Frequency of Achieving Instream Flow Targets

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Ultimate Objective

Evaluate the submitted recommendations potential impact on future water supply and strategies

4-Step Process:

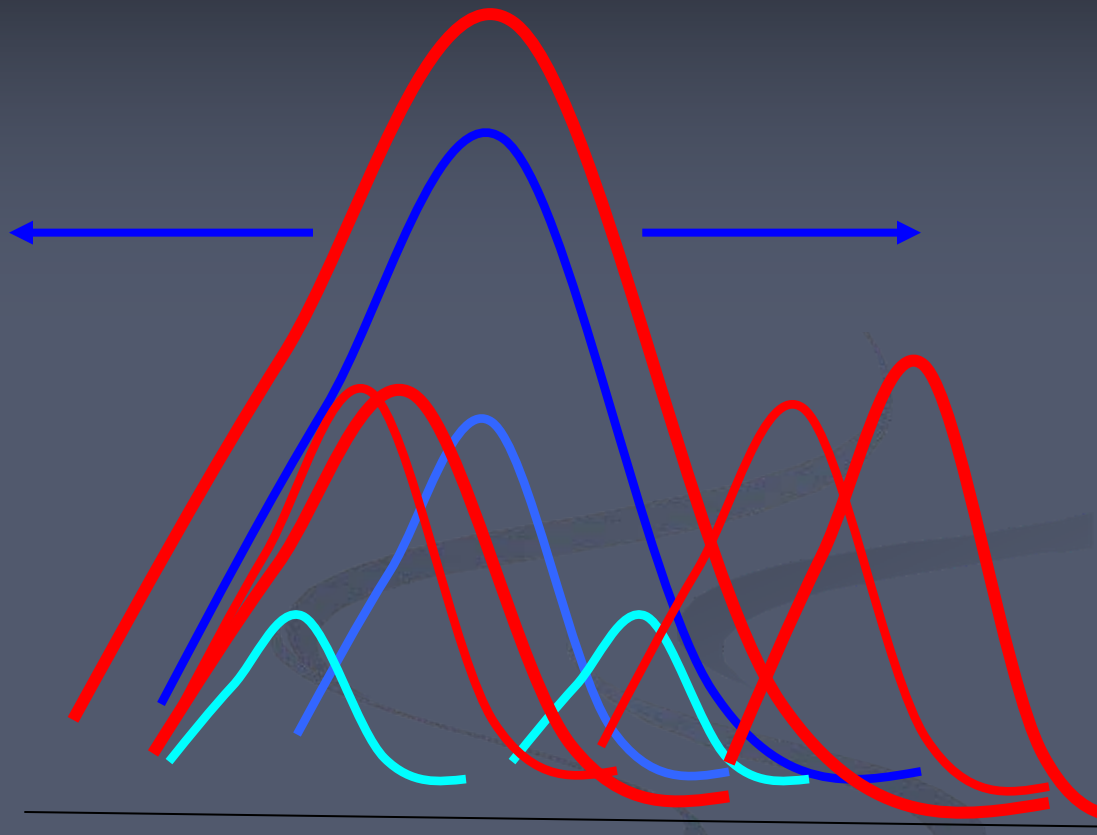
1) How often criteria met historically
2) How often criteria met under current conditions (which BBEST consensus identifies as sound)
3) How often criteria met under future conditions with SB1 Regional Water Planning strategies implemented
4) Determine shortages to assess potential magnitude of impacts

TSJ BBEST

- Regime Recommendations
- Conditional Recommendations

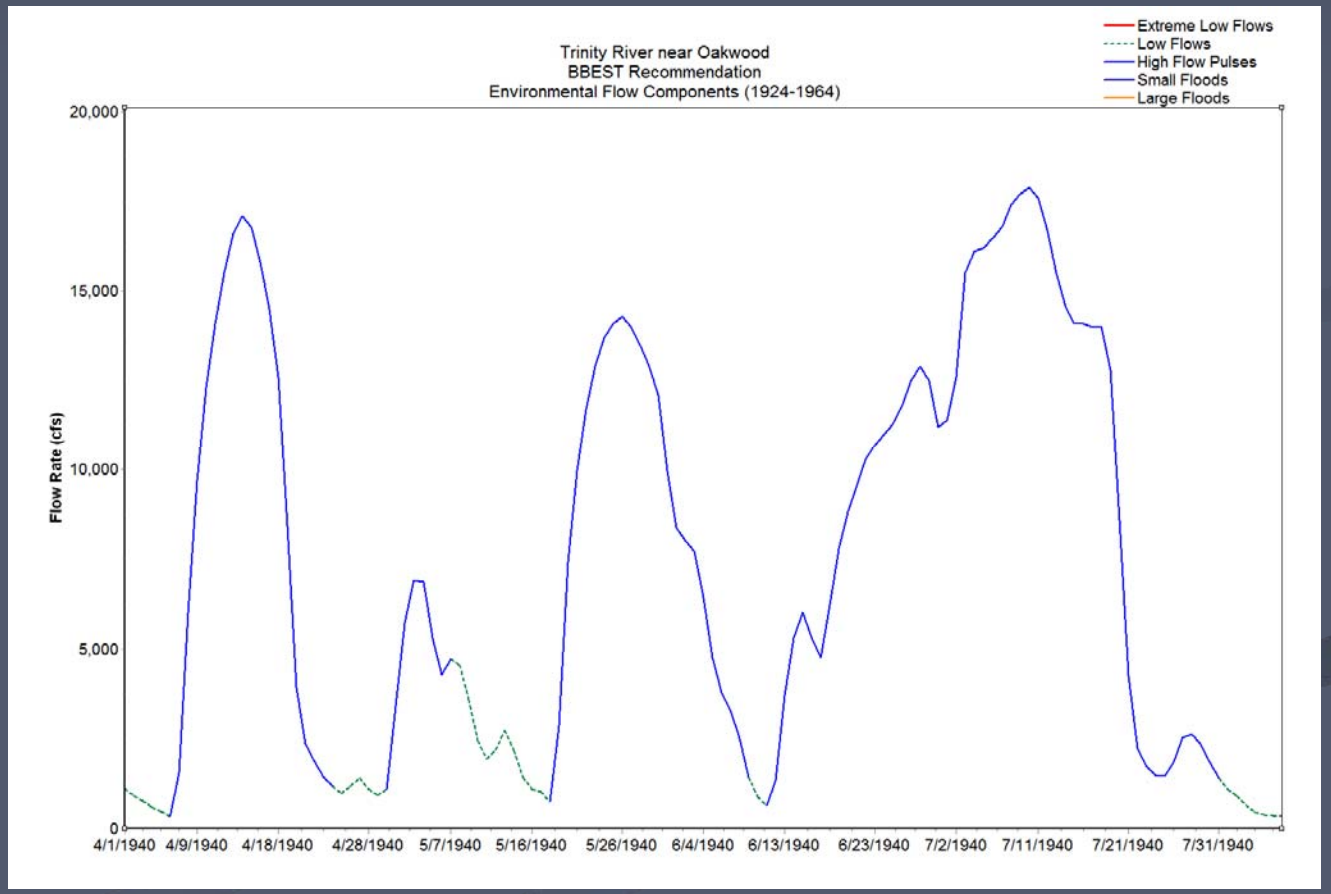
Leaves Much to Interpretation

- To assess frequency of achievement
  1. Liberal
     - Pulses can get credit quicker
  2. Conservative
     - Most restrictive
  3. Between



How do we Identify a Pulse?

- Remain consistent with computational methods employed
- IHA



Scenarios

Gage Sites	Naturalized	Observed			WAM Modeled (1940-1996)		
11 sites	WAM Period	BBEST HEFR Development Period	WAM Period	Full Period of Record	Current Condition	Full Implementation	Future Water Strategies
	1940-1996	Varies by Gage- Pre-impoundment	1940-1996	Varies by Gage: 1924-2008	Run 8	Run 3	Run 9/ Region H Model E

First Critical Question

- If we are to meet these recommendations in the future, how often have we met them in the past?

For Base/Subsistence Flows

	Winter			Spring		
Year	Dec	Jan	Feb	Mar	Apr	May
1940	Daily Flows	Daily Flows	Daily Flows			
1941						
1942						
↓		↓				
1996						

Example: We can determine if we achieve:

Winter Dry = 340 cfs 85% of the time

Winter Avg = 623 cfs 72% of the time

Winter Wet = 1,110 cfs 58% of the time

→ Do this for each season

Environmental Instream Flow Recommendation for Trinity near Oakwood

Can evaluate each component individually.

To remain consistent with recommendation, can assess how often a year meets the cumulative criteria.

- Dry
- Average
- Wet

Overbank Flows	**Q: 24,600 cfs with Frequency 1 per 2 years Volume is 626,471 Duration is 26**			
High Flow Pulses	**Q: 15,000 cfs with Frequency 2 per year Volume is 326,119 Duration is 18**			
	Q: 11,200 cfs with Frequency 1 per season Volume is 257,289 Duration is 14	**Q: 15,700 cfs with Frequency 1 per season Volume is 362,910 Duration is 19**	**Q: 2,930 cfs with Frequency 1 per season Volume is 26,246 Duration is 5**	**Q: 3,050 cfs with Frequency 1 per season Volume is 39,239 Duration is 5**
	Q: 3,200 cfs with Frequency 2 per season Volume is 18,931 Duration is 5	**Q: 7,840 cfs with Frequency 2 per season Volume is 141,705 Duration is 11**	**Q: 1,180 cfs with Frequency 2 per season Volume is 4,866 Duration is 2**	

For a given year you must achieve at least <u>all</u> of the "dry" pulse conditions.

Oakwood: Peak, Volume, and Duration

	Development Data 1925-1964		Recent Data 1981-2008		WAM 3 Data 1941-1996		WAM 9a Data 1941-1996	
	Total	% of Time	Total	% of Time	Total	% of Time	Total	% of Time
Overbank	19	48%	16	57%	26	46%	29	52%
Annual High 1	26	65%	13	46%	21	38%	26	46%
Annual High 2	11	28%	4	14%	4	7%	8	14%
Winter High	12	30%	5	18%	8	14%	5	9%
Winter Low 1	27	68%	18	64%	30	54%	36	64%
Winter Low 2	18	45%	9	32%	17	30%	23	41%
Spring High	3	8%	0	0%	1	2%	1	2%
Spring Low 1	25	63%	7	25%	20	36%	26	46%
Spring Low 2	8	20%	2	7%	6	11%	3	5%
Summer High	19	48%	7	25%	9	16%	12	21%
Summer Low 1	30	75%	6	21%	14	25%	17	30%
Summer Low 2	17	43%	1	4%	3	5%	4	7%
Fall	21	53%	6	21%	22	39%	20	
Total Number of Pulses	236		94		181		210	
Number of Years for this Condition	40		28		56		56	

Achievement Frequency for Trinity near Oakwood (1924-1964)

Liberal Approach

Overbank Flows	**Q: 24,600 cfs with Frequency 1 per 2 years Volume is 626,471 Duration is 26**													
High Flow Pulses	49%													7%
	46%			68%				54%			56%			
	56%			59%				61%						
Base Flows (cfs)	1110		58%	1398			66%	682		36%	819		41%	
	623		72%	820			79%	411		53%	439		57%	
	340		85%	458			89%	257		69%	265		73%	
Subsistence Flows (cfs)	196		95%	280			95%	70		95%	101		95%	
	Dec	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**		
	Winter			**Spring**				**Summer**			**Fall**			

Hydrologic Conditions	
	Wet
	Average
	Dry
	Subsistence

High Flow Pulse Characteristics	
	F = Frequency (per season)
	D = Duration (days)
	Q = Peak Flows (cfs)
	V = Volume (ac-ft)

Achievement Frequency for Trinity near Oakwood (1924-1964) Conservative Approach – Dry Seasonal Events

Overbank Flows	**Q: 24,600 cfs with Frequency 1 per 2 years Volume is 626,471 Duration is 26**													
High Flow Pulses	--%													0%
	46%			68%				54%			56%			
	37%			24%				29%						
Base Flows (cfs)	1110		58%	1398			66%	682		36%	819		41%	
	623		72%	820			79%	411		53%	439		57%	
	340		85%	458			89%	257		69%	265		73%	
Subsistence Flows (cfs)	196		95%	280			95%	70		95%	101		95%	
	Dec	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**		
	Winter			**Spring**				**Summer**			**Fall**			

Hydrologic Conditions	
	Wet
	Average
	Dry
	Subsistence

High Flow Pulse Characteristics	
	F = Frequency (per season)
	D = Duration (days)
	Q = Peak Flows (cfs)
	V = Volume (ac-ft)

Achievement Frequency for Trinity near Oakwood (1924-1964)

Conservative Approach – Average Seasonal Events

Overbank Flows	Q: 24,600 cfs with Frequency 1 per 2 years Volume is 626,471 Duration is 26													
High Flow Pulses	49%													0%
	27%			0%				49%			49%			
	37%			20%				29%						
Base Flows (cfs)	1110		58%	1398			66%	682		36%	819		41%	
	623		72%	820			79%	411		53%	439		57%	
	340		85%	458			89%	257		69%	265		73%	
Subsistence Flows (cfs)	196		95%	280			95%	70		95%	101		95%	
	Dec	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**		
	Winter			**Spring**				**Summer**			**Fall**			

Hydrologic Conditions
Wet
Average
Dry
Subsistence

High Flow Pulse Characteristics
F = Frequency (per season)
D = Duration (days)
Q = Peak Flows (cfs)
V = Volume (ac-ft)

Achievement Frequency for Trinity near Oakwood (1924-1964) Libertarian Approach – Dry Seasonal Events

Overbank Flows	**Q: 24,600 cfs with Frequency 1 per 2 years Volume is 626,471 Duration is 26**														
High Flow Pulses	--%														0%
	46%			68%				54%			56%				
	49%			37%				44%							
Base Flows (cfs)	1110		58%	1398			66%	682		36%	819		41%		
	623		72%	820			79%	411		53%	439		57%		
	340		85%	458			89%	257		69%	265		73%		
Subsistence Flows (cfs)	196		95%	280			95%	70		95%	101		95%		
	Dec	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**			
	Winter			**Spring**				**Summer**			**Fall**				

Hydrologic Conditions
Wet
Average
Dry
Subsistence

High Flow Pulse Characteristics
F = Frequency (per season)
D = Duration (days)
Q = Peak Flows (cfs)
V = Volume (ac-ft)

Achievement Frequency for Trinity near Oakwood (1924-1964)

Libertarian Approach – Average Seasonal Events

Overbank Flows	Q: 24,600 cfs with Frequency 1 per 2 years Volume is 626,471 Duration is 26													
High Flow Pulses	49%													0%
	32%			12%				51%			54%			
	37%			22%				44%						
Base Flows (cfs)	1110		58%	1398			66%	682		36%	819		41%	
	623		72%	820			79%	411		53%	439		57%	
	340		85%	458			89%	257		69%	265		73%	
Subsistence Flows (cfs)	196		95%	280			95%	70		95%	101		95%	
	Dec	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**		
	Winter			**Spring**				**Summer**			**Fall**			

Hydrologic Conditions
Wet
Average
Dry
Subsistence

High Flow Pulse Characteristics
F = Frequency (per season)
D = Duration (days)
Q = Peak Flows (cfs)
V = Volume (ac-ft)

Achievement Frequencies of All Recommendations for Dry and Average Conditions for High Flow Pulses

Trinity

Gage Site	Analysis Period	Pulse Interpretation Approach	Highest Attainment Frequency
Oakwood	HEFR Dev	1-For-All	7%
		Dry	0%
		Avg	0%
	WAM Period	1-For-All	5%
		Dry	0%
		Avg	0%
	Full POR	1-For-All	5%
		Dry	0%
		Avg	0%
Carrollton	HEFR Dev	1-For-All	7%
		Dry	0%
		Avg	0%
	WAM Period	1-For-All	0%
		Dry	0%
		Avg	0%
	Full POR	1-For-All	3%
		Dry	0%
		Avg	0%
Dallas	HEFR Dev	1-For-All	6%
		Dry	0%
		Avg	0%
	WAM Period	1-For-All	5%
		Dry	0%
		Avg	0%
	Full POR	1-For-All	6%
		Dry	0%
		Avg	0%
Grand Prairie	HEFR Dev	1-For-All	3%
		Dry	0%
		Avg	0%
	WAM Period	1-For-All	4%
		Dry	0%
		Avg	0%
	Full POR	1-For-All	5%
		Dry	0%
		Avg	0%
Romayor	HEFR Dev	1-For-All	7%
		Dry	0%
		Avg	0%
	WAM Period	1-For-All	4%
		Dry	0%
		Avg	0%
	Full POR	1-For-All	7%
		Dry	0%
		Avg	0%
Rosser	HEFR Dev	1-For-All	14%
		Dry	0%
		Avg	0%
	WAM Period	1-For-All	2%
		Dry	0%
		Avg	0%
	Full POR	1-For-All	1%
		Dry	0%
		Avg	0%

San Jacinto

Gage Site	Analysis Period	Pulse Interpretation Approach	Highest Attainment Frequency
Brays	HEFR Dev	1-For-All	4%
		Dry	0%
		Avg	0%
	WAM Period	1-For-All	7%
		Dry	0%
		Avg	0%
	Full POR	1-For-All	7%
		Dry	0%
		Avg	0%
Cleveland	HEFR Dev	1-For-All	
		Dry	
		Avg	
	WAM Period	1-For-All	7%
		Dry	0%
		Avg	0%
	Full POR	1-For-All	7%
		Dry	0%
		Avg	0%
Conroe	HEFR Dev	1-For-All	9%
		Dry	0%
		Avg	0%
	WAM Period	1-For-All	9%
		Dry	0%
		Avg	0%
	Full POR	1-For-All	12%
		Dry	0%
		Avg	0%
Piney Point	HEFR Dev	1-For-All	0%
		Dry	0%
		Avg	0%
	WAM Period	1-For-All	
		Dry	
		Avg	
	Full POR	1-For-All	
		Dry	
		Avg	
Spring	HEFR Dev	1-For-All	
		Dry	
		Avg	
	WAM Period	1-For-All	7%
		Dry	0%
		Avg	0%
	Full POR	1-For-All	9%
		Dry	0%
		Avg	0%

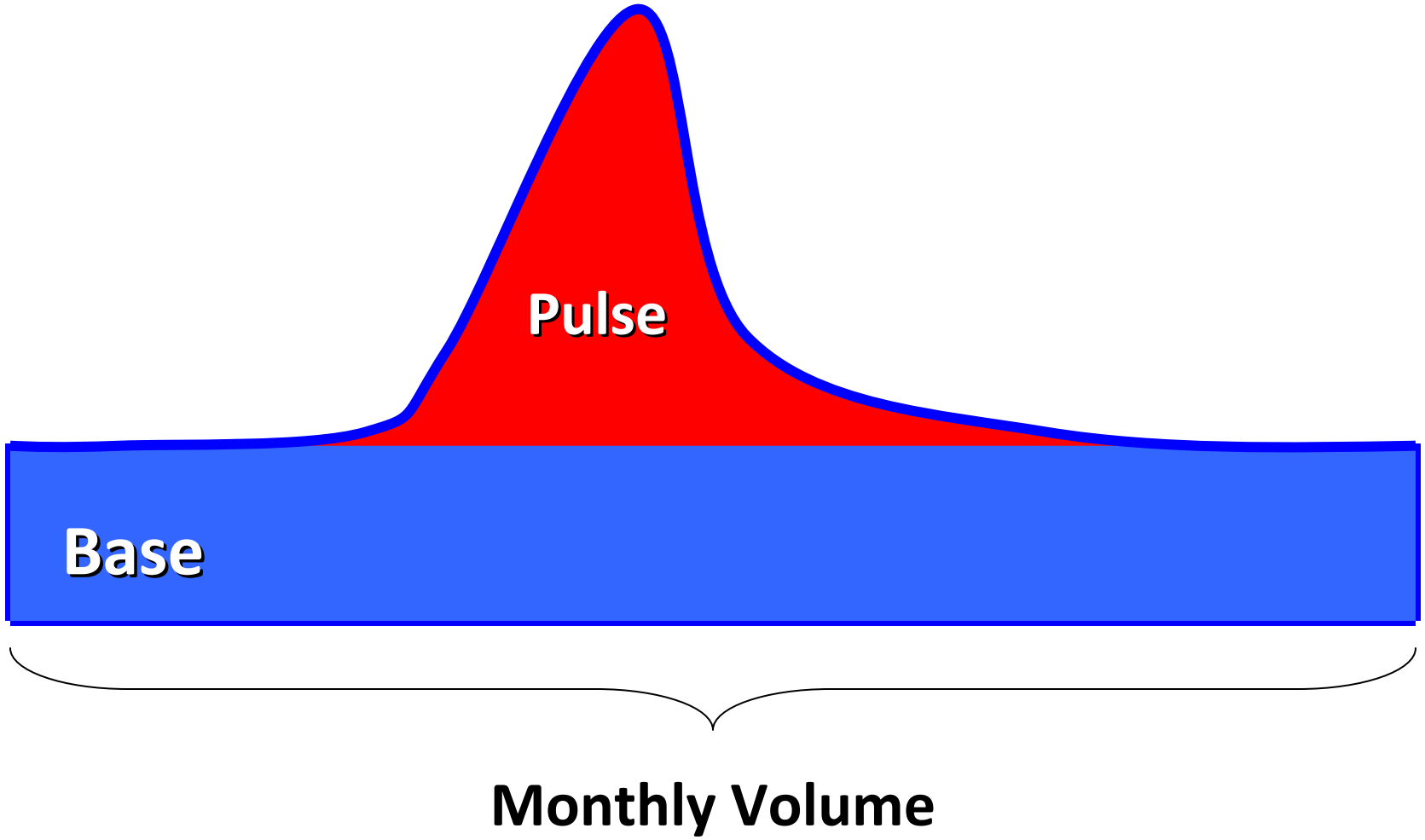
Shortage Analysis

- Characterization of pulses derived from specific daily data:
  - Peak, Volume, Duration, Frequency
- Only assessment tool is WAM
  - Monthly Volume

Three Varying Implementations

1. Monthly volume of recommendations
   - For a given condition (Wet/Avg/Dry)
     - Volume of pulse (# days) + Volume of base flow (percentage of days) + Volume of next lower level flow (remaining days)
2. TWDB Approach
   - Assume daily distribution is precisely the same as historical for any given month
3. Sabine Approach

Build Monthly Volume from Recommendation



Approach

- Develop monthly criteria based on recommended volumes of flow
- Requires multiple WAM runs
  - Condition's highest pulse required at seasons' highest monthly flow
- Assess attainment of "Dry" criteria and "Avg" criteria

Current Demand (Run 8)
Regime Recommendation
Shortage Analyses – Dry Criteria

2009 Priority Date - % Achievement

Location	Scenario	Winter	Spring	Summer	Fall	Overall
WTGP	Run 8	61%	70%	100%	100%	52%
ELCA	Run 8	11%	39%	5%	18%	0%
TRDA	Run 8	55%	58%	100%	100%	41%
TRRS	Run 8	48%	65%	100%	98%	38%
TROA	Run 8	46%	65%	96%	77%	29%
TRRO	Run 8	54%	67%	100%	49%	18%

The minimum shortage, on average, is:

	Winter		Spring		Summer		Fall	
Location	**1/Season**	**2/Season**	**1/Season**	**2/Season**	**1/Season**	**2/Season**	**1/Season**	**2/Season**
WTGP	5,700	0	19,200	0	0	0	0	0
ELCA	27,000	5,200	76,700	0	5,100	3,300	4,600	1,200
TRDA	17,800	0	64,500	0	0	0	0	0
TRRS	52,700	5,700	93,400	0	0	0	2,600	0
TROA	145,300	18,800	230,800	38,900	600	10,900	5,200	0
TRRO	213,500	94,600	261,100	183,600	0	0	68,000	2,000

* ac-ft

Current Demand (Run 8)
Regime Recommendation
Shortage Analyses – Average Criteria

2009 Priority Date - % Achievement

Location	Scenario	Winter	Spring	Summer	Fall	Overall
WTGP	Run 8	38%	43%	86%	86%	23%
ELCA	Run 8	4%	2%	0%	5%	0%
TRDA	Run 8	21%	20%	71%	86%	13%
TRRS	Run 8	13%	18%	84%	84%	9%
TROA	Run 8	36%	27%	75%	54%	13%
TRRO	Run 8	41%	34%	73%	32%	13%

The minimum shortage, on average, is:

	Winter			Spring			Summer			Fall		
Location	Annual Pulse	1/Season	2/Season	Annual Pulse	1/Season	2/Season	Annual Pulse	1/Season	2/Season	Annual Pulse	1/Season	2/Season
WTGP	23,000	7,000	1,000	27,000	27,000	2,000	23,000	1,000	0	21,000	0	0
ELCA	69,000	29,000	7,000	135,000	135,000	61,000	87,000	7,000	7,000	77,000	6,000	0
TRDA	55,000	20,000	0	93,000	93,000	28,000	66,000	2,000	0	57,000	0	0
TRRS	75,000	65,000	13,000	125,000	125,000	57,000	108,000	5,000	1,000	74,000	3,000	0
TROA	173,000	170,000	9,000	302,000	302,000	139,000	175,000	4,000	7,000	140,000	10,000	0
TRRO	199,000	219,000	112,000	431,000	431,000	199,000	327,000	4,000	0	234,000	79,000	0

* ac-ft

2060 w/RWP Strategies (Scenario E)
Regime Recommendation
Shortage Analyses – Dry Criteria

2009 Priority Date - % Achievement

Location	Scenario	Winter	Spring	Summer	Fall	Overall
WTGP	Run E	100%	82%	100%	100%	82%
ELCA	Run E	48%	54%	100%	100%	36%
TRDA	Run E	100%	71%	100%	100%	71%
TRRS	Run E	71%	80%	100%	100%	66%
TROA	Run E	54%	73%	100%	100%	48%
TRRO	Run E	55%	68%	100%	43%	18%

The minimum shortage, on average, is:

	Winter		Spring		Summer		Fall	
Location	1/Season	2/Season	1/Season	2/Season	1/Season	2/Season	1/Season	2/Season
WTGP	0	0	9,000	0	0	0	0	0
ELCA	17,000	0	63,000	0	0	0	0	0
TRDA	0	0	40,000	0	0	0	0	0
TRRS	18,000	0	57,000	0	0	0	0	0
TROA	114,000	35,000	203,000	5,000	0	0	0	0
TRRO	206,000	78,000	257,000	136,000	0	0	50,000	0

* ac-ft

2060 w/RWP Strategies (Scenario E)
Regime Recommendation
Shortage Analyses – Average Criteria

2009 Priority Date - % Achievement

Location	Scenario	Winter	Spring	Summer	Fall	Overall
WTGP	Run E	82%	66%	96%	88%	52%
ELCA	Run E	20%	13%	63%	88%	4%
TRDA	Run E	71%	59%	93%	93%	43%
TRRS	Run E	46%	63%	96%	93%	39%
TROA	Run E	39%	39%	95%	91%	27%
TRRO	Run E	43%	38%	75%	32%	11%

The minimum shortage, on average, is:

	Winter			Spring			Summer			Fall		
Location	Annual Pul	1/Season	2/Season	Annual Pul	1/Season	2/Season	Annual Pul	1/Season	2/Season	Annual Pul	1/Season	2/Season
WTGP	14,000	0	0	14,000	14,000	0	13,000	0	0	8,000	0	0
ELCA	54,000	17,000	0	92,000	92,000	35,000	74,000	0	0	55,000	0	0
TRDA	33,000	3,000	0	58,000	58,000	3,000	36,000	0	0	52,000	0	0
TRRS	54,000	34,000	0	94,000	94,000	13,000	72,000	0	0	45,000	0	0
TROA	135,000	140,000	46,000	235,000	235,000	107,000	138,000	0	0	98,000	0	0
TRRO	135,000	197,000	105,000	390,000	390,000	152,000	274,000	0	0	60,000	66,000	0

* ac-ft

Observations

- No present consensus on applying recommended pulse criteria
- Analyses are strictly WAM model oriented
  - Difficult to translate to an operational context
- Implementation WAM means 'Monthly'
  - Difficult to determine if recommended pulse criteria are actually achieved

Observations

- Pulses, as characterized in the full HEFR recommendation, have rarely occurred

- The volumetric pulse recommendations appear higher than what is seen under present demand conditions

Conditional Recommendation Shortage Analysis

Oakwood

Overbank Flows	Historic Qp: 24,600 cfs Historic Duration is 18 to 61 (Average: 33) DEFINITION: Overbank flows are naturally driven, infrequent, high magnitude flow events that produce water levels that exceed channel banks and result in water entering the floodplain. BBEST does not recommend action be taken to produce such flows			
High Flow Pulses	DEFINITION: High flow pulses are short duration, high magnitude (but still within channel) flow events that occur during or immediately following rainfall events. PURPOSE: The BBEST recognizes that high flow pulses provide an important ecological function to riverine habitat. Lacking specific ecological data, conditional flow magnitudes identified are an arbitrary representation of high flow pulses, and not a representation of the flow necessary to support a sound ecological environment until such supporting specific ecological data are developed.			
Base Flows (cfs)	265 at (91% over 41 yrs)	322 at (95% over 41 yrs)	186 at (85% over 41 yrs)	162 at (82% over 41 yrs)
	DEFINITION: Base flows represent the range of "average" or "normal" flow conditions in the absence of significant precipitation or runoff events. PURPOSE: Maintain typical occurrence and persistence of consecutive base flow days			
Subsistence Flows (cfs)	98 at (100% over 41 yrs)	80 at (100% over 41 yrs)	75 at (97% over 41 yrs)	85 at (96% over 41 yrs)
	DEFINITION: An atypical, short-duration (days to weeks) low flow event PURPOSE: Maintain historical occurrence and persistence, prevent development of poor water quality conditions			

Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Winter			Spring			Summer			Fall		

Conditional Achievement and Shortage Magnitudes

Volumetric Targets

	Winter			Spring			Summer			Fall		
Gage	December	January	February	March	April	May	June	July	August	September	October	November
Romayor	43,252	43,252	39,066	54,016	52,273	54,016	27,437	28,352	28,352	26,384	27,263	26,384
Oakwood	15,366	15,366	13,879	19,050	18,436	19,050	10,075	10,410	10,410	8,813	9,107	8,813
Cleveland	1,513	1,513	1,367	1,611	1,559	1,611	823	850	850	810	837	810
Conroe	2,164	2,164	1,954	2,674	2,588	2,674	932	963	963	870	899	870

Achievement Frequencies

		Winter			Spring			Summer			Fall		
Gage	Scenario	December	January	February	March	April	May	June	July	August	September	October	November
Romayor	Run 8	96%	98%	100%	98%	98%	100%	100%	100%	100%	100%	100%	100%
	RWP	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Oakwood	Run 8	100%	98%	100%	100%	98%	100%	100%	100%	100%	98%	100%	100%
	RWP	100%	98%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Cleveland	Run 8	93%	96%	98%	98%	98%	95%	96%	86%	79%	86%	82%	93%
	RWP	95%	96%	98%	98%	98%	96%	96%	89%	81%	88%	89%	95%
Conroe	Run 8	95%	96%	98%	98%	100%	100%	100%	96%	86%	82%	84%	91%
	RWP	98%	100%	100%	98%	100%	100%	100%	100%	100%	100%	100%	100%

Shortages

		Winter			Spring			Summer			Fall		
Gage	Scenario	December	January	February	March	April	May	June	July	August	September	October	November
Romayor	Run 8	7,590	4,670	0	1,020	30	0	0	0	0	0	0	0
	RWP	0	0	0	0	0	0	0	0	0	0	0	0
Oakwood	Run 8	0	14,680	0	0	1,370	0	0	0	0	3,850	0	0
	RWP	0	14,720	0	0	0	0	0	0	0	0	0	0
Cleveland	Run 8	340	530	240	560	630	310	90	210	210	220	170	140
	RWP	390	490	200	510	590	410	40	230	180	200	220	140
Conroe	Run 8	630	230	10	620	0	0	0	440	340	330	390	360
	RWP	950	0	0	440	0	0	0	0	0	0	0	0

SPARE SLIDES