are computed in each of the 32,142 days of the *SIMD* simulation. High pulse flow targets are computed during days that satisfy the criteria outlined in Table 5.4. Multiple instream flow targets are computed by *SIMD* in each day. The largest target is adopted.

Statistics for the SB3 EFS instream flow targets for the 32,142 days recorded in the *SIMD* simulation results DSS file are tabulated in Table 6.5. DSS record part C labels TIF-WR and IFT-CP are defined in Table 5.7. TIF-WR and IFT-CP refers to intermediate and final targets. The TIF-WR quantities are the combined subsistence and base flow targets and the combined pulse flow targets. These component targets and the final IFT-CP target are included in Table 6.5.

The last column of Table 6.5 shows the mean of the shortages (failures) in meeting the targets during the 32,142 days. Instream flow shortages are labeled IFS-WR and IFS-CP in DSS record part C (Table 5.7). No shortages occur in meeting the high flow pulse targets. Non-zero shortages in meeting the subsistence or base flow targets occur in some days of the simulation.

Combined subsidence and base flow targets in each day at control point CP01 range from 14.0 cfs to 65.0 cfs with a mean of 47.16 cfs. High flow pulse flow targets range between 0.0 and 590 cfs with a 32,142-day mean of 14.64 cfs. The highest target is selected in each individual day resulting in final adopted targets that average 57.67 cfs at control point CP01. The mean of the shortages in meeting instream flow targets in each day are tabulated in the last column of Table 6.5. Subsidence and base flow targets occur shortages in some days. The mean of the shortages averaged over the 32,142 days of the simulation is 0.284 cfs at control point CP01.

The final daily targets adopted each day at a control point are labeled IFT-CP in DSS record part C (Table 5.7). The final targets labeled TIF-WR for the pulse flow *IF* record water rights and IFT-CP for control points are the same for this case with no *IF* records other than the SB3 EFS assigned to the control point.

The daily and monthly instream flow targets for the SB3 EFS computed in the daily *SIMD* simulation are plotted in Figures 6.4 through 6.37. The aggregated monthly SB3 EFS instream flow targets are computed in the daily *SIMD* simulation by summing daily targets. The monthly targets are converted to target series *TS* records as discussed in the next section for incorporation in the monthly *SIM* input dataset.

Table 6.5
Statistics for Daily SB3 EFS Instream Flow Targets in the Full Authorization Simulation

	Daily Instream Flow Target (cfs)			Shortage
SB3 EFS Targets	Minimum	Mean	Maximum	Mean (cfs)
		Nueces River at Laguna (CP01)		
Subsistence and Base	14.0	47.16	65.0	0.284
High Flow Pulse	0.00	14.64	590.0	-
Final Target	14.0	57.67	590.0	0.284
		West Nueces River near Bracketville (CP02)		
Subsistence and Base	1.00	1.00	1.00	0.659
High Flow Pulse	0.00	0.190	25.0	-
Final Target	1.00	1.173	25.0	0.659
		Nueces River below Uvalde (CP03)		
Subsistence and Base	1.00	12.28	21.0	0.148
High Flow Pulse	0.00	6.13	510.0	-
Final Target	1.00	17.80	510.0	0.148
		Nueces River at Cotulla (CP05)		
Subsistence and Base	1.00	4.016	15.00	0.567
High Flow Pulse	0.00	2.980	190.0	-
Final Target	1.00	6.684	190.0	0.567
		Nueces River near Tilden (CP06)		
Subsistence and Base	1.00	2.177	12.0	0.510
High Flow Pulse	0.00	20.72	880.0	-
Final Target	1.00	22.51	880.0	0.510
		Frio River at Concan (CP07)		
Subsistence and Base	10.00	39.57	61.00	0.356
High Flow Pulse	0.00	12.75	540.0	-
Final Target	10.00	48.06	540.0	0.356
		Dry Frio River near Reagan Wells (CP08)		
Subsistence and Base	1.00	8.060	35.00	0.0305
High Flow Pulse	0.00	4.809	210.0	-
Final Target	1.00	11.89	210.0	0.0305
		Sabinal River near Sabinal (CP12)		
Subsistence and Base	1.00	11.78	21.00	0.1411
High Flow Pulse	0.00	6.848	330.0	-
Final Target	1.00	17.20	330.0	0.1411
		Sabinal River at Sabinal (CP13)		
Subsistence and Base	1.00	1.243	2.000	0.3596
High Flow Pulse	0.00	3.602	1,070	-
Final Target	1.00	4.798	1,070	0.3596

Table 6.5 Continued
Statistics for Daily SB3 EFS Instream Flow Targets in the Full Authorization Simulation

SB3 EFS Targets	Daily Instream Flow Target (cfs) Minimum	Mean	Maximum	Mean (cfs)
Seco Creek at Miller Ranch near Utopia (CP16)				
Subsistence and Base	1.00	2.665	4.000	0.2106
High Flow Pulse	0.00	1.384	120.0	-
Final Target	1.00	3.944	120.0	0.2106
Hondo Creek near Tarpley (CP18)				
Subsistence and Base	1.00	4.222	9.000	0.1694
High Flow Pulse	0.00	5.656	330.0	-
Final Target	1.00	9.319	330.0	0.1694
Frio River near Derby (CP25)				
Subsistence and Base	1.00	6.359	17.00	0.4351
High Flow Pulse	0.00	19.36	1,670	-
Final Target	1.00	25.06	1,670	0.4351
Frio River at Tilden (Control Point 320603)				
Subsistence and Base	1.00	4.693	12.00	0.3235
High Flow Pulse	0.00	12.09	960.0	-
Final Target	1.00	16.34	960.0	0.3235
San Miguel Creek near Tilden (CP26)				
Subsistence and Base	1.00	1.507	2.000	0.3079
High Flow Pulse	0.00	10.04	990.0	-
Final Target	1.00	11.38	990.0	0.3079
Atascosa River at Whitsett (CP28)				
Subsistence and Base	1.00	4.607	9.000	0.0856
High Flow Pulse	0.00	25.16	1,990	-
Final Target	1.00	29.19	1,990	0.0856
Nueces River near Three Rivers (CP29)				
Subsistence and Base	1.00	28.90	37.00	0.0570
High Flow Pulse	0.00	94.30	4,090	-
Final Target	1.00	119.5	4,090	0.0570
Nueces River near Mathis (CP30)				
Subsistence and Base	37.00	95.64	140.0	3.488
High Flow Pulse	0.00	37.21	2,540	-
Final Target	37.00	124.6	2,540	3.488

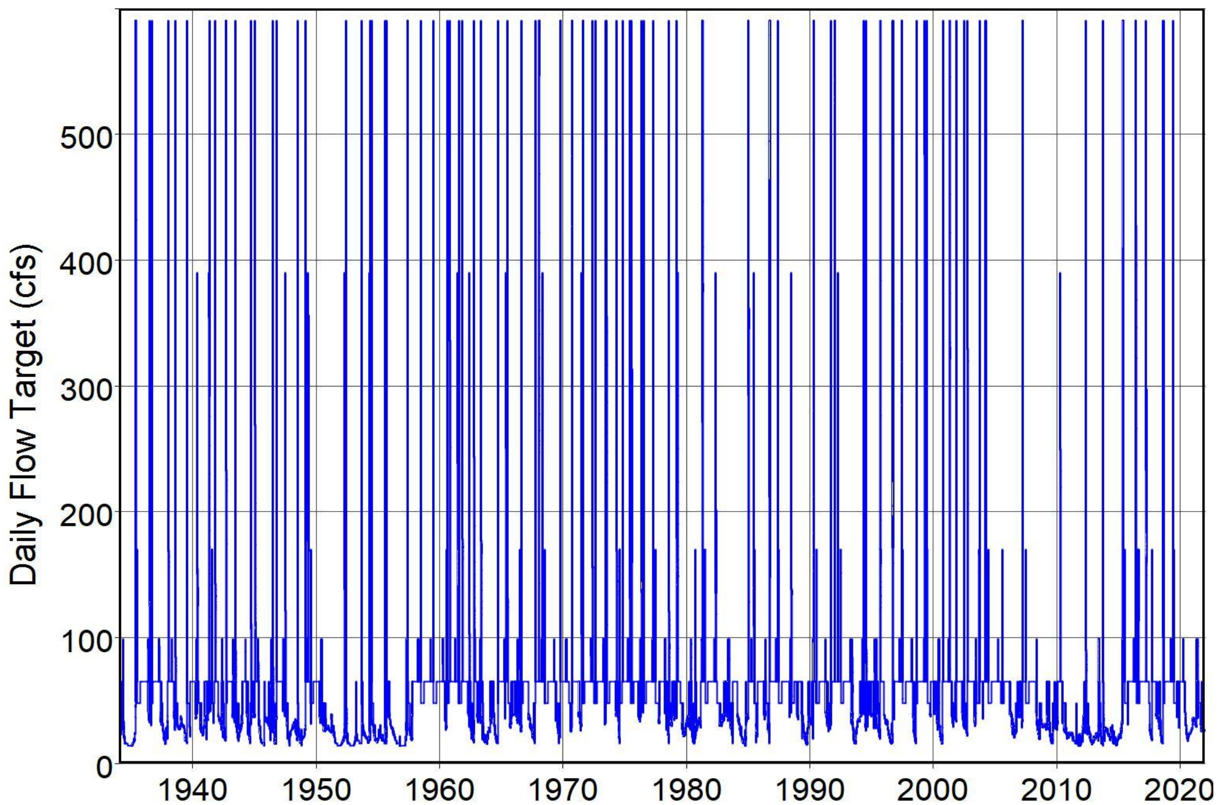

Figure 6.4 Daily SB3 EFS Instream Flow Target (cfs) at CP01

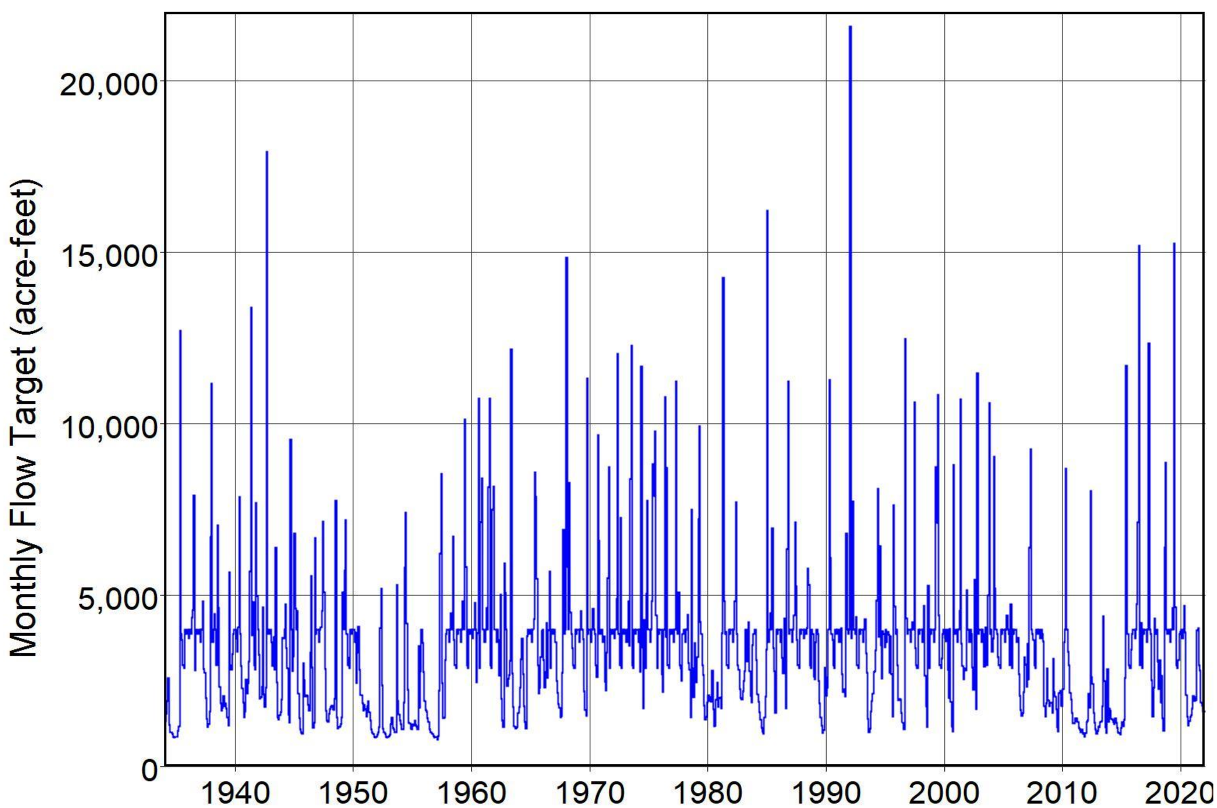

Figure 6.5 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP01

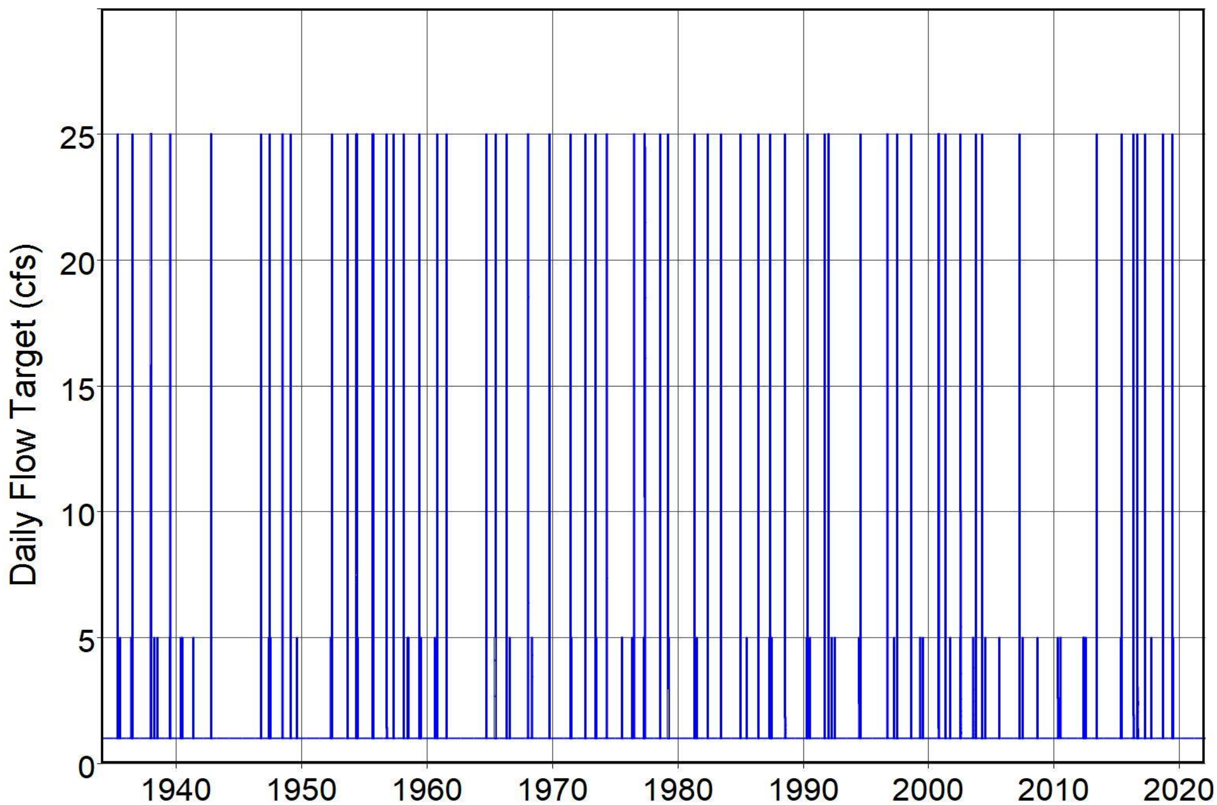

Figure 6.6 Daily SB3 EFS Instream Flow Target (cfs) at CP02

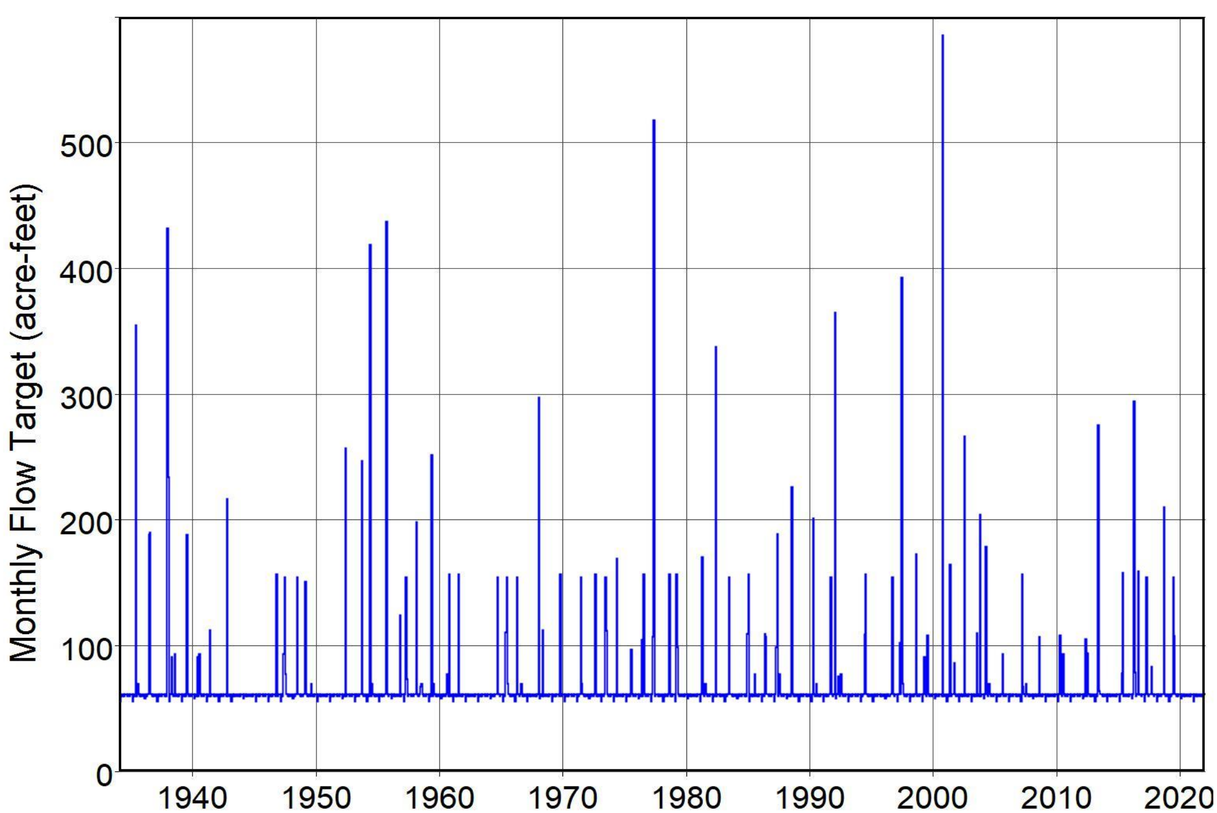

Figure 6.7 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP02

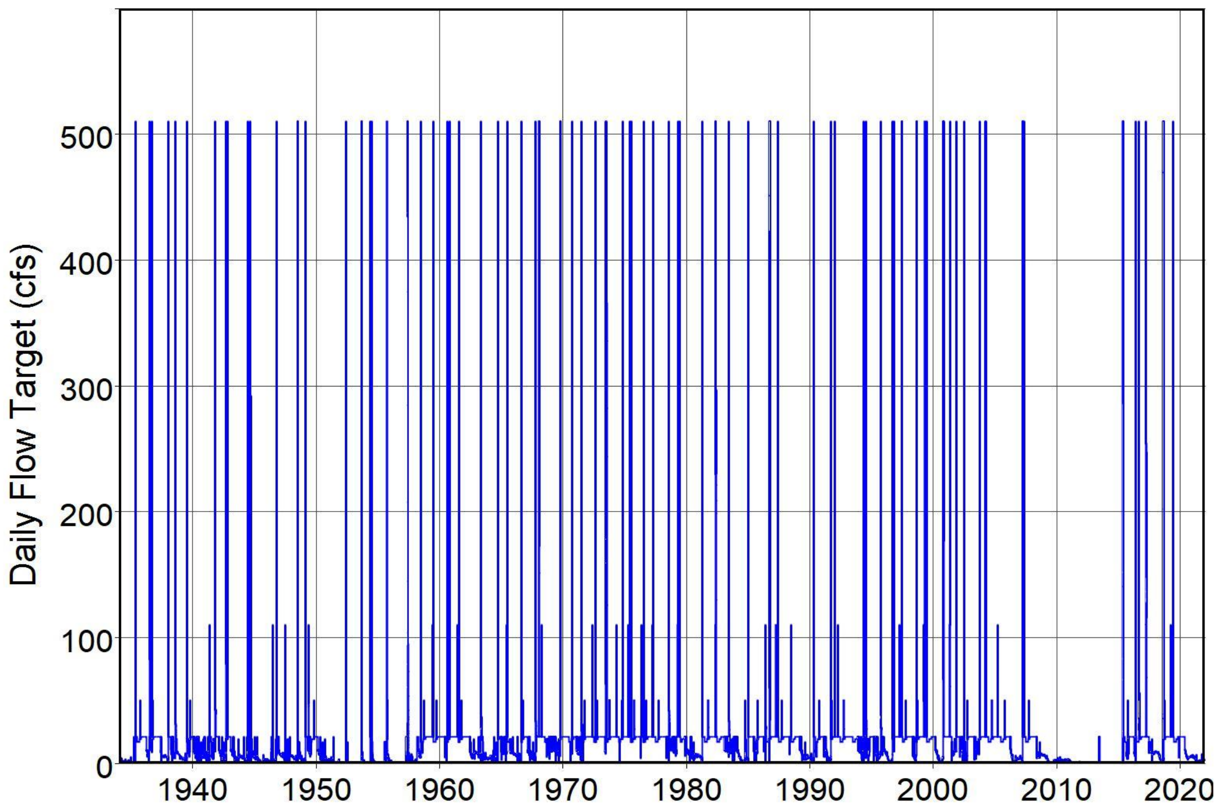

Figure 6.8 Daily SB3 EFS Instream Flow Target (cfs) at CP03

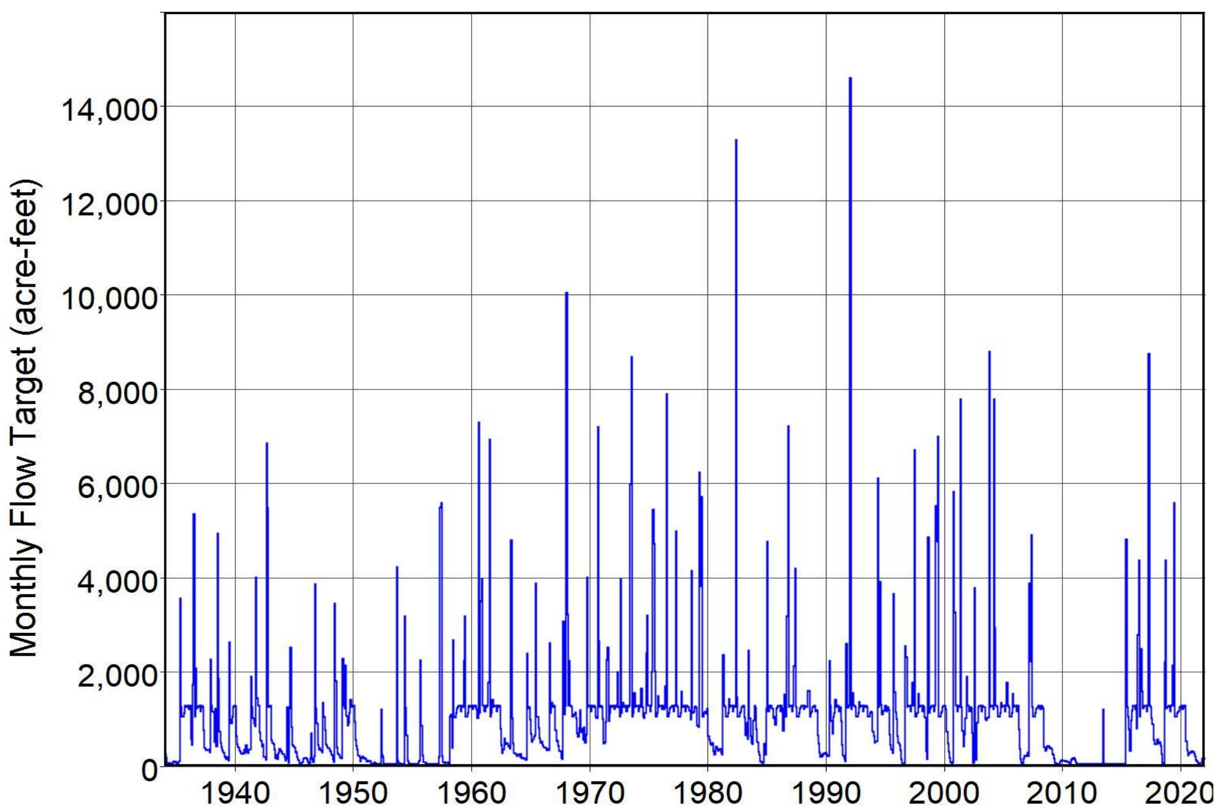

Figure 6.9 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP03

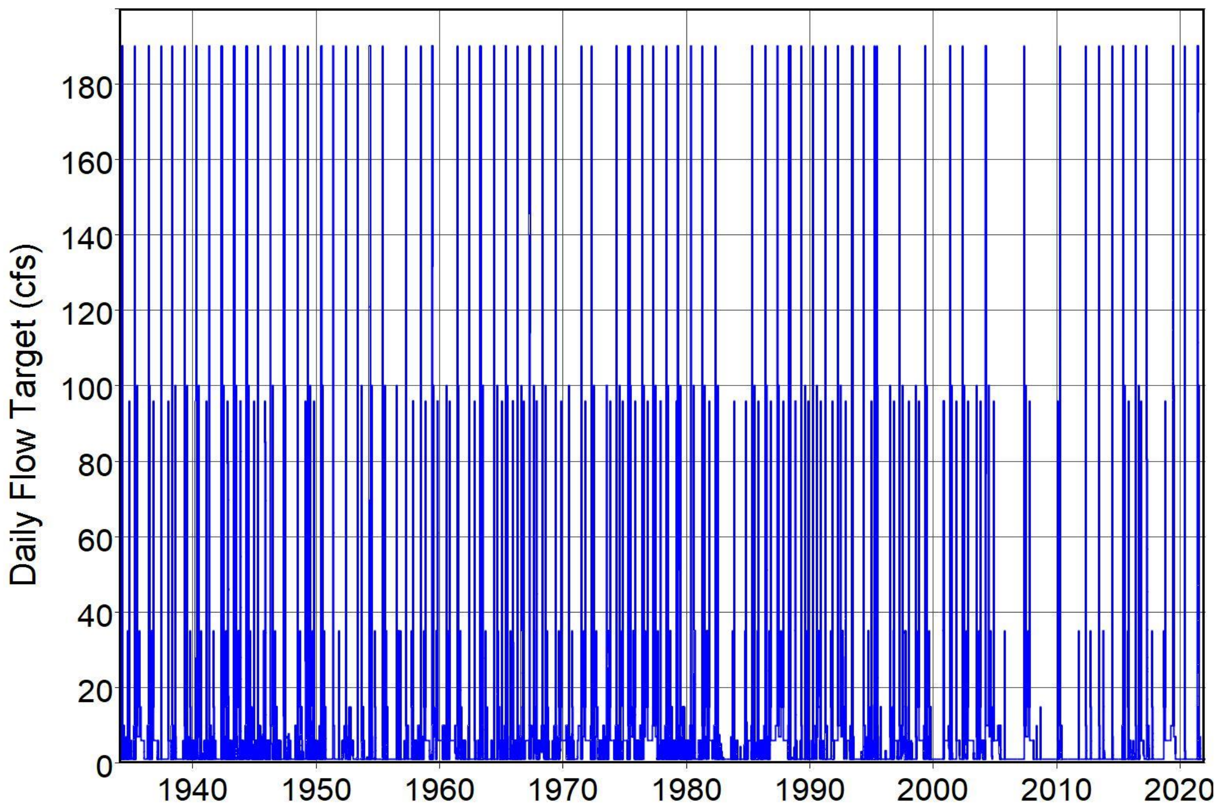

Figure 6.10 Daily SB3 EFS Instream Flow Target (cfs) at CP05

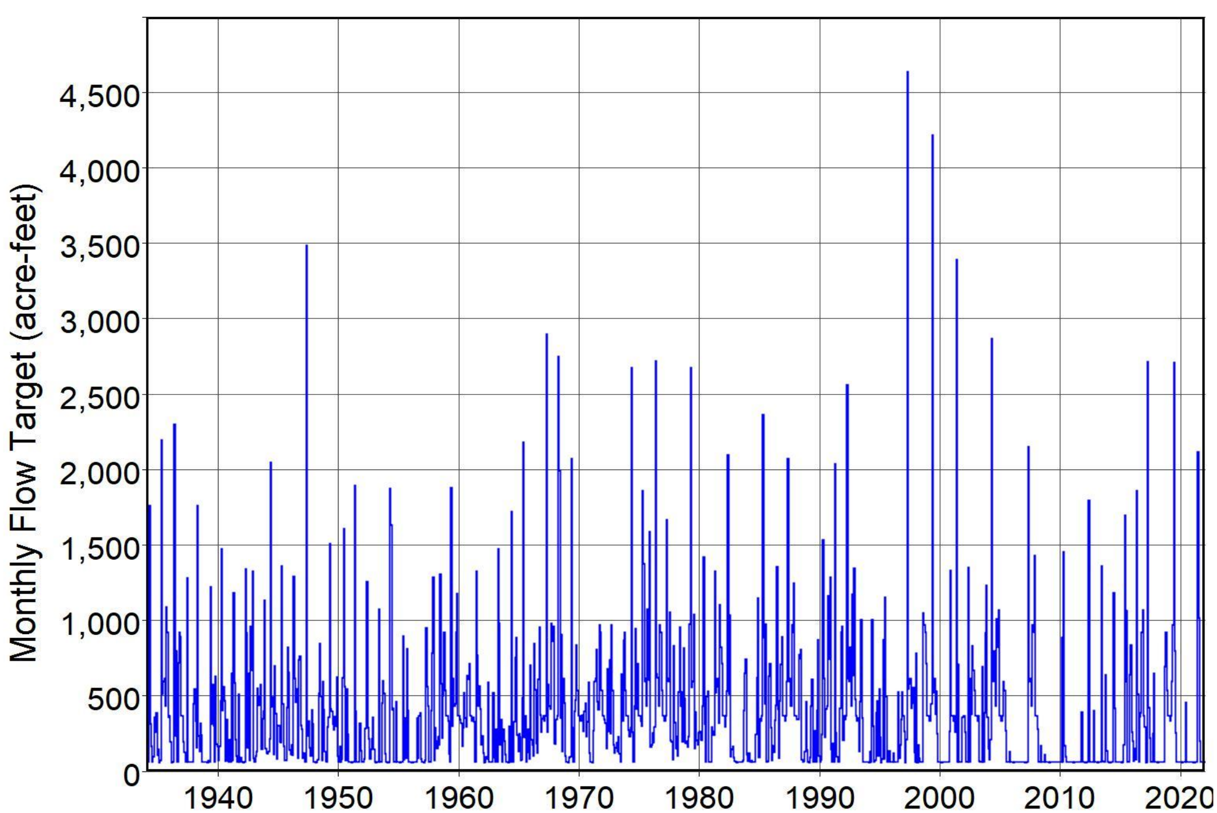

Figure 6.11 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP05

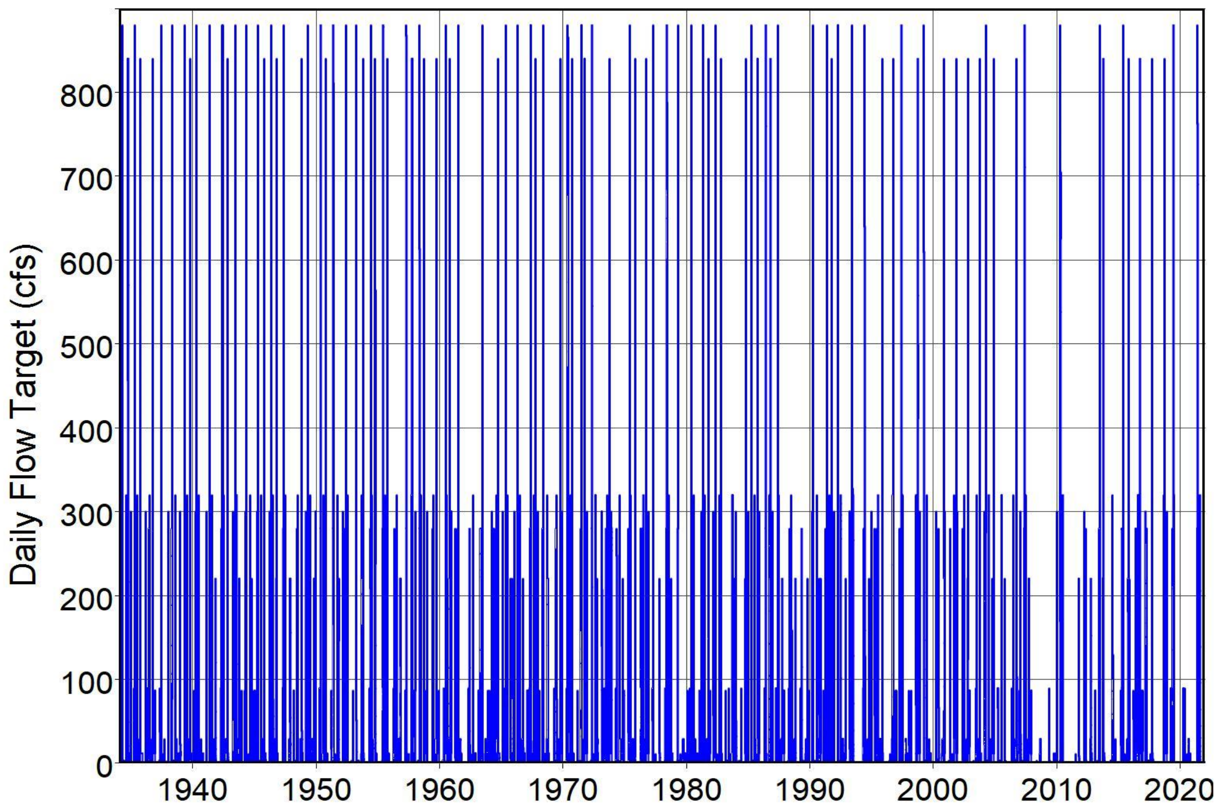

Figure 6.12 Daily SB3 EFS Instream Flow Target (cfs) at CP06

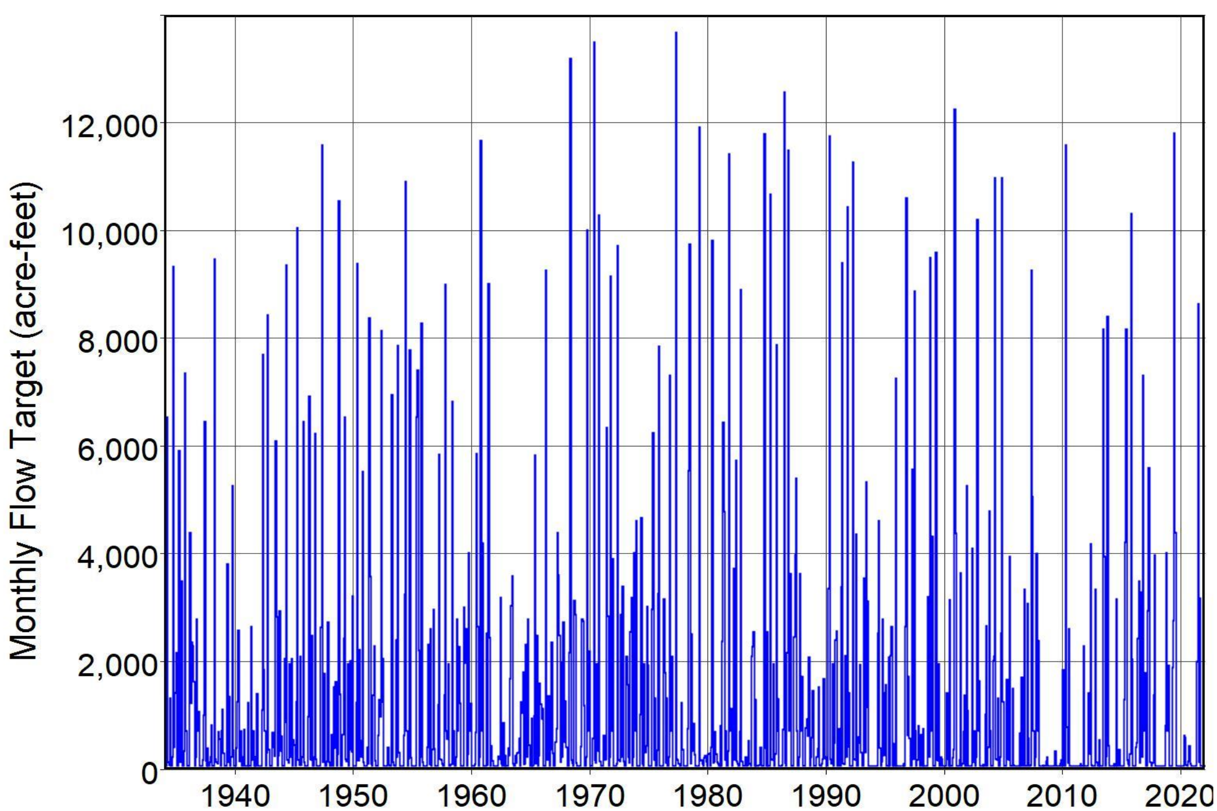

Figure 6.13 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP06

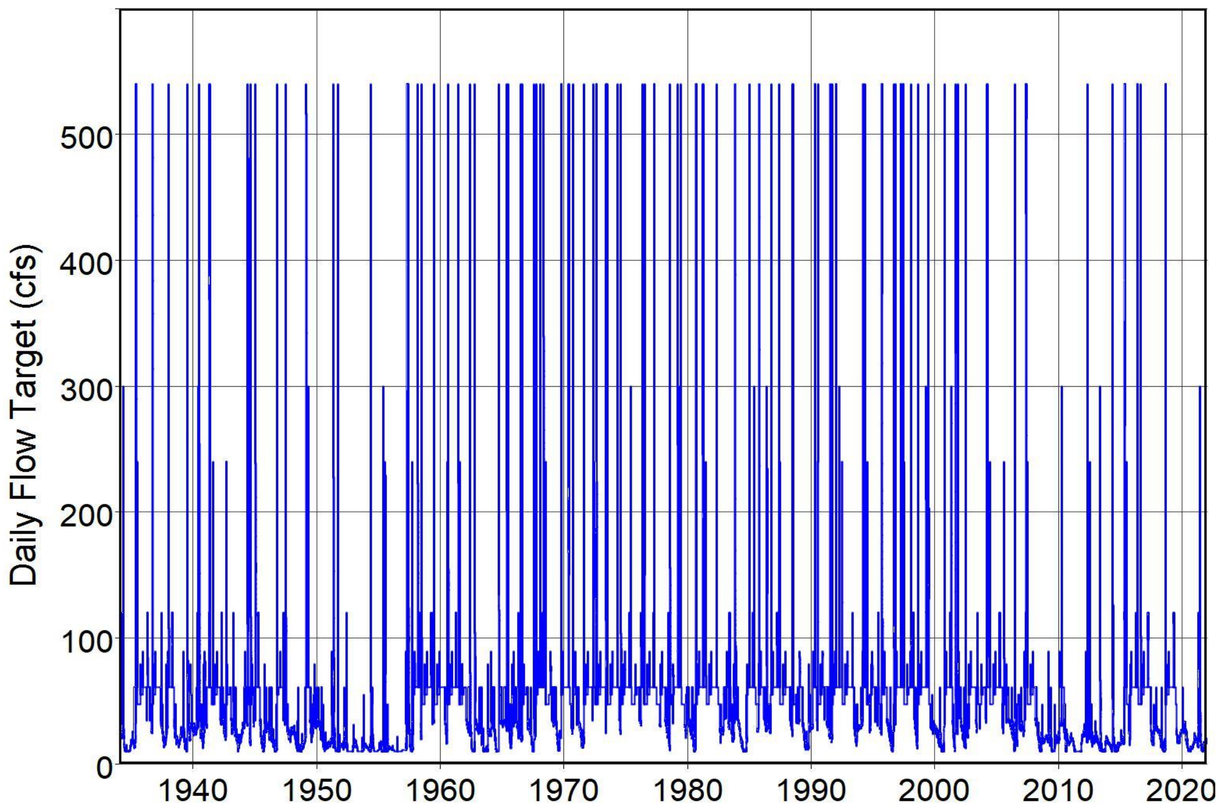

Figure 6.14 Daily SB3 EFS Instream Flow Target (cfs) at CP07

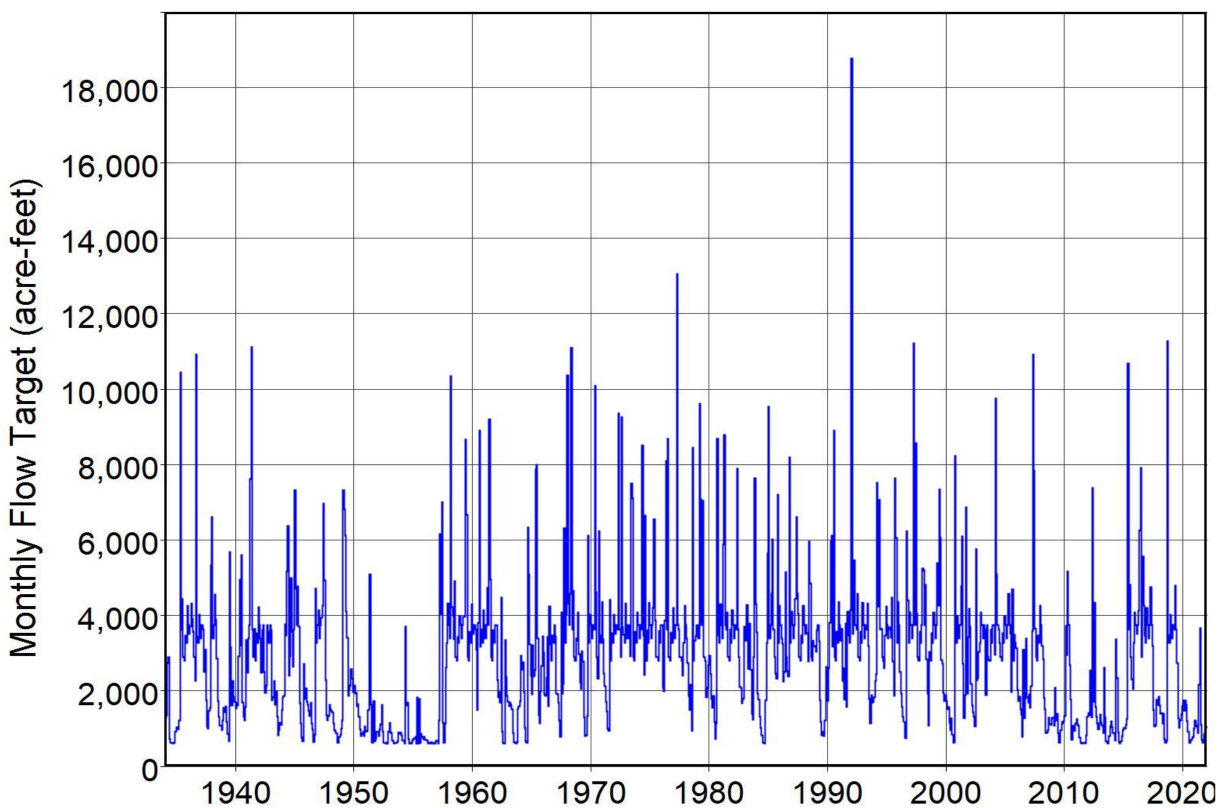

Figure 6.15 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP07

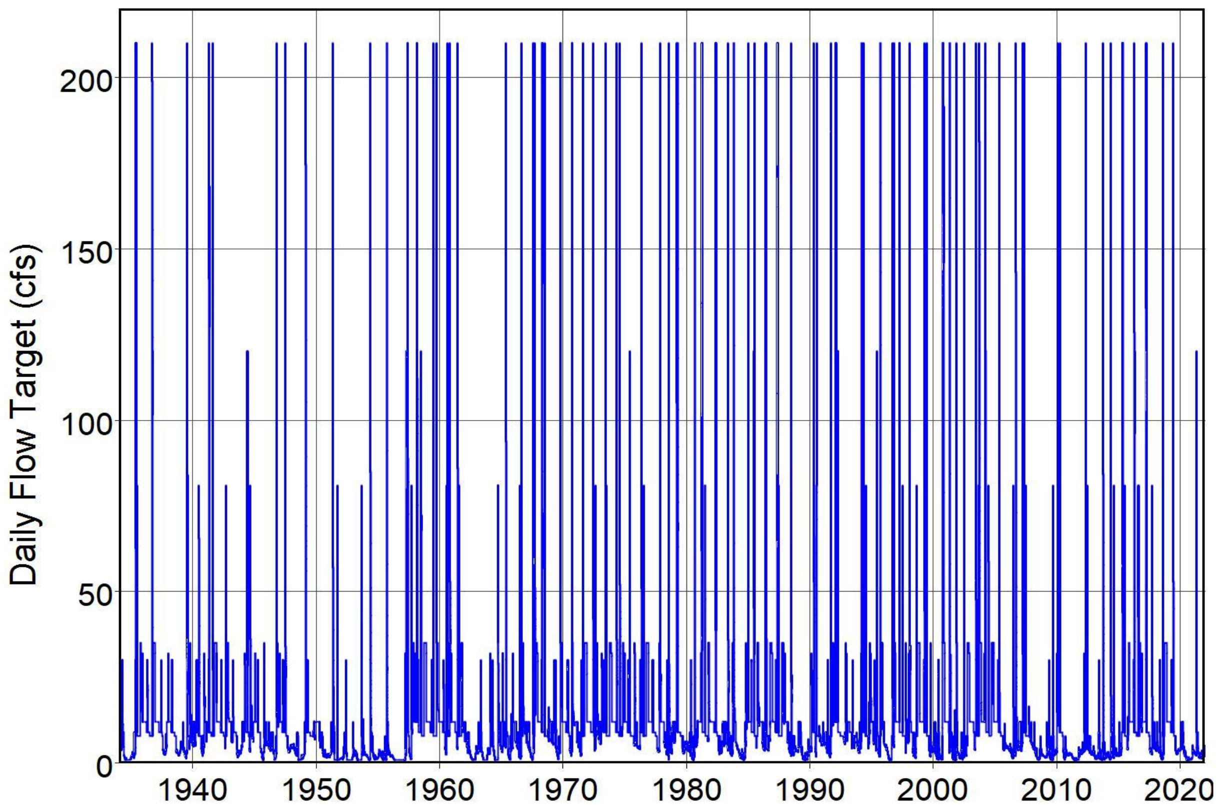

Figure 6.16 Daily SB3 EFS Instream Flow Target (cfs) at CP08

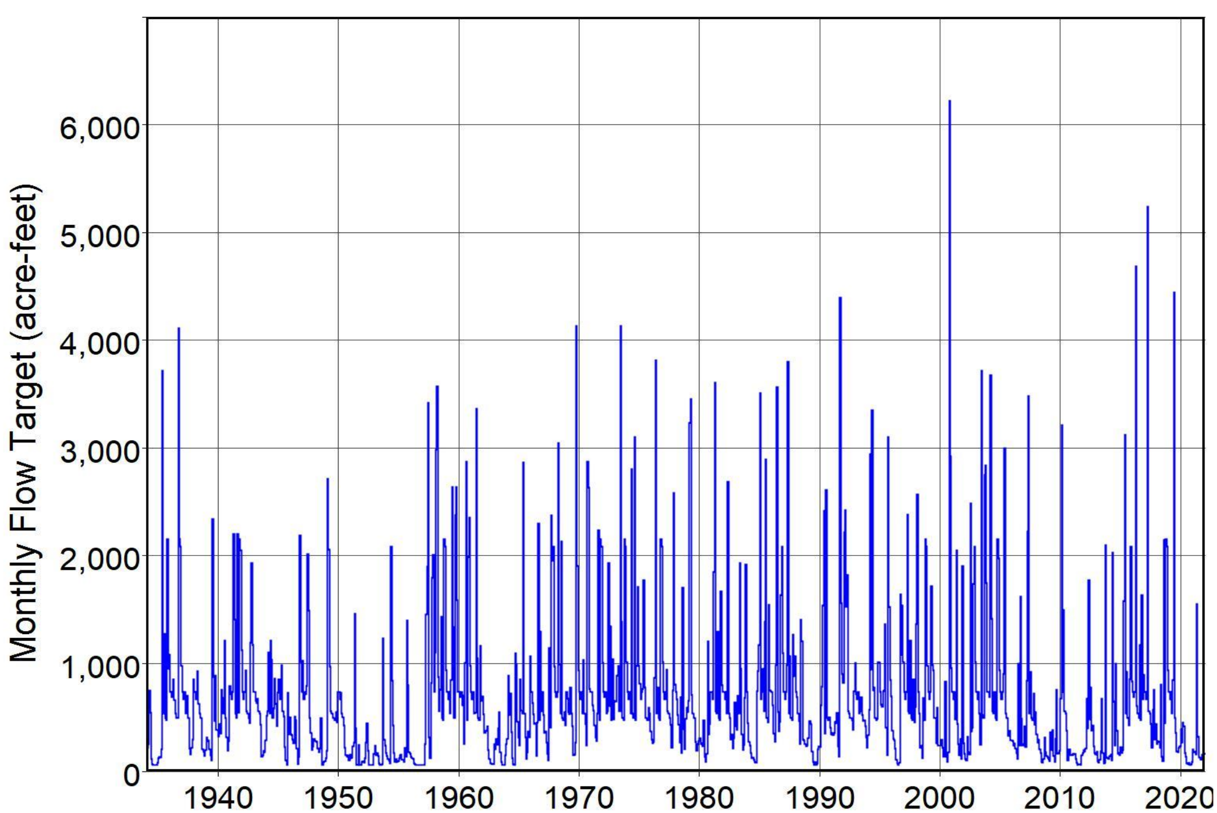

Figure 6.17 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP08

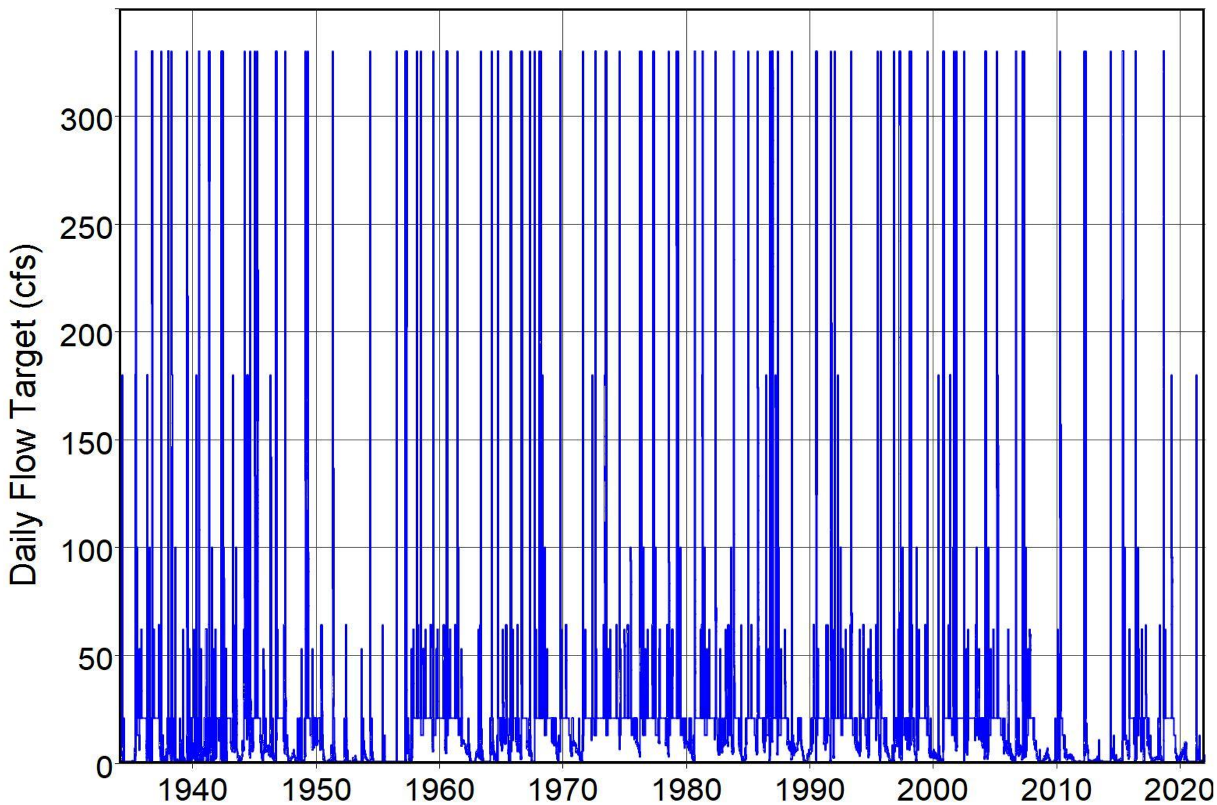

Figure 6.18 Daily SB3 EFS Instream Flow Target (cfs) at CP12

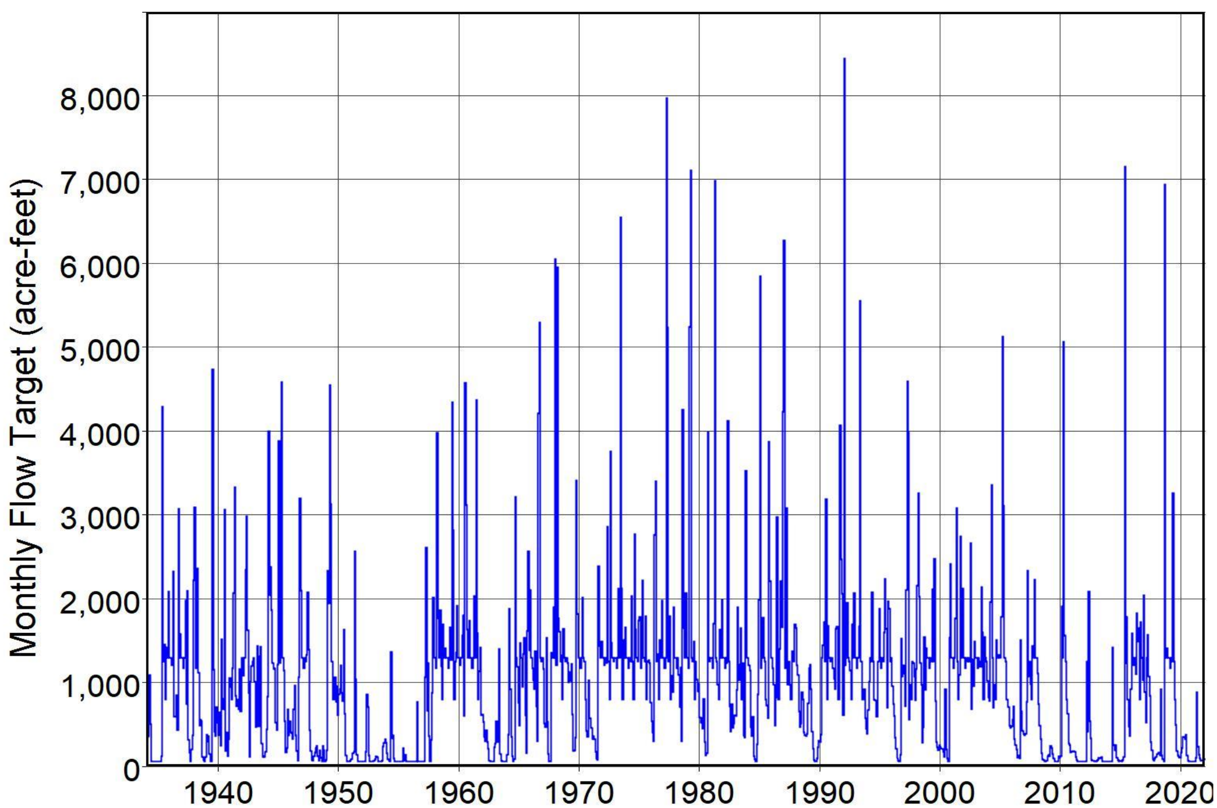

Figure 6.19 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP12

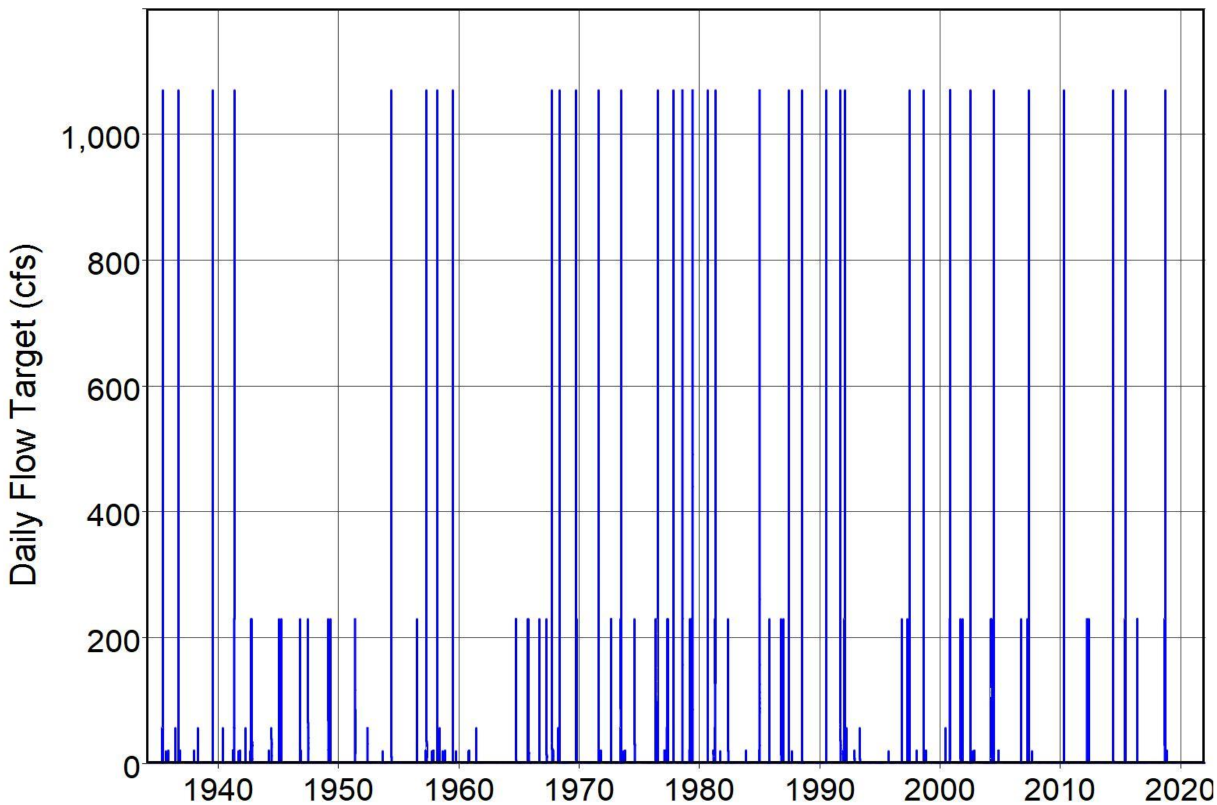

Figure 6.20 Daily SB3 EFS Instream Flow Target (cfs) at CP13

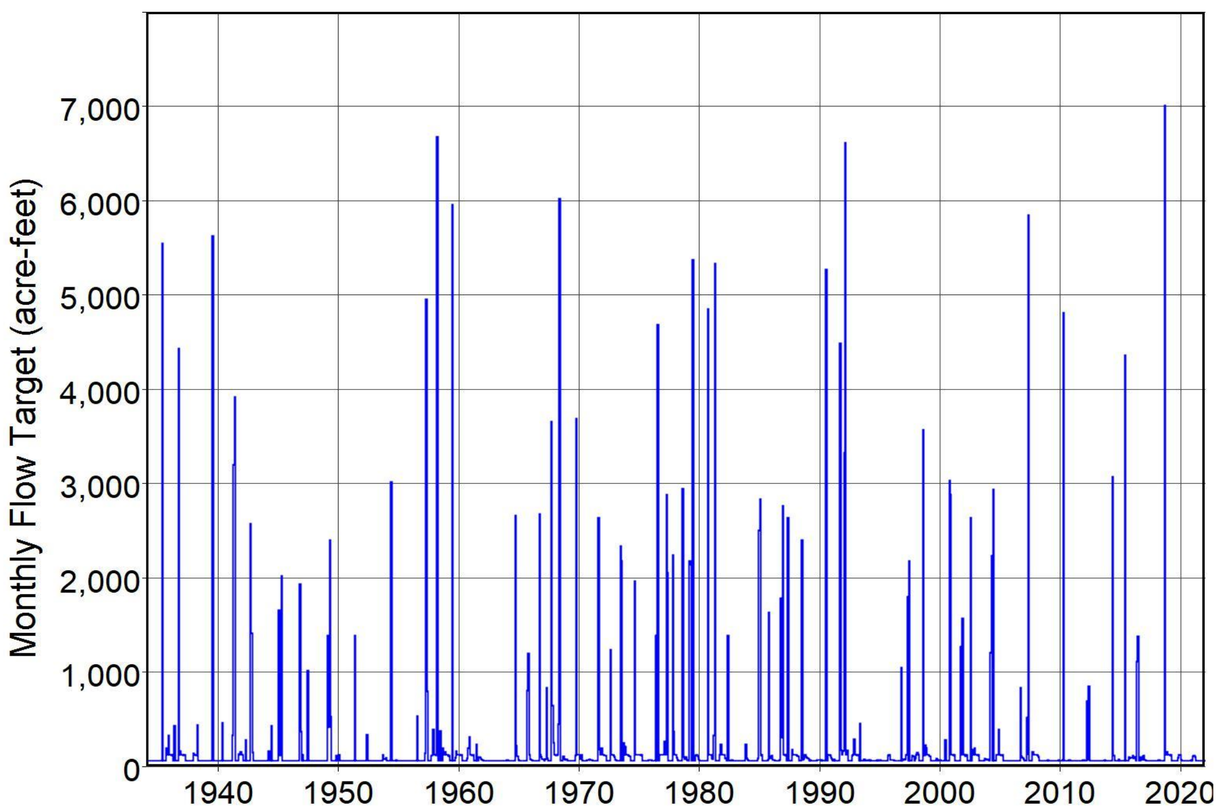

Figure 6.21 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP13

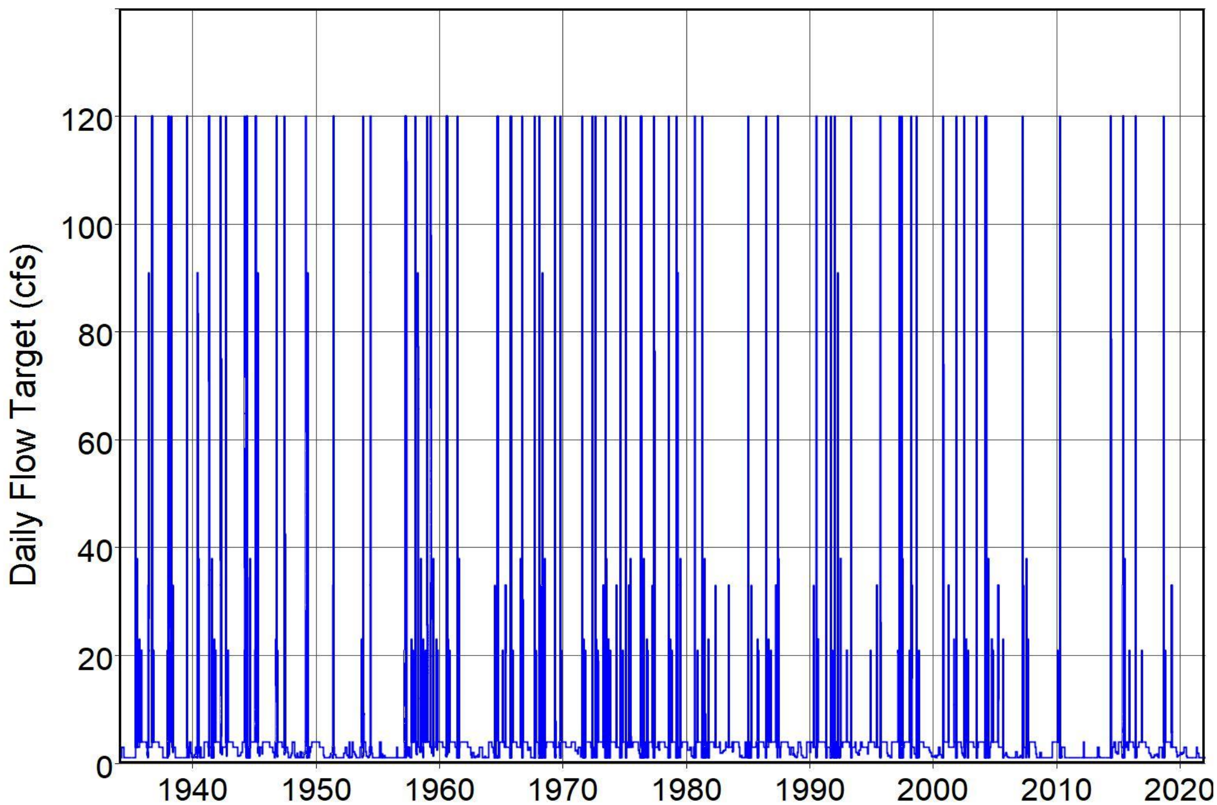

Figure 6.22 Daily SB3 EFS Instream Flow Target (cfs) at CP16

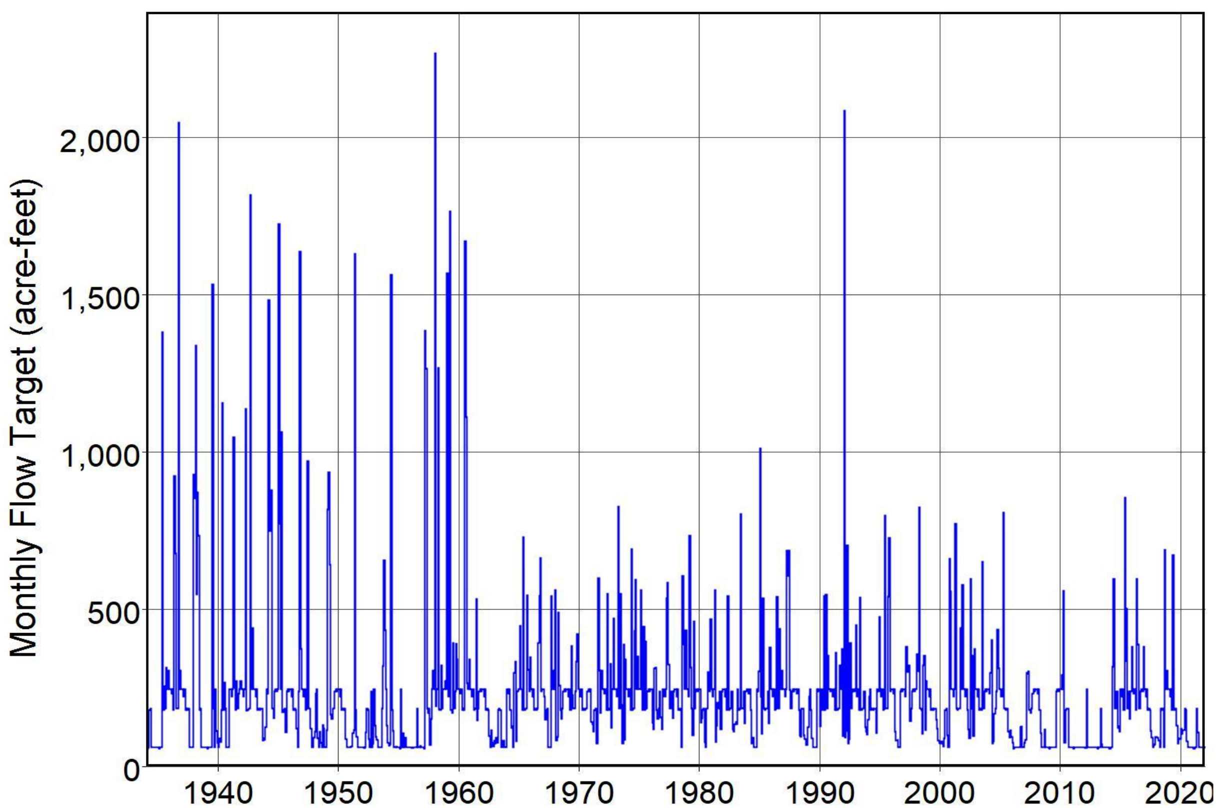

Figure 6.23 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP16

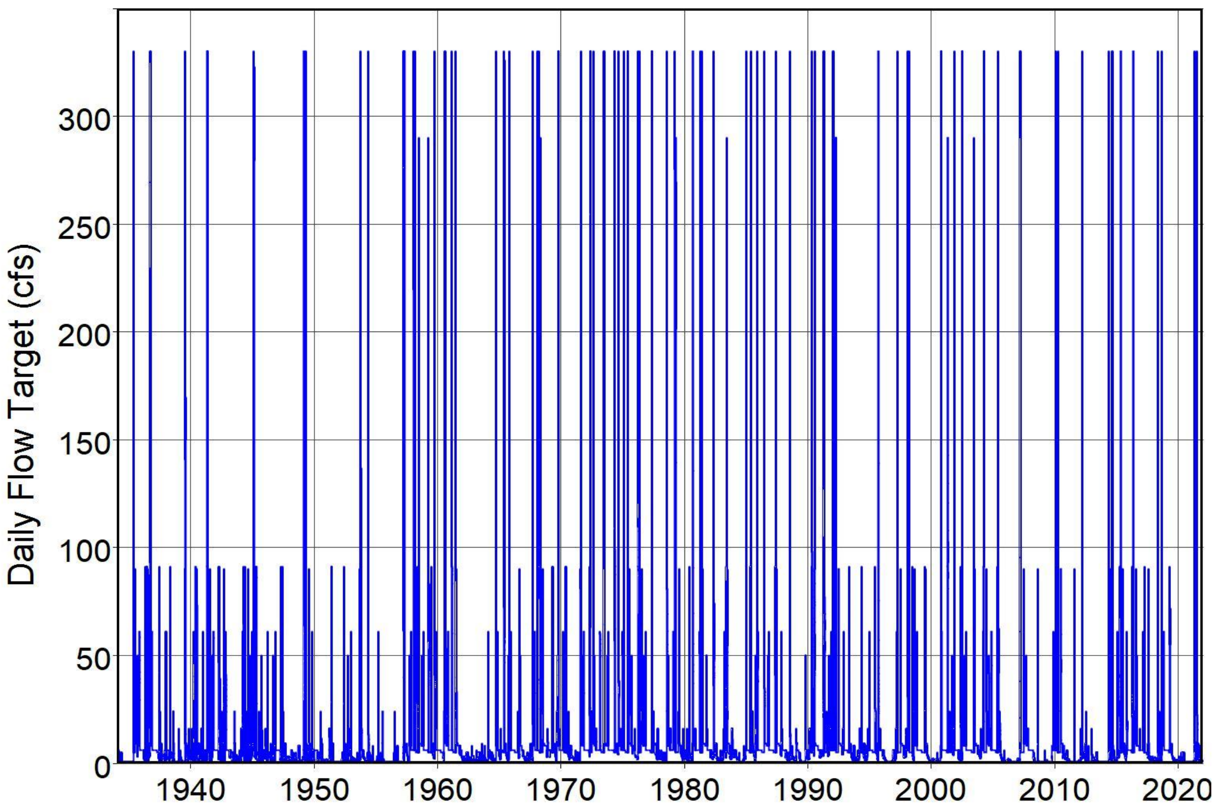

Figure 6.24 Daily SB3 EFS Instream Flow Target (cfs) at CP18

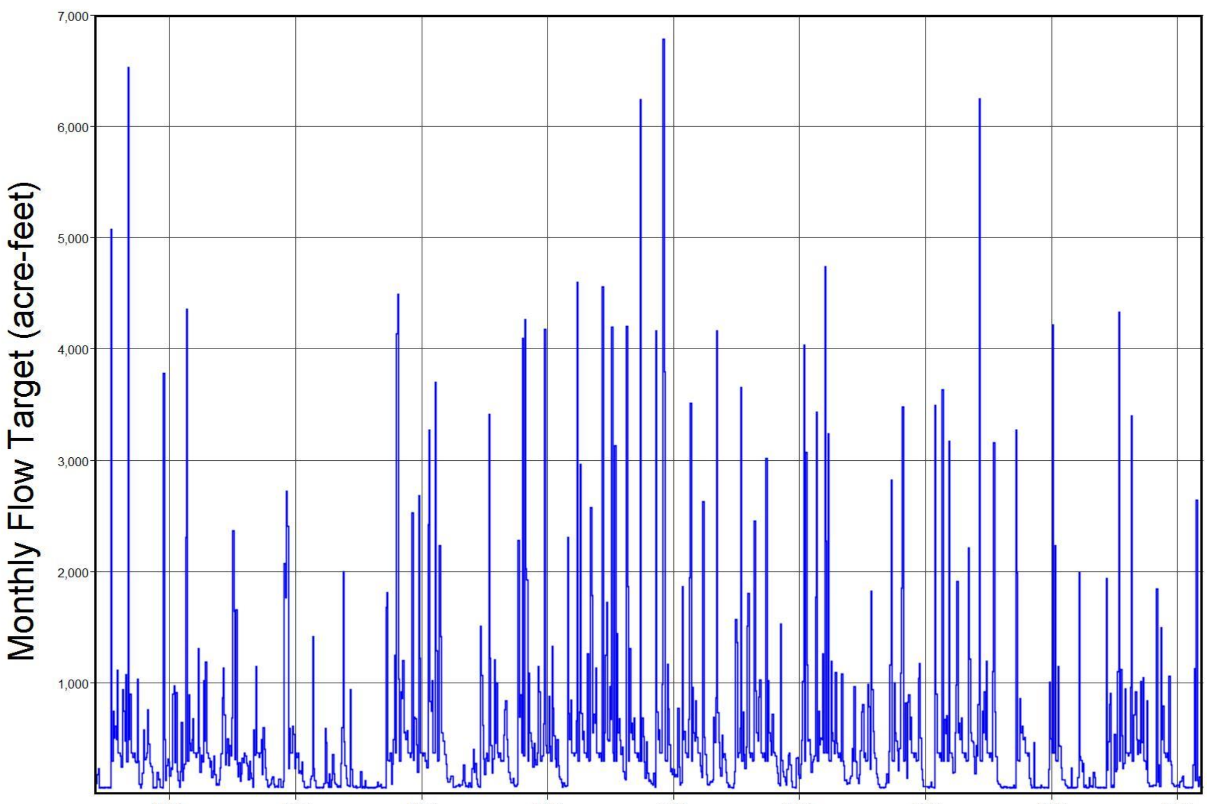

Figure 6.25 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP18

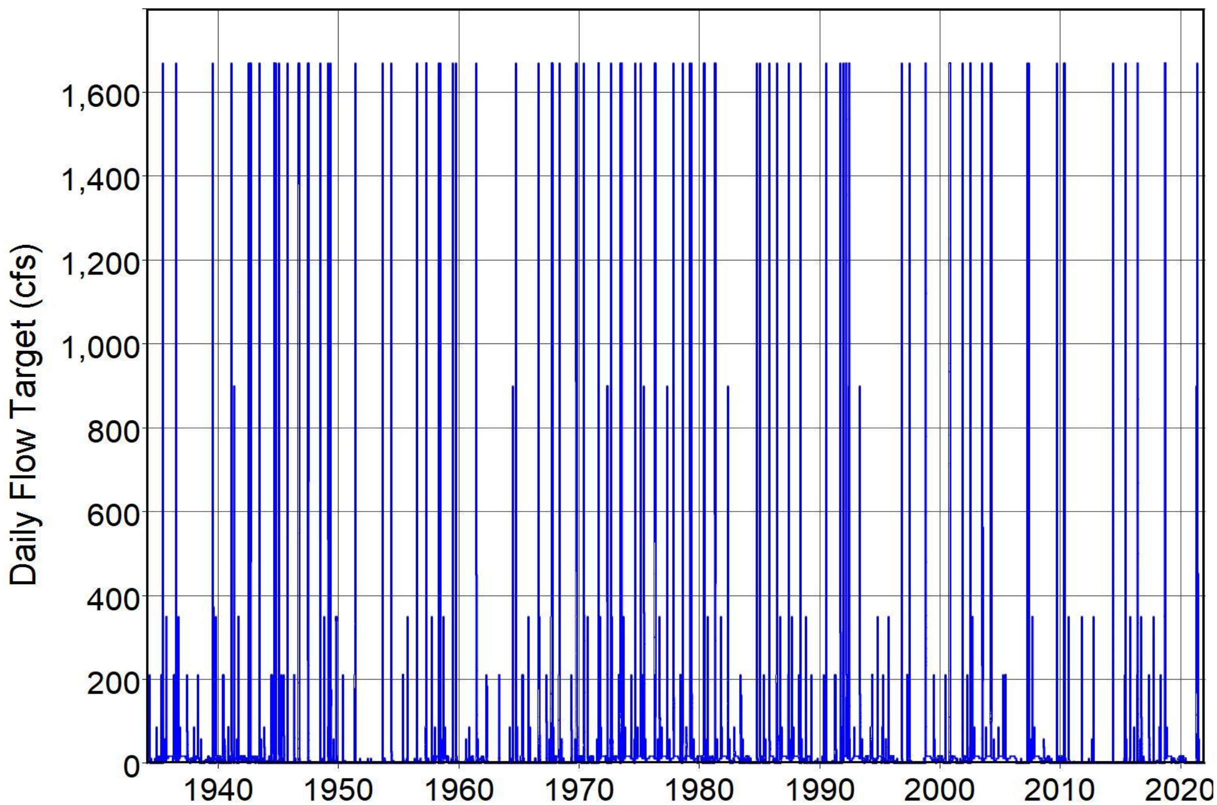

Figure 6.26 Daily SB3 EFS Instream Flow Target (cfs) at CP25

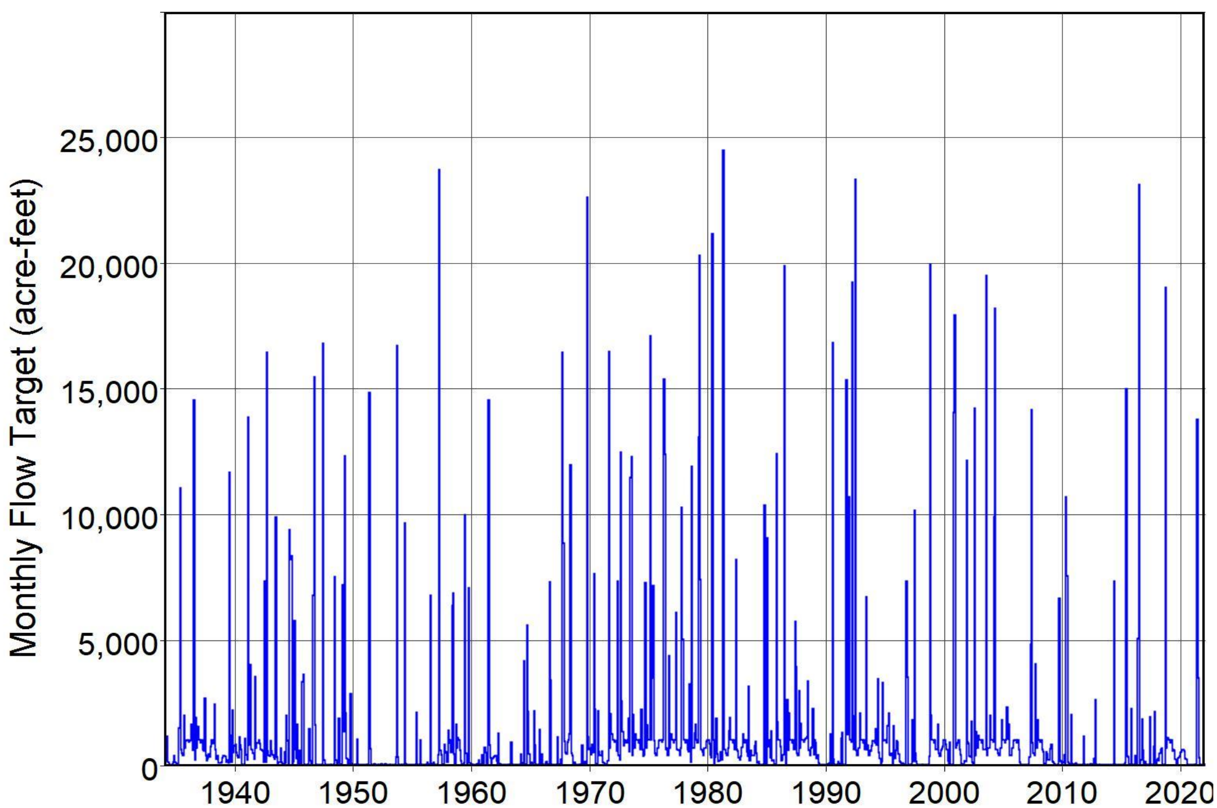

Figure 6.27 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP25

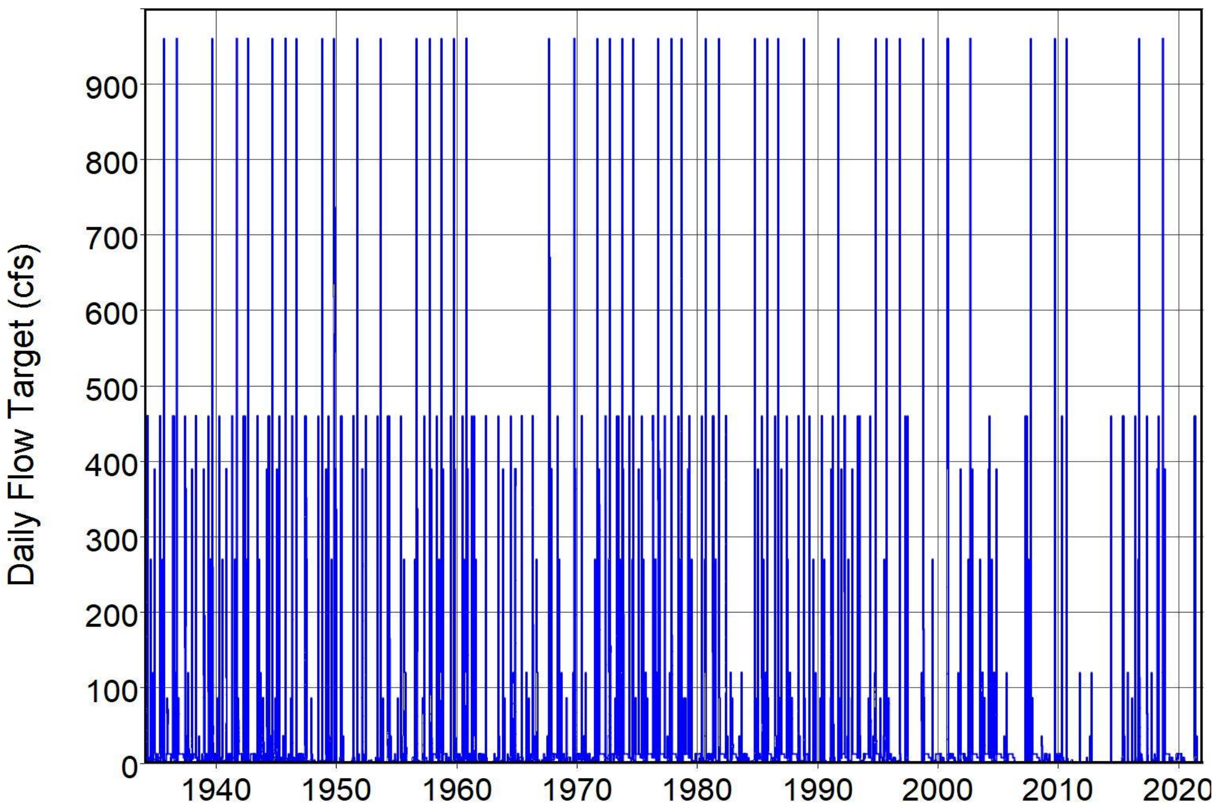

Figure 6.28 Daily SB3 EFS Instream Flow Target (cfs) at Control Point 320603

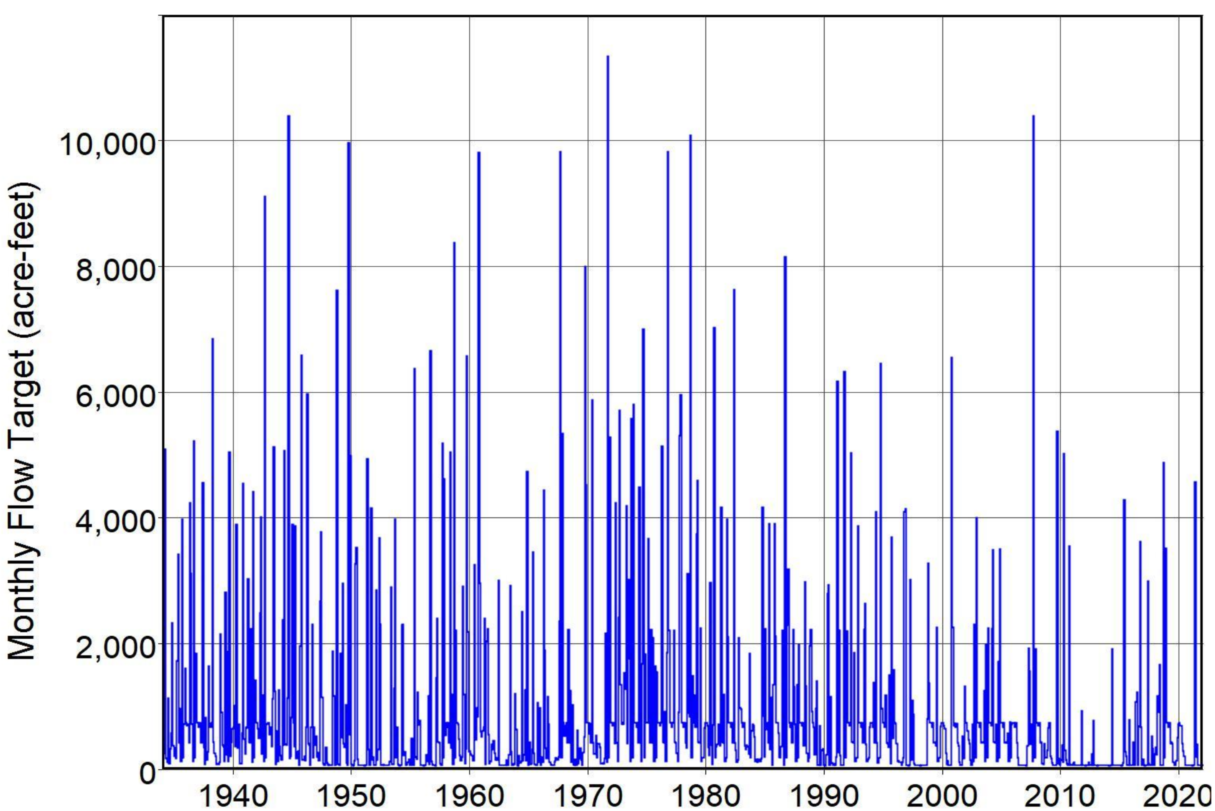

Figure 6.29 Monthly SB3 EFS Instream Flow Target (acre-feet) at 320603

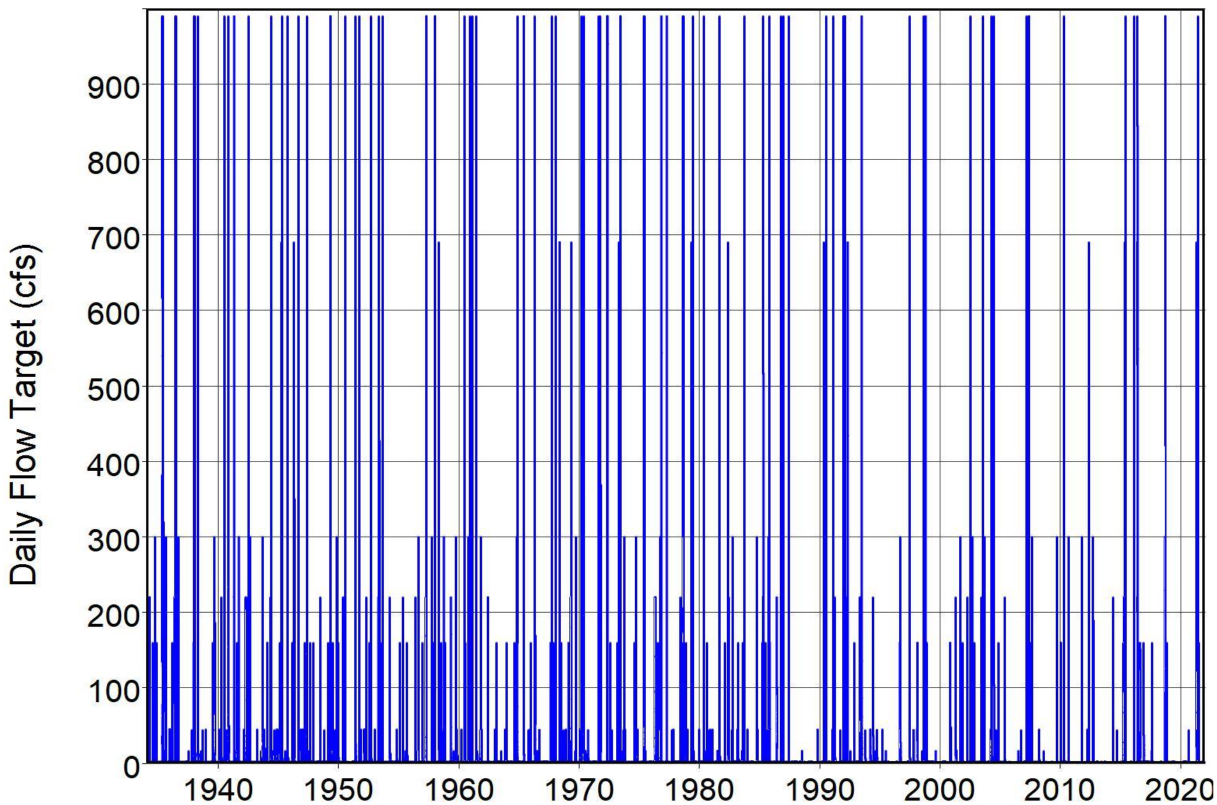

Figure 6.30 Daily SB3 EFS Instream Flow Target (cfs) at CP26

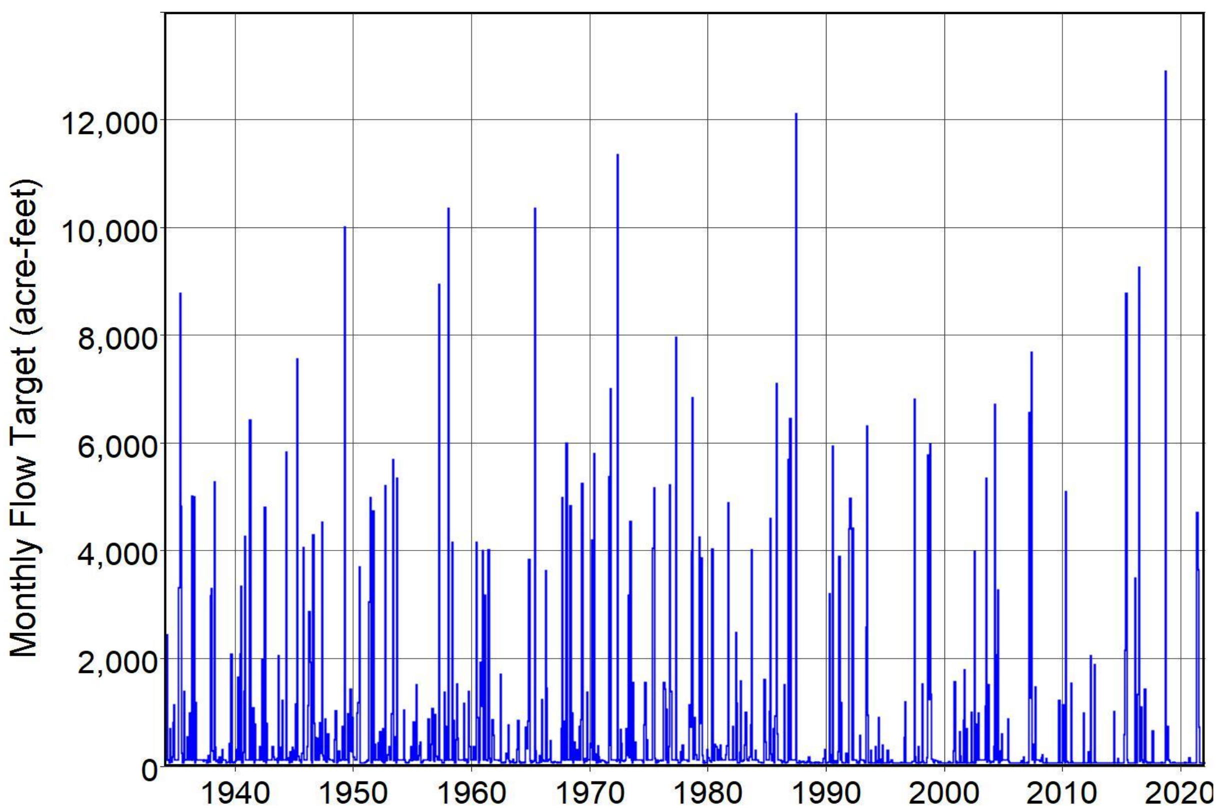

Figure 6.31 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP26

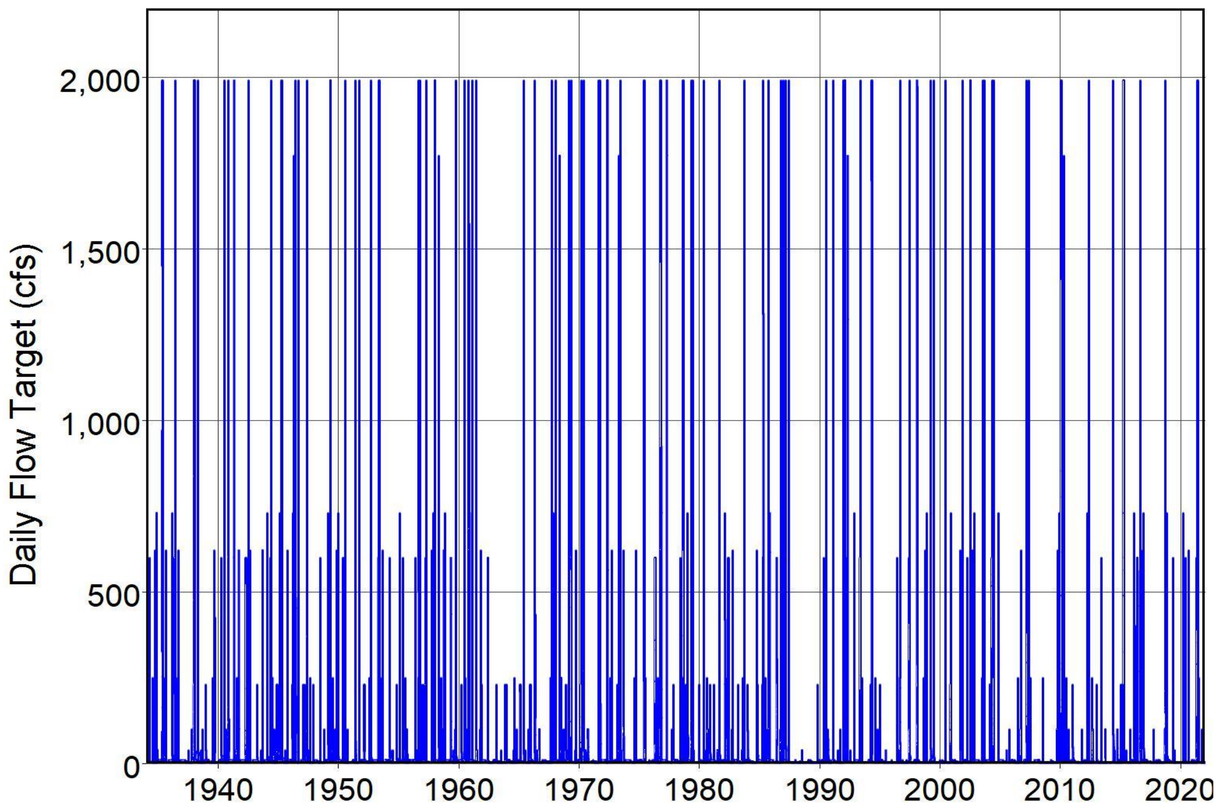

Figure 6.32 Daily SB3 EFS Instream Flow Target (cfs) at CP28

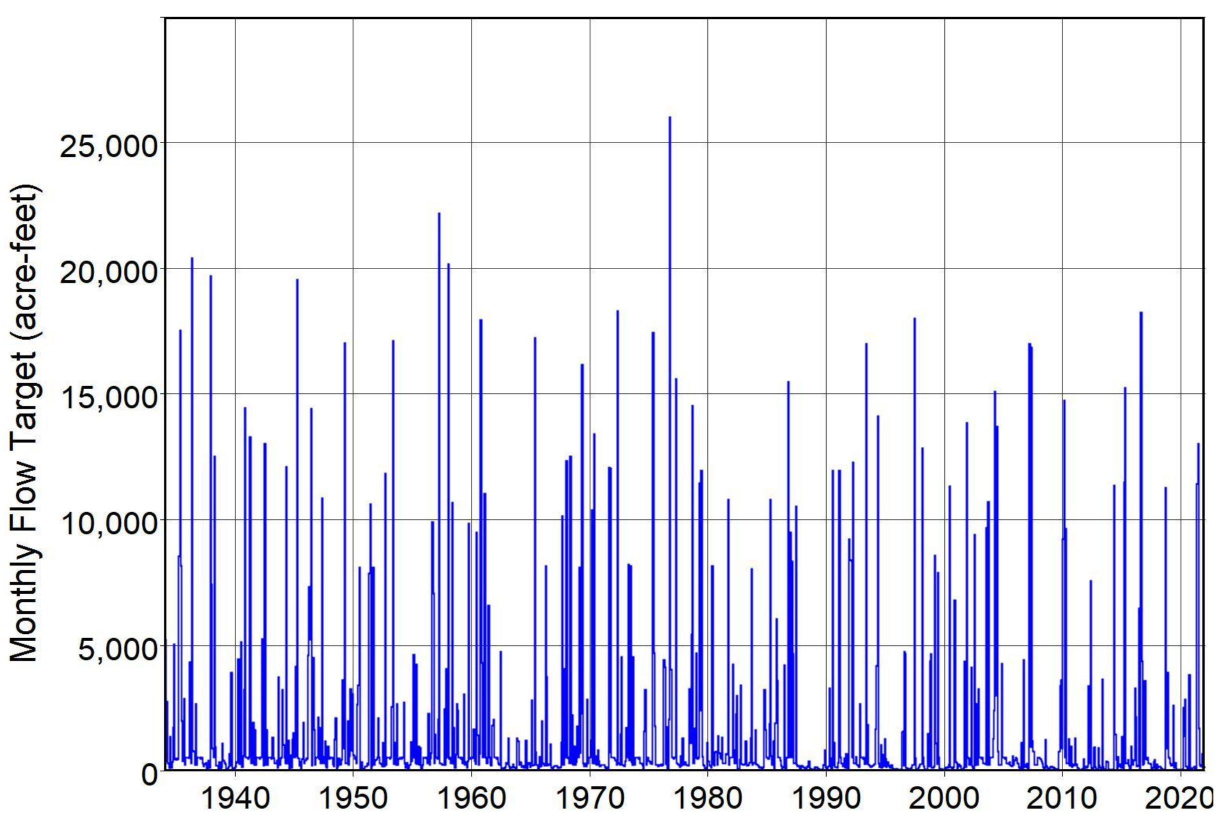

Figure 6.33 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP28

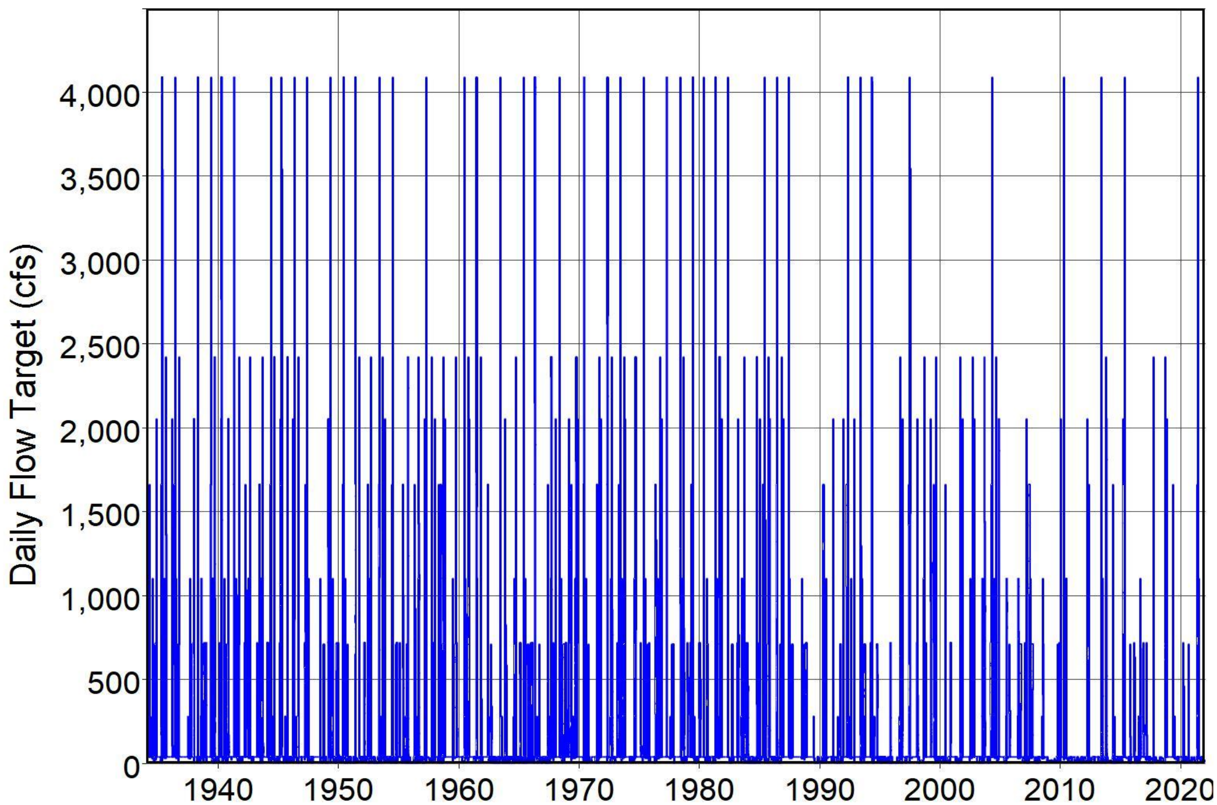

Figure 6.34 Daily SB3 EFS Instream Flow Target (cfs) at CP29

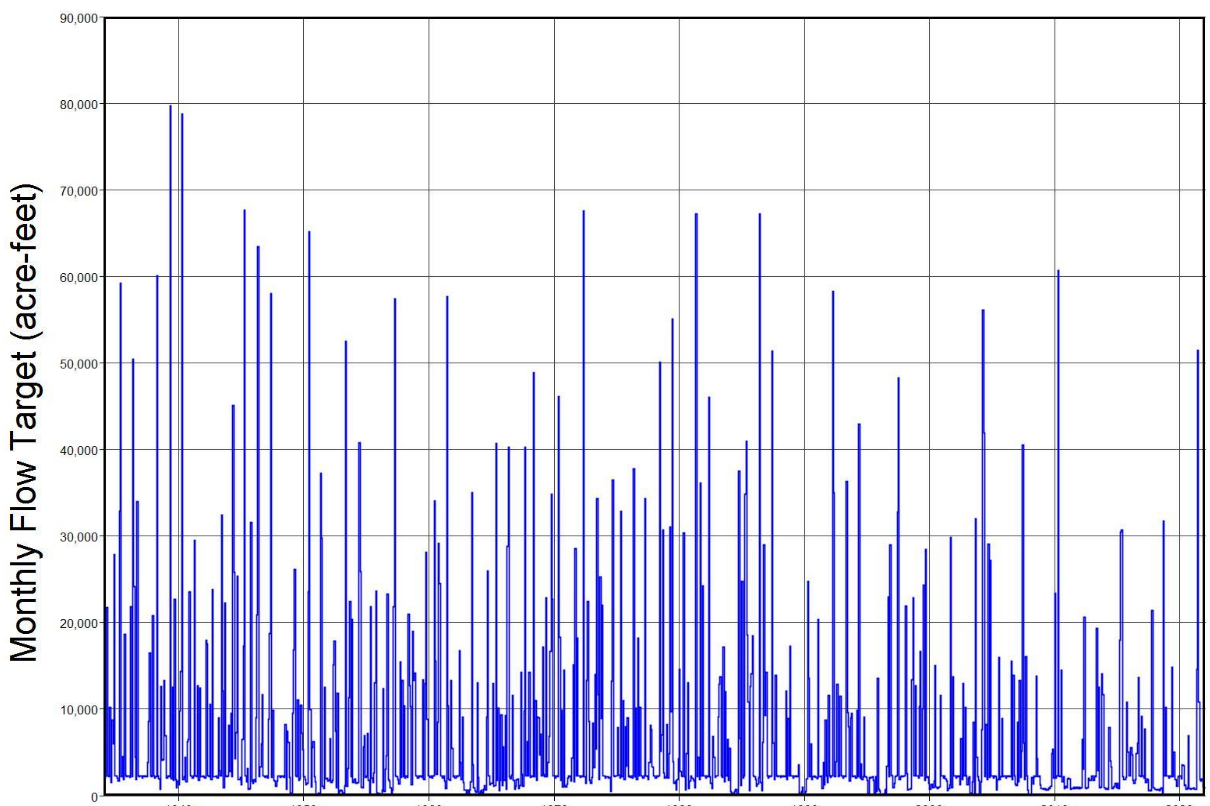

Figure 6.35 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP29

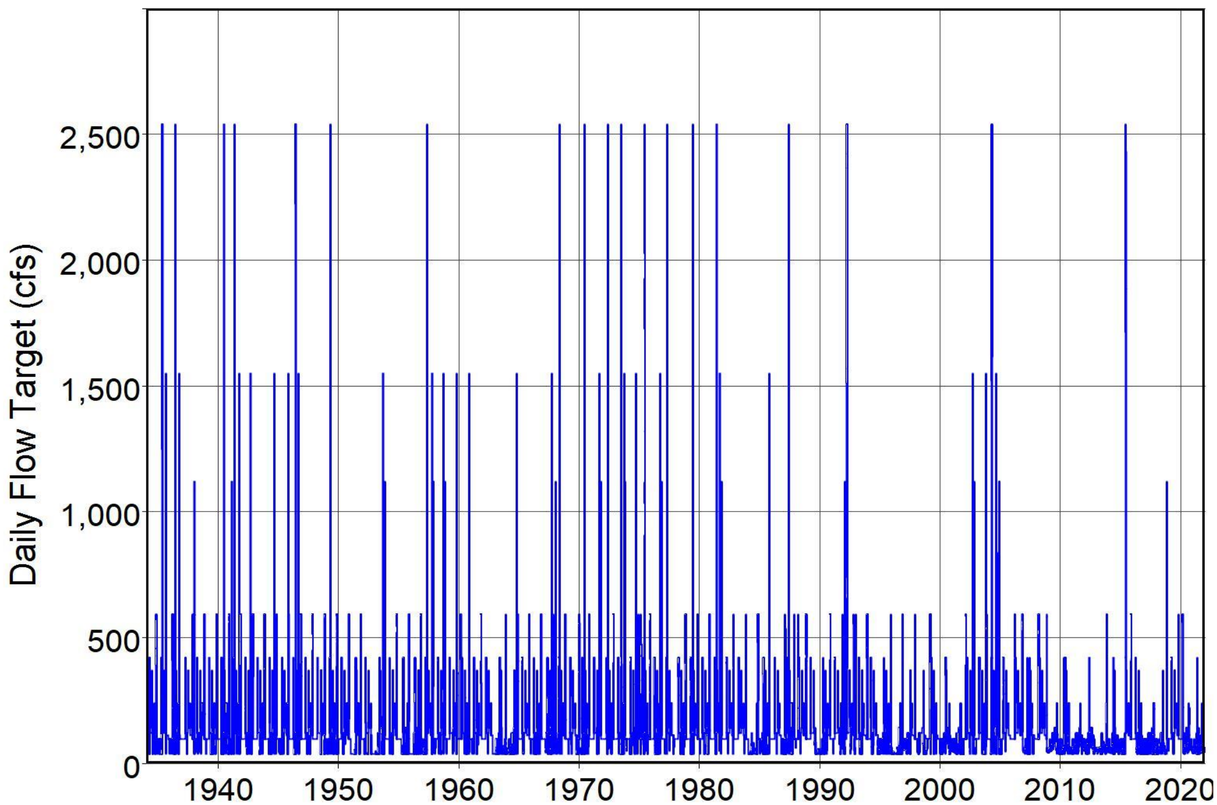

Figure 6.36 Daily SB3 EFS Instream Flow Target (cfs) at CP30

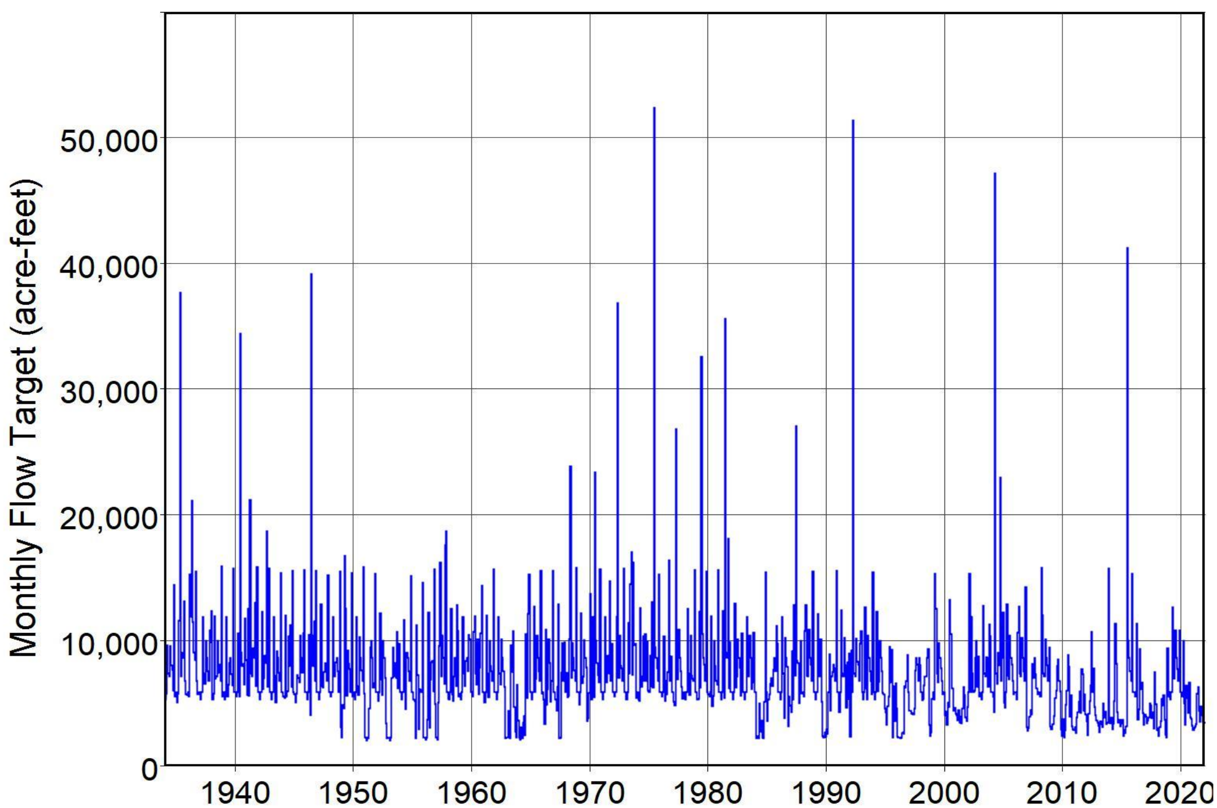

Figure 6.37 Monthly SB3 EFS Instream Flow Target (acre-feet) at CP30

Monthly Full Authorization WAM

The monthly full authorization Nueces WAM last updated by the TCEQ in January 2013 does not include the SB3 EFS. The SB3 EFS are modeled in the June 2023 monthly WAM by addition of monthly targets developed in the daily simulation described in the preceding section of this chapter. The DSS and DAT file input records shown in Tables 5.9 and 5.10 are employed to model the SB3 EFS in the June 2023 version of the monthly Nueces WAM discussed in this report.

Daily instream flow targets in acre-feet/day for the SB3 EFS computed in the daily *SIMD* simulation are summed by *SIMD* to monthly totals in acre-feet/month that are included in the *SIMD* simulation results. The final targets labeled IFT-CP in DSS pathname part C (Table 5.7) are plotted in Figures 6.5, 6.7, 6.9, 6.11, 6.13, 6.15, 6.17, 6.19, 6.21, 6.23, 6.25, 6.27, 6.29, 6.31, 6.33, 6.35, and 6.37. The time series of monthly targets are converted to target series *TS* records (Table 5.9) within *HEC-DSSVue* and incorporated in the input DSS file read in a monthly *SIM* simulation. The target series *TS* records in the DSS file are referenced by *TS* records in the DAT file which are replicated in Table 5.10.

Statistics for the SB3 EFS instream flow targets in acre-feet for the 1,056 months of the *SIM* simulation tabulated in Table 6.6 include the minimum, median (50% exceedance), mean (average), and maximum of the 1,056 monthly targets and the mean of the shortages in meeting the targets. These monthly volume metrics are in units of acre-feet.

Table 6.6
Statistics for SB3 EFS Monthly Instream Flow Targets
for the Full Authorization WAM

Control	Monthly Instream Flow Targets (acre-feet)				Mean Shortage (acre-feet)	
Point	Minimum	Median	Mean	Maximum	*SIM*	*SIMD*
CP01	777.5	3,513	3,482	21,587	14.22	15.19
CP02	55.54	61.49	70.83	585.7	36.54	36.69
CP03	55.54	1,045	1,075	14,598	9.761	7.260
CP05	55.54	254.9	403.5	4,639	70.30	19.37
CP06	55.54	178.5	1,359	13,675	61.49	12.44
CP07	595.0	2,875	2,901	18,769	19.33	18.38
CP08	56.01	491.9	717.9	6,222	1.645	1.627
CP12	55.54	917.4	1,039	8,447	6.642	6.334
CP13	55.54	61.49	289.7	7,004	22.88	19.36
CP16	55.54	184.5	238.1	2,269	8.517	8.513
CP18	55.54	307.4	562.6	6,785	7.730	7.568
CP25	55.54	430.4	1,513	24,496	27.59	18.00
320603	55.54	405.5	986.5	11,347	15.41	11.18
CP26	55.54	119.0	687.0	12,896	11.88	11.81
CP28	55.54	342.7	1,762	26,005	2.299	2.173
CP29	57.52	2,275	7,212	79,687	39.31	0.5749
CP30	2,055	6,325	7,520	52,368	593.0	65.98

The monthly SB3 EFS instream flow targets recorded in the monthly *SIM* simulation results are identical to the monthly targets computed in the daily *SIMD* simulation since the monthly targets are read by *SIM* as input. The monthly targets are read by *SIM* from *TS* records stored in the time series input DSS file.

The shortages in meeting the monthly targets in the monthly *SIM* simulation differ from the summation of daily shortages in meeting daily targets computed in the daily *SIMD* simulation reflected in the last two columns of Table 6.6. The next-to-last column in Table 6.6 shows the average of the 1,056 shortages in meeting the instream flow targets in the monthly *SIM* simulation. The averages of the 1,056 monthly shortages computed in the daily *SIMD* simulation by summing daily shortages are tabulated in the last column.

Daily and Monthly Current Use Scenario WAMs

The current use scenario (run 8) monthly Nueces WAM last updated by the TCEQ in January 2013 was converted to daily and the SB3 EFS were added in the same manner as employed with the full authorization scenario (run 3) WAM. The DIF file and the *IN*, *EV*, and *DF* records in the hydrology input DSS file are the same for the June 2023 current use and full authorization WAMs. The methodology for modeling the SB3 EFS is the same in both the current use and full authorization daily WAMs. The *IF* record instream flow targets for the SB3 EFS computed in the *SIMD* simulation differ between the current use scenario and full authorization WAMs since the simulated regulated flows differ.

Table 6.7
Pathnames for the Current Use Scenario *TS* Records
for the SB3 EFS in the Input DSS File

Part A	Part B	Part C	Part D	Part E
Nueces	CUCP01	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP02	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP03	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP05	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP06	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP07	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP08	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP12	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP13	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP16	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP18	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP25	TS	01Jan1934-31Dec2021	1Month
Nueces	CU3206	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP26	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP28	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP29	TS	01Jan1934-31Dec2021	1Month
Nueces	CUCP30	TS	01Jan1934-31Dec2021	1Month

Daily SB3 EFS instream flow targets are summed to monthly quantities within the daily *SIMD* simulation for incorporation in the monthly *SIM* simulation time series input file. The monthly instream flow targets are stored as target series *TS* records in the *SIM*/*SIMD* shared time series input DSS file with filename NuecesHYD.DSS.

DSS and DAT file records of Tables 5.11 and 5.12 were used with the full authorization WAM to add the SB3 EFS to the monthly *SIM* input dataset as discussed in Chapter 5 and earlier in Chapter 6. However, different identifiers are needed in order to store *TS* records for both the current use and full authorization WAMs in the same DSS file. The identifiers on the records of Tables 5.11 and 5.12 are changed to those of Tables 6.7 and 6.8 for the current use WAM. Parameter DSSTS on the *JO* record activates reading of *TS* records from the DSS input file.

Table 6.8
Instream Flow Rights that Model the SB3 EFS in the DAT File
of the Current Use Scenario Monthly WAM

```
IF  CP01                20111028   2            CP01ES
TS       DSSCUCP01
IF  CP02                20111028   2            CP02ES
TS       DSSCUCP02
IF  CP03                20111028   2            CP03ES
TS       DSSCUCP03
IF  CP05                20111028   2            CP05ES
TS       DSSCUCP05
IF  CP06                20111028   2            CP06ES
TS       DSSCUCP06
IF  CP07                20111028   2            CP07ES
TS       DSSCUCP07
IF  CP08                20111028   2            CP08ES
TS       DSSCUCP08
IF  CP12                20111028   2            CP12ES
TS       DSSCUCP12
IF  CP13                20111028   2            CP13ES
TS       DSSCUCP13
IF  CP16                20111028   2            CP16ES
TS       DSSCUCP16
IF  CP18                20111028   2            CP18ES
TS       DSSCUCP18
IF  CP25                20111028   2            CP25ES
TS       DSSCUCP25
IF320603                20111028   2            CP320603ES
TS       DSSCU3206
IF  CP26                20111028   2            CP26ES
TS       DSSCUCP26
IF  CP28                20111028   2            CP28ES
TS       DSSCUCP28
IF  CP29                20111028   2            CP29ES
TS       DSSCUCP29
IF  CP30                20111028   2            CP30ES
TS       DSSCUCP30
```

Statistics for SB3 EFS Instream Flow Targets

Statistics for the daily SB3 EFS instream flow targets and shortages in cfs for the 32,142 days of 1934-2021 for the current use scenario *SIMD* simulation are tabulated in Table 6.9. Similarities and differences between the statistics for the daily SB3 EFS instream flow targets and shortages computed with the full authorization versus current use scenario daily WAMs are assessed by comparing Tables 6.5 and 6.9.

The metrics of Tables 6.5 and 6.9 reflect the final instream flow targets in each day for the combined subsidence and base flow component, high pulse flow component, and final combined targets. With both subsistence/base flow and high pulse flow target components, the highest component target is adopted in each individual day. Computations are performed and simulation results output in acre-feet/day. Conversions to cfs are performed within *HEC-DSSVue*. The means (averages) of the shortages in meeting the instream flow target during each of the 32,142 days are shown in the last column of Tables 6.5 and 6.9.

Monthly instream flow targets computed in a daily *SIMD* simulation are provided as input for monthly *SIM* simulations. Statistical metrics for the SB3 EFS monthly instream flow targets in acre-feet derived from a daily *SIMD* simulation tabulated in Table 6.10 include the minimum, median (50% exceedance), mean (average), and maximum of the 1,056 monthly targets. The two alternative mean monthly shortages in meeting the targets in the last two columns of Table 6.10 are computed differently. The next-to-last column in Table 6.10 is the average of the 1,056 zero and non-zero shortages in meeting the monthly instream flow targets in the monthly *SIM* simulation. The last column lists averages of the 1,056 monthly shortages computed in the daily *SIMD* simulation by summing the daily shortages.

Simulated Storage Contents of Choke Canyon Reservoir and Lake Corpus Christi

Choke Canyon Reservoir and Lake Corpus Christi are the only reservoirs in the Nueces WAM with storage capacities of at least 5,000 acre-feet. The two reservoirs are discussed in Chapter 1 with descriptive information tabulated in Table 1.1. Choke Canyon Reservoir and Lake Corpus Christi have a total combined authorized storage capacity of 1,000,000 acre-feet, which accounts for 96.1 percent of the total authorized storage capacity of 1,040,446 acre-feet in the 121 reservoirs included in the full authorization Nueces WAM. The two reservoirs have a total storage capacity of 918,600 acre-feet in the current use scenario WAM, which is 97.5 percent of the total capacity of 959,830 acre-feet of 125 reservoirs. Full authorization and current use scenario *SIM* monthly storage in Choke Canyon Reservoir and Lake Corpus Christi plotted in Figures 1.5 and 1.6 in Chapter 1 is from monthly *SIM* simulations with the extended 1934-2021 hydrology but before adding the SB3 EFS. Figures 6.1 and 6.2 in Chapter 6 compare daily *SIMD* and monthly *SIM* full authorization WAM simulations.

Figures 6.38 and 6.39 compare storage plots for Choke Canyon Reservoir and Lake Corpus Christi, respectively, from current use scenario simulations with the final June 2023 versions of the daily and monthly WAMs with the SB3 EFS. The monthly *SIM* and daily *SIMD* versions of the WAM simulations reflected in Figures 6.38 and 6.39 both activate negative incremental flow option 6. The only difference between the two current use scenario simulations is one is a daily *SIMD* and the other a monthly *SIM* simulation.

Table 6.9
Statistics for SB3 EFS Daily Instream Flow Targets from Current Use Scenario WAM

SB3 EFS Targets	Daily Instream Flow Target (cfs) Minimum	Mean	Maximum	Shortage Mean (cfs)
	Nueces River at Laguna (CP01)			
Subsistence and Base	14.0	47.68	65.0	0.218
High Flow Pulse	0.00	14.73	590.0	-
Final Target	14.0	58.24	590.0	0.218
	West Nueces River near Bracketville (CP02)			
Subsistence and Base	1.00	1.00	1.00	0.658
High Flow Pulse	0.00	0.191	25.0	-
Final Target	1.00	1.173	25.0	0.658
	Nueces River below Uvalde (CP03)			
Subsistence and Base	1.00	13.14	21.0	0.101
High Flow Pulse	0.00	6.174	510.0	-
Final Target	1.00	18.69	510.0	0.101
	Nueces River at Cotulla (CP05)			
Subsistence and Base	1.00	4.129	15.00	0.549
High Flow Pulse	0.00	3.038	190.0	-
Final Target	1.00	6.845	190.0	0.549
	Nueces River near Tilden (CP06)			
Subsistence and Base	1.00	2.254	12.0	0.458
High Flow Pulse	0.00	21.23	880.0	-
Final Target	1.00	23.08	880.0	0.458
	Frio River at Concan (CP07)			
Subsistence and Base	10.00	41.03	61.00	0.227
High Flow Pulse	0.00	12.98	540.0	-
Final Target	10.00	49.67	540.0	0.227
	Dry Frio River near Reagan Wells (CP08)			
Subsistence and Base	1.00	8.079	35.00	0.0297
High Flow Pulse	0.00	4.810	210.0	-
Final Target	1.00	11.91	210.0	0.0297
	Sabinal River near Sabinal (CP12)			
Subsistence and Base	1.00	11.88	21.00	0.1411
High Flow Pulse	0.00	6.877	330.0	-
Final Target	1.00	17.25	330.0	0.1411
	Sabinal River at Sabinal (CP13)			
Subsistence and Base	1.00	1.252	2.000	0.3198
High Flow Pulse	0.00	3.602	1,070	-
Final Target	1.00	4.807	1,070	0.3198

Table 6.9 Continued
Statistics for SB3 EFS Daily Instream Flow Targets from Current Use Scenario WAM

SB3 EFS Targets	Daily Instream Flow Target (cfs) Minimum	Mean	Maximum	Mean (cfs)
Seco Creek at Miller Ranch near Utopia (CP16)				
Subsistence and Base	1.00	2.668	4.000	0.1695
High Flow Pulse	0.00	1.384	120.0	-
Final Target	1.00	3.946	120.0	0.1695
Hondo Creek near Tarpley (CP18)				
Subsistence and Base	1.00	4.238	9.000	0.1694
High Flow Pulse	0.00	5.684	330.0	-
Final Target	1.00	9.359	330.0	0.1694
Frio River near Derby (CP25)				
Subsistence and Base	1.00	6.895	17.00	0.0827
High Flow Pulse	0.00	19.43	1,670	-
Final Target	1.00	25.63	1,670	0.0827
Frio River at Tilden (Control Point 320603)				
Subsistence and Base	1.00	4.951	12.00	0.1992
High Flow Pulse	0.00	12.34	960.0	-
Final Target	1.00	16.81	960.0	0.1992
San Miguel Creek near Tilden (CP26)				
Subsistence and Base	1.00	1.556	2.000	0.1465
High Flow Pulse	0.00	10.12	990.0	-
Final Target	1.00	11.50	990.0	0.1465
Atascosa River at Whitsett (CP28)				
Subsistence and Base	1.078	4.992	9.000	0.0000
High Flow Pulse	0.00	25.30	1,990	-
Final Target	1.078	29.70	1,990	0.0000
Nueces River near Three Rivers (CP29)				
Subsistence and Base	1.00	32.06	37.00	0.0156
High Flow Pulse	0.00	90.25	4,090	-
Final Target	1.00	118.6	4,090	0.0156
Nueces River near Mathis (CP30)				
Subsistence and Base	37.00	99.22	140.0	2.576
High Flow Pulse	0.00	37.43	2,540	-
Final Target	37.00	128.3	2,540	2.576

Table 6.10
Statistics for SB3 EFS Monthly Instream Flow Targets
for the Current Use Scenario WAM

Control Point	Monthly Instream Flow Targets (acre-feet)				Mean Shortage (acre-feet)	
	Minimum	Median	Mean	Maximum	*SIM*	*SIMD*
CP01	777.5	3,585	3,517	21,539	11.62	11.70
CP02	55.54	61.49	70.83	585.7	36.47	36.68
CP03	55.54	1,045	1,128	14,573	6.276	5.156
CP05	55.54	263.2	413.2	4,538	66.32	18.96
CP06	55.54	213.3	1,394	13,488	59.15	10.33
CP07	595.0	2,890	2,999	18,741	12.13	11.82
CP08	55.91	491.9	719.1	6,222	1.604	1.603
CP12	55.54	923.5	1,041	8,447	6.500	6.321
CP13	55.54	61.49	290.2	7,004	18.59	17.31
CP16	55.54	184.5	238.3	2,269	8.514	8.512
CP18	55.54	307.4	565.0	6,789	7.788	7.630
CP25	55.54	498.5	1,547	24,522	7.728	2.176
320603	55.54	416.5	1,015	11,334	9.219	6.435
CP26	55.54	119.0	694.2	12,920	5.709	5.263
CP28	64.11	405.9	1,793	26,007	0.000	0.000
CP29	57.52	2,275	7,160	79,581	32.65	0.1867
CP30	2,202	6,030	7,743	51,748	527.9	11.24

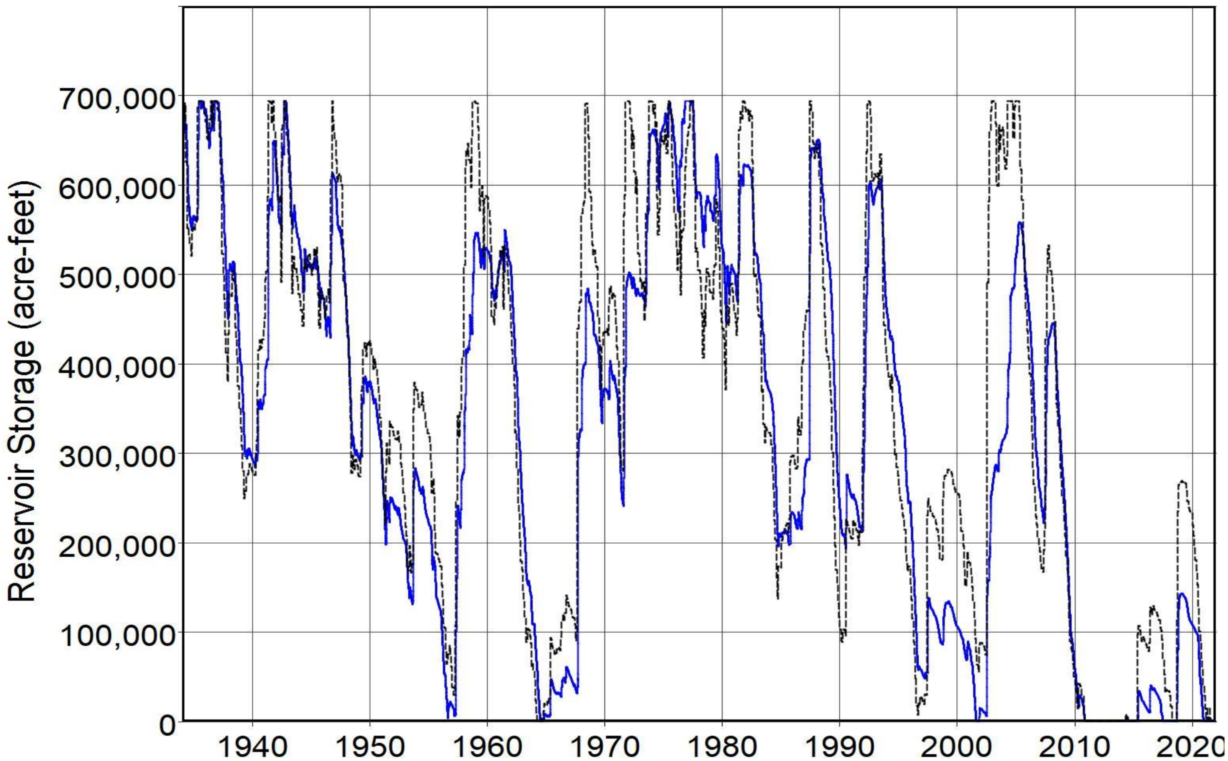

Figure 6.38 Choke Canyon Reservoir Storage from Daily (blue solid line) and Monthly (black dashed line) Full Authorization Simulations

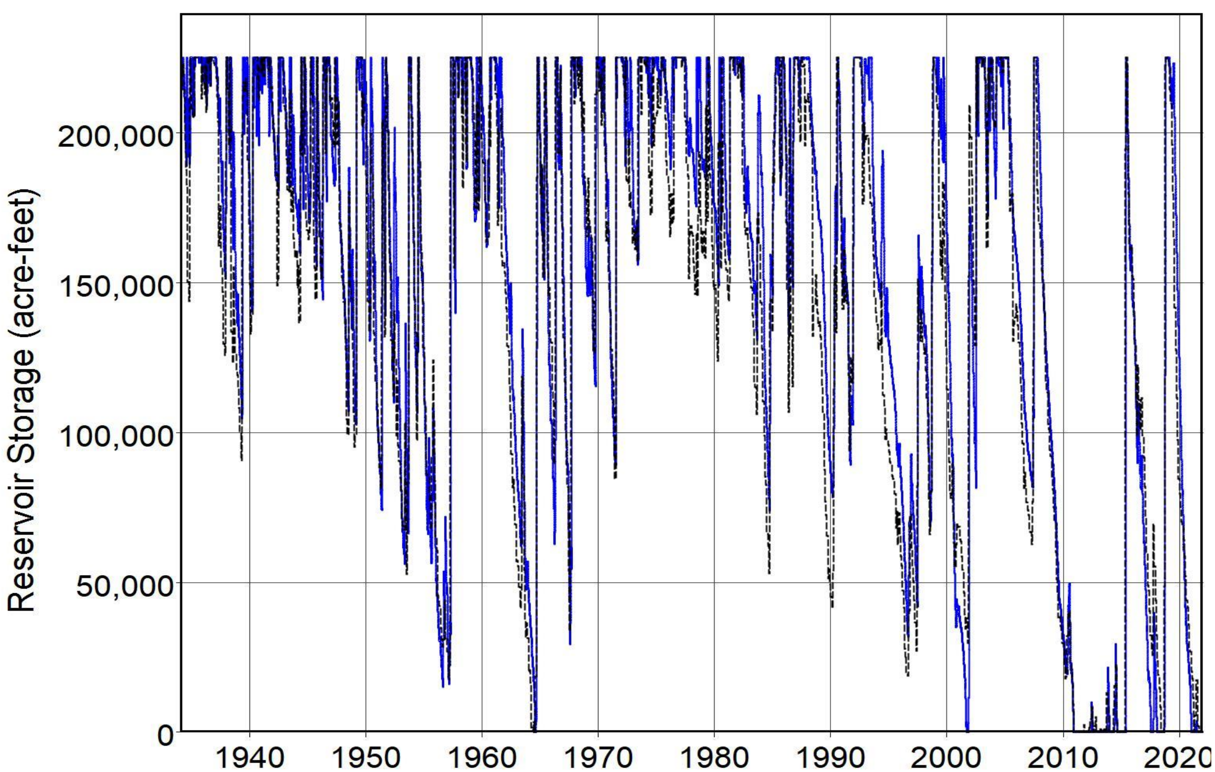

Figure 6.39 Lake Corpus Christi Storage from Daily (blue solid line) and Monthly (black dashed line) Full Authorization Simulations

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