

Review of Brazos BBEST High Flow Pulses

Presentation to Brazos BBASC

June 28, 2012

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Basic Approach of Brazos BBEST

- Adopted Environmental Flow Regime
- Mimic Natural Flow Patterns
- Critical Flow Components:
 - Magnitude
 - Frequency
 - Timing (seasonality)
 - Duration
 - Rate of Change in Flow

Basic Approach of Brazos BBEST

- Recommendations Protect Environmental Flow Regime by:

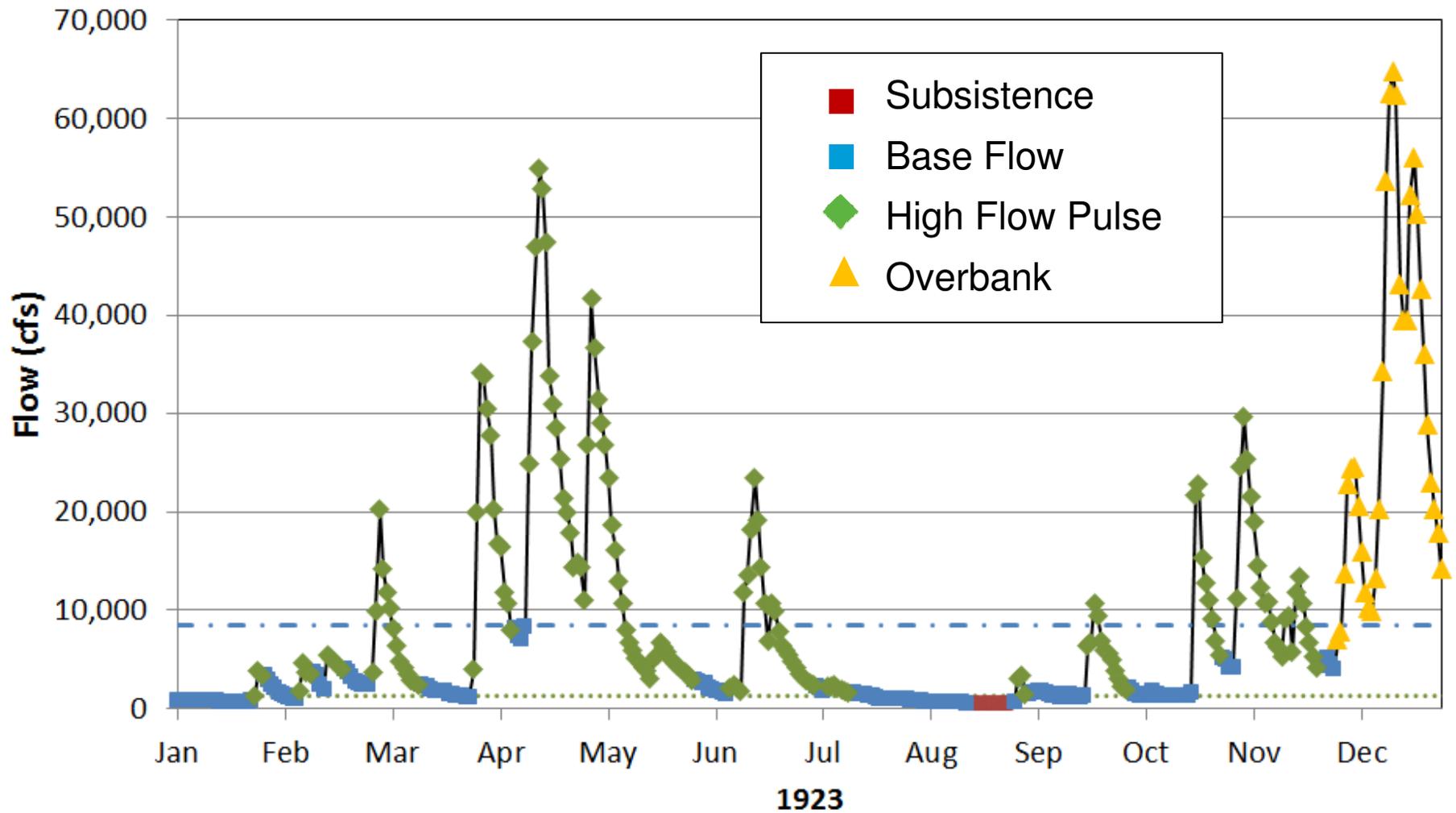
- Subsistence Flows
- Base Flows
- High Flow Pulses

**Each Element Has
Environmental Functions**

- Recommended Environmental Flows Vary:

- With Season
- Hydrologic Condition (wet, average, dry)

HEFR Flow Separation - Richmond





Designation of Flow Regime

- Used HEFR tool
- Based on statistical analysis of separated flows
- Flow recommendations example on following slide

Environmental Flow Recommendation

Brazos near Richmond

| | | | | | | | | | | | | |
|-------------------------|---|-----|-----|-----|---|-----|-----|-----|---|-----|-----|-----|
| High Flow Pulses | Overbank Events Qp: 68,100 cfs with Average Frequency 1 per 2 years Regressed Volume is 1,487,000 Duration Bound is 41 | | | | | | | | | | | |
| | Qp: 51,600 cfs with Average Frequency 1 per year Regressed Volume is 1,019,000 Duration Bound is 35 | | | | | | | | | | | |
| | Qp: 24,600 cfs with Average Frequency 1 per season Regressed Volume is 383,000 Duration Bound is 23 | | | | Qp: 35,000 cfs with Average Frequency 1 per season Regressed Volume is 617,000 Duration Bound is 29 | | | | Qp: 12,900 cfs with Average Frequency 1 per season Regressed Volume is 144,000 Duration Bound is 15 | | | |
| | Qp: 12,400 cfs with Average Frequency 2 per season Regressed Volume is 150,000 Duration Bound is 16 | | | | Qp: 16,300 cfs with Average Frequency 2 per season Regressed Volume is 215,000 Duration Bound is 19 | | | | Qp: 5,430 cfs with Average Frequency 2 per season Regressed Volume is 46,300 Duration Bound is 10 | | | |
| | Qp: 6,410 cfs with Average Frequency 3 per season Regressed Volume is 60,600 Duration Bound is 11 | | | | Qp: 8,930 cfs with Average Frequency 3 per season Regressed Volume is 94,000 Duration Bound is 13 | | | | Qp: 2,460 cfs with Average Frequency 3 per season Regressed Volume is 16,400 Duration Bound is 6 | | | |
| Base Flows (cfs) | 3,310 | | | | 3,980 | | | | 2,190 | | | |
| | 1,650 | | | | 2,140 | | | | 1,330 | | | |
| | 990 | | | | 1,190 | | | | 930 | | | |
| Subsistence Flows (cfs) | 550 | | | | 550 | | | | 550 | | | |
| | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct |
| | Winter | | | | Spring | | | | Summer | | | |

| | |
|------------------|--------------------|
| Base Flow Levels | High (75th %ile) |
| | Medium (50th %ile) |
| | Low (25th %ile) |

Pulse volumes are in units of acre-feet and durations are in days.

Period of record used : 1/1/1923 to 12/31/2010.

Episodic events are terminated when the volume or duration criteria are met, or when the flow drops below 1260 cfs, or when the flow is below 8430 cfs and the flow drops from one day to the next by less than 5%.



Environmental Functions

Pulse Flows

- High Flow Pulses/Overbank Flows (Pages 4-8 through 4-17)
 - Shape physical habitat
 - Sediment and nutrient transport
 - Flushing of silt
 - Other geomorphic and water quality functions
 - Increase success of fish reproduction
 - Lateral connectivity (oxbows, marshes, floodplains, etc.)



Determination of BBEST Recommended Pulse Flows

- Considered 8 pulse levels for each gage
 - 1, 2, 3, and 4 times per season
 - 1 and 2 times per year
 - 1 time in 2 years and one time in 5 years
- Eliminated twice per year
- Selected based on ecological significance
 - Flow magnitude changes
 - Lateral connectivity



Determination of BBEST Recommended Pulse Flows

- Five to seven levels at each location
- Generally only one overbank flow per location
- Considered Pulse Connectivity with Oxbow Habitats in the Lower Basin

BBEST Implementation

Recommendations – Pulse Flows

- Define Hydrologic Condition Using Palmer Hydrologic Drought Index Data (Pages 3-8 through 3-11)
 - Data published by National Climatic Data Center
 - Table 3.1 – Climatic zones to use for each gage
 - Table 3.2 – Boundaries for hydrologic condition by gage

BBEST Implementation

Recommendations – Pulse Flows

- Qualifying Pulse (for which Releases Are Required) Initiates When Flow Exceeds Pulse Peak Flow Magnitude
- Pulses Are Counted in the Season or Year They Begin
- If Flows Reach Trigger for a Greater Magnitude Event, Higher Pulse Controls
- Pulse Counts As One Pulse for All Lower Magnitude Events in the Season

Environmental Flow Recommendation

Brazos near Richmond

| | | | | | | | | | | | | |
|-------------------------|--|-----|-----|-----|---|-----|-----|-----|---|-----|-----|-----|
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| | 1,650 | | | | 2,140 | | | | 1,330 | | | |
| | 990 | | | | 1,190 | | | | 930 | | | |
| Subsistence Flows (cfs) | 550 | | | | 550 | | | | 550 | | | |
| | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct |
| | Winter | | | | Spring | | | | Summer | | | |

| | |
|------------------|--------------------|
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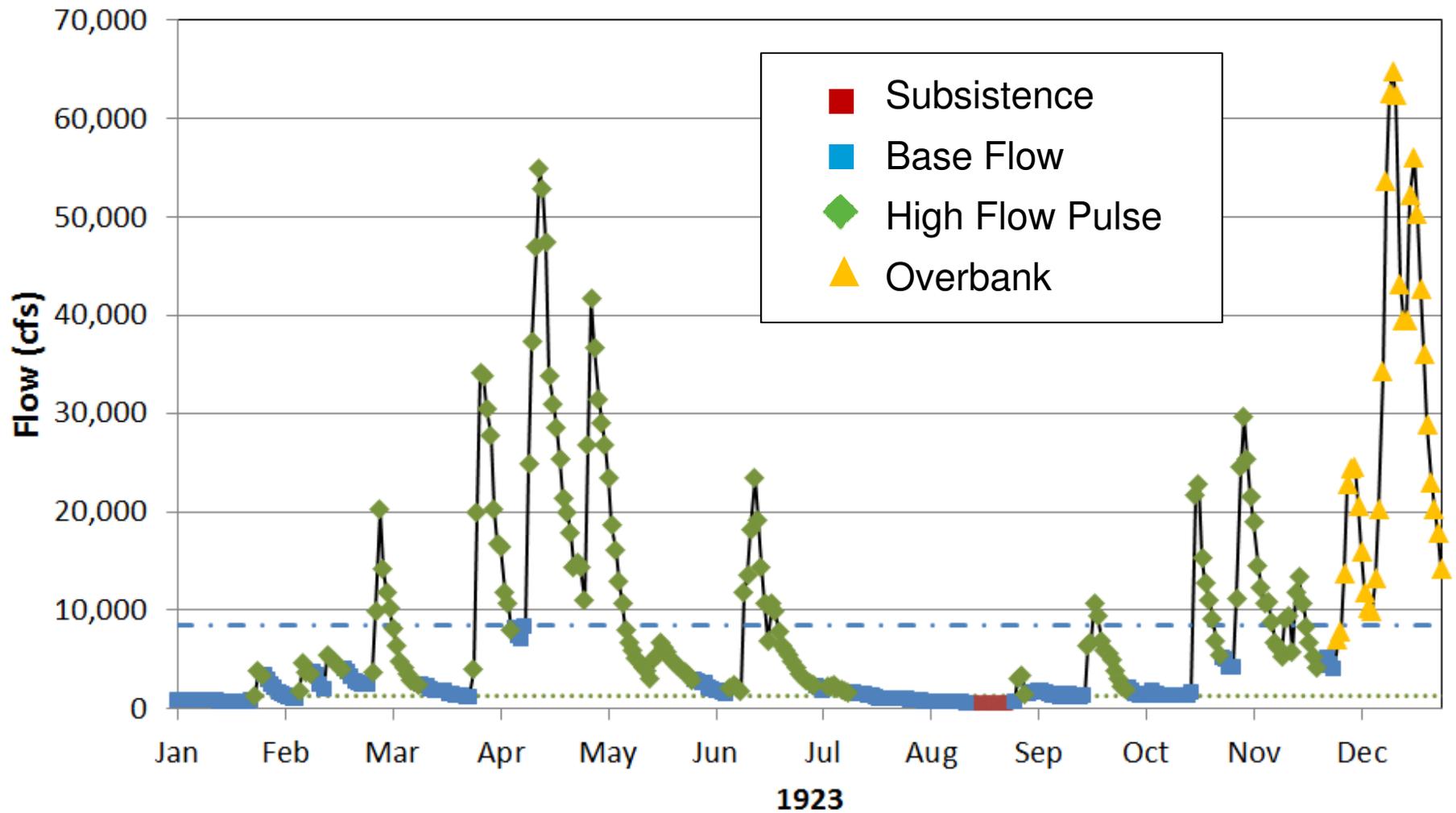
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BBEST Implementation

Recommendations – Pulse Flows

- Pulse Continues (Flows Are Passed up to the Pulse Peak Flow Magnitude) until:
 - The prescribed volume is passed
 - The daily flow is less than the *minimum flow for pulse flows*
 - The prescribed duration is met, or
 - The daily flow is less than *maximum flow for base flows* and decreases by 5 percent or less a day.
- Once Number of Pulses is Met for Year or Season, No Additional Qualifying Pulses Are Initiated (Bypasses Controlled by Base Flows)

HEFR Flow Separation - Richmond





Questions?

Double Mountain Fork Brazos River near Aspermont

| | | | | | | | | | | | | |
|-------------------------|---|-----|-----|---|--------|-----|-----|---|--------|-----|-----|-----|
| High Flow Pulses | Qp: 16,300 cfs with Average Frequency 1 per 5 years Regressed Volume is 77,100 Duration Bound is 31 | | | | | | | | | | | |
| | Qp: 9,490 cfs with Average Frequency 1 per 2 years Regressed Volume is 44,900 Duration Bound is 27 | | | | | | | | | | | |
| | Qp: 5,130 cfs with Average Frequency 1 per year Regressed Volume is 24,300 Duration Bound is 23 | | | | | | | | | | | |
| | Qp: 92 cfs with Average Frequency 1 per season Regressed Volume is 610 Duration Bound is 12 | | | Qp: 2,730 cfs with Average Frequency 1 per season Regressed Volume is 12,500 Duration Bound is 17 | | | | Qp: 2,540 cfs with Average Frequency 1 per season Regressed Volume is 11,900 Duration Bound is 19 | | | | |
| | Qp: 30 cfs with Average Frequency 2 per season Regressed Volume is 180 Duration Bound is 8 | | | Qp: 1,120 cfs with Average Frequency 2 per season Regressed Volume is 5,120 Duration Bound is 14 | | | | Qp: 1,040 cfs with Average Frequency 2 per season Regressed Volume is 4,750 Duration Bound is 14 | | | | |
| | | | | Qp: 570 cfs with Average Frequency 3 per season Regressed Volume is 2,600 Duration Bound is 12 | | | | Qp: 480 cfs with Average Frequency 3 per season Regressed Volume is 2,160 Duration Bound is 12 | | | | |
| | | | | Qp: 280 cfs with Average Frequency 4 per season Regressed Volume is 1,270 Duration Bound is 10 | | | | Qp: 230 cfs with Average Frequency 4 per season Regressed Volume is 990 Duration Bound is 9 | | | | |
| Base Flows (cfs) | 15 | | | 8 | | | | 7 | | | | |
| | 4 | | | 3 | | | | 2 | | | | |
| | 1 | | | 1 | | | | 1 | | | | |
| Subsistence Flows (cfs) | 1 | | | 1 | | | | 1 | | | | |
| | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct |
| | Winter | | | | Spring | | | | Summer | | | |

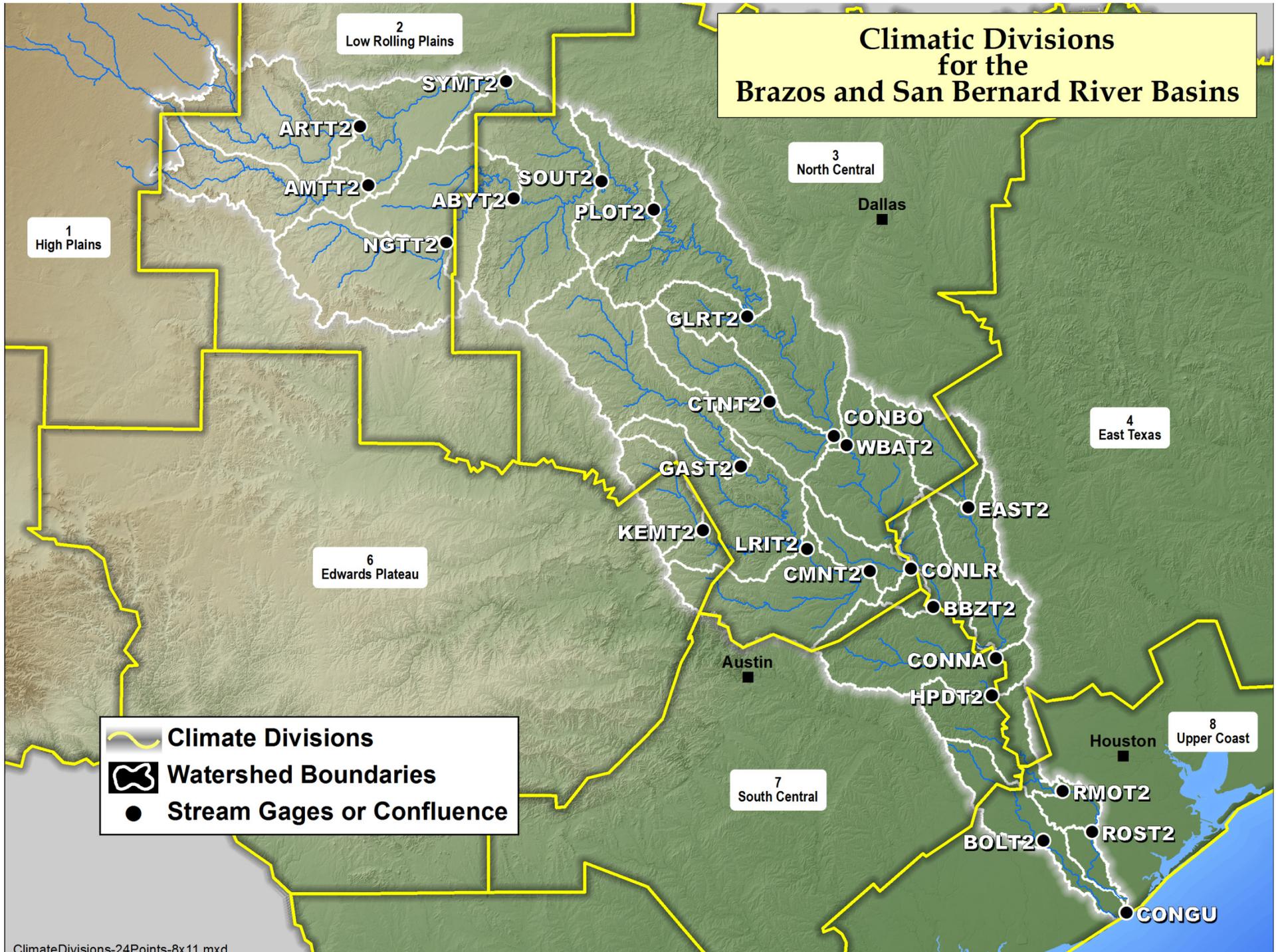
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Pulse volumes are in units of acre-feet and durations are in days.

Period of record used : 1/1/1940 to 12/31/2010.

Episodic events are terminated when the volume or duration criteria are met, or when the flow drops below 8cfs, or when the flow is below 45 cfs and the flow drops from one day to the next by less than 5%.

Climatic Divisions for the Brazos and San Bernard River Basins



Climatic Zones to Determine Palmer Drought Index by Gage

| Watershed ID | Watershed Name | Climatic Zone | | | | | | | | | |
|--------------|---|-----------------------|------------------------------|-------------------------|----------------------|-----------------------|---------------------------|-------------------------|-----------------------|--------------------|-------------------------|
| | | High Plains Zone 1 | Low Rolling Plains Zone 2 | North Central Zone 3 | East Texas Zone 4 | Trans Pecos Zone 5 | Edwards Plateau Zone 6 | South Central Zone 7 | Upper Coast Zone 8 | Southern Zone 9 | Lower Valley Zone 10 |
| ARTT2 | South Fork at Aspermont | 14.6% | 85.4% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| AMTT2 | Double Mountain Fork at Aspermont | 4.4% | 95.6% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| NGTT2 | Clear Fork at Nugent | 0.0% | 98.2% | 1.8% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ABYT2 | Total Clear Fork at Ft Griffin | 0.0% | 82.8% | 17.2% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| SYMT2 | Total Brazos River at Seymour | 6.9% | 93.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| SOUT2 | Total Brazos River at South Bend | 2.9% | 69.6% | 27.5% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| PLOT2 | Total Brazos River at Palo Pinto | 2.6% | 63.7% | 33.7% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| GLRT2 | Total Brazos River at Glen Rose | 2.3% | 55.4% | 42.3% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| CTNT2 | North Bosque River at Clifton | 0.0% | 0.0% | 100.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| CONBO | Confluence Bosque River at Brazos Rv | 0.0% | 0.0% | 100.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| WBAT2 | Brazos River at Waco | 1.9% | 44.6% | 53.6% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| GAST2 | Leon River at Gatesville | 0.0% | 0.0% | 100.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| KEMT2 | Lampasas River at Kempner | 0.0% | 0.0% | 35.4% | 0.0% | 0.0% | 64.6% | 0.0% | 0.0% | 0.0% | 0.0% |
| LRIT2 | Total Little River at Little Rv | 0.0% | 0.0% | 84.3% | 0.0% | 0.0% | 15.7% | 0.0% | 0.0% | 0.0% | 0.0% |
| CMNT2 | Total Little River at Cameron | 0.0% | 0.0% | 85.2% | 0.0% | 0.0% | 14.7% | 0.1% | 0.0% | 0.0% | 0.0% |
| CONLR | Total Confluence of Brazos at Little Rv | 0.0% | 0.0% | 86.2% | 0.0% | 0.0% | 13.7% | 0.1% | 0.0% | 0.0% | 0.0% |
| BBZT2 | Total Brazos River at Bryan | 1.2% | 29.8% | 64.7% | 0.3% | 0.0% | 3.6% | 0.3% | 0.0% | 0.0% | 0.0% |
| EAST2 | Navasota River at Easterly | 0.0% | 0.0% | 72.6% | 27.4% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| CONNA | Confluence Navasota River at Brazos | 0.0% | 0.0% | 30.9% | 69.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| HPDT2 | Total Brazos River at Hempstead | 1.1% | 25.5% | 57.9% | 7.2% | 0.0% | 3.1% | 5.1% | 0.0% | 0.0% | 0.0% |
| RMOT2 | Total Brazos River at Richmond | 1.0% | 24.8% | 56.1% | 7.8% | 0.0% | 3.0% | 6.9% | 0.4% | 0.0% | 0.0% |
| ROST2 | Total Brazos River at Rosharon | 1.0% | 24.5% | 55.6% | 7.7% | 0.0% | 3.0% | 6.9% | 1.3% | 0.0% | 0.0% |
| CONGU | Total Brazos River at Gulf of Mexico | 1.0% | 24.3% | 55.2% | 7.6% | 0.0% | 3.0% | 6.8% | 2.0% | 0.0% | 0.0% |
| BOLT2 | San Bernard River near Boling | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 30.4% | 69.6% | 0.0% | 0.0% |

Palmer Drought Index for 25th and 75th Percentile by Gage

| Watershed ID | Watershed Name | Percentile | |
|--------------|--------------------------------------|------------|------|
| | | 25th | 75th |
| ARTT2 | South Fork at Aspermont | -1.88 | 2.19 |
| AMTT2 | Double Mountain Fork at Aspermont | -1.92 | 2.21 |
| NGTT2 | Clear Fork at Nugent | -1.93 | 2.25 |
| ABYT2 | Clear Fork at Ft Griffin | -1.84 | 2.21 |
| SYMT2 | Brazos River at Seymour | -1.90 | 2.21 |
| SOUT2 | Brazos River at South Bend | -1.79 | 2.19 |
| PLOT2 | Brazos River at Palo Pinto | -1.78 | 2.19 |
| GLRT2 | Brazos River at Glen Rose | -1.80 | 2.21 |
| CTNT2 | North Bosque River at Clifton | -1.96 | 2.39 |
| CONBO | Confluence Bosque River at Brazos | -1.96 | 2.39 |
| WBAT2 | Brazos River at Waco | -1.84 | 2.22 |
| GAST2 | Leon River at Gatesville | -1.96 | 2.39 |
| KEMT2 | Lampasas River at Kempner | -1.78 | 2.23 |
| LRIT2 | Little River at Little Rv | -1.84 | 2.31 |
| CMNT2 | Little River at Cameron | -1.85 | 2.32 |
| CONLR | Confluence of Brazos Rv at Little Rv | -1.85 | 2.32 |
| BBZT2 | Brazos River at Bryan | -1.83 | 2.24 |
| EAST2 | Navasota River at Easterly | -1.84 | 2.20 |
| CONNA | Confluence Navasota River at Brazos | -1.79 | 2.13 |
| HPDT2 | Brazos River at Hempstead | -1.75 | 2.16 |
| RMOT2 | Brazos River at Richmond | -1.74 | 2.14 |
| ROST2 | Brazos River at Rosharon | -1.74 | 2.13 |
| CONGU | Brazos River at Gulf of Mexico | -1.73 | 2.13 |
| BOLT2 | San Bernard River near Boling | -1.83 | 2.02 |

Minimum Flow for Pulse Flows by Gage

| Focal Stream Reach | Minimum Flow for Pulse Flows (cfs) |
|--------------------------------------|------------------------------------|
| DMF Brazos Rv nr Aspermont, TX | 8 |
| Salt Fk Brazos Rv nr Aspermont, TX | 6 |
| Brazos Rv at Seymour, TX | 42 |
| Clear Fk Brazos Rv at Nugent, TX | 6 |
| Clear Fk Brazos Rv at Ft Griffin, TX | 6 |
| Brazos Rv nr South Bend, TX | 115 |
| Brazos Rv nr Palo Pinto, TX | 169 |
| Brazos Rv nr Glen Rose, TX | 180 |
| N Bosque Rv nr Clifton, TX | 24 |
| Brazos Rv at Waco, TX | 300 |
| Leon Rv at Gatesville, TX | 43 |
| Lampasas Rv nr Kempner, TX | 40 |
| Little Rv nr Little River, TX | 242 |
| Little Rv nr Cameron, TX | 190 |
| Brazos Rv at SH 21 nr Bryan, TX | 833 |
| Navasota Rv nr Easterly, TX | 27 |
| Brazos Rv nr Hempstead, TX | 1,200 |
| Brazos Rv at Richmond, TX | 1,260 |
| Brazos Rv nr Rosharon, TX | 1,310 |
| San Bernard Rv nr Boling, TX | 120 |

Maximum Flow for Base Flows by Gage

| Focal Stream Reach | Maximum Flow for Base Flows (cfs) |
|--------------------------------------|-----------------------------------|
| DMF Brazos Rv nr Aspermont, TX | 45 |
| Salt Fk Brazos Rv nr Aspermont, TX | 28 |
| Brazos Rv at Seymour, TX | 152 |
| Clear Fk Brazos Rv at Nugent, TX | 29 |
| Clear Fk Brazos Rv at Ft Griffin, TX | 73 |
| Brazos Rv nr South Bend, TX | 388 |
| Brazos Rv nr Palo Pinto, TX | 693 |
| Brazos Rv nr Glen Rose, TX | 920 |
| N Bosque Rv nr Clifton, TX | 104 |
| Brazos Rv at Waco, TX | 1,960 |
| Leon Rv at Gatesville, TX | 225 |
| Lampasas Rv nr Kempner, TX | 96 |
| Little Rv nr Little River, TX | 1,110 |
| Little Rv nr Cameron, TX | 1,730 |
| Brazos Rv at SH 21 nr Bryan, TX | 5,080 |
| Navasota Rv nr Easterly, TX | 108 |
| Brazos Rv nr Hempstead, TX | 7,680 |
| Brazos Rv at Richmond, TX | 8,430 |
| Brazos Rv nr Rosharon, TX | 9,850 |
| San Bernard Rv nr Boling, TX | 367 |