Draft Reference handout for San Juan River Recovery Implementation Program Environmental Flows Workshop #2 (sub-group meeting)

These tables and figures are provided as quick references.

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Table 1. Table S.1 from the 1999 Flow recommendations. These describe the flow characteristics that are supposed to elicit biological and habitat responses.

Table S.1. Flow requirements needed to produce important biological responses and habitats in the San Juan River.

BIOLOGICAL RESPONSE/ HABITAT REQUIREMENT	FLOW CHARACTERISTIC
Reproductive success of Colorado pikeminnow lower in years with low spring runoff peaks, and higher in years with high and broad runoff peaks.	Mimicry of a natural hydrograph, especially during relatively high runoff years.
Decline in flannelmouth sucker abundance, increase in bluehead sucker abundance, and increased condition factor in both species.	Mimicry of natural hydrograph with higher spring flows and lower base flows.
Bluehead sucker reproductive success.	Increased number of days of spring runoff >5,000 and 8,000 cfs correlated with increased success.
Speckled dace reproductive success.	Increased number of days of spring runoff >5,000 and 8,000 cfs correlated with increased success.
Success of stocking YOY Colorado pikeminnow and subadult razorback sucker.	Mimicry of natural hydrograph has provided suitable habitat for these size-classes.
Eddies, pools, edge pools, other low-velocity habitats year round for adult Colorado pikeminnow and razorback sucker.	Mimicry of natural hydrograph has lowered base flows to provide more low-velocity habitats. Flows >10,000 cfs provide more channel complexity which provides for more habitat complexity.
Flows to cue razorback sucker and Colorado pikeminnow for migration and/or spawning.	Mimicry of natural hydrograph with higher spring flows.
Adult Colorado pikeminnow and razorback sucker use complex river areas.	Flows >10,000 cfs provide more channel complexity which provides for more habitat complexity, lower base flows add to amount of low-velocity habitats.
Clean cobble bars for spawning of all native species, especially Colorado pikeminnow.	Flows >8,000 cfs for 8 days to construct cobble bars, and >2,500 cfs for 10 days to clean cobble bars, during spring runoff.
Backwaters and other low-velocity habitats are important nursery habitats for Colorado pikeminnow and other native fishes.	High spring flows create conditions for backwater formation, low base flows allow them to appear in late summer and fall, flows >5,000 cfs for 3 weeks create and clean backwaters.
Flooded bottomlands appear to be important nursery areas for razorback sucker, but other habitats may be used in the San Juan River.	Overbank flows (> 8,000 cfs) increase flooded vegetation, and backwaters formed in association with edge features maximize on receding flows of 8,000 to 4,000 cfs.
Temperatures of 10 to 14 • C at peak runoff for razorback sucker spawning and near 18 to 20 • C at bottom of descending limb for Colorado pikeminnow spawning.	Proposed releases from Navajo Dam are too cool to replicate pre-dam temperature timing, but temperatures are above spawning threshold for Colorado pikeminnow during the correct period.
Reduction of nonnative fish abundance.	Most nonnative fishes did not decrease during research period, summer flow spikes reduce numbers of red shiner in secondary channels in the short term.

Note: cfs = cubic feet per second, YOY = young-of-the-year.

Table 2. Recommended flow metrics and purposes from the 1999 Flow Recommendations.

A.

Frequency: **Flows > 10,000 cfs for 5 days or more need to occur in 20% of the years on average for the period of record 1929-1993**. Maximum number of consecutive years without meeting at least a flow of 9,700 cfs (97% of 10,000 cfs) within the 65-year period of record is 10 years.

Purpose: Flows above 10,000 cfs provide significant out-of-bank flow, generate new cobble sources, change channel configuration providing for channel diversity, and provide nutrient loading to the system, thus improving habitat productivity. Such flows provide material to develop spawning habitat and maintain channel diversity and habitat complexity necessary for all life stages of the endangered fishes. The frequency and duration are based on mimicry of the natural hydrograph, which is important for Colorado pikeminnow reproductive success and maintenance of channel complexity, as evidenced by the increase in the number of islands following high flow conditions. Channel complexity is important to both Colorado pikeminnow and razorback sucker.

B. Category: Flow > 8,000 cfs during runoff period.

Duration: **A minimum of 10 days between March 1 and July 31**.

Frequency: **Flows > 8,000 cfs for 10 days or more need to occur in 33% of the years on average for the period of record 1929-1993**. Maximum number of consecutive years without meeting at least a flow of 7,760 cfs (97% of 8,000 cfs) within the 65-year period of record is 6 years.

Purpose: Bankfull discharge is generally between 7,000 and 10,500 cfs in the San Juan River below Farmington, New Mexico, with 8,000 cfs being representative of the bulk of the river. Bankfull discharge approximately 1 year in 3 on average is necessary to maintain channel cross-section. Flows at this level provide sufficient stream energy to move cobble and build cobble bars necessary for spawning Colorado pikeminnow. Duration of 8 days at this frequency is adequate for channel and spawning bar maintenance. However, research shows a positive response of bluehead sucker and speckled dace abundance with increasing duration of flows above 8,000 cfs from 0 to 19 days. Therefore, the minimum duration was increased from 8 to 10 days to account for this measured response. Flows above 8,000 cfs may be important for providing habitat for larval razorback sucker if flooded vegetation and other habitats formed during peak and receding flows are used by the species. This flow level also maintains mimicry of the natural hydrograph during higher flow years, an important feature for Colorado pikeminnow reproductive success.

Table 2. Recommended flow metrics and purposes from the 1999 Flow Recommendations (continued)

	Category:	Flow > 5,000 cfs during runoff period.
	Duration:	**A minimum of 21 days between March 1 and July 31**.
	Frequency:	**Flows > 5,000 cfs for 21 days or more need to occur in 50% of the years on average for the period of record 1929-1993**. Maximum number of consecutive years without meeting at least a flow of 4,850 cfs (97% of 5,000 cfs) within the 65-year period of record is 4 years.
	Purpose:	Flows of 5,000 cfs or greater for 21 days are necessary to clean backwaters and maintain low-velocity habitat in secondary channels in Reach 3, thereby maximizing nursery habitat for the system. The required frequency of these flows is dependent upon perturbating storm events in the previous period, requiring flushing in about 50% of the years on average. Backwaters in the upper portion of the nursery habitat range clean with less flow but may be too close to spawning sites for full utilization. Maintenance of Reach 3 is deemed critical at this time because of its location relative to the Colorado pikeminnow spawning area (RM 132) and its backwater habitat abundance.
3.	Category:	Flow >2,500 cfs during runoff period.
	Duration:	**A minimum of 10 days between March 1 and July 31**.
	Frequency:	**Flows > 2,500 cfs for 10 days or more need to occur in 80% of the years on average for the period of record 1929-1993**. Maximum number of consecutive years without meeting at least a flow of 2,425 cfs (97% of 2,500 cfs) within the 65-year period of record is 2 years.
	Purpose:	Flows above 2,500 cfs cause cobble movement in higher gradient areas on spawning bars. Flows above 2,500 cfs for 10 days provide sufficient movement to produce clean cobble for spawning. These conditions also provide sufficient peak flow to trigger spawning in Colorado pikeminnow. The frequency specified represents a need for frequent spawning conditions but recognizes that it is better to provide water for larger flow events than to force a release of this magnitude each year. The specified frequency represents these tradeoffs.
E.	Category:	Timing of the peak flows noted in A through D above must be similar to historical conditions, and the variability in timing of the peak flows that occurred historically must also be mimicked.
	Timing:	Mean date of peak flow in the habitat range (RM180 and below) for any future level of development when modeled for the period of 1929 to 1993

Table 2. Recommended flow metrics and purposes from the 1999 Flow Recommendations (continued)

		must be within 5 days ± of historical mean date of May 31 for the same period.
	Variability:	Standard deviation of date of peak to be 12 to 25 days from the mean date of May 31.
	Purpose:	Maintaining similar peak timing will provide ascending and descending hydrograph limbs timed similarly to the historical conditions that are suspected important for spawning of the endangered fishes.
F.	Category:	Target Base Flow (mean weekly nonspring runoff flow).
	Level:	500 cfs from Farmington to Lake Powell, with 250 cfs minimum from Navajo Dam.
	Purpose:	Maintaining low, stable base flows enhances nursery habitat conditions. Flows between 500 and 1,000 cfs optimize backwater habitat. Selecting flows at the low end of the range increases the availability of water for development and spring releases. It also provides capacity for storm flows to increase flows and still maintain optimum backwater area. This level of flow balances provision of near-maximum low-velocity habitat and near-optimum flows in secondary channels, while allowing water availability to maintain the required frequency, magnitude, and duration of peak flows important for Colorado pikeminnow reproductive success.
G.	Category:	Flood Control Releases (incorporated in operating rule).
	Control:	Handle flood control releases as a spike (high magnitude, short duration) and release when flood control rules require, except that the release shall not occur earlier than September 1. If an earlier release is required, extend the duration of the peak of the release hydrograph. A ramp up and ramp down of 1,000 cfs per day should be used to a maximum release of 5,000 cfs. If the volume of water to release is less than that required to reach 5,000 cfs, adjust the magnitude of the peak accordingly, maintaining the ramp rates. Multiple releases may be made each year. These spike releases shall be used in place of adjustments to base flow.
	Purpose:	Historically, flood control releases were made by increasing fall and winter base flows. This elevates flows above the optimum range for nursery habitat. Periodic clean-water spike flows improve low-velocity habitat quality by flushing sediment and may suppress red shiner and fathead minnow abundance.

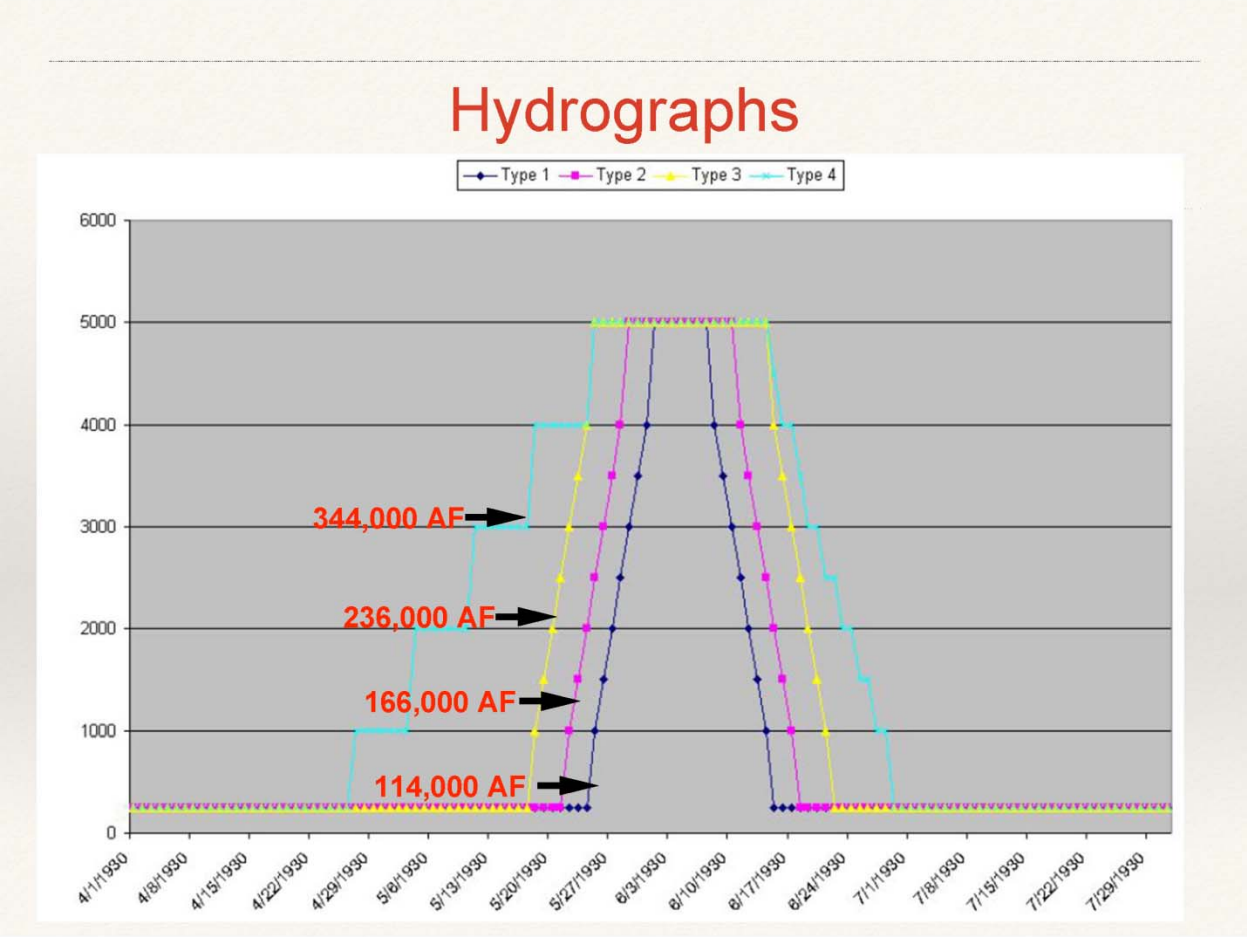

Figure 1. Discharge and duration of the four types of releases from Navajo Dam. Discharge is cfs and the red text demonstrates the volume of water used by each release. (From Bliesner, Flow Workshop #1)

Annual Flow Statistics		# OF DAYS MEETING FLOW				YEARS MEETING GOAL			
YEAR	Hydrograph Released	>9,975 cfs	>7,760 cfs	>4,850 cfs	>2,425 cfs	>9,975 cfs	>7,760 cfs	>4,850 cfs	>2,425 cfs
	Minimum Target	*5*	*10*	*21*	*10*	*10*	*6*	*4*	*2*
1998	2-wk	0	4	35	66	1	1	0	0
1999	1-wk	0	1	31	72	2	2	0	0
2000	ns 1-wk	0	0	6	40	3	3	1	0
2001	2-wk	0	4	36	56	4	4	0	0
2002	none	0	0	0	0	5	5	1	1
2003	none	0	0	0	14	6	6	2	0
2004	none	0	0	1	26	7	7	3	0
2005	full+	11	18	52	85	0	0	0	0
2006	1-wk	0	0	8	24	1	1	1	0
2007	2-wk	0	3	21	56	2	2	0	0
2008	3-wk	6	25	62	121	0	0	0	0
2009	1-wk	0	0	20	41	1	1	1	0
2010	none	0	0	0	19	2	2	2	0
2011	1-wk	0	7	12	29	3	3	3	0
2012	1-wk	0	0	6	10	4	4	4	0
2013	none	0	0	0	0	5	5	5	1
2014	none	0	0	0	22	6	6	6	0
2015	none	0	0	0	0	7	7	7	1

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Figure 2. Annual hydrograph released from Navajo Dam, the number of days that was reached at each flow recommendation, and the accumulation of years that each flow rec was not met. Blue cells denote the days in which flow recommendation was met for each year and the red cells denote when the minimum number of years without each flow recommendation was exceeded (From Behery, 2015 Annual Meeting)

Water Year	Spring Most Probable Forecast Values					Actual		Flow Recs				Notes
	Avail Water	Spill	SPR Path	SPR Rec	SPR Rank	Perturb	SPR Rank	>10k	>8k	>5k	>2.5k	
1999	*?*						*1*			*X*	*X*	
2000	*?*						*1*				*X*	
2001	861,000	106,000	acfjimp	Release > of 166,000 or Spill	max(2,spill)		2			X	X	Followed DT
2002	353,908	0	acghlo	No Release	0	no	0					Even in the late spring, there was AW forecast! DT changed to **ab** and followed.
2003	1,388	0	ab	No Release	0		0				X	Followed DT
2004	39,889	0	ab	No Release	0		0				X	Followed DT
2005	956,000	255,000	acfjie	Release Full Hydrograph	4		4	X	X	X	X	Followed DT
2006	617,402	0	acgk	Release 114k	1	yes	1				X	Followed DT
2007	725,000	24,000	acfjimp	Release > of 166k or Spill	max(2,spill)		2			X	X	Followed DT
2008	1,011,000	309,400	acfjimqp	Release > of 166k or Spill	max(2,spill)	yes	3+		X	X	X	Added flood control nose to Hydrograph 3 (spill > 166k). Followed DT.
2009	645,000	0	ackg	1 week	1	yes	1				X	Followed DT
2010	474,500	0	acghdb	No Release	0	no	0				X	No release (look-back). Followed DT.
2011	500,426	0	acghlk	Release 114k	1	no	1				X	Followed DT.
2012	374,000	0	acghlk	Release 114k	1	no	1				X	Began timing peak with Animas. Followed DT.
2013	-13,000	0	ab	No Release	0		0					Followed DT.

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Figure 3. History of path from decision tree, flow releases, and flow recommendations met from 1999-2013. Table shows Available Water, volume of spill, Spring Peak Release Path from decision tree (SPR Rec; see Figure 4 below for lettering), type of Spring Peak Release (SPR Rank), annual perturbations (Perturb), observed Spring Peak Release (SPR Rank), the four flow recommendations, and related notes (From Behery, 2015 Annual Meeting)

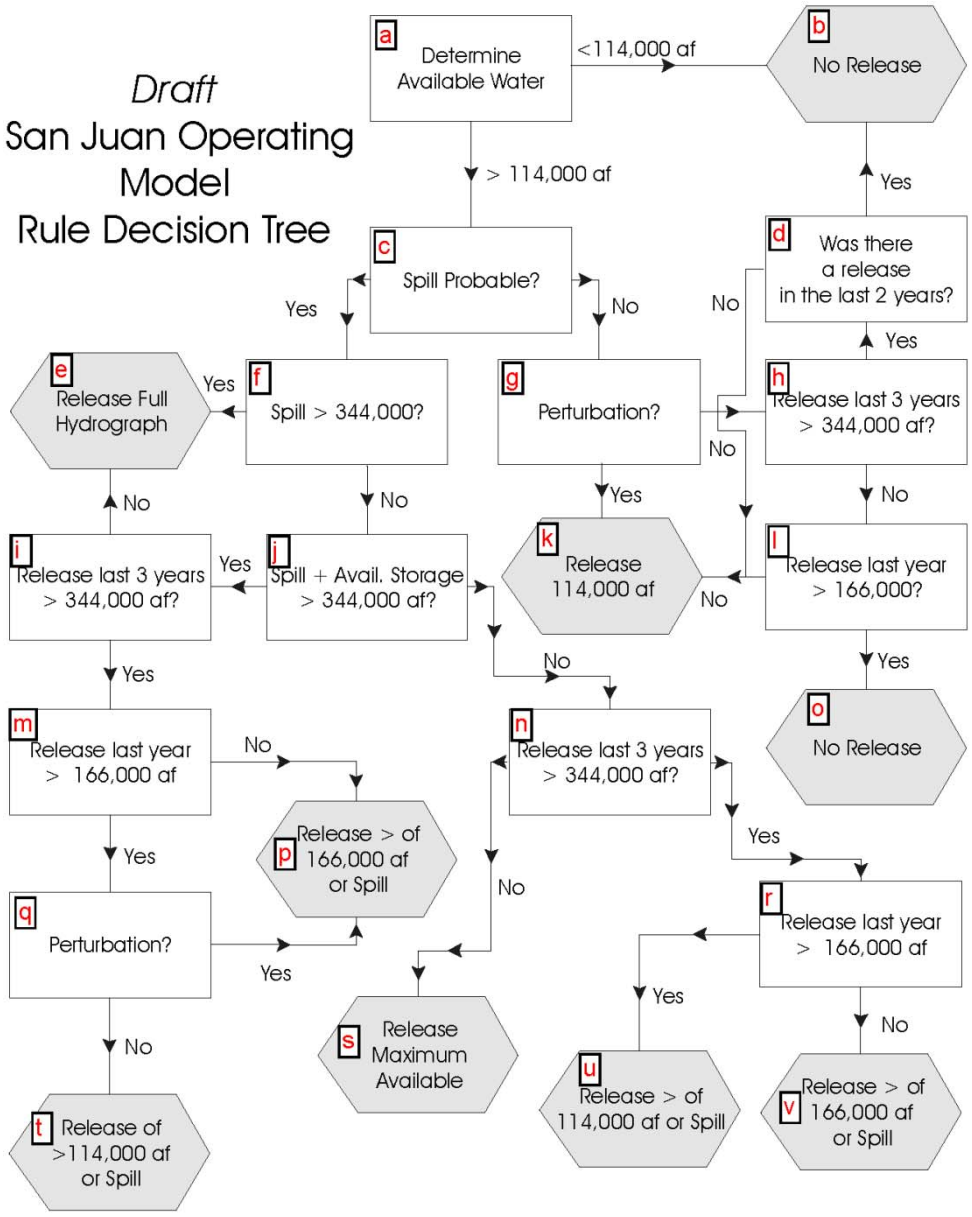

Figure 4. Decision tree from the 1999 Flow Recommendations.

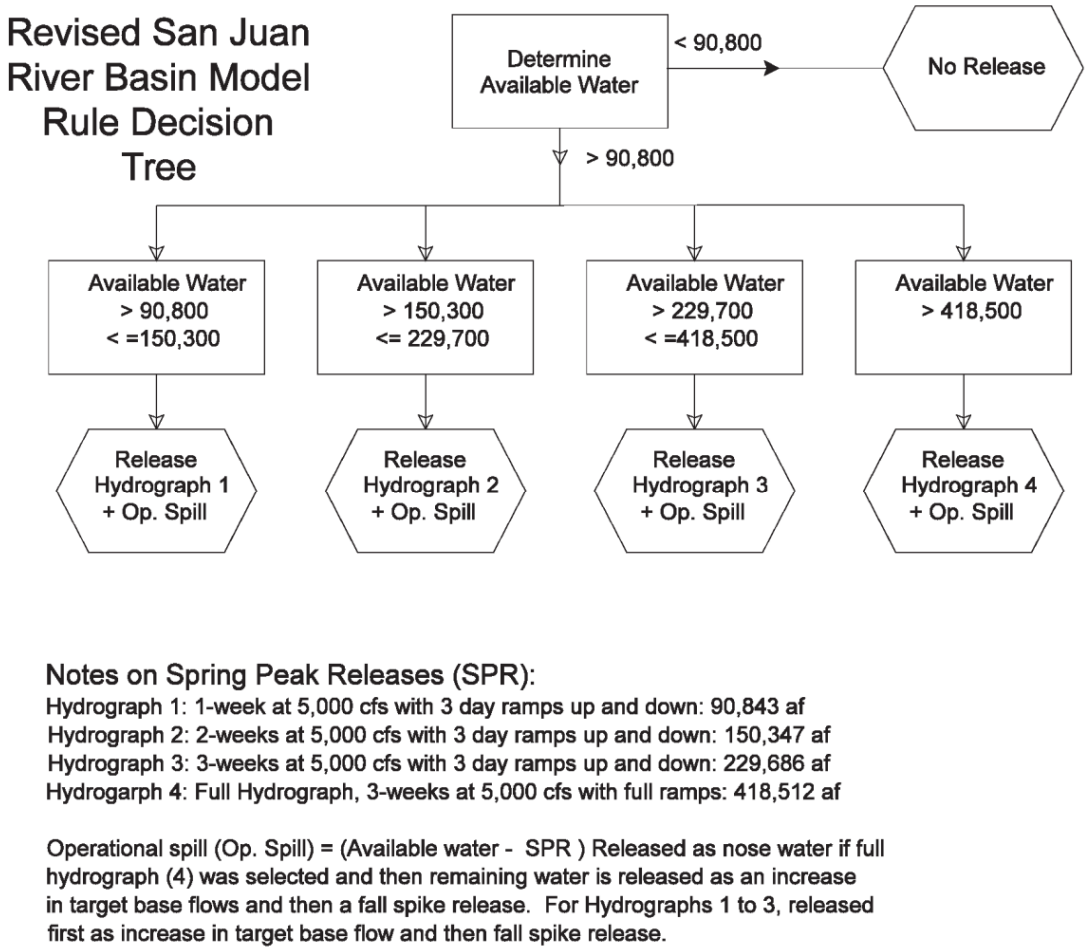

Figure 5. Proposed decision tree from BOR and Keller-Bliesner.

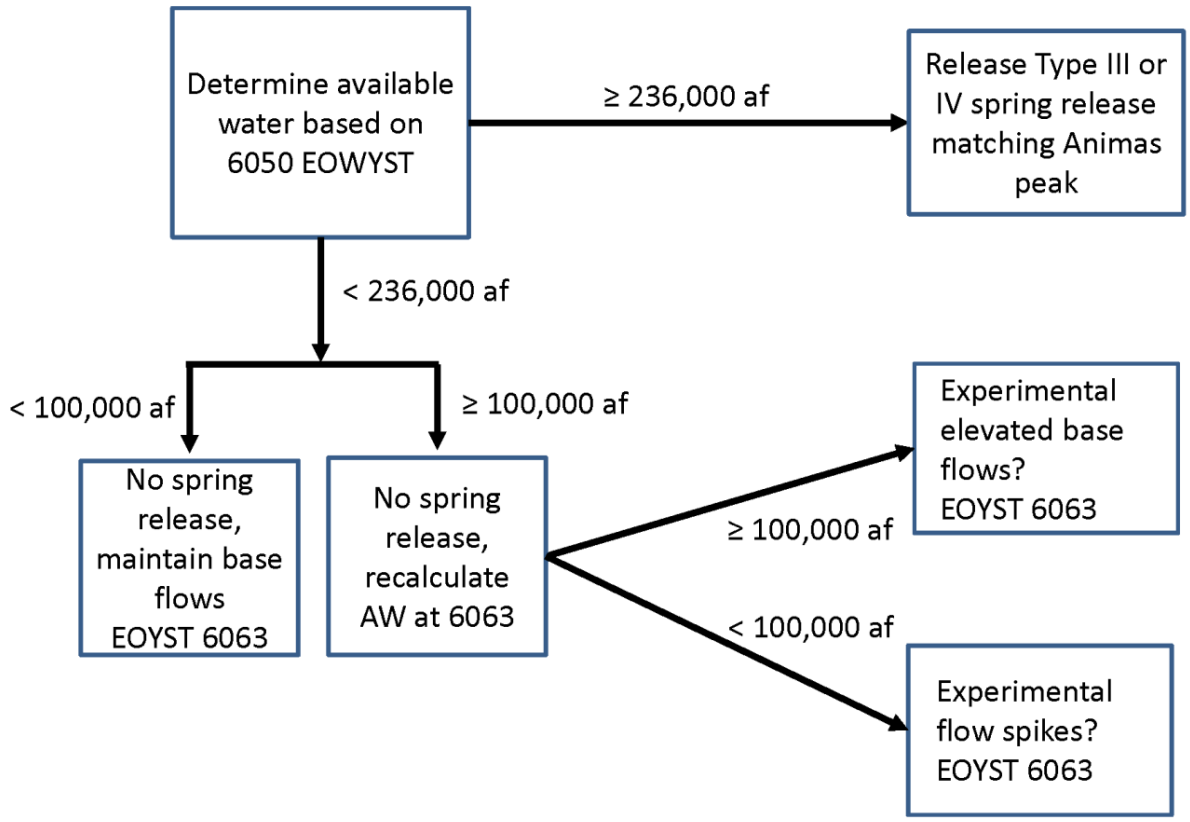

Figure 6. Proposed decision tree from BOR and Program Office.