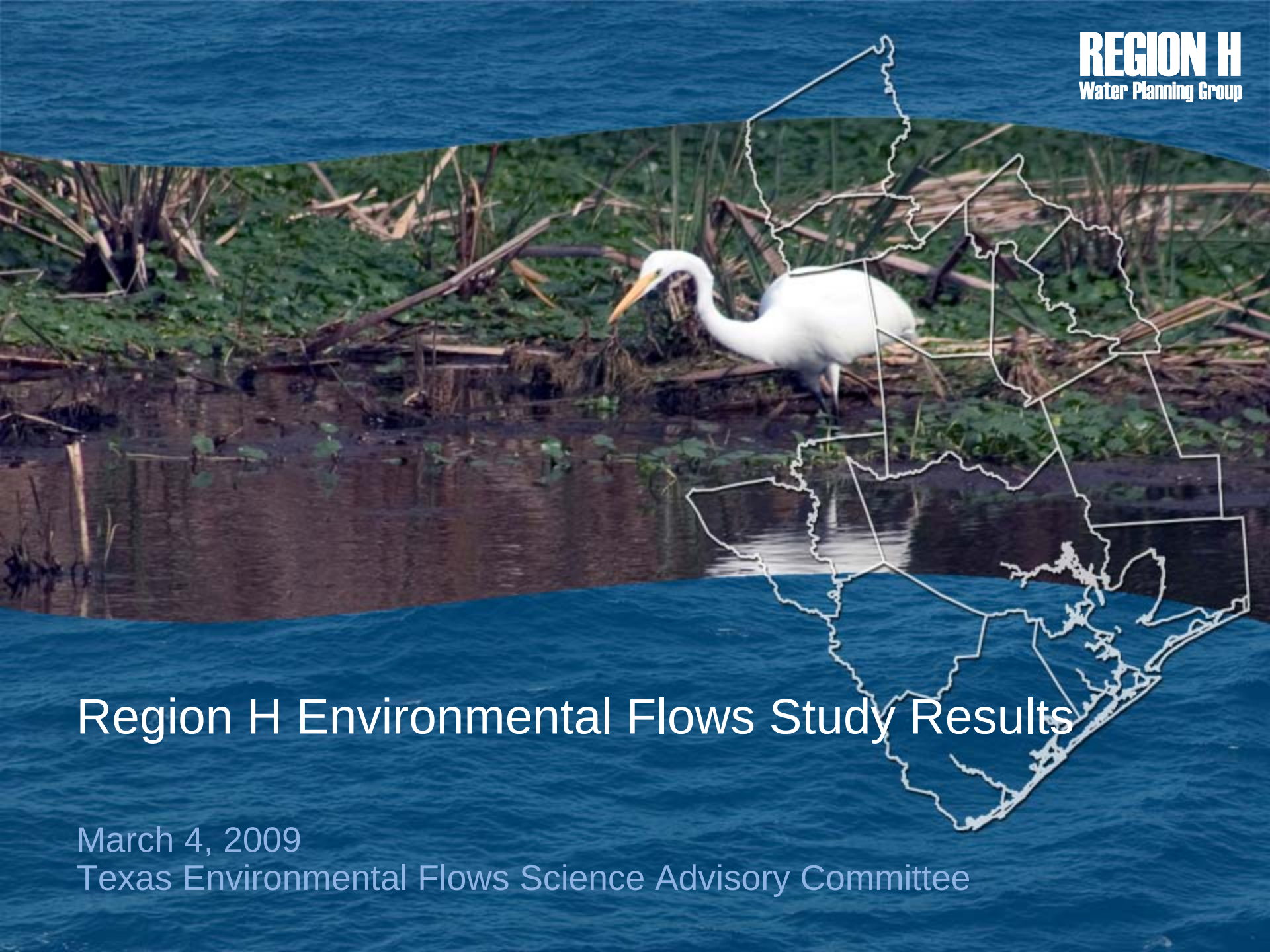

REGION H
Water Planning Group

Region H Environmental Flows Study Results

March 4, 2009
Texas Environmental Flows Science Advisory Committee

Goals of the Instream Flows Study

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- Identify critical points likely to experience impacts from WMS.
- Determine the magnitude of impacts to low flow conditions (10th percentile flows) due to WMS.
- Develop estimates of Lyons flows for segments for comparison to anticipated future instream flows.
- Perform field investigations of sites in order to qualitatively compare Lyons flows to observed conditions during low flow conditions.

Critical Segment Identification

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Water Planning Group

- Examined stream segments identified by the Region H Planning Group for evaluation in the TWDB Streamflow Assessment found in the 2007 SWP.
- Examined 26 segments in total.
- Compared 10th percentile flows with and without implementation of Region H strategies to determine impacts by WMS.
- Impacts could result in either positive or negative impacts to 10th percentile flows.
- Identified six “high-impacted” control points in Brazos and San Jacinto River basins.

Critical Segment Impacts

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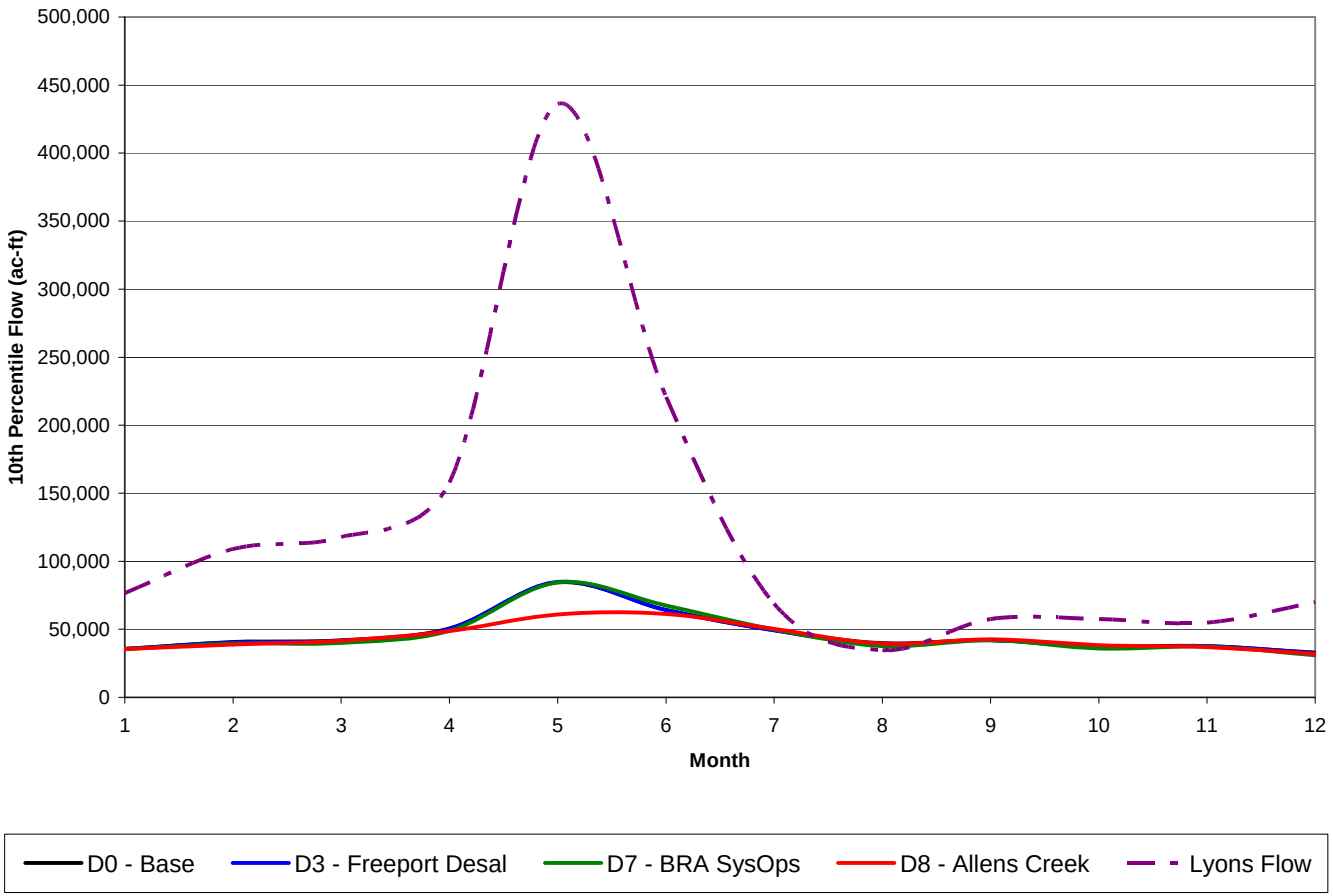
Water Planning Group

Control Point 532801 – Brazos River below Navasota River



Minor flow reductions due to Freeport Desalination (-0.8%), BRA System Ops (-4.5%), and Allens Creek Reservoir (-2.6%)

Critical Segment Impacts

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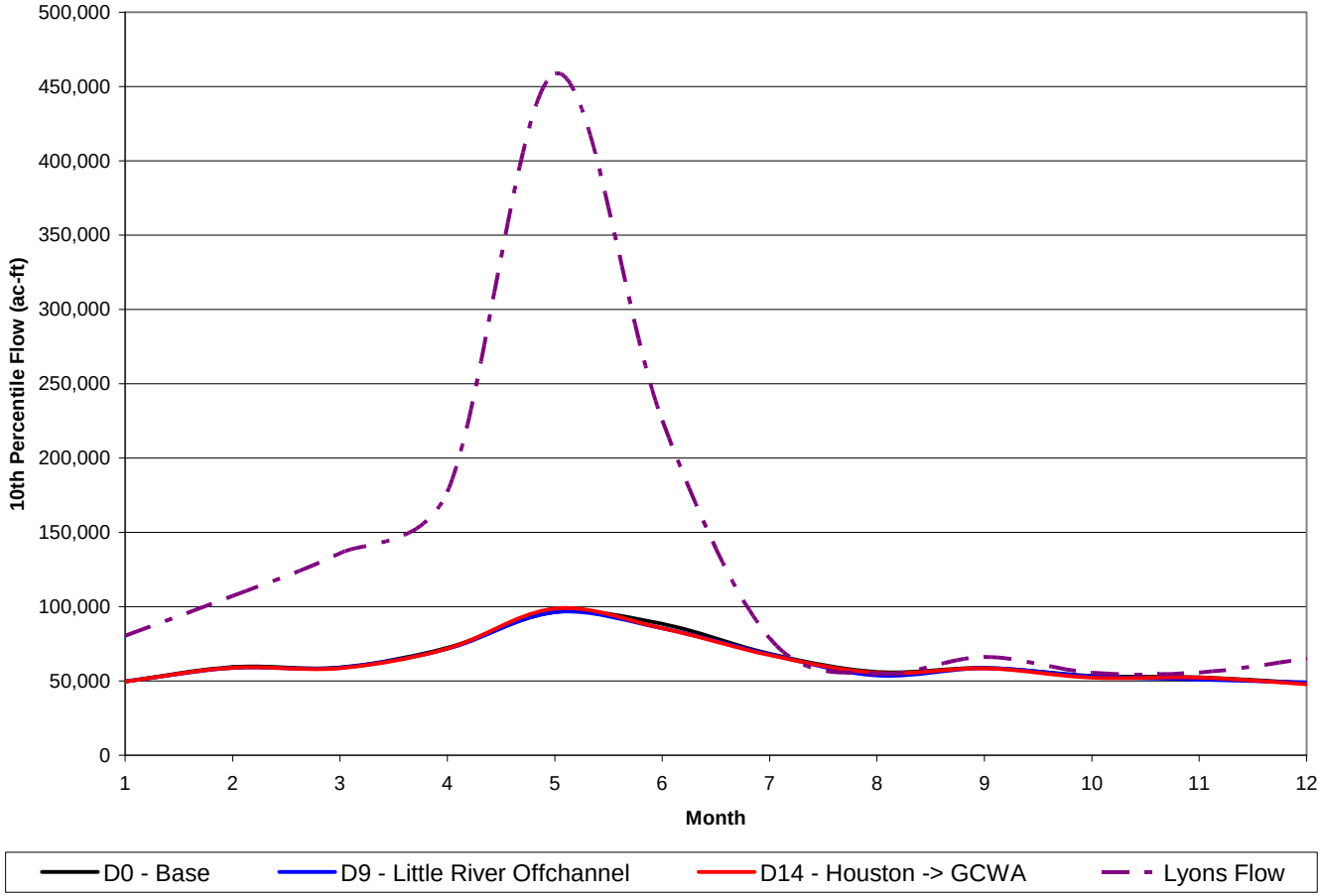
Water Planning Group

Control Point BRR170 – Brazos River below Navasota River



Minor flow reductions due to Little River Reservoir (-1.6%) and Houston to GCWA Transfer (-1.1%)

Critical Segment Impacts

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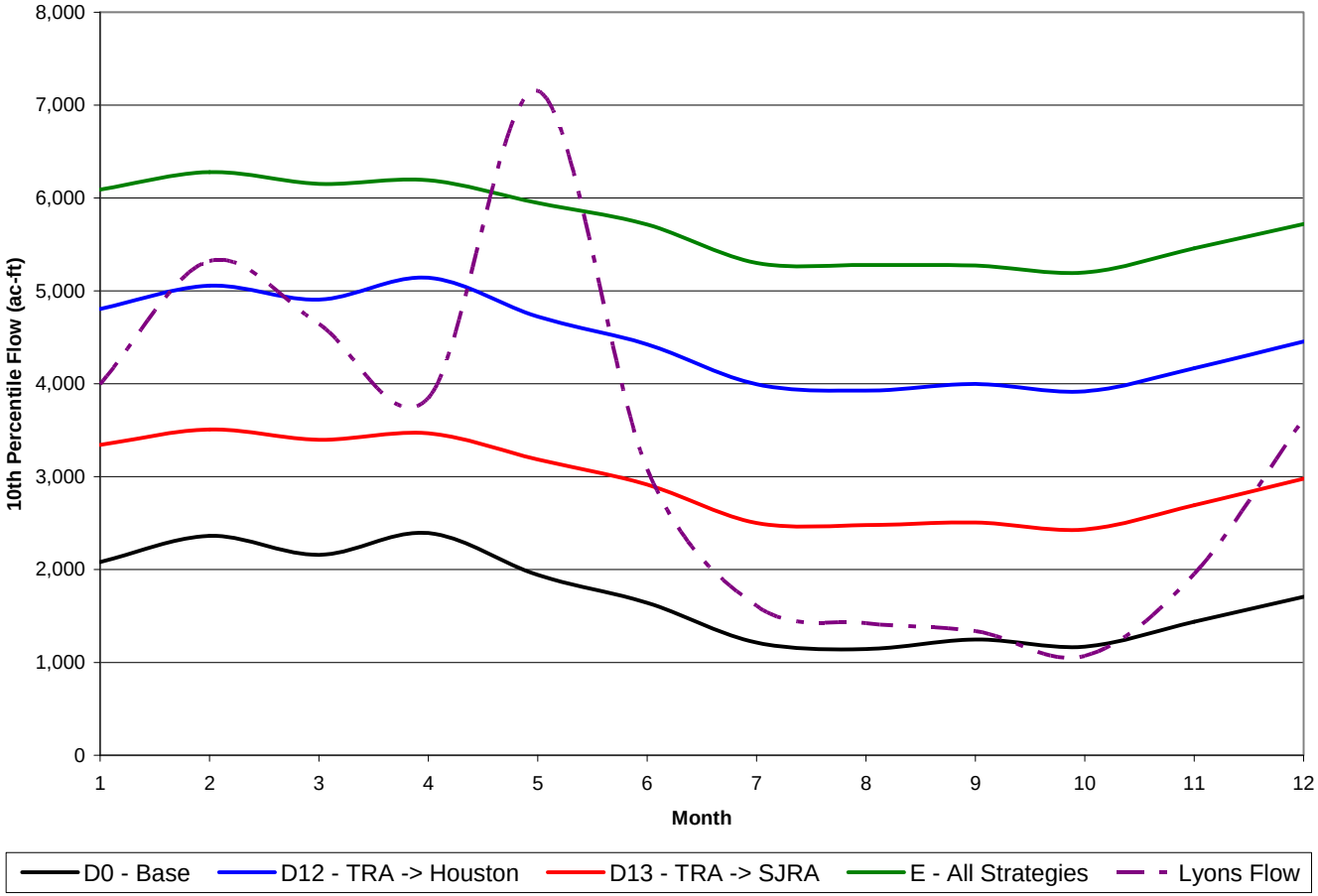
Control Point SPSP – Spring Creek



Major flow increases due to TRA to Houston Transfer (189.1%), TRA to SJRA Transfer (87.3%), and All Strategies (278.0%)

Critical Segment Impacts

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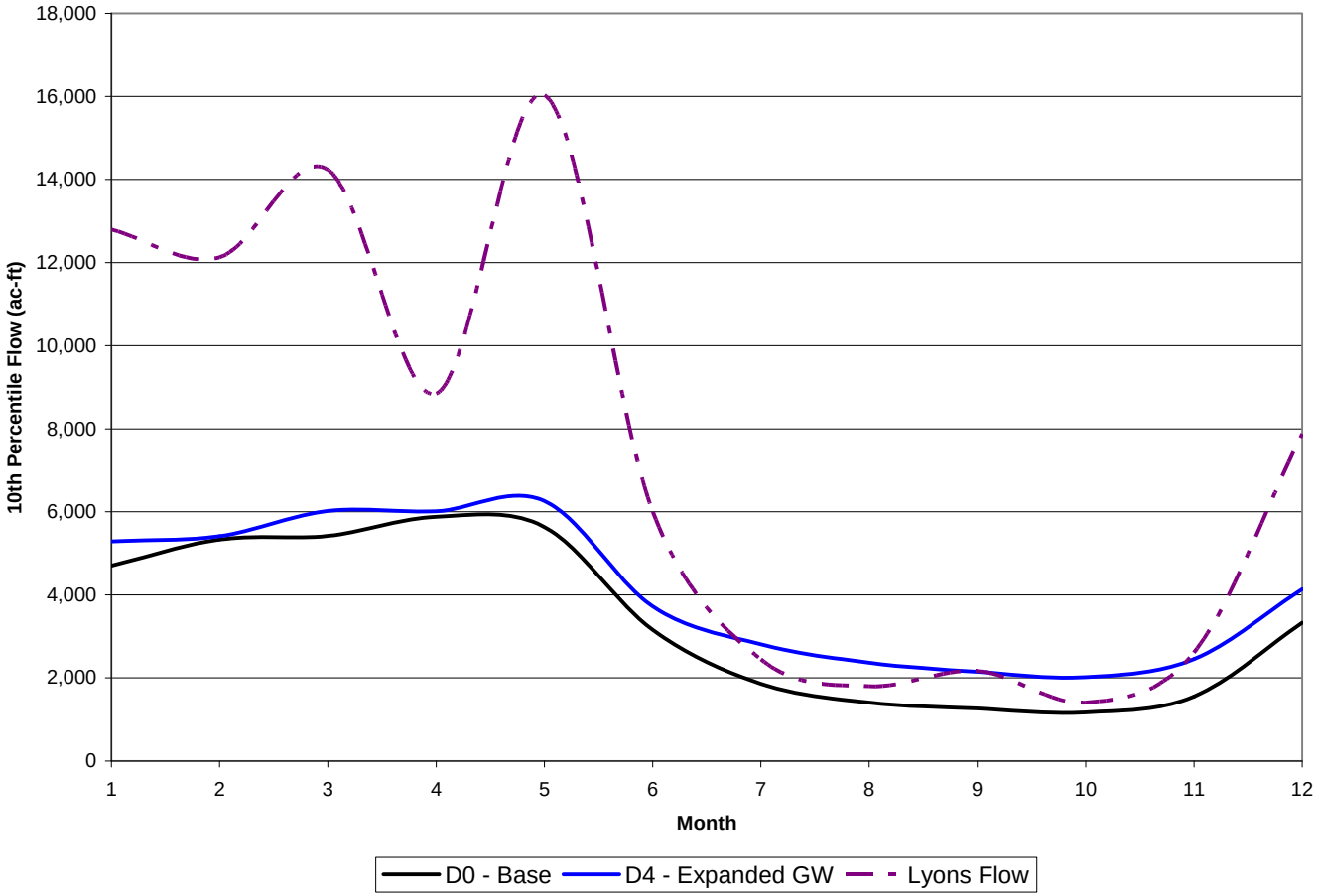
Control Point 1004 – W. Fork of the San Jacinto River



Major flow increase due to Expanded Use of Groundwater (41.1%)

Critical Segment Impacts

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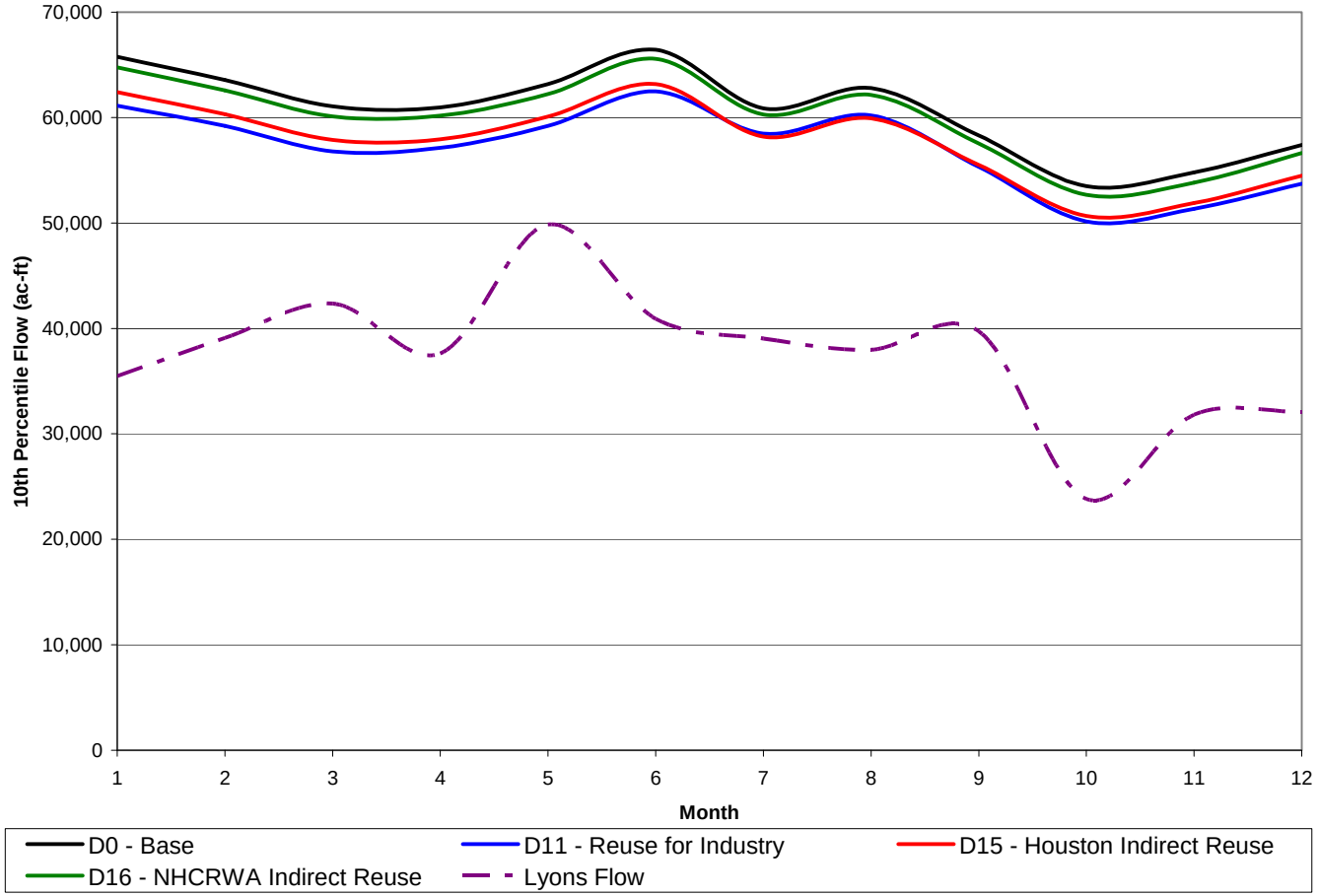
Control Point A5191P – Ship Channel / San Jacinto Tidal



Minor flow reductions due to Industrial WW Reuse (-5.6%), Houston Indirect Reuse (-5.0%), and NHCRWA indirect Reuse (-1.3%)

Critical Segment Impacts

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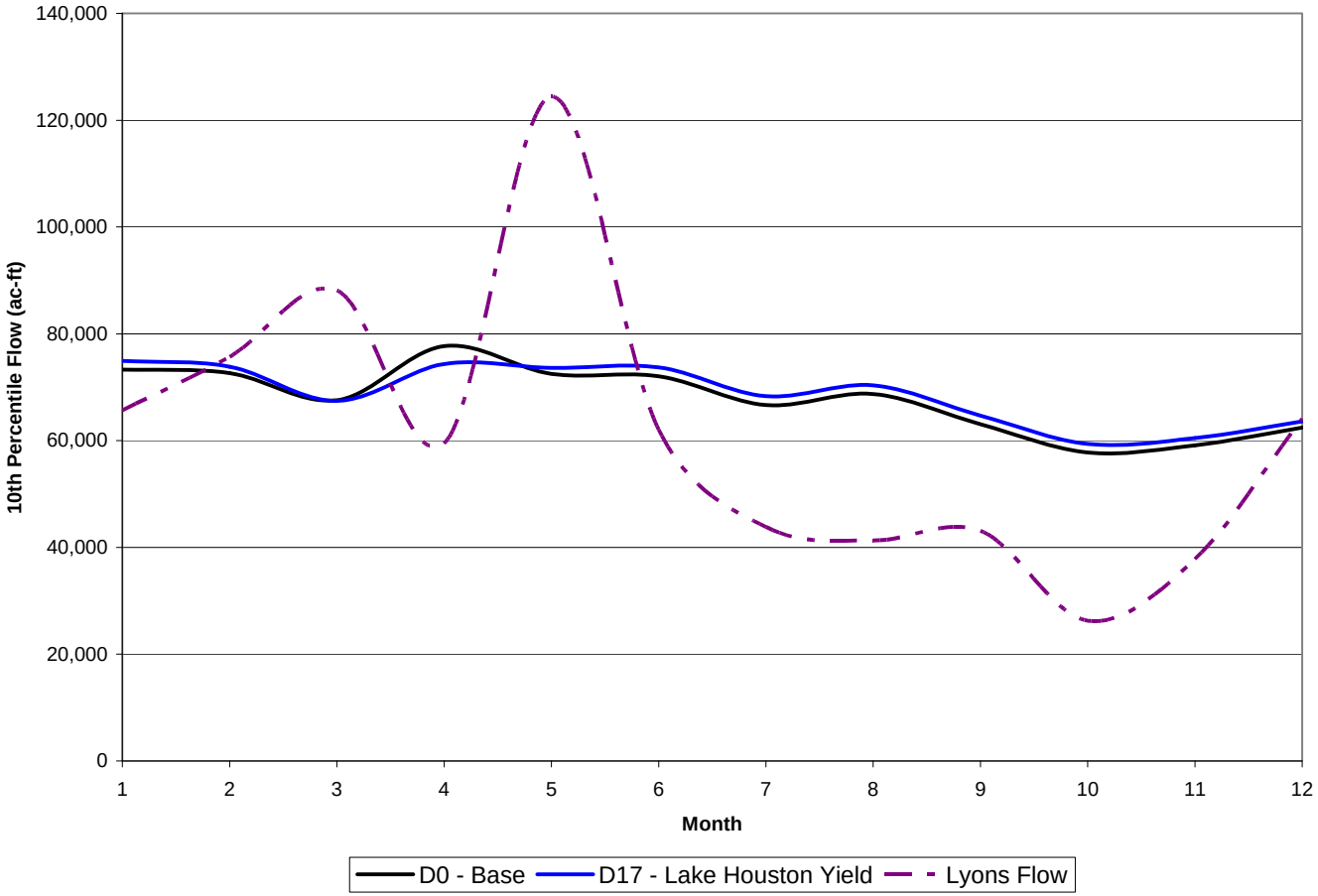
Water Planning Group

Control Point SRGB – Ship Channel / San Jacinto Tidal



Minor flow increase due to Lake Houston Additional yield (2.2%)

Conclusions

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Water Planning Group

- The predominant “impacts” to instream flows are increases in flow due to new water sources such as IBTs and groundwater.
- Reservoir operations projects in the Brazos River Basin resulted in some reduction in stream flow.
- Reclaimed wastewater projects accounted for small reductions in stream flow due to reduced return flows.

Field Investigation

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Water Planning Group

- Limited analysis of field conditions performed to compare actual low flow conditions to Lyons flows.
- Lyons flows were estimated using results of the WAM Run 8 (Current conditions).
- Selected observation points based on:
  - Accessibility
  - Available flow measurement
- Visually assessed environmental conditions at seven stations and determined Channel Flow Status.

Field Investigation

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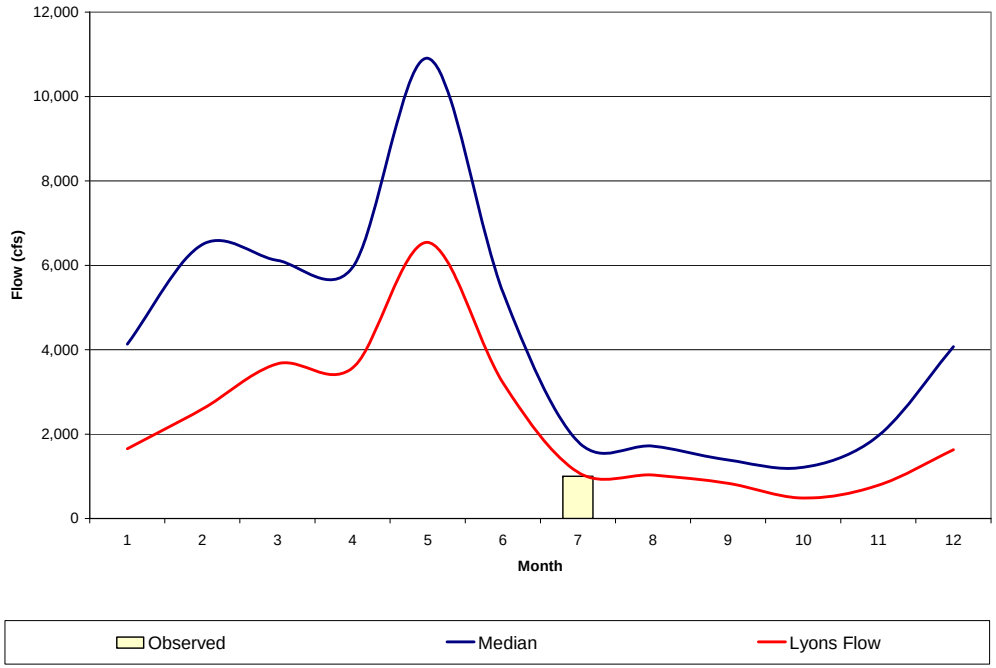
Water Planning Group

Trinity River at Romayor
CP 8TRRO



- Moderate Channel Flow Status
- No potential wetlands recognized
- Small riparian corridor observed

Field Investigation

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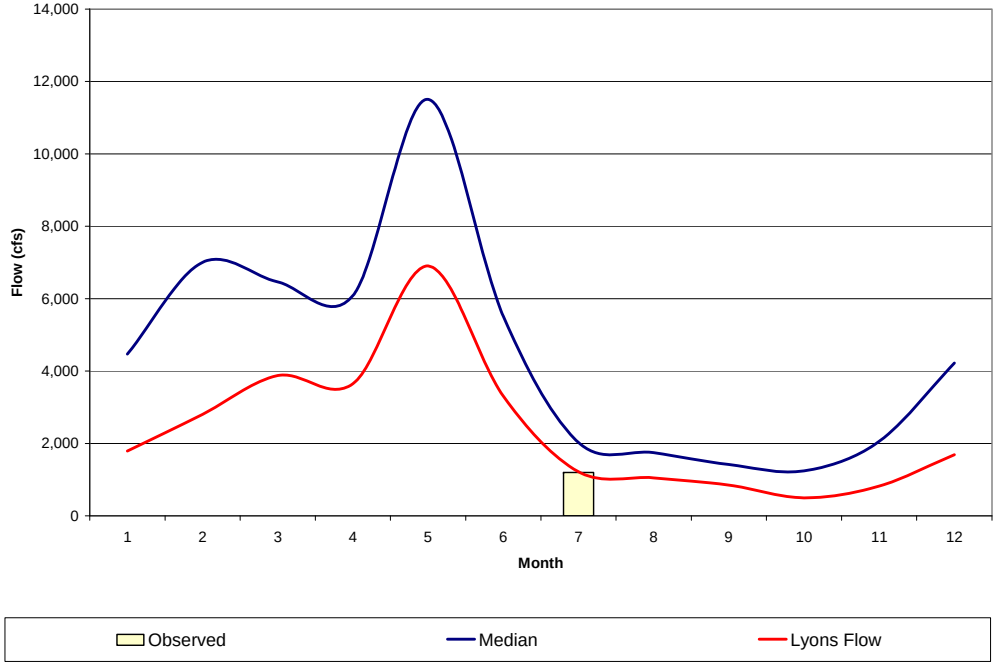
Trinity River at Liberty
CP 802



- Moderate Channel Flow Status
- No potential wetlands recognized
- Small riparian corridor observed

Field Investigation

REGION H
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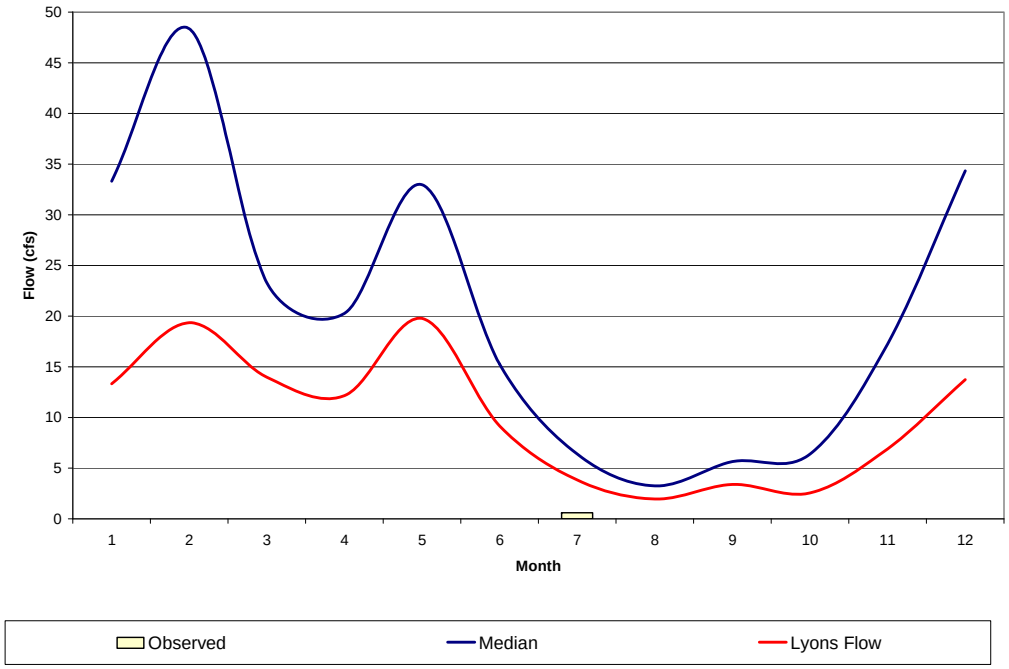
Cedar Bayou near Crosby
CP 9CBCR

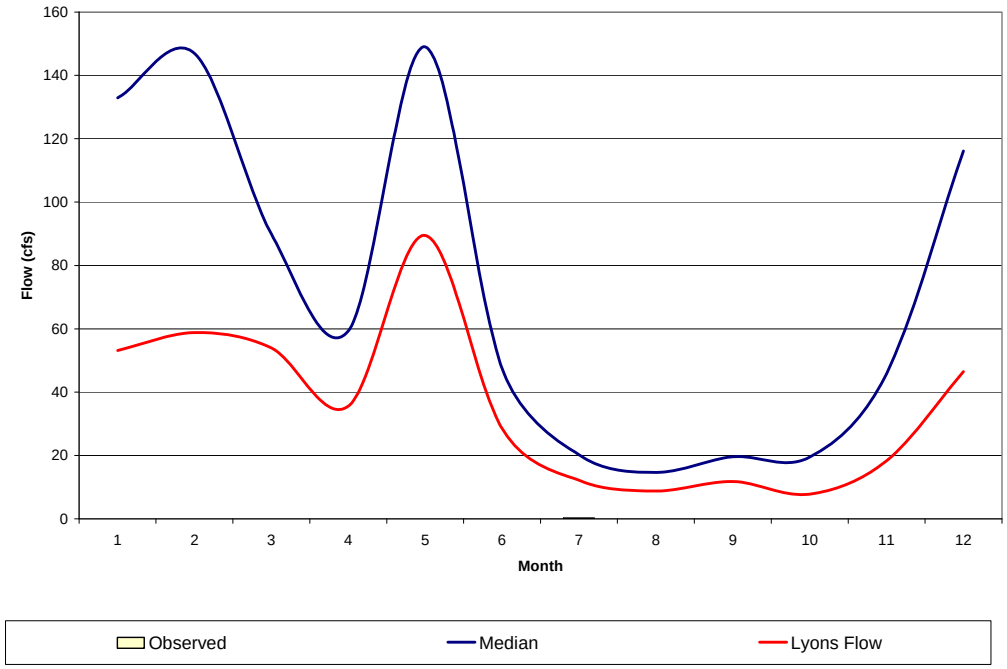


- Low Channel Flow Status
- No potential wetlands recognized
- No riparian corridor observed

Field Investigation

REGION H
Water Planning Group

Luce Bayou near Huffman
CP A3979A



- Low Channel Flow Status
- Potential fringe wetlands recognized
- Potential riparian corridor observed

Field Investigation

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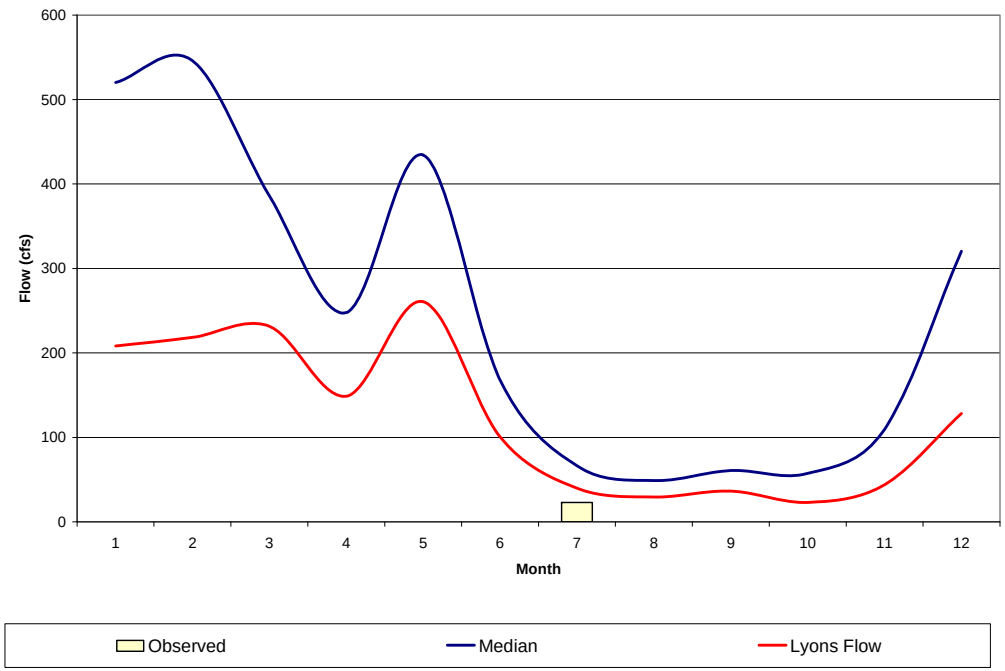
W Fork San Jacinto near Porter
CP 1004



- Moderate Channel Flow Status
- Potential wetlands recognized in sloughs
- Some potential riparian corridor observed

Field Investigation

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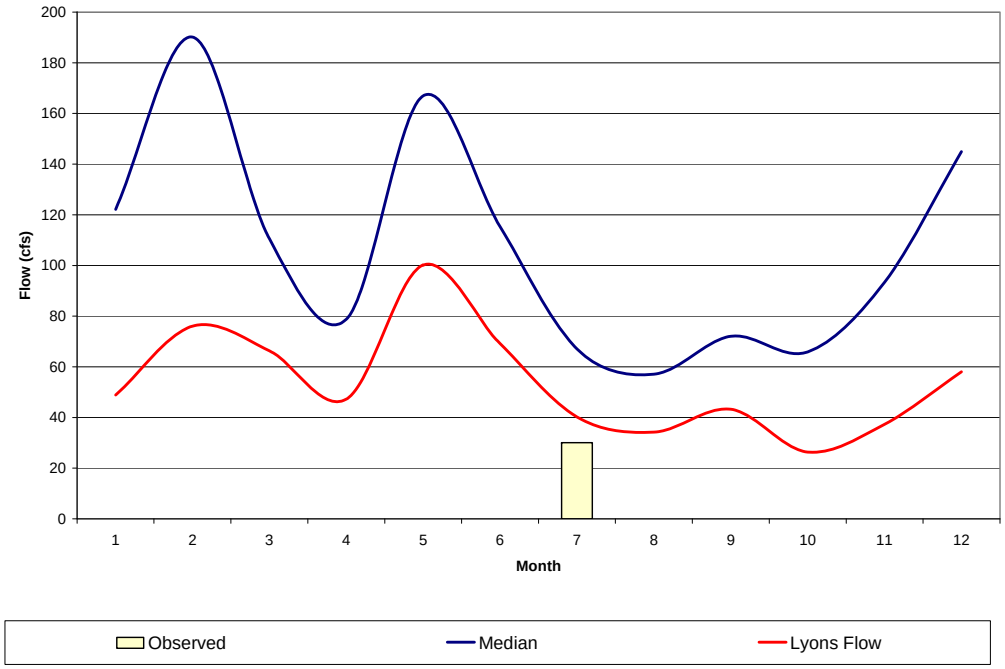
Cypress Creek near Westfield
CP 1009



- High Channel Flow Status
- No potential wetlands recognized
- No riparian corridor observed

Field Investigation

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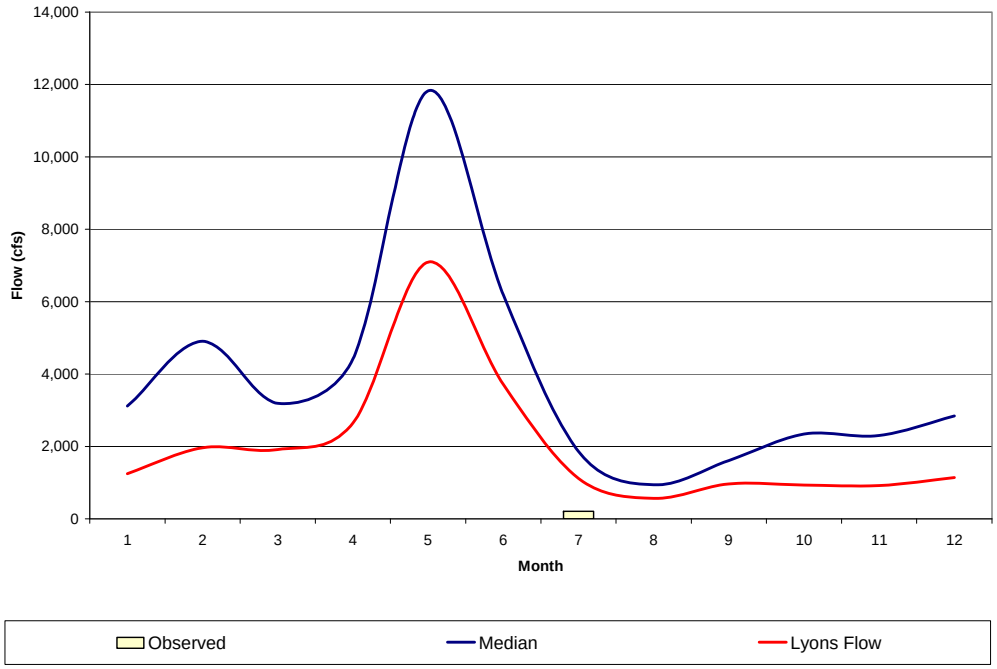
Brazos River near Rosharon
CP 532801



- Low Channel Flow Status
- No potential wetlands recognized
- No riparian habitats observed

Conclusions

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Water Planning Group

- Observed flows were approximately at or below Lyons Flow condition for all segments.
- Despite low flow conditions, no qualitative indications of impaired stream health were observed that would represent a long-term problem.
- Field survey points were selected based on accessibility and proximity stream gaging stations and may not be fully representative of conditions in other reaches.

Purpose of B&E Flows Study

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Water Planning Group

- Evaluate TWDB recommended B&E target flows in relationship to target frequencies established by GBFIG and adopted by Region H.
  - Evaluate the ability to meet these target frequencies under various baseline hydrologic conditions and variable durations (i.e., annual, monthly, seasonal).
  - Evaluate whether changes (pass through flows and/or reservoir releases) could be made to potentially achieve the target frequencies.
  - Evaluate what impacts would occur to our water supplies if these changes were made.

What This Study Isn't

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- Not evaluating the validity or accuracy of the recommended TWDB freshwater inflow targets.
- Not validating the accuracy of the recommended Region H freshwater inflow target frequencies.
- Not trying to figure out the "needs of the bay".
- Not really trying to develop or recommend an operational "solution" for achieving the desired B&E flows.
- *Simply using the goals already established by TWDB and Region H to evaluate how we might achieve those goals and what impacts to future water supply may result.*

Project Overview

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- Used WRAP to assess bay and estuary (B&E) target inflows in the year 2060.
- Models are based on a full diversion scenario with expected return flows.
- Models include all 2006 RWP Region H strategies, including:
  - TRA to Houston and SJRA transfers
  - Municipal and industrial effluent reuse
- Models include all upstream strategies in Region C 2006 RWP, including:
  - Water imports (Marvin Nichols, Toledo Bend, etc.)
  - Reuse projects

Project Overview

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Water Planning Group

- Identify shortages (defined as target B&E flows – simulated B&E flows) for period of record

- Evaluated the feasibility of operational changes (i.e., pass through flows and/or reservoir releases) to reduce the frequency of B&E target flow shortages.

- The underlying assumption to our approach is that B&E needs are met if the desired frequency of occurrence is achieved.

- *Can a methodology be developed to achieve a desired target B&E inflow frequency while also maintaining current and future water supplies?*

Future Model B&E Results

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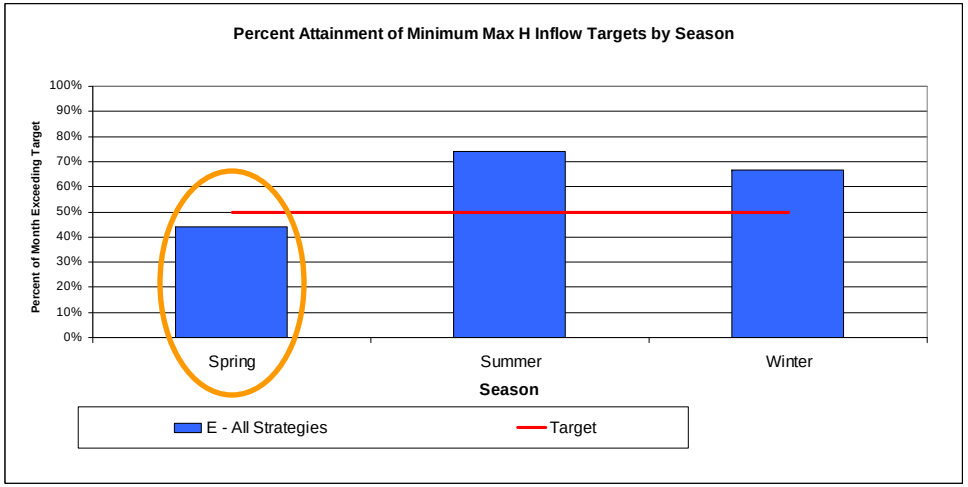
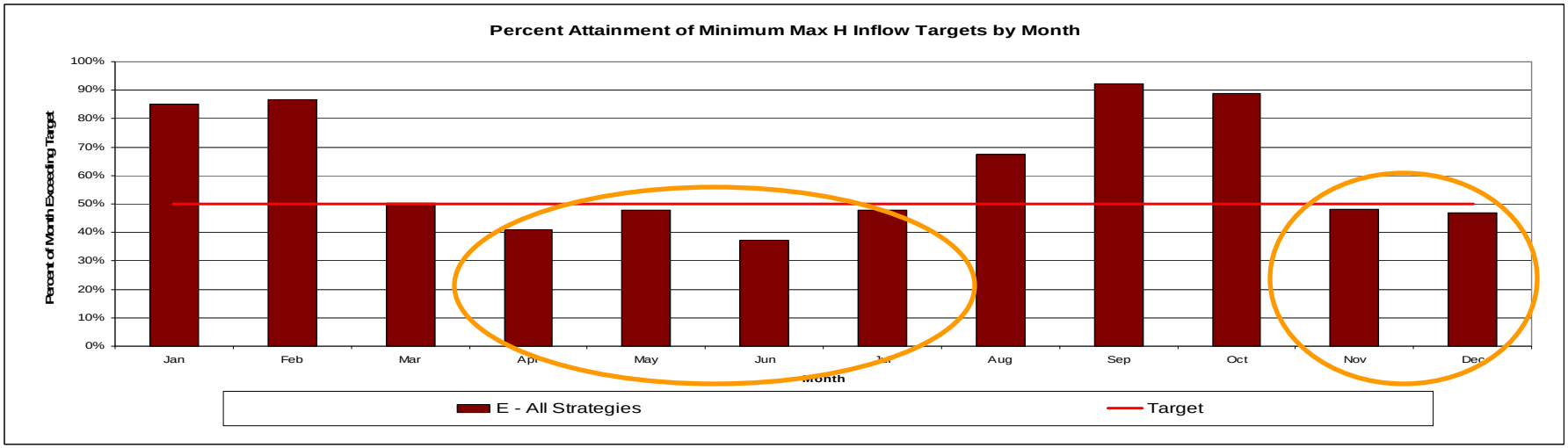
Max H

Scenario	Annual Max H
GBFIG Target	50%
E – All Strategies	61%





Future Model B&E Results

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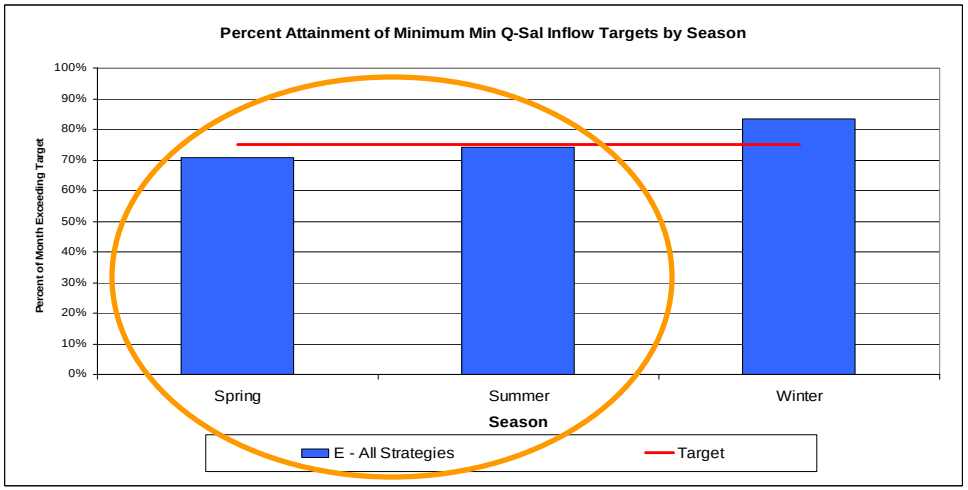
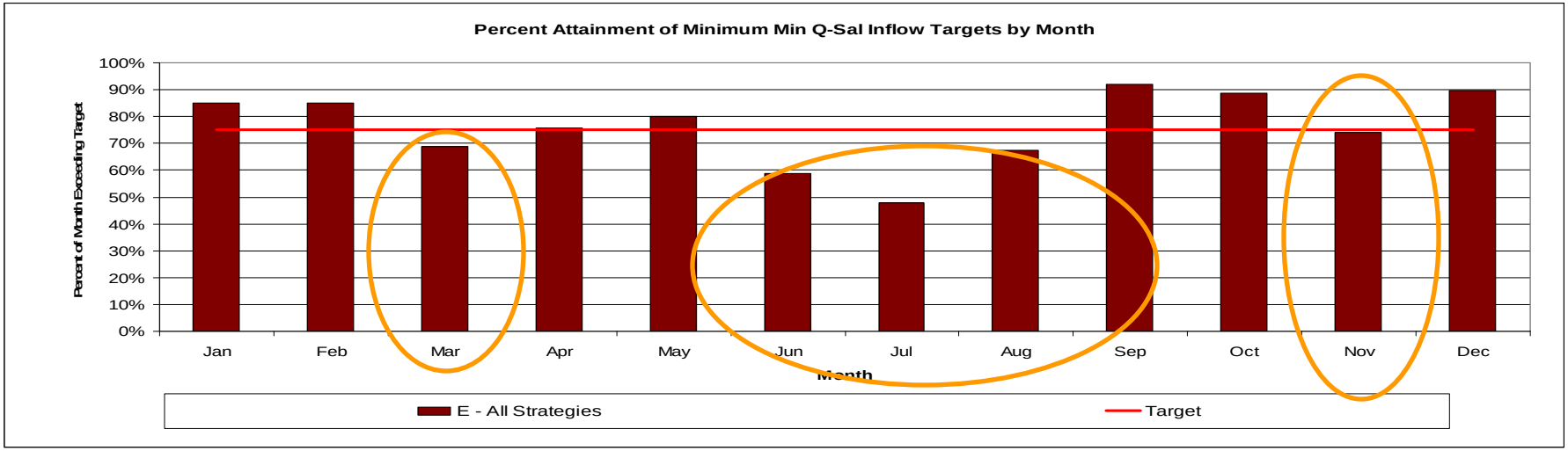
Min Q-Sal

Scenario	Annual Min Q-Sal
GBFIG Target	75%
E – All Strategies	76%





It's About Frequency…..Not Volume

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Strategy for Increasing Frequency of Achieving Target Flows

- B&E target flows are "achieved" by any flow that equals or exceeds that target flow. Flow can't be too high, only too low.
- Study focused on desired frequency for Max H of 50% and Min Q-Sal of 75%.
- Frequency is increased by increasing the number of months meeting the volume target, not by increasing the volume.
- Target the months with the smallest shortages.
- Manage reservoir releases when shortages for a particular month are ***less than some specified level.***

It's About Frequency…..Not Volume

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Strategy for Increasing Frequency of Achieving Target Flows

- Larger shortages, typically during dry periods, are "off the table" because these likely can't be achieved without significant loss to water supply.
- Focus on the "most efficient" (least water volume) approach for meeting target frequencies.
- Once the desired target frequencies are achieved, determine impacts to existing and future water supplies.
- "Success" of methodology will be determined by the ability to achieve recommended frequencies while minimizing impacts to water supply.

Max H Target Flow Shortages

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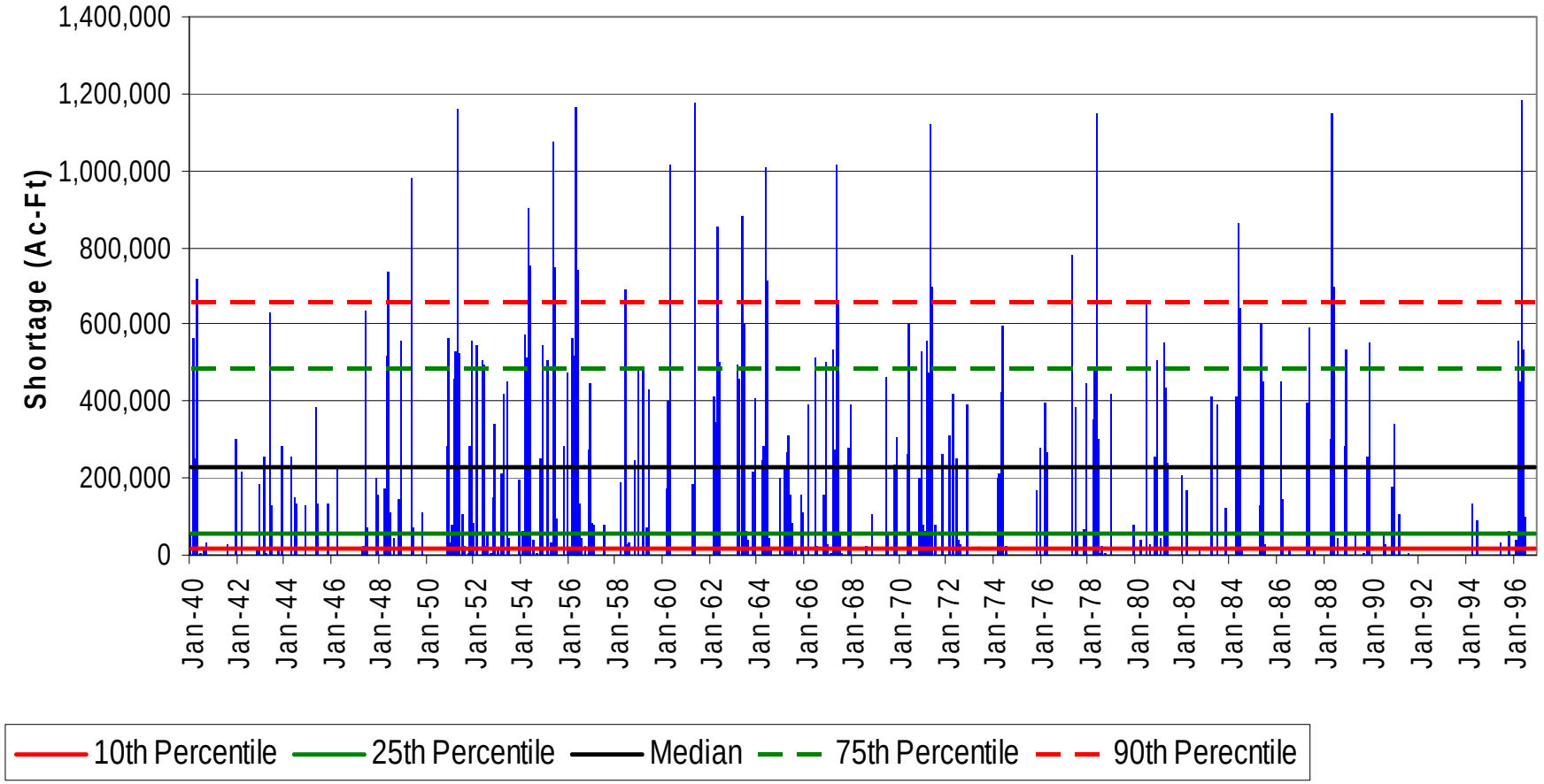

Target Reservoir Releases for Max H

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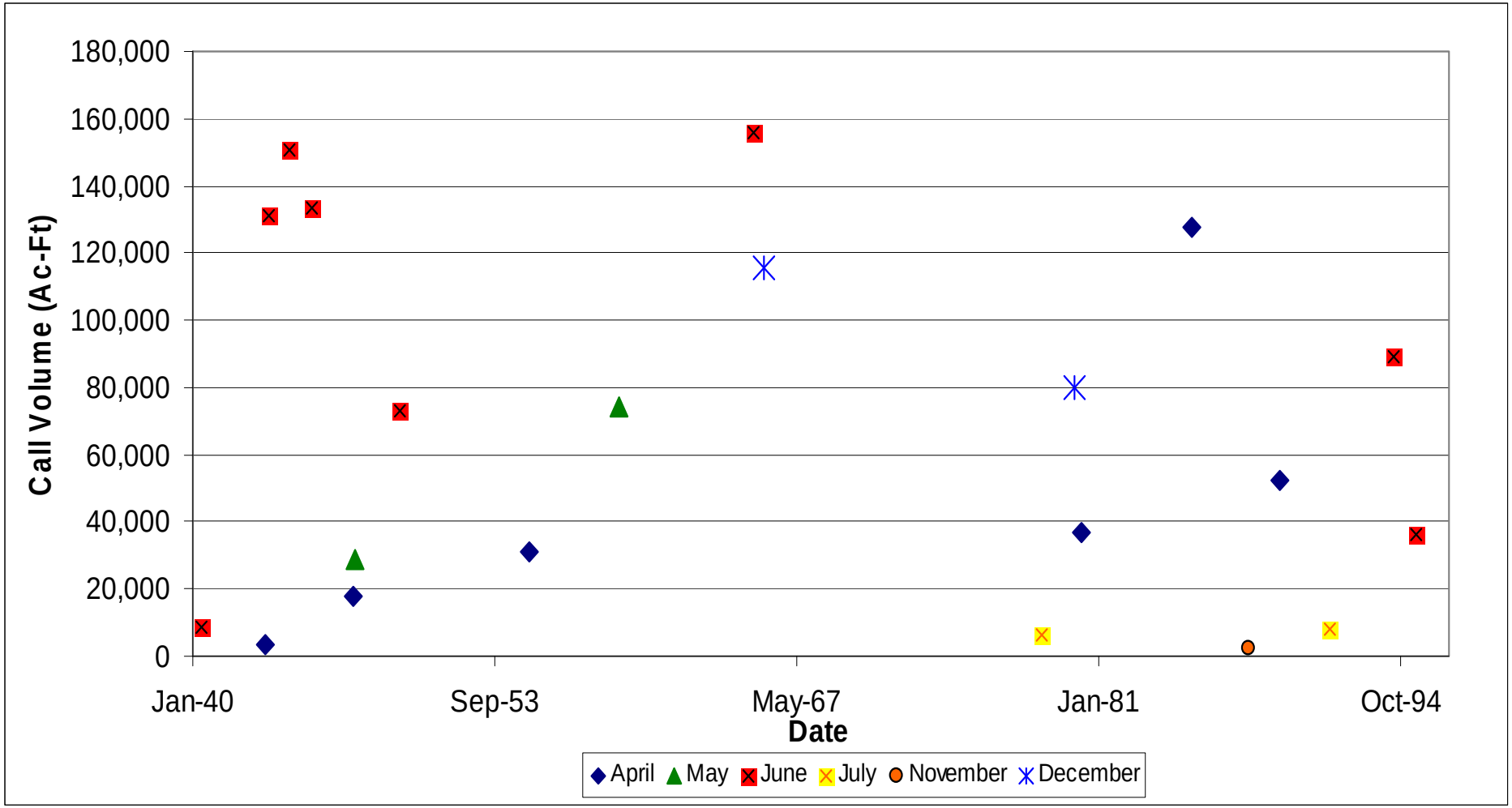

Pass Through Flows or Reservoir Releases?

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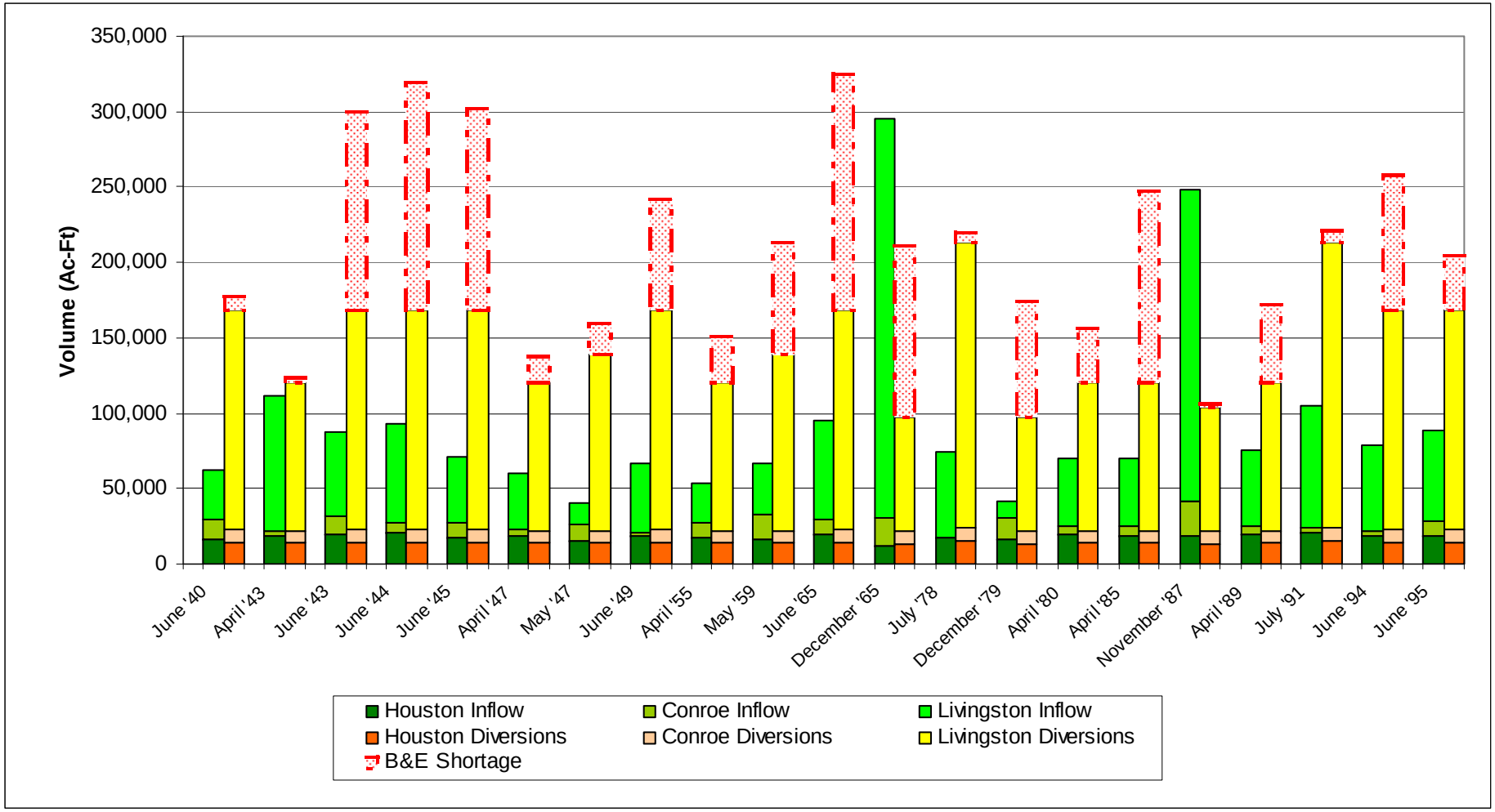

Applying Methodology for Max H

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Water Planning Group

- Identified shortages between simulated B&E inflow and the B&E target flows.
- Released water from reservoir storage to increase simulated inflows.
- Target releases increased until shortages were reduced to achieve the desired frequency of 50%.

Month	E Model Frequency	Maximum Target Volume (Ac-Ft)	Target Percentile of Shortage	Revised Frequency	Months Adjusted
January	85.0%			85.0%	
February	86.5%			86.5%	
March	50.3%			50.3%	
April	**41.0%**	127,500	15.1%	50.1%	6
May	**47.8%**	74,200	3.4%	50.1%	2
June	**37.3%**	156,100	20.0%	50.1%	8
July	**47.9%**	7,900	3.4%	50.1%	2
August	67.5%			67.5%	
September	92.1%			92.1%	
October	88.8%			88.8%	
November	**48.1%**	2,100	0.0%	50.1%	1
December	**46.8%**	115,400	3.5%	50.1%	2

Min Q-Sal Target Flow Shortages

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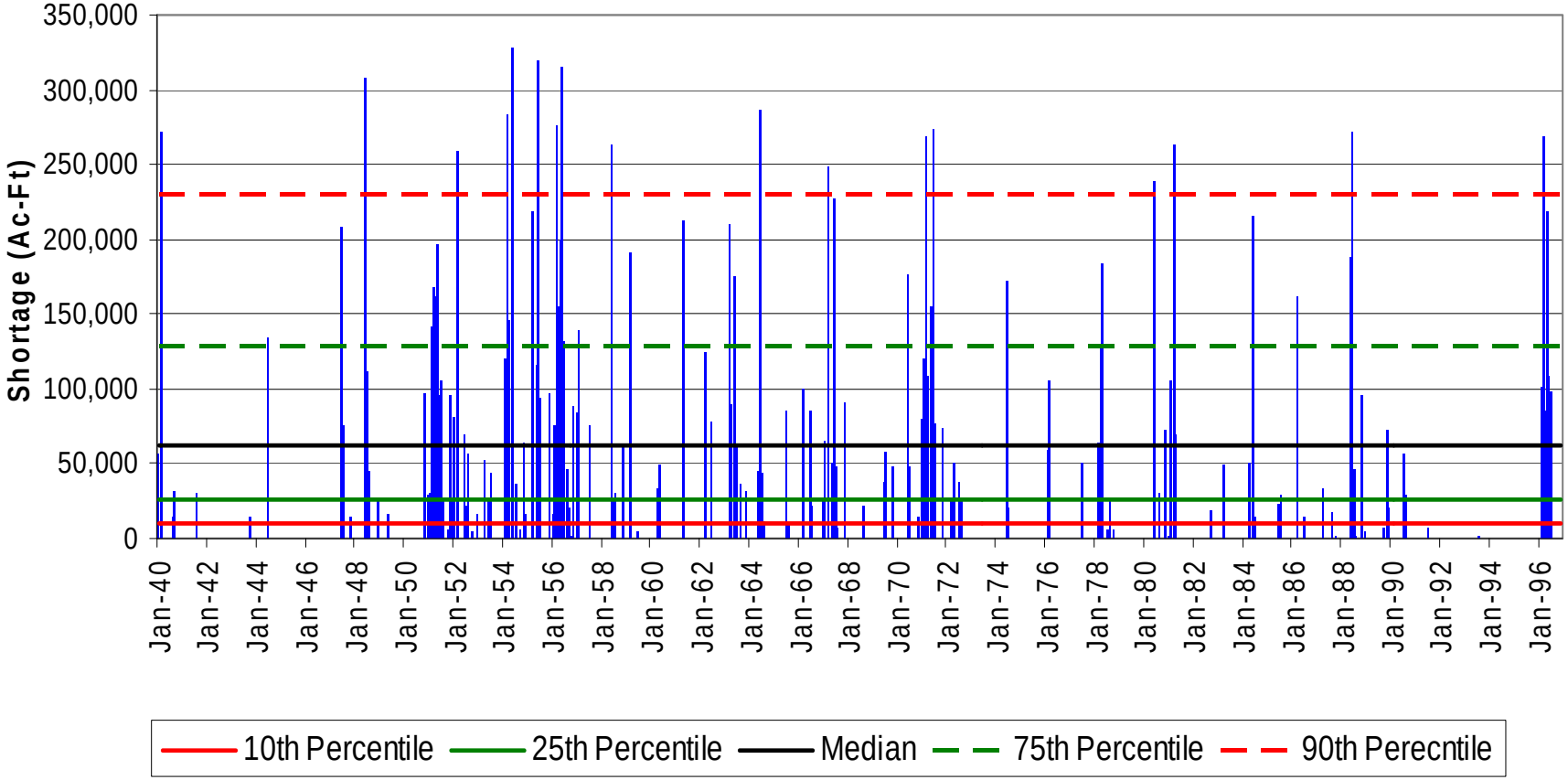

Target Reservoir Releases for Min Q-Sal

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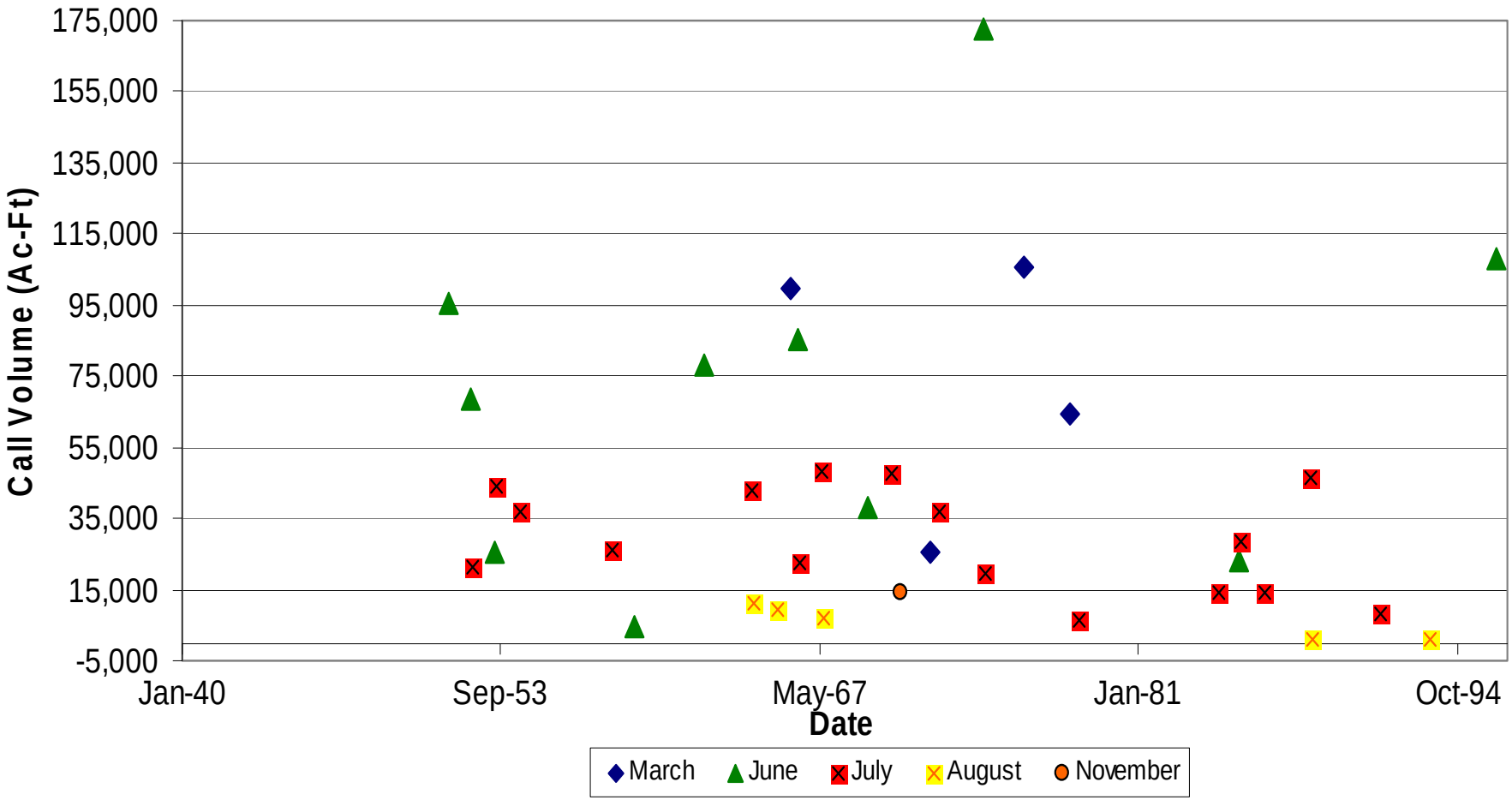
Water Planning Group



Applying Methodology for Min Q-Sal

REGION H
Water Planning Group

- Identified shortages between simulated B&E inflow and the B&E target flows.
- Released water from reservoir storage to increase simulated inflows.
- Target releases increased until shortages were reduced to achieve the desired frequency of 75%.

Month	E Model Frequency	Maximum Target Volume (Ac-Ft)	Target Percentile of Shortage	Revised Frequency	Months Adjusted
January	85.0%			85.0%	
February	84.9%			84.9%	
March	**68.9%**	105,500	17.6%	75.1%	4
April	75.7%			75.7%	
May	80.0%			80.0%	
June	**58.8%**	172,600	39.2%	75.1%	10
July	**47.9%**	48,100	51.8%	75.1%	16
August	**67.5%**	11,200	22.2%	75.1%	5
September	92.1%			92.1%	
October	88.8%			88.8%	
November	**74.0%**	14,200	1.5%	75.1%	1
December	89.6%			89.6%	

Impacts to Future Water Supply

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- Current firm yields of existing supplies and water management strategies are not impacted as a result of B&E releases.
- This is a function primarily of the upper basin return flows included in the model.
- Without these return flows, significant impacts to current firm yields would result from the B&E releases.
- Future potential yields of existing projects may also be impacted as a result of B&E releases.
- Future potential yields equate to future water supplies as a result of return flows and upper basin water imports.
- B&E releases from storage may also erode the drought “resistance” of our water supplies and make them vulnerable to longer more severe “drought of records”.

Impacts to Future Reservoir Storage

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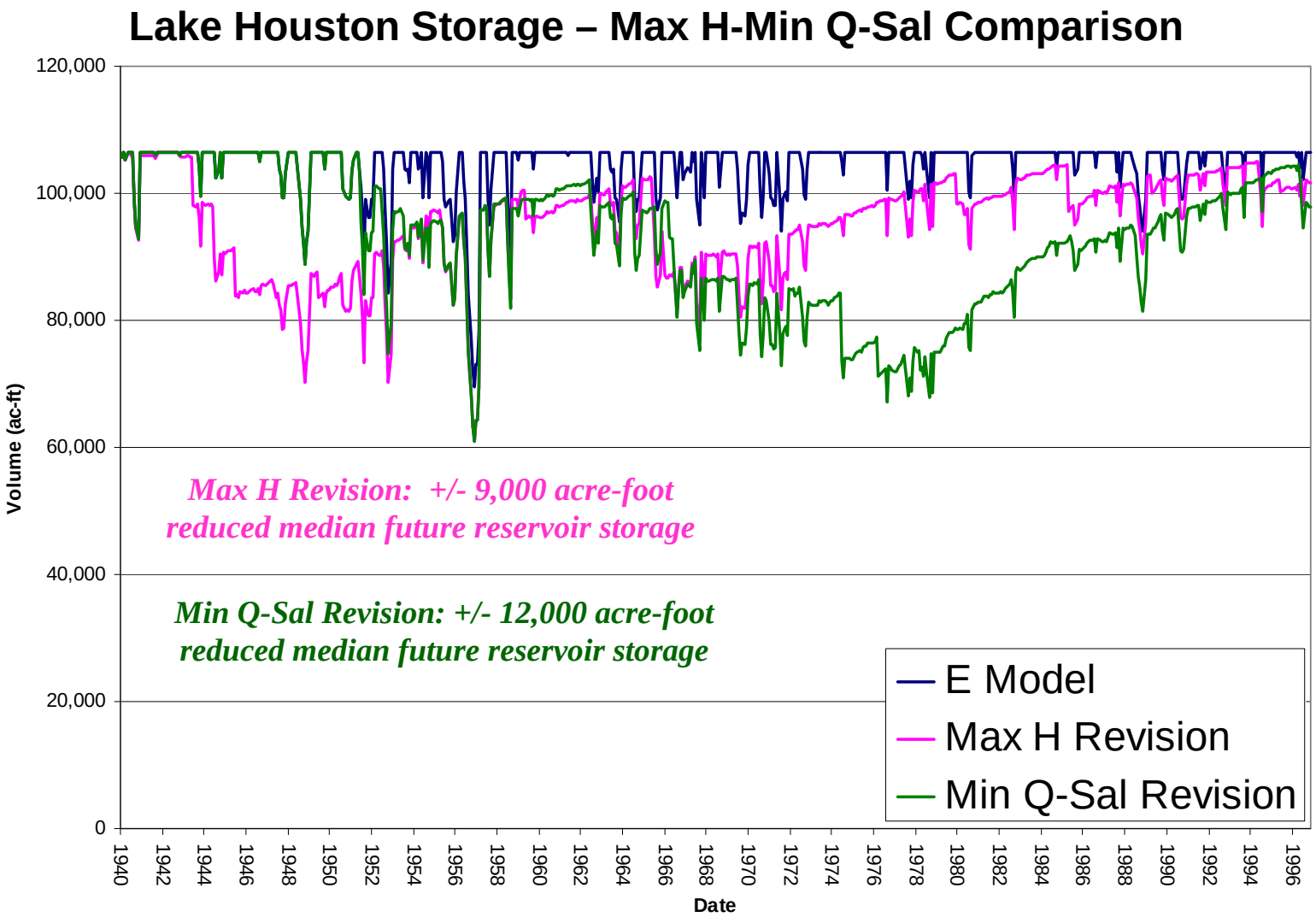

Impacts to Future Reservoir Storage

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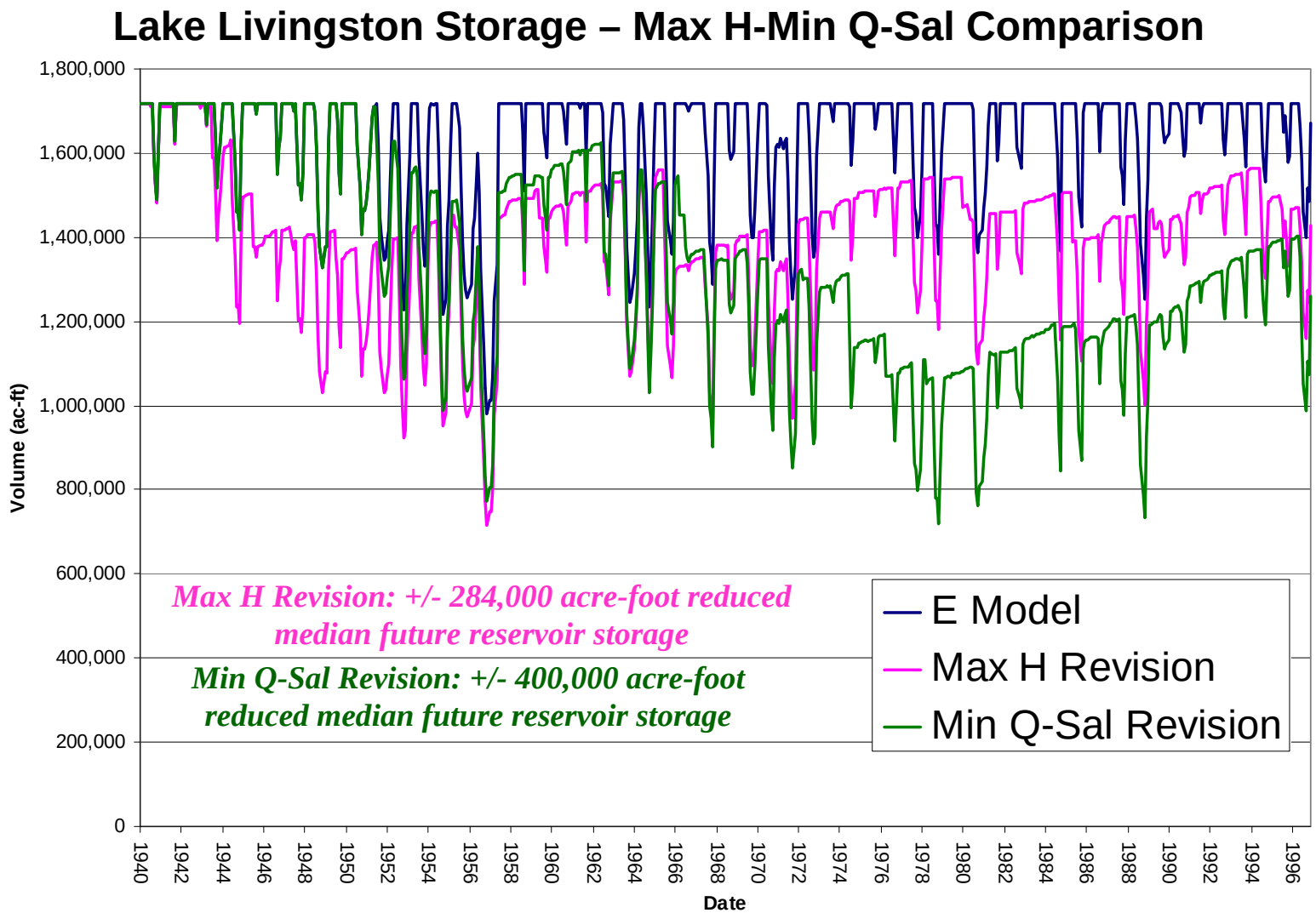
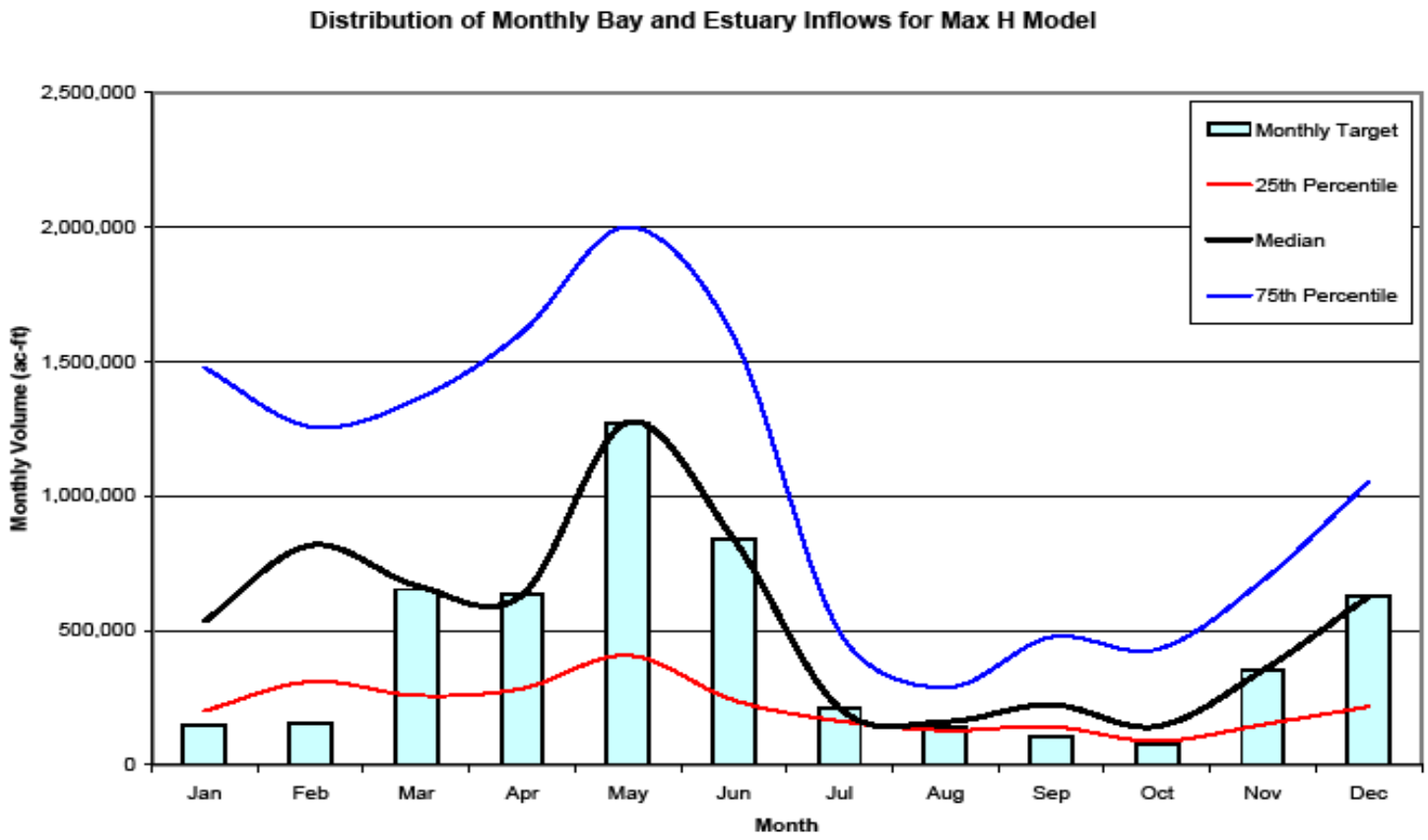


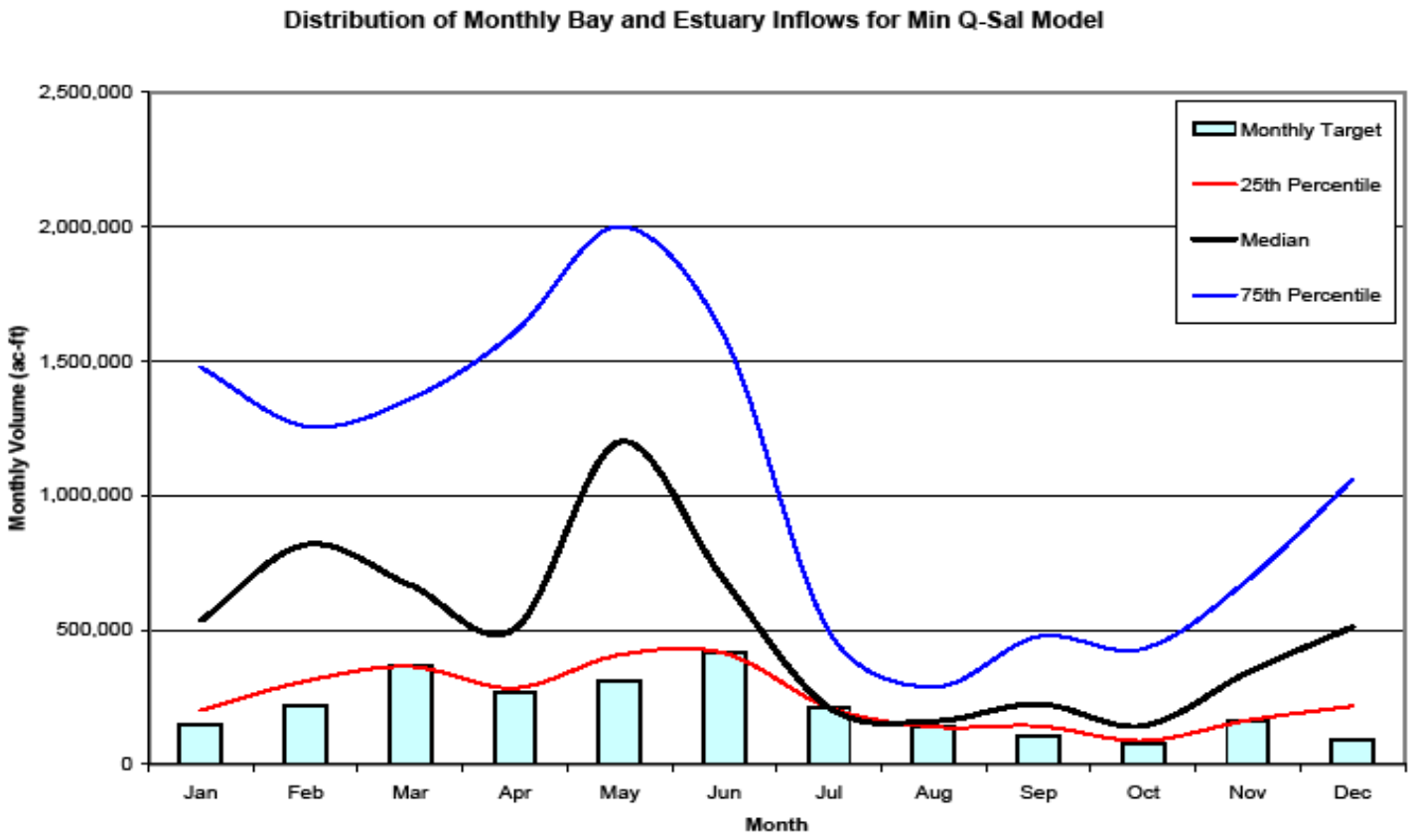
Bracketing of Inflows
Inflow Distribution for Max H Model

REGION H
Water Planning Group

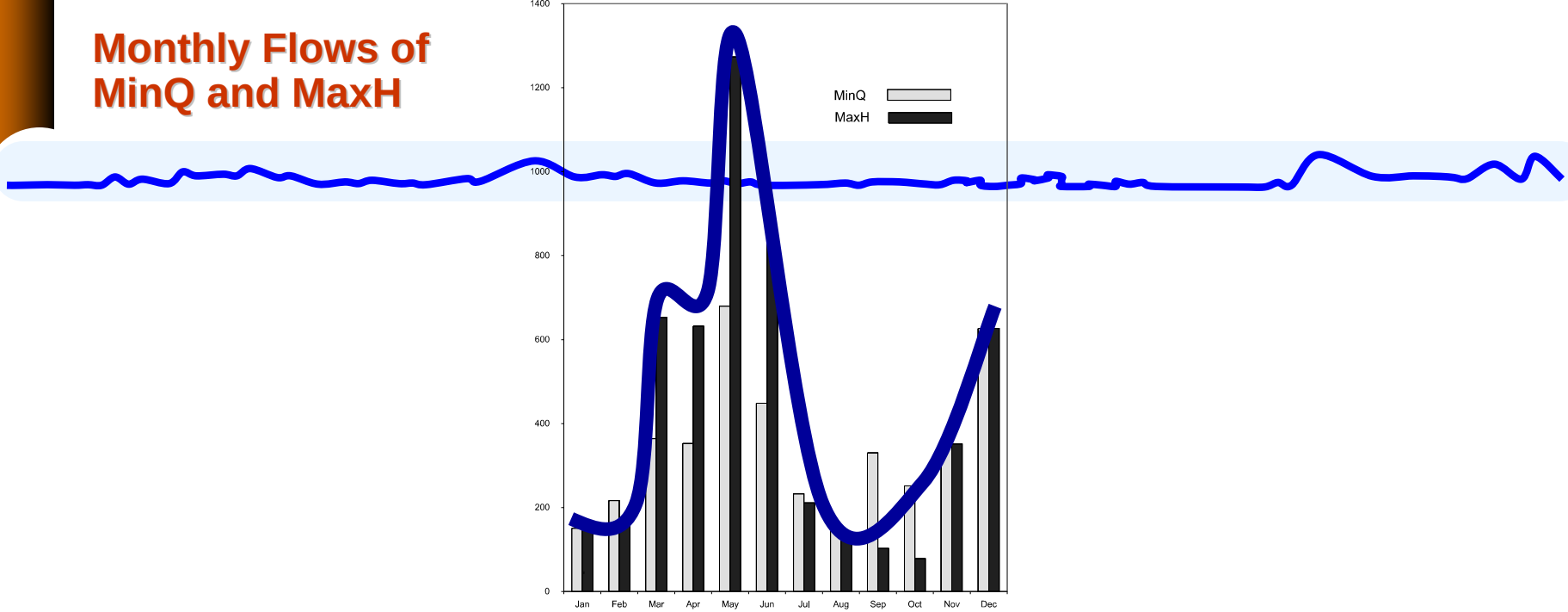


Bracketing of Inflows
Inflow Distribution for Min Q-Sal Model

REGION H
Water Planning Group



Monthly Flows of MinQ and MaxH



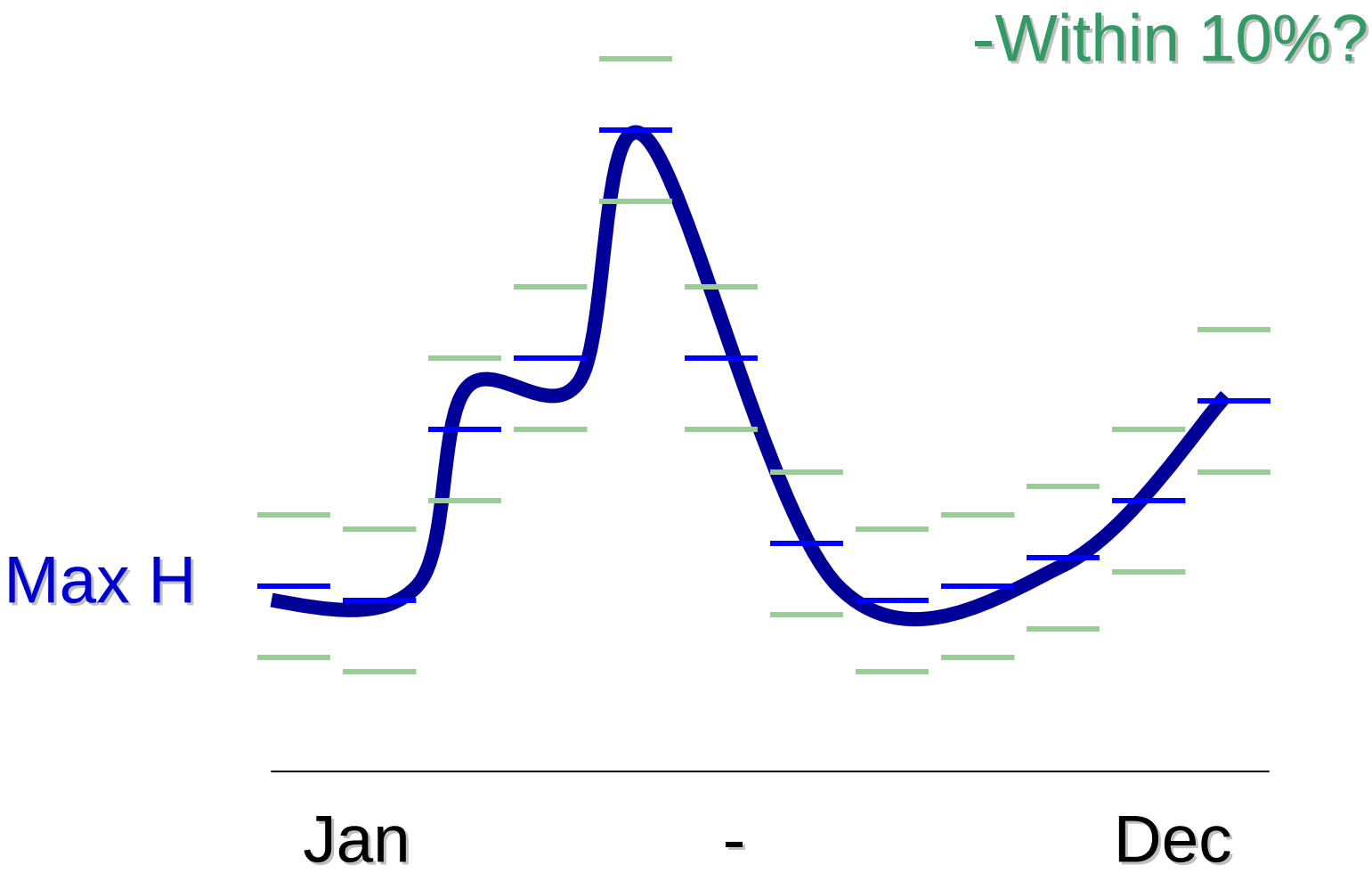
Monthly flows of MinQ and MaxH solutions

- The State Methodology's Max H flow regime is not comprised of individual Max H flow targets.

- Rather, to achieve maximum harvest in a given year monthly flows must be at (or near) all 12 of those flow targets in their respective months.

Test to Achieve Max H

Does a year provide the optimal flow pattern as defined by the state methodology?



Inflows (within 10%)

Recall, Maximum Harvest is achieved by <u>all twelve months</u> in year being optimum

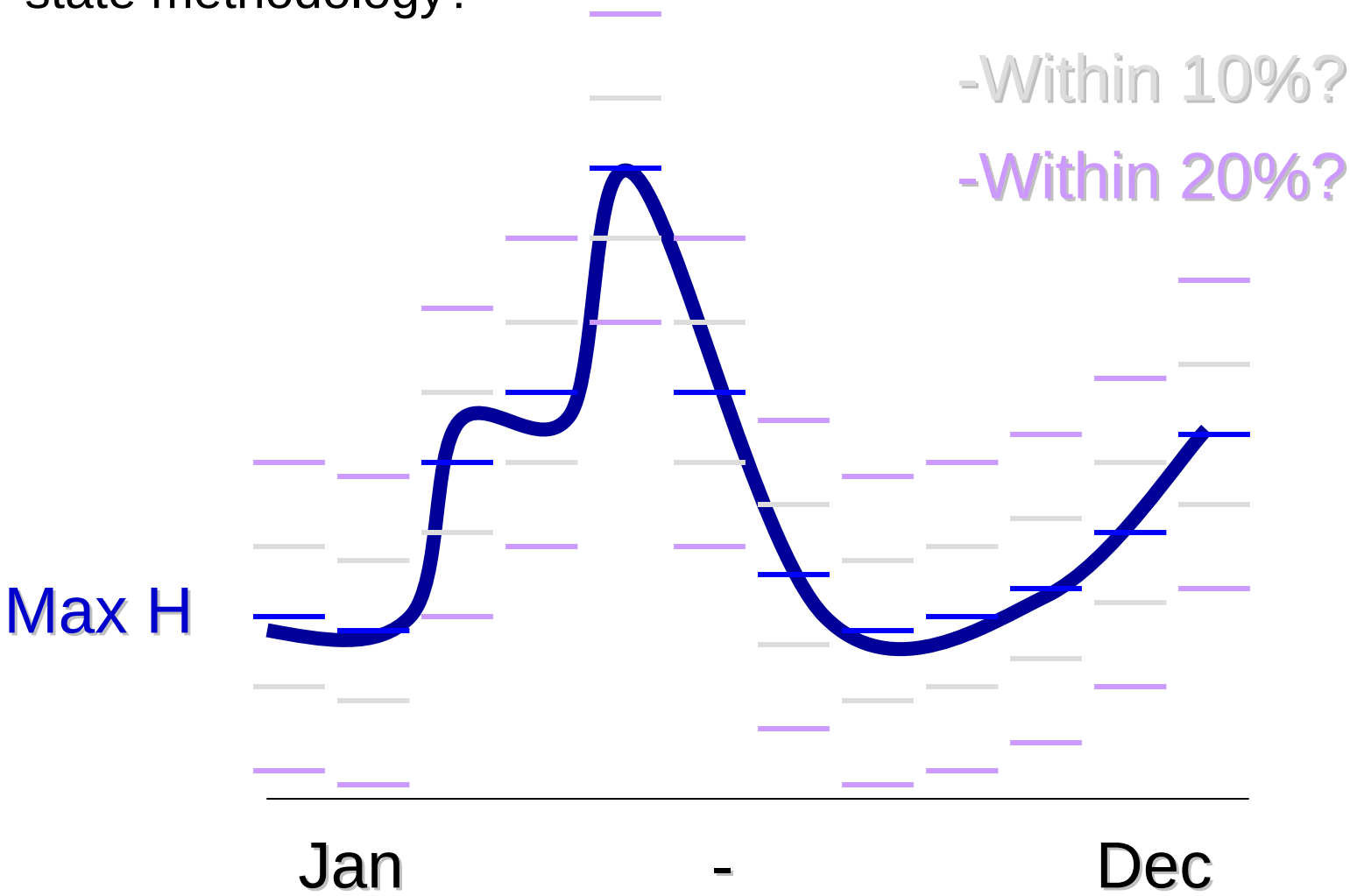
												Dec
1943						911,100						
1944						848,100		135,020			378,600	
1945					1,177,100						323,900	
1946												
1947				661,500						81,680		
1948												
1949									100,240			
1950												
1951		159,400										
1952												625,300
1953											348,800	
1954							217,790					
1955				675,300						83,140		
1956												
1957												
1958				645,200								
1959											354,200	
1960												
1961				619,800								
1962							229,600				341,900	
1963												
1964			677,100									
1965			628,500		1,329,000			132,220				
1966						831,300						
1967		150,980										
1968												612,200
1969												

Inflows (within 10%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1970					1,311,900		232,000					
1971											346,097	
1972												
1973												
1974					1,235,500							
1975												
1976												
1977							196,385					
1978							219,854			83,335		
1979												628,459
1980								136,969				
1981		144,442										
1982			627,602									
1983						792,112					348,551	669,614
1984												
1985				659,034		862,874						
1986												
1987												
1988												
1989												
1990											376,161	
1991												
1992										77,416		
1993												
1994				606,518								
1995												
1996												

Test to Achieve Max H

Does a year provide the optimal flow pattern as defined by the state methodology?



Inflows (within 20%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1941												
1942			586,300									
1943			562,200			911,100						
1944						848,100		135,020			378,600	
1945					1,177,100	941,200					323,900	
1946				544,200								
1947				661,500	1,488,600					81,680		
1948				516,600			185,300		116,150			
1949						926,000			100,240			
1950					1,429,000							
1951	128,100	159,400										
1952												625,300
1953			574,200								348,800	726,100
1954							217,790					
1955				675,300						83,140		
1956												
1957		174,700										712,200
1958				645,200				113,400				
1959					1,484,900						354,200	
1960			530,900									
1961				619,800								
1962							229,600				341,900	
1963									86,410			
1964			677,100								417,600	
1965			628,500		1,329,000	1,005,800		132,220			305,000	
1966						831,300						
1967		150,980										
1968												612,200
1969						966,500						528,600

Inflows (within 20%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1970					1,311,900		232,000					
1971											346,097	
1972								123,356				
1973												
1974					1,235,500		250,254					
1975			770,507									
1976	172,870	127,541		549,930							413,510	
1977			728,524				196,385					
1978							219,854			83,335		
1979												628,459
1980							246,871	136,969				
1981		144,442										
1982			627,602									
1983						792,112					348,551	669,614
1984												
1985				659,034		862,874						
1986												
1987								154,266			408,387	
1988												
1989			559,738									
1990											376,161	
1991												
1992										77,416		
1993												
1994				606,518								
1995												
1996		181,627					248,984					

Inflows (within 1045%)

To achieve 50% of years must adjust such that historic flows must be within 1045% of Max H.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1941											1,542,900	357,400
1942	288,2									700	443,700	495,300
1943	1,098,5									700	514,240	462,600
1944										640	378,600	1,408,900
1945											323,900	1,298,400
1946										150		1,120,400
1947										680	173,100	911,400
1948	817,6									060	143,750	55,290
1949	379,000	1,401,400	1,910,000	1,643,800	384,800	926,000	420,000	228,330	100,240		270,100	1,609,100
1950	1,574,400		853,500	978,300	1,429,000	1,693,900	484,000	258,700	677,900	215,600	90,660	71,560
1951	128,100	159,400	388,600	136,200	139,400	597,300	150,500	49,580	507,090	42,900	45,050	75,050
1952	73,100	695,800	288,300	1,462,500	1,010,400	443,100	285,750	20,590	61,100	28,710	138,160	625,300
1953	363,000	656,900	574,200	286,400	3,351,000	521,300	92,630	571,200	69,080	47,710	348,800	726,100
1954	317,900	81,720	73,530	145,510	461,500	56,540	217,790	93,840	15,740	214,400	276,000	92,880
1955	352,700	1,189,100	208,900	675,300	251,100	147,500	84,260	745,420	169,660	83,140	31,300	176,050
1956	180,700	432,800	131,700	189,900	388,200	138,080	44,350	54,860	26,830	21,100	95,520	167,240
1957	41,630	174,700	1,415,500	2,027,500	4,126,000	3,273,000	701,000	678,300	412,900		2,097,000	712,200
1958	1,567,500	1,024,300	517,100	645,200	2,422,000	517,200	416,300	113,400		341,000	88,300	118,700
1959	218,080		207,100	2,027,700	1,484,900	469,300	1,518,700	764,100	160,800		354,200	1,055,400
1960	1,505,000	1,333,000	530,900	268,900	282,900	1,548,900	329,900	878,280	193,340		1,004,100	2,582,000
1961			820,300	619,800	150,500	1,826,800	1,265,100	172,850		96,940	832,900	788,200
1962	433,100	295,300	327,000	322,900	564,900	471,900	229,600	303,300	422,400	556,100	341,900	1,075,700
1963	615,200	486,900	168,000	188,900	476,000	320,100	138,030	63,750	86,410	40,420	81,940	194,560
1964	255,590	596,360	677,100	384,400	268,900	176,900	103,640	111,770	216,320	372,300	417,600	981,100
1965	401,900	1,064,700	628,500	407,300	1,329,000	1,005,800	111,770	132,220	136,060	124,590	305,000	983,400
1966	782,100	1,344,300	302,800	1,675,000	4,571,000	831,300	490,700	730,000	263,700	265,800	241,640	94,850
1967	106,550	150,980	120,730	463,200	389,200	359,900	291,700	92,210	274,700	240,400	525,100	395,100
1968	1,512,500	616,700	1,053,900	2,183,000	3,087,000	3,171,000	734,400	194,800	300,800	256,090	250,540	612,200
1969	288,500	1,374,600	1,889,000	2,213,000	3,057,000	966,500	287,700	201,520	211,390	183,960	173,700	528,600

Inflows (within 1045%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1970	399,400	352,900	1,912,000	762,300	1,311,900	312,900	232,000	170,780	581,660		190,740	89,610
1971	63,310	70,990	108,210	197,970	153,090	119,950	153,580	295,400	625,930	122,511	346,097	1,904,850
1972	1,611,070	431,120	293,620	421,980	1,584,050	382,720	319,080	123,356	463,570	101,620	744,110	421,510
1973	1,096,890	1,093,660	2,250,030	3,132,680	1,741,020	4,011,820	1,046,890	550,350			1,162,130	1,147,070
1974		643,276	518,320	428,700	1,235,500	278,831	250,254	316,230		540,840	3,217,410	2,000,490
1975	1,174,310		770,507	1,471,960	2,127,080	1,784,680	571,020	680,880	246,162	322,390	246,575	204,630
1976	172,870	127,541	224,111	549,930	276,260	1,615,280	759,150	198,855	325,650	390,580	413,510	1,606,280
1977	672,654	1,346,984	728,524	2,483,480	822,157	561,989	196,385	216,927	356,242	117,139	570,367	449,329
1978	1,140,469	984,419	439,787	166,514	161,481	512,117	219,854	171,138	335,434	83,335	461,198	282,025
1979	1,416,306	1,460,504	1,620,518	3,134,120	1,899,800	2,042,148	2,387,442	641,356		313,664	634,952	628,459
1980	1,450,677	1,038,146	950,560	771,168	1,709,478	321,883	246,871	136,969	584,127	424,883	136,320	165,558
1981	188,749	144,442	161,204	234,102	919,102	3,674,986	1,311,544	346,893	1,053,224		1,783,010	892,675
1982	728,692	654,847	627,602	960,395	2,001,583	1,550,919	936,525	553,662	193,134	146,595	787,968	1,805,511
1983	807,453		1,505,404	382,804	1,731,824	792,112	1,138,575			224,518	348,551	669,614
1984	626,169	635,400	927,617	356,239	528,271	294,455	314,642	209,571	233,328		904,977	969,674
1985	1,091,971	1,379,032	2,015,201	659,034	902,381	862,874	352,022	276,931	462,290	899,573	1,763,157	1,827,069
1986	311,759	1,340,362	370,369	401,150	1,561,330	2,957,854	605,028	237,042	615,560		1,727,561	2,168,585
1987	998,087	910,759	1,560,093	396,326	540,534	2,536,267	1,122,183	154,266	325,502	122,680	408,387	913,150
1988	581,338	415,809	804,665	466,340	290,255	203,841	261,983	267,840	358,979	112,438	88,068	103,134
1989	358,352	445,789	559,738	820,156	2,534,524	3,615,843		929,499	209,071	314,223	193,024	104,258
1990	731,678	1,128,868	1,950,090	2,291,570	4,355,617	1,850,399	517,124	340,626	242,278	286,292	376,161	323,617
1991			1,234,321	2,993,057	2,100,966	1,682,881	972,321	690,098		453,762	2,208,921	3,427,117
1992			4,249,316	2,255,058	1,848,335	2,418,949	995,548	679,250	264,294	77,416	863,499	1,892,896
1993		1,559,573	3,361,311	2,361,784	2,290,356	3,116,278	1,095,797	493,887	480,115	721,124	1,077,556	765,086
1994	469,944	1,040,829	1,674,030	606,518	1,997,939	1,078,111	427,111	596,629	385,497		1,272,848	2,625,314
1995		783,937	2,339,693	2,224,262	2,370,657	1,445,844	760,794	975,573	217,460	357,231	462,950	1,003,947
1996	446,653	181,627	117,830	199,175	148,855	502,987	248,984	768,018		309,632	224,856	847,411

Summary of Results

REGION H
Water Planning Group

- Annual volumetric recommendations appear to be achieved at the desired frequencies.
- A desired seasonality (monthly distribution) of flow appears to be highly problematic both in terms of developing an achievable goal as well as potential impacts to water supplies.
- Meeting the prescribed seasonal frequencies used in this study for Max H and Min Q-Sal requires releases from reservoir storage for several months (21 for Max H, 36 for Min Q-Sal) over the period of record.
- Firm yields of existing supplies are not impacted primarily as a result of significant upper basin return flows assumed in our approach and simulated in the model. Lesser upper basin return flows in combination with B&E releases would impact current estimated firm yields.
- Loss of reservoir storage (loss of future water supply) appears to be unavoidable unless the desired frequency of achieving the seasonal target flows is different from the current GBFIG annual flow recommendations.
- The Min Q-Sal seasonal target frequency appears to result in greater impacts to future reservoir storage than Max H due to the higher level of desired frequency (75% for Min Q-Sal versus 50% for Max H).

Issues and Considerations

REGION H
Water Planning Group

- This study focused on the “end game” (i.e., 2060 conditions). This decade may not represent the most critical scenario due to the staging of strategies and return flows over time. Region H 2011 plan scope has elements to address the planning decades prior to 2060.
- The underlying assumption that B&E flow needs are met if desired frequency of occurrence is achieved has no real technical basis.
- The approach does not consider a “bracket” of acceptable flows, only whether the flow equals or exceeds the desired B&E flow.
- The strategy used to “fix” the problem represents a hard-wired approach to meeting the desired frequency and couldn’t be replicated in the real world.
- The validity of using the same annual recommended frequencies for Max H and Min Q-Sal for evaluating seasonality (i.e., monthly target flows) is questionable and should be studied further.

What Does All this Mean to the SAC and BBEST?

REGION H
Water Planning Group

- The basic definitions and goals for a “flow regime” is very important to our discussions.
- How do we develop a “flow regime” that accomplishes the seasonal and monthly variations prescribed that is also feasible from a water supply perspective?
- A single annual volumetric flow probably doesn’t address the seasonal needs of the environment.
- 12 monthly prescribed numbers is likely not going to be successful. Can’t always be achieved as a function of natural hydrology. Frequency and seasonal pattern become difficult issues in relationship to water supply management.
- Given what we know today about existing water rights and near term future changes, what flow conditions do we consider when developing our “flow regime”?