**Coastal Hydrology for the Mission-Aransas Estuary**

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Bays & Estuaries Program
Surface Water Resources Division
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## Purpose

This technical memo documents the procedure for estimating combined freshwater inflow data for the Mission-Aransas Estuary and the specifics related to producing hydrology dataset versions #TWDB201001 and #TWDB201004 for this estuary.

## Introduction

The goal of the Texas Water Development Board (TWDB) Coastal Hydrology program is to provide estimates of historical freshwater inflows into Texas bays and estuaries to support environmental and water planning studies. The earliest freshwater inflow estimates were compiled in a series of reports published by the Texas Department of Water Resources between 1980 and 1983. Monthly inflows to the seven major estuaries in Texas for the period 1941-1976 were estimated in those studies, with estimates for the Mission-Aransas Estuary published in Chapter 4 of LP-108, *Nueces and Mission-Aransas Estuaries: A Study of the Influence of Freshwater Inflows* (TDWR 1981, available on the TWDB website or upon request).

Inflow records for each estuary have been updated periodically since then in support of ongoing research and planning studies both within and external to TWDB. Additionally, subsequent updates are provided in daily as well as monthly format. This report covers the most recent update of freshwater inflow estimates for the Mission-Aransas Estuary and extends the hydrology through 2009. Therefore, complete hydrology is available for this estuary for 1941-2009, with daily estimates of inflows available only after 1977.

## Estimates of Combined Freshwater Inflows

Estimates of hydrology for the areas draining to the Mission-Aransas Estuary include gaged and ungaged portions of the Mission and Aransas river basins, as well as other small coastal basins. The combination of *Gaged Inflows* + *Ungaged Inflows* + *Return Flows - Diversions* below the last gage station provide for estimates of ***Combined Freshwater Inflow*** to the estuary. The ***Freshwater Inflow Balance*** then consists of *Combined Inflows* + *Precipitation* on the estuary – *Evaporation* from the estuary. Although inflow estimates are updated on an ongoing basis, there are two distinct periods of estimation. Before 1977, inflow estimates are available only in monthly intervals.  Starting in 1977 and thereafter, inflow estimates became available on a daily basis.

**<u>1941-1976 Period of Record</u>**

This period of record uses measurements from U.S. Geological Survey (USGS) stream gages along with rainfall-runoff estimates from a water yield model to determine flows in gaged and ungaged watersheds (TDWR 1981).  In these early estimates of coastal hydrology, flows in ungaged areas were adjusted for known agricultural, municipal, and industrial return flows obtained from the Texas Department of Water Resources or equivalent agency (TDWR 1981).  However, LP-108 does not clearly document the treatment of diversion data when estimating combined inflows to the estuary.  Data on inflows to the Mission-Aransas Estuary for the 1941-1976 period is available as monthly or annual estimates.

**<u>1977-2009 Period of Record</u>**

This period of record uses measurements from USGS stream gages along with rainfall-runoff estimates from the Texas Rainfall-Runoff (TxRR) model, adjusted for known diversion and return flows obtained from the TCEQ (or equivalent agency), the South Texas Water Master, and the TWDB Irrigation Water Use estimates.   In some cases, diversion and return data may be obtained through other entities, such as in the TWDB report on *Coastal Hydrology for the Guadalupe Estuary* (Guthrie and Lu 2010) where recent diversion and return data were obtained from HDR Inc.  Data on inflows to the Mission-Aransas Estuary for the 1977-2009 period is available as daily, monthly, or annual estimates.

**<u>Gaged Watersheds</u>**

Four USGS stream gages have been used to develop the gaged inflow component of combined inflows to the Mission-Aransas Estuary.  The gage location at the Mission River at Refugio has been utilized since 1939.  Table 1 lists these USGS stream gages and the corresponding period of record utilized in estimating combined inflows.  Approved USGS stream gage data was available through November 2009 and was provisional for December 2009.

Table 1.  USGS stream gages used to develop the gaged inflow component of combined inflows to the Mission-Aransas Estuary.  Gage number, location, and period of record utilized in estimating inflows are shown.

| Estuary | Gage Station Number | Gage Location | Utilized Period of Record |
|---|---|---|---|
| Mission-Aransas | 08189800 | Chiltipin Creek at Sinton | 1970-1991 |
| | 08189700 | Aransas River near Skidmore | 1964-present |
| | 08189500 | Mission River at Refugio | 1939-present |
| | 08189200 | Copano Creek near Refugio | 1970-present |

**<u>Ungaged Watersheds</u>**

The number of ungaged watersheds for which ungaged inflows are estimated has changed through time as USGS gages become available or unavailable.  Figures 1-3 show watershed boundaries for the ungaged watersheds during the period from 1941 to present.  Major differences in watersheds occur as watersheds #20125 and #20030 transitioned from ungaged to gaged in 1970, and as watershed #20030 transitioned back to ungaged in 1991 (Figures 1-3). Also, watershed #20010 was divided into two watersheds, #20012 and #20014, in 1977 (Figure 2).

The ungaged inflow component of combined inflows is estimated using a rainfall-runoff model. Before 1977, stream flows in ungaged watersheds were obtained using a *water yield model* which required daily precipitation, Soil Conservation Service average curve numbers, and soil depletion index (TDWR 1981). This water yield model provided for monthly estimates of ungaged inflows – not daily. TWDB does not have daily estimates of ungaged inflows for the period prior to 1977.

Since 1977, however, TWDB has used the Texas Rainfall-Runoff (TxRR) model to estimate daily stream flows in ungaged watersheds. This model is conceptually similar to the Agricultural Research Service (ARS) rainfall-runoff model which is based on the Soil Conservation Service's curve number method to estimate direct runoff from a precipitation event. TxRR, however, has three key differences: (1) use of a simpler and more straightforward mathematics, (2) introduction of 12 monthly depletion factors, instead of single depletion factor used in the ARS Model, and (3) introduction of a base flow component into the model. TxRR has been used to estimate daily stream flows from over 50 coastal ungaged watersheds as a part of the Bays & Estuaries Coastal Hydrology Program to study the effect of freshwater inflows to Texas bays and estuaries.

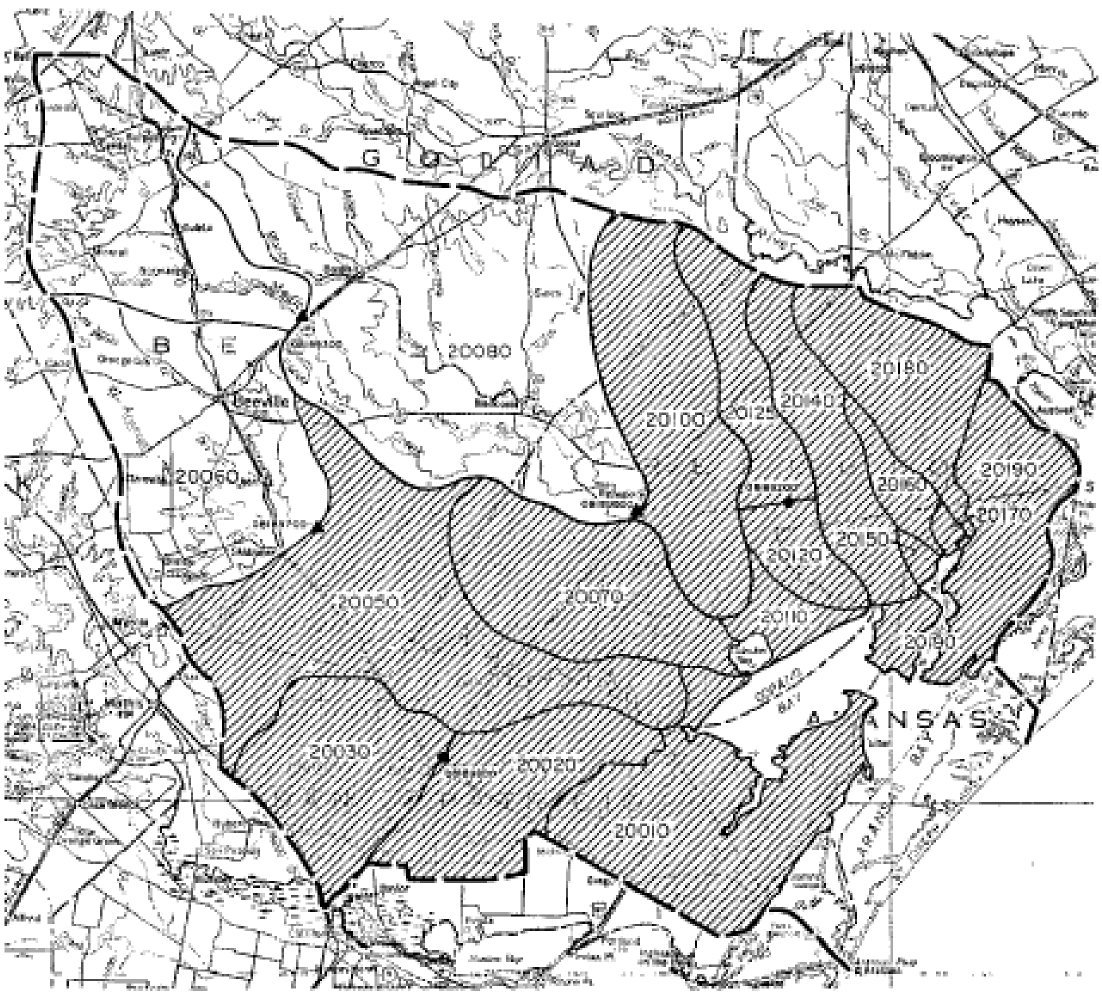

Figure 1. Ungaged watershed delineation used to determine ungaged inflows to the Mission-Aransas Estuary from 1941 to 1970. From 1970 to 1976, watersheds #20125 (upper right) and #20030 (lower left) transitioned from ungaged to gaged watersheds as shown in Figure 2. Triangles represent USGS Streamflow Gages. Ungaged watersheds are identified by cross-hatching.

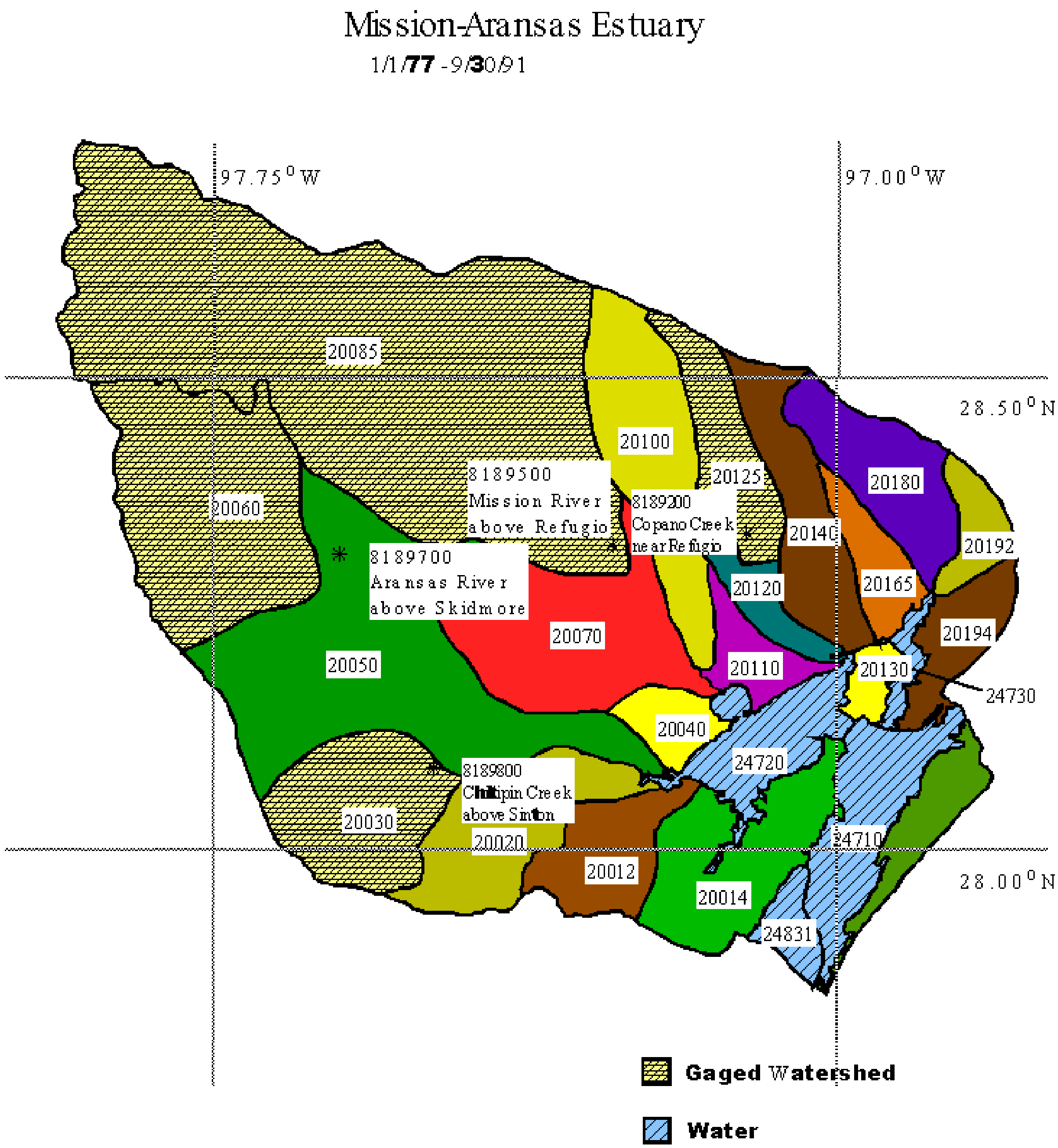


Figure 2. Ungaged watershed delineation used by TxRR to determine ungaged inflows to the Mission-Aransas Estuary from 1977 to 1991. Gaged watersheds are identified by yellow cross-hatching. Watershed numbers changed when watershed# 20010 (lower right, see Figure 1) was split into two watersheds, #20012 and #20014, and ungaged watersheds #20125 and #20030 transitioned to gaged watersheds in 1970.

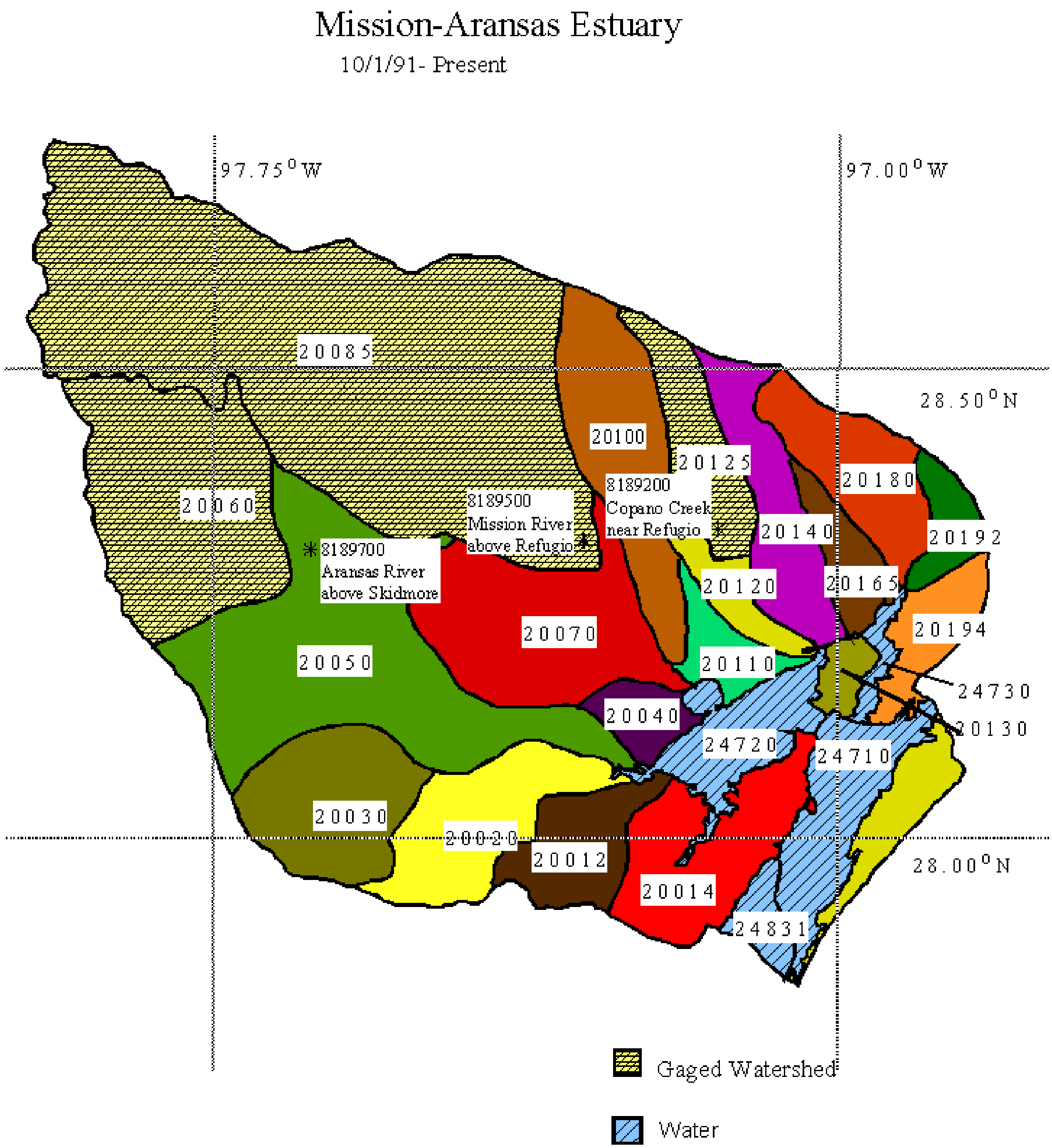


Figure 3. Ungaged watershed delineation used in TxRR to determine ungaged flows to the Mission-Aransas Estuary from 1991 to Present. Gaged watersheds are identified by yellow cross-hatching. Watershed #20030 (lower left) transitioned back to an ungaged watershed in 1991.

## Diversion and Return Points

The major discharge permits and dischargers providing return flows to the Mission-Aransas Estuary are listed in Table 2, with locations shown in Figure 4. Although the TWDB coastal hydrology database includes several small diversions in the 1980's (Appendix A), owners of these diversion permits are unknown at this time.

Table 2. Major discharge permits in the Mission-Aransas basin below the lowest USGS streamgages.

| | National Pollutant Discharge Elimination System Number | OWNER |
|---|---|---|
| RETURN FLOWS | TX0022152 | City Of Rockport |
| | TX0024562 | City Of Sinton |
| | TX0025135 | City Of Odem |
| | TX0027472 | City Of Taft |
| | TX0032492 | Town Of Refugio |
| | TX0032638 | Town Of Woodsboro |
| | TX0047007 | City Of Beeville |
| | TX0054780 | Pettus Mud |
| | TX0102920 | Texas Dept Of Transportation |
| | TX0110361 | City Of Sinton |
| | TX0113859 | City Of Beeville |
| | TX0116157 | Town Of Bayside |
| | TX0119407 | Skidmore WSC |
| | TX0119563 | St Paul WSC |
| | TX0119601 | Tynan WSC |
| | TX0123871 | Holiday Beach WSC |

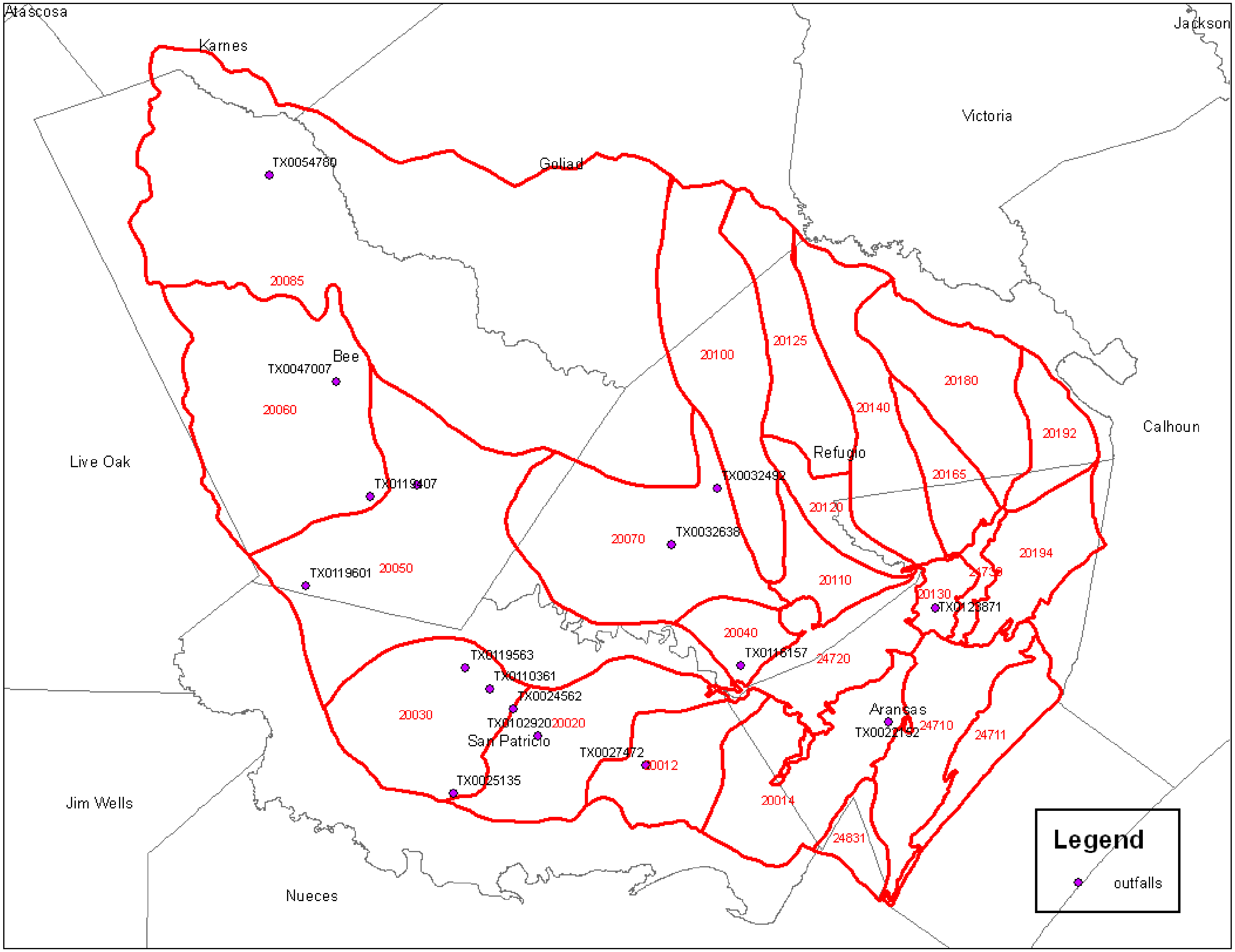


Figure 4. Location of discharge permits in the Mission – Aransas River basins

## Estimates of Freshwater Inflow Balance

*Total Freshwater Inflow* to the estuary may include estimates of ***Combined Freshwater Inflow*** to the estuary + Precipitation on the estuary. The ***Freshwater Inflow Balance***, then, considers the effect of Evaporation from the estuary. Due to limitations on estimates of evaporation throughout the period of record, estimates of the freshwater inflow balance are available only in monthly intervals.

### <u>Precipitation and Evaporation</u>

Direct precipitation onto the surface of the Mission-Aransas Estuary was calculated using Thiessen-weighted precipitation techniques as described in LP-108 (TDWR 1981). Station based rainfall data were obtained from the National Weather Service (NWS) and processed using Arc/Info Macro Language (AML). Figure 5 shows the Thiessen polygons that were built over the rainfall stations to calculate watershed rainfall.

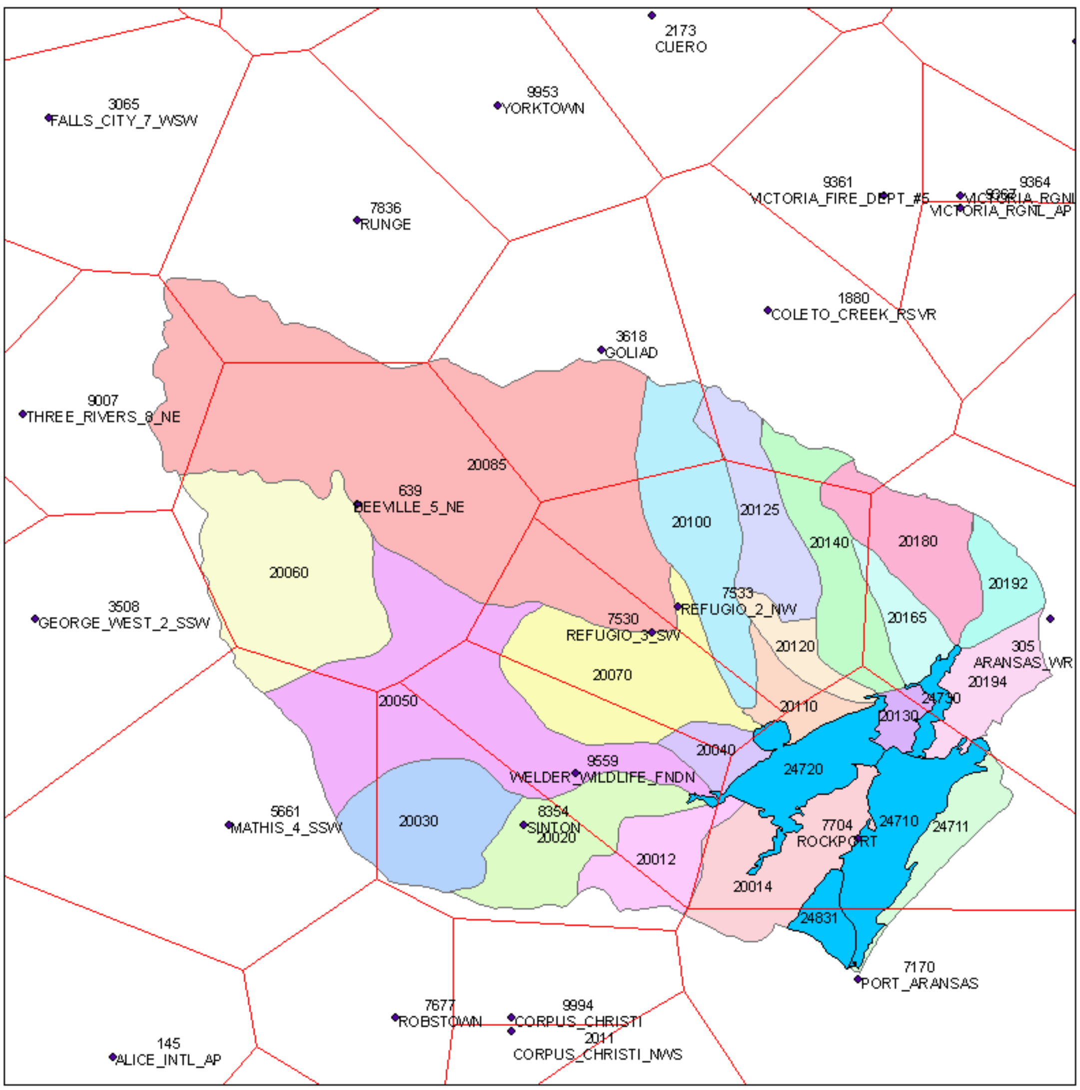


Figure 5: Rainfall stations (♦) and Thiessen polygons (red lines) used to estimate direct precipitation onto the Mission-Aransas Estuary.

Evaporation was calculated for the surface area of the bay using TWDB and NWS pan evaporation data to estimate evaporation rates. Bay watersheds used to calculate evaporation include watershed #24720, #24730, and #24710 which are located within quadrangles 910, 911, 1010, and 1011 (Figure 6). The total water evaporated from this watershed is calculated by multiplying the watershed area by the evaporation rates obtained from the TWDB. Evaporation rates were determined with a GIS based program, *ThEvap*, using TWDB and NWS pan evaporation data. The *ThEvap* program replaced an older program, *WD0300*, previously run by the Texas Department of Water Resources (http://midgewater.twdb.state.tx.us/Evaporation/evap.html).

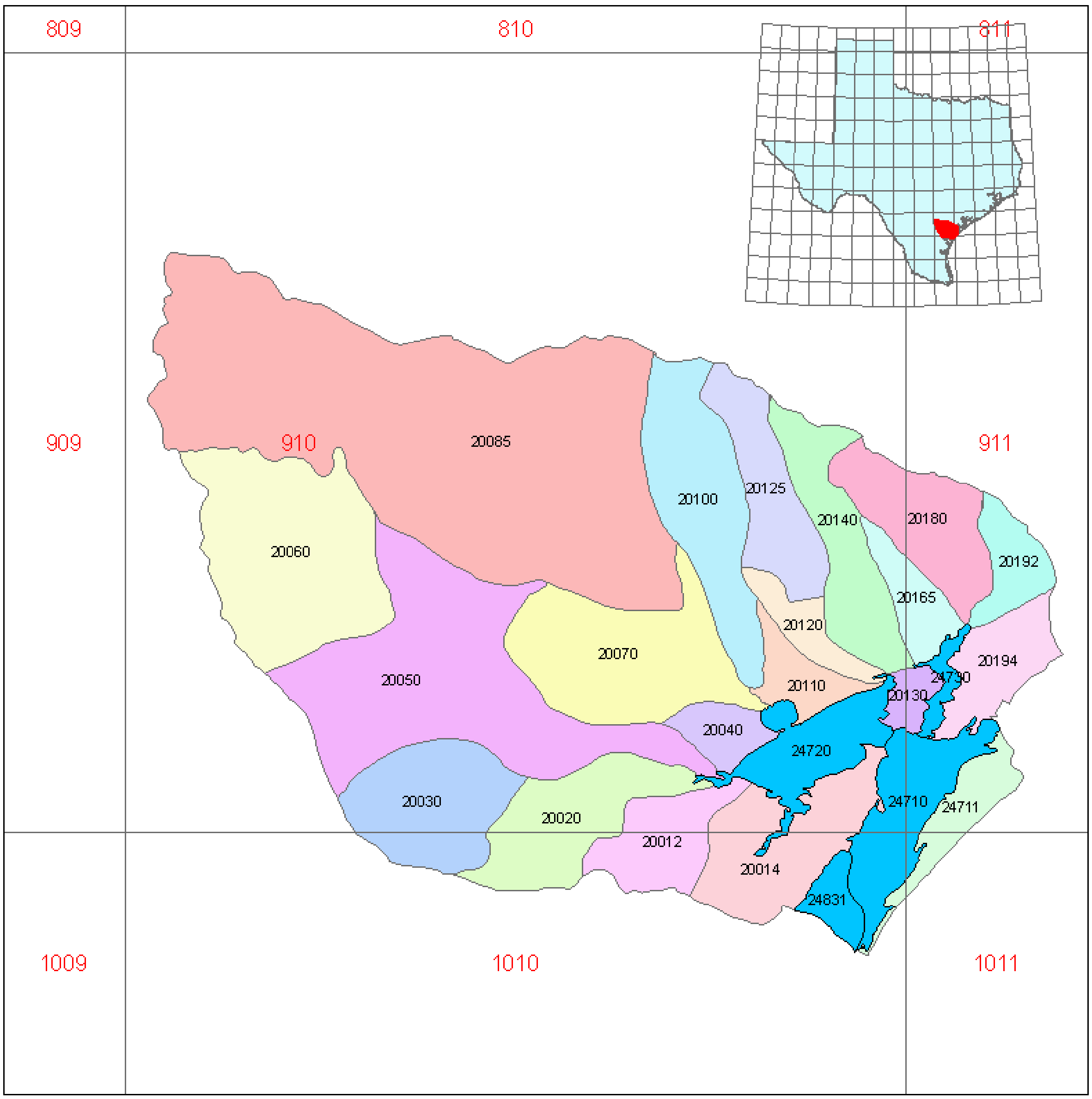


Figure 6. TWDB evaporation quadrangles used to estimate evaporation for the Mission-Aransas Estuary. Quadrangles 910, 911, 1010, and 1011 are used to estimate evaporation from the Mission-Aransas Estuary segments #24720, #24730, #24710, and #24831.

**Hydrology: Version #TWDB201001**

TWDB coastal hydrology version #TWDB201001 for the Mission-Aransas Estuary included gaged and ungaged inflows through December 2008. There were no diversion permits found for the period 1941 through 1976 or in the raw diversion data obtained from the South Texas Water Master (STWM) for the period from 1989 through October 2005. Although the TWDB coastal hydrology database includes a few diversions in the 1980's, the permit owners are unknown at this time. Industrial and municipal return flow data was obtained from the Texas Department of Water Resources (TDWR) self-reporting system from 1941 through 1976 and from TCEQ for the period from 1977 to 2007. Additional return flow data was obtained from TWDB's agricultural return flow estimates through December 2005.

**Hydrology: Version #TWDB201004**

TWDB coastal hydrology version #TWDB201004 for the Mission-Aransas Estuary extended the gaged data through November 2009 and used provisional data for December 2009. Ungaged inflows were updated from coastal hydrology version #TWDB201001 using approved daily precipitation data from the National Weather Service through November 2009, with provisional data for December 2009. Diversions were the same as in version #TWDB201001, but additional data from the STWM extended the dataset to 2009. Return flows were the same as in version #TWDB201001 and additional data obtained from TCEQ was updated through December 2009, and agricultural return flows data obtained from TWDB were extended to December 2007. Figure 7 displays the combined freshwater inflow to the Mission-Aransas Estuary as calculated by this version.

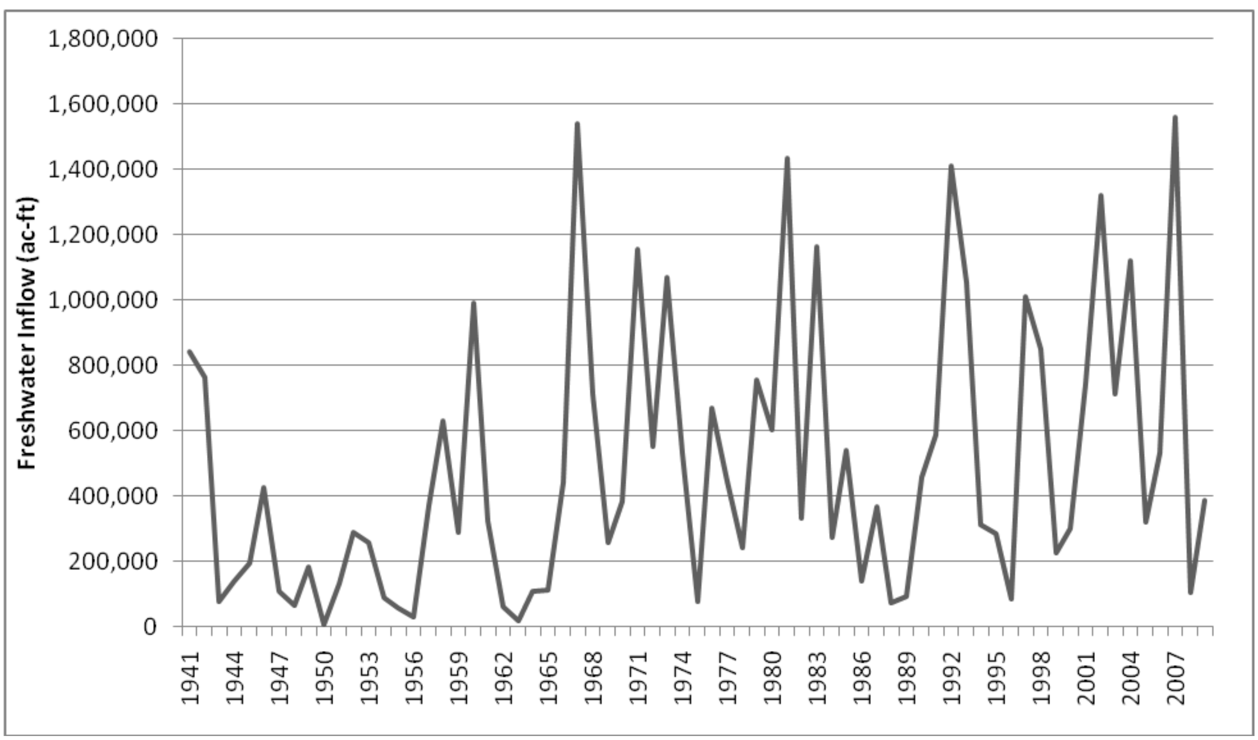


Figure 7: Combined freshwater inflow to the Mission-Aransas Estuary as calculated for version #TWDB201004.

## Conclusion

Version #TWDB201004 of coastal hydrology for the Mission-Aransas Estuary is the most up-to-date data set representing not only combined freshwater inflows but also the individual components of inflows (*i.e*., gaged flows, ungaged flows, diversions, return flows) for this estuary. Appendix A summarizes recent updates, by version, to hydrology for the Mission-Aransas Estuary. Appendix B lists the annual combined freshwater inflow along with the four components, as well as estimates for evaporation and precipitation on the estuary and the total freshwater inflow balance of the Mission-Aransas Estuary. Appendix C lists summary statistics for the inflow components over the 1941 through 2009 period.

Over the period from 1941 to 2009, gaged inflow from the Mission and Aransas Rivers accounted for approximately 29 percent of combined inflow, while ungaged flows accounted for nearly 70 percent of combined inflow. In general, net diversions accounted for only a small percent of the combined freshwater inflow to the estuary. In the Mission and Aransas river basins, annual average diversions total 0.02 percent of combined freshwater inflows, and annual average return flows total 0.94 percent of inflows. The difference then between diversions and returns accounts for 0.92 percent of the total combined freshwater inflow to the estuary. Nonetheless, it is still important to obtain the best data to allow for the most accurate representation of coastal hydrology and total freshwater inflows to the Mission-Aransas Estuary. Average combined surface inflow to the Mission-Aransas Estuary over the study period was approximately 490,000 acre-feet per year and the median surface inflow was approximately 366,000 acre-feet per year.

Finally, when considering total freshwater inflow balance, evaporation from and precipitation onto the surface of the estuary also must be considered. In 24 out of 69 years, there is a negative freshwater inflow balance, which indicates that evaporation exceeded precipitation and combined inflow to the estuary during periods of extreme drought. During the study period, annual average evaporation was approximately 583,000 acre-feet, while annual average precipitation was 373,000 acre-feet over the surface of the Mission-Aransas estuary. Surface evaporation from the Mission-Aransas estuary, when compared to both combined freshwater inflow and precipitation input, was 68% of the freshwater inflow balance. For the 1941 through 2009 period, the average freshwater inflow balance for the Mission-Aransas estuary was approximately 280,000 acre-feet per year. However, as Appendix B shows, wide variations from the mean freshwater inflow balance occur as a result of drought and flood conditions.

## Literature Cited

TDWR. 1981. *Nueces and Mission-Aransas Estuaries: A study of the influence of freshwater inflows*. LP-108. Texas Department of Water Resources, Austin, Texas.

Guthrie, C.G. and Q.Lu. 2010. Coastal Hydrology for the Guadalupe Estuary: Updated Hydrology with Emphasis on Diversion and Return Flow Data for 2000-2009. Texas Water Development Board, Austin, Texas.

**Appendix A:** Record of Coastal Hydrology Versions Developed by the TWDB Bays & Estuaries Program

<table>
<tr><th>Estuary</th><th>Version</th><th>Date Range</th><th>Gaged Flows</th><th>Ungaged Flows</th><th>Diversions</th><th>Return Flows</th><th>Creation Date</th></tr>
<tr><td rowspan="4">Mission-Aransas</td><td>TWDB201001</td><td>1941-2008</td><td>1941-2008</td><td>1941-2008</td><td>1941-2005<br><br>STWM<br>1989-10/2005</td><td>1941-2007<br><br>TDWR<br>1941-1976<br><br>TCEQ<br>1977-2007<br><br>TWDB 1977-2005 (Agricultural)</td><td>01/2010</td></tr>
<tr><td>TWDB201002</td><td colspan="6">Dataset does not exist.</td></tr>
<tr><td>TWDB201003</td><td colspan="6">Dataset does not exist.</td></tr>
<tr><td>TWDB201004</td><td>1941-2009</td><td>1941-2009, provisional 12/09</td><td>1941-2009, Precipitation data provisional for 12/09</td><td>1941-2009<br><br>STWM<br>1989-2009</td><td>1941-2009<br><br>TDWR<br>1941-1976<br><br>TCEQ<br>1977-2009<br><br>TWDB 1977-2007 (Agricultural)</td><td>09/2010</td></tr>
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**Appendix B:** Annual Hydrology for the Mission-Aransas Estuary, Version #TWDB201004. Included are estimates of gaged and ungaged (modeled) inflows, diversions and return flows, combined surface inflow to the estuary, as well as evaporation and direct precipitation on the estuary and the total freshwater balance of the estuary. All values are in units of acre-feet.

| Year | Gage | Model | Diversion | Return | Surface Inflow | Evaporation | Precipitation | Freshwater Balance |
|---|---|---|---|---|---|---|---|---|
| 1941 | 219,803 | 623,229 | 0 | 0 | 843,032 | 457,000 | 473,435 | 859,467 |
| 1942 | 262,749 | 501,053 | 0 | 0 | 763,802 | 448,000 | 404,849 | 720,651 |
| 1943 | 35,025 | 41,629 | 0 | 0 | 76,654 | 543,000 | 263,866 | -202,480 |
| 1944 | 48,814 | 89,152 | 0 | 0 | 137,966 | 476,000 | 344,836 | 6,802 |
| 1945 | 36,359 | 157,883 | 0 | 0 | 194,242 | 533,000 | 336,261 | -2,497 |
| 1946 | 83,160 | 344,549 | 0 | 0 | 427,709 | 487,000 | 447,713 | 388,422 |
| 1947 | 59,378 | 48,831 | 0 | 0 | 108,209 | 506,000 | 291,490 | -106,301 |
| 1948 | 5,681 | 60,294 | 0 | 0 | 65,975 | 534,000 | 282,917 | -185,108 |
| 1949 | 33,262 | 148,509 | 0 | 0 | 181,771 | 503,000 | 385,797 | 64,568 |
| 1950 | 2,677 | 4,826 | 0 | 0 | 7,503 | 571,000 | 158,128 | -405,369 |
| 1951 | 28,230 | 105,086 | 0 | 0 | 133,316 | 581,000 | 294,349 | -153,335 |
| 1952 | 102,799 | 185,744 | 0 | 0 | 288,543 | 580,000 | 276,249 | -15,208 |
| 1953 | 38,274 | 217,717 | 0 | 0 | 255,991 | 553,000 | 315,304 | 18,295 |
| 1954 | 4,431 | 82,384 | 0 | 0 | 86,815 | 628,000 | 203,855 | -337,330 |
| 1955 | 3,875 | 53,053 | 0 | 0 | 56,928 | 742,000 | 224,809 | -460,263 |
| 1956 | 8,078 | 14,428 | 0 | 7,000 | 29,506 | 705,000 | 215,285 | -460,209 |
| 1957 | 111,735 | 251,719 | 0 | 7,000 | 370,454 | 600,000 | 377,223 | 147,677 |
| 1958 | 144,141 | 479,856 | 0 | 7,000 | 630,997 | 467,000 | 432,473 | 596,470 |
| 1959 | 45,931 | 232,007 | 0 | 9,000 | 286,938 | 599,000 | 434,378 | 122,316 |
| 1960 | 156,612 | 823,953 | 0 | 9,000 | 989,565 | 582,000 | 558,215 | 965,780 |
| 1961 | 58,922 | 256,306 | 0 | 9,000 | 324,228 | 542,000 | 347,694 | 129,922 |
| 1962 | 36,622 | 15,304 | 0 | 9,000 | 60,926 | 667,000 | 261,960 | -344,114 |
| 1963 | 4,613 | 2,365 | 0 | 11,000 | 17,978 | 627,000 | 198,138 | -410,884 |
| 1964 | 11,985 | 83,785 | 0 | 11,000 | 106,770 | 600,000 | 261,963 | -231,267 |
| 1965 | 48,267 | 54,631 | 0 | 11,000 | 113,898 | 560,000 | 305,780 | -140,322 |
| 1966 | 105,499 | 326,999 | 0 | 11,000 | 443,498 | 515,000 | 326,737 | 255,235 |
| 1967 | 526,022 | 1,005,120 | 0 | 11,000 | 1,542,142 | 609,000 | 482,007 | 1,415,149 |
| 1968 | 122,031 | 579,369 | 0 | 13,000 | 714,400 | 506,000 | 488,676 | 697,076 |
| 1969 | 72,212 | 174,141 | 0 | 13,000 | 259,353 | 630,000 | 372,460 | 1,813 |
| 1970 | 73,723 | 293,522 | 0 | 14,000 | 381,245 | 591,000 | 405,801 | 196,046 |
| 1971 | 575,207 | 567,252 | 0 | 14,000 | 1,156,459 | 603,000 | 421,042 | 974,501 |
| 1972 | 248,755 | 288,225 | 0 | 14,000 | 550,980 | 524,000 | 406,753 | 433,733 |
| 1973 | 475,001 | 582,150 | 0 | 14,000 | 1,071,151 | 530,000 | 492,486 | 1,033,637 |
| 1974 | 157,347 | 361,301 | 0 | 14,000 | 532,648 | 582,000 | 442,001 | 392,649 |
| 1975 | 43,335 | 23,898 | 0 | 11,000 | 78,233 | 565,000 | 308,000 | -178,767 |
| 1976 | 313,240 | 341,599 | 0 | 13,000 | 667,839 | 554,000 | 468,000 | 581,839 |
| 1977 | 141,904 | 302,670 | 0 | 2,663 | 447,237 | 674,051 | 364,231 | 137,417 |

| Year | Gage | Model | Diversion | Return | Surface Inflow | Evaporation | Precipitation | Freshwater Balance |
|---|---|---|---|---|---|---|---|---|
| 1978 | 115,249 | 122,594 | 0 | 2,480 | 240,323 | 645,303 | 354,312 | -50,668 |
| 1979 | 196,633 | 557,621 | 0 | 2,739 | 756,993 | 614,076 | 547,375 | 690,292 |
| 1980 | 165,705 | 434,414 | 0 | 1,658 | 601,777 | 707,112 | 349,314 | 243,979 |
| 1981 | 471,440 | 961,019 | 36 | 2,208 | 1,434,631 | 623,658 | 601,028 | 1,412,001 |
| 1982 | 139,482 | 190,128 | 45 | 1,952 | 331,517 | 688,483 | 266,682 | -90,284 |
| 1983 | 261,437 | 898,610 | 0 | 2,265 | 1,162,312 | 651,548 | 505,662 | 1,016,426 |
| 1984 | 67,245 | 204,064 | 37 | 2,444 | 273,716 | 749,864 | 290,438 | -185,710 |
| 1985 | 126,505 | 410,152 | 32 | 2,665 | 539,290 | 640,568 | 427,902 | 326,624 |
| 1986 | 45,745 | 92,422 | 23 | 2,306 | 140,450 | 746,956 | 350,598 | -255,908 |
| 1987 | 151,820 | 217,186 | 5,804 | 2,390 | 365,592 | 719,175 | 382,596 | 29,013 |
| 1988 | 15,841 | 56,553 | 18 | 2,018 | 74,394 | 634,645 | 259,838 | -300,413 |
| 1989 | 3,286 | 87,246 | 17 | 1,852 | 92,367 | 548,174 | 236,132 | -219,675 |
| 1990 | 214,070 | 242,522 | 0 | 1,892 | 458,484 | 572,299 | 317,046 | 203,231 |
| 1991 | 162,806 | 423,751 | 0 | 2,117 | 588,674 | 565,512 | 546,972 | 570,134 |
| 1992 | 355,862 | 1,053,362 | 0 | 2,781 | 1,412,005 | 500,689 | 425,136 | 1,336,452 |
| 1993 | 255,049 | 796,805 | 0 | 2,394 | 1,054,248 | 602,660 | 397,677 | 849,265 |
| 1994 | 103,393 | 205,842 | 0 | 1,977 | 311,212 | 497,784 | 296,538 | 109,966 |
| 1995 | 32,895 | 247,815 | 0 | 3,789 | 284,499 | 521,476 | 377,707 | 140,730 |
| 1996 | 28,553 | 51,518 | 0 | 3,778 | 83,849 | 556,577 | 192,953 | -279,775 |
| 1997 | 299,426 | 708,101 | 0 | 4,065 | 1,011,592 | 554,661 | 538,646 | 995,577 |
| 1998 | 301,923 | 543,970 | 0 | 3,941 | 849,834 | 591,382 | 428,117 | 686,569 |
| 1999 | 36,633 | 186,141 | 0 | 3,298 | 226,072 | 551,579 | 465,546 | 140,039 |
| 2000 | 24,042 | 273,549 | 0 | 2,567 | 300,158 | 671,170 | 381,441 | 10,429 |
| 2001 | 385,955 | 357,397 | 0 | 2,099 | 745,451 | 583,517 | 323,714 | 485,648 |
| 2002 | 225,341 | 1,093,435 | 0 | 2,590 | 1,321,366 | 563,826 | 530,126 | 1,287,666 |
| 2003 | 106,469 | 602,926 | 0 | 3,104 | 712,499 | 472,284 | 387,971 | 628,186 |
| 2004 | 413,158 | 705,719 | 0 | 3,098 | 1,121,975 | 468,820 | 594,562 | 1,247,717 |
| 2005 | 124,984 | 192,852 | 0 | 2,315 | 320,151 | 622,738 | 264,702 | -37,885 |
| 2006 | 62,250 | 467,072 | 0 | 2,305 | 531,627 | 625,456 | 522,172 | 428,343 |
| 2007 | 395,194 | 1,161,317 | 0 | 3,226 | 1,559,737 | 528,791 | 528,811 | 1,559,757 |
| 2008 | 14,358 | 87,450 | 0 | 2,364 | 104,172 | 634,300 | 228,710 | -301,418 |
| 2009 | 120,827 | 263,185 | 0 | 2,394 | 386,406 | 586,431 | 343,597 | 143,572 |

*Surface Inflow = Gage + Model - Diversion + Return

**Freshwater Balance = Surface Inflow - Evaporation+ Precipitation

**Appendix C:** Summary statistics for annual freshwater inflow (in acre-feet) over the 1941-2009 period for the Mission-Aransas Estuary, Version #TWDB201004.

| | Gage | Model | Diversion | Return | Surface Inflow* | Evaporation | Precipitation | Freshwater Balance** |
|---|---|---|---|---|---|---|---|---|
| MIN | 2,677 | 2,365 | 0 | 0 | 7,503 | 448,000 | 158,128 | -460,263 |
| 5%ile | 4,504 | 18,742 | 0 | 0 | 58,527 | 470,206 | 208,427 | -380,867 |
| 10%ile | 11,204 | 50,981 | 0 | 0 | 76,202 | 495,627 | 234,648 | -300,614 |
| 25%ile | 36,622 | 92,422 | 0 | 1,892 | 137,966 | 533,000 | 291,490 | -140,322 |
| MEDIAN | 105,499 | 251,719 | 0 | 2,567 | 365,592 | 581,000 | 372,460 | 140,039 |
| MEAN | 143,033 | 342,337 | 87 | 4,605 | 489,888 | 582,834 | 373,032 | 280,085 |
| 75%ile | 214,070 | 501,053 | 0 | 9,000 | 714,400 | 627,000 | 442,001 | 628,186 |
| 90%ile | 361,881 | 802,235 | 17 | 13,000 | 1,128,872 | 676,937 | 529,074 | 1,019,868 |
| 95%ile | 448,127 | 987,480 | 34 | 14,000 | 1,375,749 | 714,350 | 547,214 | 1,316,938 |
| MAX | 575,207 | 1,161,317 | 5,804 | 14,000 | 1,559,737 | 749,864 | 601,028 | 1,559,757 |
| TOTAL All Years | 9,869,275 | 23,621,277 | 6,012 | 317,734 | 33,802,274 | 40,215,565 | 25,739,182 | 19,325,891 |
| % of Total Surface Inflow | 29.20 | 69.88 | 0.02 | 0.94 | 100 | - | - | - |