Using Water Availability Models to Assess Alterations in Instream Flows

Draft Report

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The Texas Parks and Wildlife Department (TPWD) is the state agency with primary responsibility for protecting the state’s fish and wildlife resources. Related to that responsibility, TPWD provides data and recommendations to conserve those resources to local, state, and federal agencies or private organizations that make decisions affecting them. In addition, the agency makes recommendations to the Texas Commission on Environmental Quality (TCEQ) on scheduling of instream flows and freshwater inflows to Texas estuaries for the management of fish and wildlife resources.

Toward those ends, TPWD has a history of evaluating water development through intensive field studies as well as through desktop or in-office methods. The recent completion of updated water availability models (WAM) by TCEQ offered the opportunity to conduct a broad-scale assessment of instream flow alteration in Texas rivers and streams assuming full exercise of all existing water rights. The evaluation used output from WAMs officially accepted by TCEQ and benchmark instream flow values as a basis for comparing different flow scenarios. These benchmarks are estimates of flow values needed to support adequate instream habitat condition and these are not intended to replace criteria currently in use in planning and permitting processes. Instead the benchmarks were used to help evaluate the overall status, from a fish and wildlife conservation perspective, of hydrologic alteration in river basins throughout the state.

Methods

Water availability model data.—Hydrologic data were assembled from WAM monthly naturalized flows and two regulated flow scenarios: current conditions (i.e., maximum reported water use of the last ten years and minimum return flow ratio for the last 5 years - WAM run 8) and full authorization (i.e. full permitted use and no return flows - WAM run 3). The WAM files were downloaded from the TCEQ website on August 21, 2003 (TCEQ 2003). The WAM for the Rio Grande is currently under development (Steve Densmore, TCEQ personal communication) and is not included in this evaluation.

The current conditions and full authorization scenarios were run for each WAM and the naturalized and regulated flows were extracted from the output file. Since the analysis in this report is limited to primary control points, the WAM input files were modified to output only data for those points in the WAMs that have inflow records. U.S. Geological Survey (USGS) gage name and number were then related to the WAM control point outputs. Detailed descriptions of how the naturalized flow values were derived can be found in Deliverable 5 of the specific WAM study. In general, those preparing the WAMs summed USGS daily flow data to a monthly value and removed the effects of human use of water (diversions, storage and returns). Further, if data for the full period of record was not available statistical regressions to a similar or nearby reference gage were developed and the record extended or missing values filled in. Lastly, naturalized flows were further adjusted to account for negative incremental inflows prior to use in the WAMs and in some cases within the model simulation.

Conversion to daily time-step.—Daily flow records were developed for naturalized, current conditions and full authorization runs at four selected points in each basin or subbasin. Larger basins were subdivided into two to three parts. Long-term daily flow patterns were developed for the selected points. The goal was to find a daily pattern reflective of a natural hydrograph at the site. In some cases a full record was available from the USGS gage while in other cases missing dates needed to be filled with flow records from nearby, similar gages. In addition to filling missing dates, major impacts to natural flows such as reservoirs, return flows and changes in spring flow or recharge rates were identified and, where possible, alternative flow records were substituted. Appendix A details the reference gages used and the potential impacts to natural flows. Monthly values from the WAM runs were converted to daily by applying the following equation 1


\[ DQ = MQ \times \frac{DGQ}{MGQ} \quad (1) \]

where:  
- DQ – daily flow  
- MQ – monthly flow from the WAM  
- DGQ – daily flow from time series developed from USGS gage(s)  
- MGQ – daily flow from time series developed from USGS gage(s) summed to a monthly value

In our conversion of the monthly WAM naturalized flow series to a daily time step we did not make specific adjustments to account for negative incremental inflows. We cannot determine at this time how the adjustment might influence our results however the conversion method we employed is consistent with past and current water planning efforts (e.g., reservoir firm yield estimates in regional water planning).

**Instream flow benchmarks.**—Benchmarks were determined by month at specific locations from each WAM river basin by calculating the median daily naturalized flow for that month and multiplying that value by 0.6 (March through September) or 0.4 (October through February). These benchmarks are similar to those derived from the Lyon’s method (Bounds and Lyons 1979) in that they are the same percentages of the daily median flow for a given month. However, in order to provide a consistent approach for this statewide evaluation, our analysis is based on naturalized daily flows derived from WAM input files rather than historical gage data as employed by TCEQ (TNRCC 1995). Developing Lyons values from gaged data at each location would have involved substantial judgment decisions regarding appropriate period of records and consideration of heavily modified stream flow records. Since this report attempts to apply a single consistent standard to locations throughout the state, this proved infeasible. Also this provides a static value that can be compared over time, unlike the gaged flows that may change with new permit implementation, new diversions, etc. Median flows (i.e., 50\textsuperscript{th} percentile; normal flow conditions) and 10\textsuperscript{th} percentile flows (low flow conditions) were also calculated.

**Comparison of flow scenarios.**—For each selected point, exceedance of the instream flow benchmark under full authorization flow conditions was compared to naturalized flow conditions. If the percent of days in which instream flow benchmarks were met or exceeded fell by 25% or more for three consecutive months the location was classified as subject to high alteration. For example, if the flow benchmark was 100 cubic feet per second (cfs) in a given month and flow under natural conditions was equal to or greater than 100 cfs 80% of the days and flow under full authorization was equal to or greater than 100 cfs only 60% of the days then there was a 25% drop in the percent of days meeting or exceeding the benchmark. Should this have occurred for three consecutive months the flow at this point was classified as high alteration. Similarly, medium alteration represents a drop of 10-24% and low alteration represent a drop of less than 10%. Low alteration may also include situations where flow benchmarks were met more often under full authorization than under natural conditions.

**Results**

Bar charts illustrate the percent of days when an instream flow benchmark was met or exceeded under three flow scenarios: naturalized, current conditions and full authorization. Instream flow benchmarks are displayed horizontally across the top of each graph. Color-coded maps for each basin were produced to indicate the level of instream flow alteration relative to naturalized flow conditions at each location (labeled A through D). The maps include major cities, rivers and reservoirs (both existing and proposed) and SB1 regional planning group boundaries. Normal (median) and low (10\textsuperscript{th} percentile) flow conditions are presented in separate figures as supplementary data intended to provide a context within which to view the primary analysis.

**Discussion**

It is hoped that the framework presented here will lend itself to further exploration of instream flow alterations and the effects of future water planning and permitting strategies. Color-coded maps illustrate the predicted level of instream flow alteration assuming full use of currently permitted water. A similar map could be developed for the adopted water plans once recommended strategies are modeled in the WAMs. The instream flow alteration classifications are intended to distinguish amongst a wide array of statewide data and may also need to be refined according to the needs and priorities of specific regions. Likewise, while the statistics presented in this report are reasonable, given readily available data, there is no doubt that they could be refined and expanded by regional experts.

Instream flow needs are far more complex than a single set of monthly values; protecting fish and wildlife resources requires more than meeting flow benchmarks a certain percent of the time. Chemical,
biological, and physical factors must also be considered. Thus, the results of this evaluation should not be used as final determinations of instream flow needs since no attempt has been made to address these factors.

References


Texas Parks and Wildlife Department, Austin, Texas.


Canadian River Basin

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

Percent of days when instream flow benchmarks are met or exceeded
- Naturalized
- Current Conditions
- Full Authorization

A
Palo Duro Ck nr Spearman
Instream Flow Benchmark (cfs)

B
Wolf Ck at Lipscomb
Instream Flow Benchmark (cfs)

C
Canadian Rv nr Amarillo
Instream Flow Benchmark (cfs)

D
Canadian Rv nr Canadian
Instream Flow Benchmark (cfs)
Canadian River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

A. Palo Duro Ck nr Spearman

B. Wolf Ck at Lipscomb

C. Canadian Rv nr Amarillo

D. Canadian Rv nr Canadian

Low Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

A. Palo Duro Ck nr Spearman

B. Wolf Ck at Lipscomb

C. Canadian Rv nr Amarillo

D. Canadian Rv nr Canadian
Red River Basin

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

Percent of days when instream flow benchmarks are met or exceeded

<table>
<thead>
<tr>
<th>Region</th>
<th>Instream Flow Benchmark (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Pr Dog Twn Fk Red Rv nr Childress</td>
</tr>
<tr>
<td>B</td>
<td>Wichita Rv at Wichita Falls</td>
</tr>
<tr>
<td>C</td>
<td>Red Rv nr Gainesville</td>
</tr>
<tr>
<td>D</td>
<td>Red Rv at Index</td>
</tr>
</tbody>
</table>

Instream Flow Benchmark (cfs)

- High (>25%)
- Medium (>10%)
- Low (<10%)
Red River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Low Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Graphs showing flow conditions at various locations throughout the year.
Instream Flow Alteration

- High (>25%)
- Medium (>10%)
- Low (<10%)

Percent of days when instream flow benchmarks are met or exceeded

- Naturalized
- Current Conditions
- Full Authorization

Sulphur River Basin

Instream Flow Alteration Map

- North Sulphur River
- South Sulphur River
- Sulphur River Region D

A

N Sulphur River at Cooper
Instream Flow Benchmark (cfs)

B

S Sulphur River at Cooper
Instream Flow Benchmark (cfs)

C

Sulphur River at Talco
Instream Flow Benchmark (cfs)

D

Sulphur River at State Line
Instream Flow Benchmark (cfs)
Sulphur River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Low Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Graphs showing flow conditions for different locations in the Sulphur River Basin.
Cypress River Basin

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

Percent of days when instream flow benchmarks are met or exceeded
- Naturalized
- Current Conditions
- Full Authorization

A

Big Cypress Ck nr Pittsburg
Instream Flow Benchmark (cfs)

B

Big Cypress Ck nr Jefferson
Instream Flow Benchmark (cfs)

C

Little Cypress Ck nr Jefferson
Instream Flow Benchmark (cfs)

D

Downstream of Caddo Lake
Instream Flow Benchmark (cfs)
Cypress River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

**Big Cypress Ck nr Pittsburg**

**Big Cypress Ck nr Jefferson**

**Little Cypress Ck nr Jefferson**

**Downstream of Caddo Lake**

Low Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

**Big Cypress Ck nr Pittsburg**

**Big Cypress Ck nr Jefferson**

**Little Cypress Ck nr Jefferson**

**Downstream of Caddo Lake**
Sabine River Basin

Percent of days when instream flow benchmarks are met or exceeded

- Naturalized
- Current Conditions
- Full Authorization

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

Instream Flow Benchmark (cfs)

A

Sabine Rv nr Gladewater

B

Sabine Rv nr Beckville

C

Sabine Rv at Toledo Bd Res nr Burkeville

D

Sabine Rv nr Ruliff

Instream Flow Benchmark (cfs)
Sabine River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Low Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Graphs showing flow conditions at Sabine River Basin locations.
### Neches River Basin

#### Instream Flow Alteration
- **High** (>25%)
- **Medium** (>10%)
- **Low** (<10%)

#### Percent of days when instream flow benchmarks are met or exceeded

<table>
<thead>
<tr>
<th>Location</th>
<th>Naturalized</th>
<th>Current Conditions</th>
<th>Full Authorization</th>
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</thead>
<tbody>
<tr>
<td><strong>A</strong> Neches River at Neches</td>
<td><img src="image" alt="Graph A" /></td>
<td><img src="image" alt="Graph A" /></td>
<td><img src="image" alt="Graph A" /></td>
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<tr>
<td><strong>B</strong> Neches River at Rockland</td>
<td><img src="image" alt="Graph B" /></td>
<td><img src="image" alt="Graph B" /></td>
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<tr>
<td><strong>C</strong> Sam Rayburn Reservoir at Jasper</td>
<td><img src="image" alt="Graph C" /></td>
<td><img src="image" alt="Graph C" /></td>
<td><img src="image" alt="Graph C" /></td>
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<tr>
<td><strong>D</strong> Neches River at Evadale</td>
<td><img src="image" alt="Graph D" /></td>
<td><img src="image" alt="Graph D" /></td>
<td><img src="image" alt="Graph D" /></td>
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</table>
Neches River Basin (cont.)

Normal Flow Conditions

<table>
<thead>
<tr>
<th>Location</th>
<th>Naturalized</th>
<th>Current Conditions</th>
<th>Full Authorization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neches Rv nr Neches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neches Rv nr Rockland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sam Rayburn Res nr Jasper</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Neches Rv at Evadale</td>
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</tr>
</tbody>
</table>

Low Flow Conditions

<table>
<thead>
<tr>
<th>Location</th>
<th>Naturalized</th>
<th>Current Conditions</th>
<th>Full Authorization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neches Rv nr Neches</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Neches Rv nr Rockland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sam Rayburn Res nr Jasper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neches Rv at Evadale</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Upper Trinity River Basin

Percent of days when instream flow benchmarks are met or exceeded
- Naturalized
- Current Conditions
- Full Authorization

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

Instream Flow Alteration

Trinity River
- Region C
- Region D
- Region B
- Region G

Elm Fork Trinity River
- Region A
- Region I

West Fork Trinity River
- Region B
- Region C
- Region D
- Region G

Dallas
- Region A
- Region I

Fort Worth
- Region C
- Region G

W Fk Trinity Rv at Ft Worth
Instream Flow Benchmark (cfs)

Trinity Rv at Dallas
Instream Flow Benchmark (cfs)

W Fk Trinity Rv at Grand Prairie
Instream Flow Benchmark (cfs)

Trinity Rv nr Rosser
Instream Flow Benchmark (cfs)
Upper Trinity River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

<table>
<thead>
<tr>
<th>Location</th>
<th>Flow (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W Fk Trinity Rv at Ft Worth</td>
<td>Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec</td>
</tr>
<tr>
<td>W Fk Trinity Rv at Grand Prairie</td>
<td>Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec</td>
</tr>
<tr>
<td>Trinity Rv at Dallas</td>
<td>Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec</td>
</tr>
<tr>
<td>Trinity Rv nr Rosser</td>
<td>Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec</td>
</tr>
</tbody>
</table>

Low Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

<table>
<thead>
<tr>
<th>Location</th>
<th>Flow (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W Fk Trinity Rv at Ft Worth</td>
<td>Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec</td>
</tr>
<tr>
<td>W Fk Trinity Rv at Grand Prairie</td>
<td>Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec</td>
</tr>
<tr>
<td>Trinity Rv at Dallas</td>
<td>Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec</td>
</tr>
<tr>
<td>Trinity Rv nr Rosser</td>
<td>Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec</td>
</tr>
</tbody>
</table>
Lower Trinity River Basin

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

Percent of days when instream flow benchmarks are met or exceeded
- Naturalized
- Current Conditions
- Full Authorization

Trinity River
Region I
Region H
Region G
Region C

Trinity Rv nr Oakwood
Instream Flow Benchmark (cfs)

Trinity Rv nr Midway
Instream Flow Benchmark (cfs)

Trinity Rv at Riverside
Instream Flow Benchmark (cfs)

Trinity Rv at Romayor
Instream Flow Benchmark (cfs)
Lower Trinity River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Low Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization
San Jacinto River Basin

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

Percent of days when instream flow benchmarks are met or exceeded
- Naturalized
- Current Conditions
- Full Authorization

A
W Fk San Jacinto Rv nr Conroe
Instream Flow Benchmark (cfs)

B
Spring Ck nr Spring
Instream Flow Benchmark (cfs)

C
E Fk San Jacinto Rv nr Cleveland
Instream Flow Benchmark (cfs)

D
Brays Bayou at Houston
Instream Flow Benchmark (cfs)
San Jacinto River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Low Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization
Upper Brazos River Basin

Percent of days when instream flow benchmarks are met or exceeded

- **Naturalized**
- **Current Conditions**
- **Full Authorization**

#### A
Salt Fork Brazos River near Aspermont
Instream Flow Benchmark (cfs)

#### B
DMF Brazos River near Aspermont
Instream Flow Benchmark (cfs)

#### C
Clear Fork Brazos River at Ft. Griffin
Instream Flow Benchmark (cfs)

#### D
Brazos River near South Bend
Instream Flow Benchmark (cfs)

---

Instream Flow Alteration
- **High (>25%)**
- **Medium (>10%)**
- **Low (<10%)**
Upper Brazos River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Low Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

(A) Salt Flk Brazos Rv nr Aspermont
(B) DMF Brazos Rv nr Aspermont
(C) Clear Flk Brazos Rv at Ft Griffin
(D) Brazos Rv nr South Bend
Middle Brazos River Basin

Percent of days when instream flow benchmarks are met or exceeded

- Naturalized
- Current Conditions
- Full Authorization

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

A

Brazos River at Palo Pinto
Instream Flow Benchmark (cfs)

B

Brazos River at Glen Rose
Instream Flow Benchmark (cfs)

C

Brazos River at Waco
Instream Flow Benchmark (cfs)

D

Little River at Cameron
Instream Flow Benchmark (cfs)
Middle Brazos River Basin (cont.)

Normal Flow Conditions

[Graphs showing water flow conditions across different locations]

Low Flow Conditions

[Graphs showing water flow conditions across different locations]
Lower Brazos River Basin

Percent of days when instream flow benchmarks are met or exceeded

- Naturalized
- Current Conditions
- Full Authorization

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

A
Brazos Rv nr Bryan
Instream Flow Benchmark (cfs)

B
Navasota Rv nr Easterly
Instream Flow Benchmark (cfs)

C
Brazos Rv nr Hempstead
Instream Flow Benchmark (cfs)

D
Brazos Rv at Richmond
Instream Flow Benchmark (cfs)
Lower Brazos River Basin (cont.)

Normal Flow Conditions

Low Flow Conditions
Upper Colorado River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Low Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization
Lower Colorado River Basin

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)
- Naturalized
- Current Conditions
- Full Authorization

Percent of days when instream flow benchmarks are met or exceeded

<table>
<thead>
<tr>
<th>Region</th>
<th>Instream Flow Benchmark (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Llano Rv at Llano</td>
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<tr>
<td>B</td>
<td>Pedernales Rv nr Johnson City</td>
</tr>
<tr>
<td>C</td>
<td>Colorado Rv at Austin</td>
</tr>
<tr>
<td>D</td>
<td>Colorado Rv at Bay City</td>
</tr>
</tbody>
</table>
Lower Colorado River Basin (cont.)

Normal Flow Conditions

Low Flow Conditions
Lavaca River Basin

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

Percent of days when instream flow benchmarks are met or exceeded
- Naturalized
- Current Conditions
- Full Authorization

A
Lavaca Rv nr Edna
Instream Flow Benchmark (cfs)

B
Navidad Rv nr Speaks
Instream Flow Benchmark (cfs)

C
Navidad Rv nr Ganado
Instream Flow Benchmark (cfs)

D
W Mustang Ck nr Ganado
Instream Flow Benchmark (cfs)
Lavaca River Basin (cont.)

Normal Flow Conditions

Low Flow Conditions
Guadalupe River Basin

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

Percent of days when instream flow benchmarks are met or exceeded

A
Guadalupe River near Spring Branch
Instream Flow Benchmark (cfs)

B
Guadalupe River near Comal River at New Braunfels
Instream Flow Benchmark (cfs)

C
San Marcos River at Luling
Instream Flow Benchmark (cfs)

D
Guadalupe River at Victoria
Instream Flow Benchmark (cfs)
Guadalupe River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Low Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization
San Antonio River Basin

Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

Percent of days when instream flow benchmarks are met or exceeded

A
San Antonio Rv nr Elmendorf
Instream Flow Benchmark (cfs)

B
San Antonio Rv nr Falls City
Instream Flow Benchmark (cfs)

C
Cibolo Ck nr Falls City
Instream Flow Benchmark (cfs)

D
San Antonio Rv at Goliad
Instream Flow Benchmark (cfs)
San Antonio River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Low Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization
Instream Flow Alteration
- High (>25%)
- Medium (>10%)
- Low (<10%)

Percent of days when instream flow benchmarks are met or exceeded
- Naturalized
- Current Conditions
- Full Authorization

Nueces River Basin

Instream Flow Aeration

- Nueces River at Cotulla
  - Instream Flow Benchmark (cfs)
- Frio River at Derby
  - Instream Flow Benchmark (cfs)
- Nueces River at Three Rivers
  - Instream Flow Benchmark (cfs)
- Nueces River at Mathis
  - Instream Flow Benchmark (cfs)
Nueces River Basin (cont.)

Normal Flow Conditions

- Naturalized
- Current Conditions
- Full Authorization

Nueces River at Cotulla

Frio River at Derby

Low Flow Conditions

Nueces River at Cotulla

Frio River at Derby

Nueces River at Three Rivers

Nueces River at Mathis
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<th>USGS</th>
<th>Name</th>
<th>Basin</th>
<th>Start</th>
<th>End</th>
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<th>Endstream</th>
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<th>Ref Name</th>
<th>Reason for using (or not using) reference gage</th>
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<td>7233500</td>
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<td>Canadian</td>
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<td>Fill in missing gage data</td>
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<tr>
<td>2</td>
<td>7235000</td>
<td>Wolf Ck at Lipscomb</td>
<td>Canadian</td>
<td>1/1/48</td>
<td>12/31/98</td>
<td>1/1/48</td>
<td>10/1/79</td>
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<td>Wolf Ck at Lipscomb</td>
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