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Report on the Bureau of Reclamation's May 2006 Ruedi Reservoir Release

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Summary

In the spring of 2006, the Bureau of Reclamation increased flows in the lower Fryingpan River because of above average snow pack and resulting increased run-off. The resultant peak flow of 814 cfs had not been reached for seven years. Since Ruedi Reservoir started filling in May 1968 and diversions from the Upper Fryingpan began in 1972 as part of the Fryingpan-Arkansas (Fry-Ark) Project, the magnitude, timing, and duration of flows have been altered. We looked at maximum flows (one, three, and seven-day) and monthly (May and June) averages to determine how the 2006 flows compared to the historical record and modeled data. Although the 2006 release was higher than the peak flow for the previous seven years, the one-, three-, and seven-day maximum flows for 2006 were below the pre-impact medians and range of variability. The average monthly flow for May 2006 was greater than the previous five year average, the 2005 average, and the modeled developed flow; however it was below the Indicators of Hydrologic Alteration (IHA) range of variability and well below the pre-developed modeled average and range of variability for the month of May. Because the 2006 release occurred in May rather than in June, the average monthly flow for June 2006 was below the previous five-year average, the 2005 average, the modeled developed flow, and well below the IHA range of variability and the pre-developed modeled average and range of variability. While not explicitly intended to improve habitat conditions on the lower Fryingpan River, the hope was that this peak flow would have a positive effect on habitat conditions. A resurvey of selected habitat parameters was conducted after the 2006 release and compared to a 2005 survey. There was no improvement in the five habitat indicators sampled: aquatic vegetation, embeddedness, sediment deposition, and bank-full depth, and in some cases there was a decline in habitat conditions. Most of the lower reaches did see an improved flow status score. We hypothesize that the 2006 release was not long enough or perhaps not high enough to improve aquatic habitat by removing entrained sediments. In addition it is possible that flows of this magnitude are not frequent enough to remove entrained sediments.

1. Background

In the spring of 2006, the Bureau of Reclamation (BOR) boosted releases from Ruedi Reservoir because of above average snow pack and resulting increased run-off. Although 2006 was above average for snow pack it was considerably less than the highest year, 1995, and another high year, 1997, for the period of record (1992-2006), based on the Ivanhoe SNOTEL site (Figure 1).

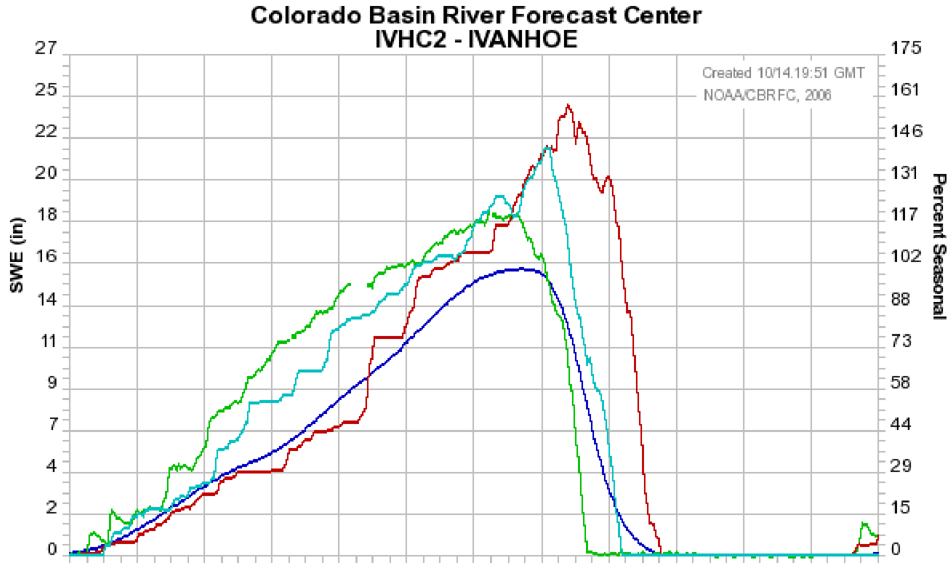

Figure 1. Snow pack for the Ivanhoe SNOTEL site. Source:

The reasons for the release were: 1) to balance the increasing inflow of snow melt with the storage needs of the reservoir, 2) to provide a steady pre- and post-release rate from the reservoir with a goal of 250 cfs, and 3) to participate in the Coordinated Reservoir Operations under the Colorado River Endangered Fish Recovery Program.

The goal of the Coordinated Reservoir Operations is to enhance spring peak flows to improve endangered fish species habitat (the Colorado pikeminnow, humpback chub, razorback sucker and bonytail chub) in the 15 Mile Reach of the Colorado River without diminishing reservoir yields or affecting the timing of reservoir filling. Participating reservoirs in the past have included Green Mountain and Ruedi (BOR), Wolford Mountain (Colorado River Water Conservation District), Dillon and Williams Fork (Denver Water), and Willow Creek and Granby (Northern Colorado Water Conservancy District and BOR). Similar attempts to enhance spring peak flows in the 15 Mile Reach from 1997-2000 were unsuccessful due to significantly lower than average runoff (Seaholm and Wilson, 2000).

The simulated "flood pulse" scours aquatic vegetation and fine sediments from the channel improving conditions for breeding aquatic insects that feed the endangered fish. The high flows also benefit spawning habitat conditions and provide access to warmer, slower backwater habitats in the floodplain and side channels of the Colorado River. We hoped that the Ruedi Reservoir release would have a similar positive effect on aquatic habitat in the lower Fryingpan River. The timing of the 2006 release was based on the predicted peak runoff on the Colorado River in the Grand Junction area.

2. May 2006 Peak Flow

Although the snow pack was above average for most of the season, the early warm weather caused rapid snowmelt and a lower than average snow pack by early May. This caused the original plan of releasing 800 cfs for 10 to 12 days to be scaled back significantly to one day. Table 1 gives the planned and actual flows.

Date	Planned (cfs)	Actual (cfs)
5/19	250-350	305
5/20	350-450	436
5/21	450-550	539
5/22	550-650	637
5/23	700-800	741
5/24		814
5/25		792
5/26		691
5/27		587
5/28		487
5/29		392
5/30		299
5/31		272

Table 1. Planned and actual flows for May 2006 Ruedi reservoir release.

Photos were taken before and during the release at several locations to show changes in water level. Figure 2 shows the location of these photo points. The photo point ids correspond to the Stream Health Initiatives reach ids (Malone and Emerick, 2006).

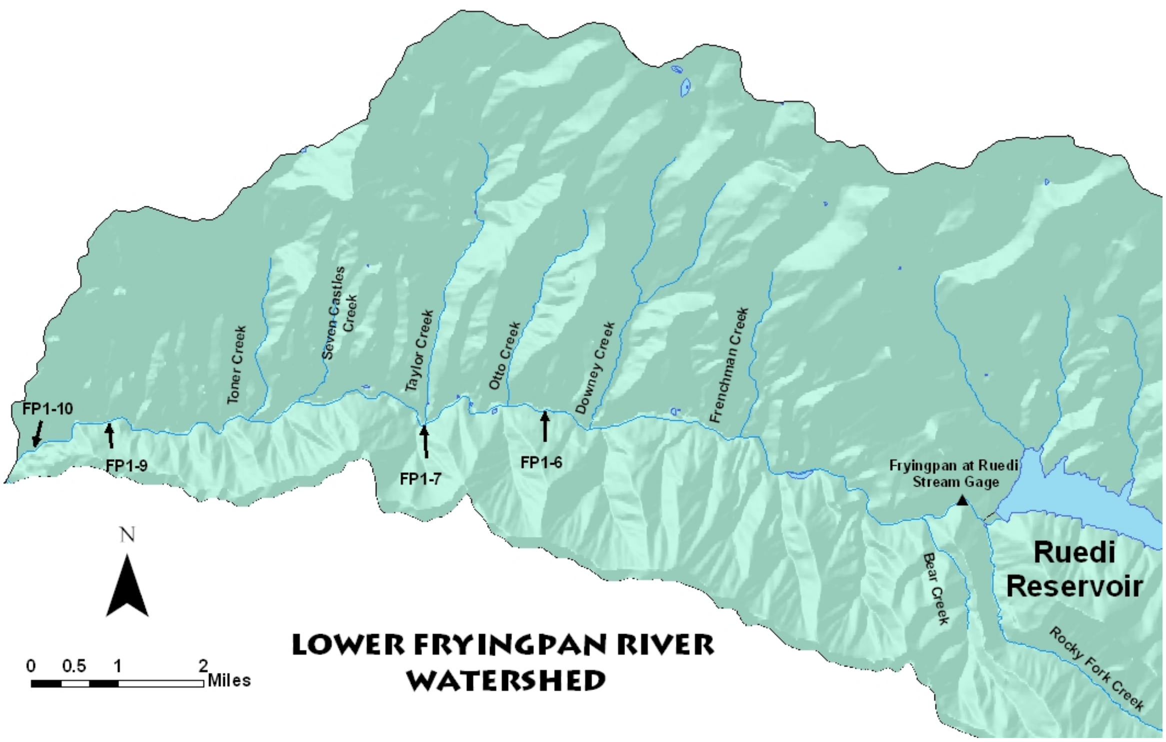

Figure 2. Map showing the location of the reaches with photo points

FP1-10

5/16/2006
274 cfs at gage
below reservoir

5/26/2006
691 cfs at gage

Photo Point FP1-10. Pull-out at state information sign

FP1-9

5/16/2006
274 cfs at gage

5/26/2006
691 cfs at gage

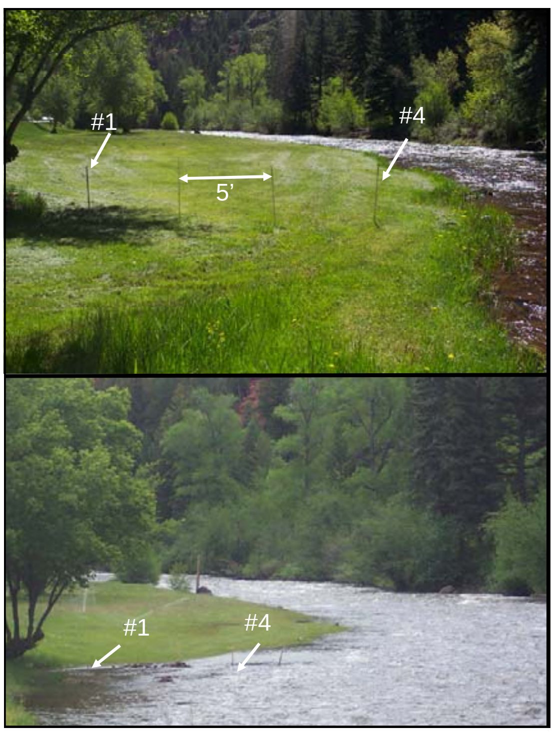

Photo Point FP1-9. Approximately Mile Marker 2

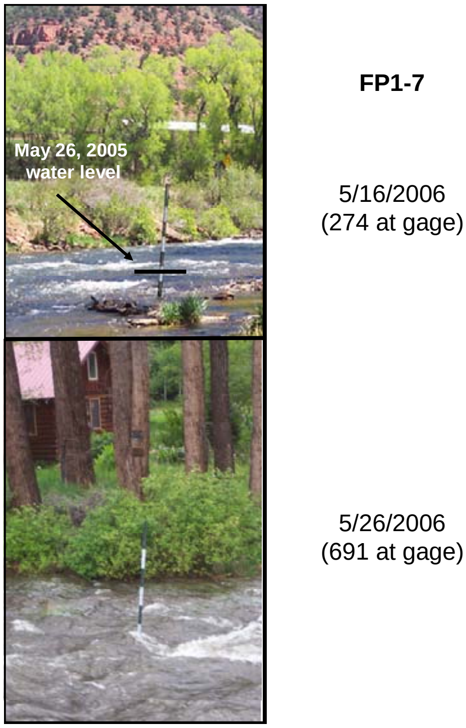

Photo Point FP1-7. Near the King Ranch (photos taken from different vantage points)

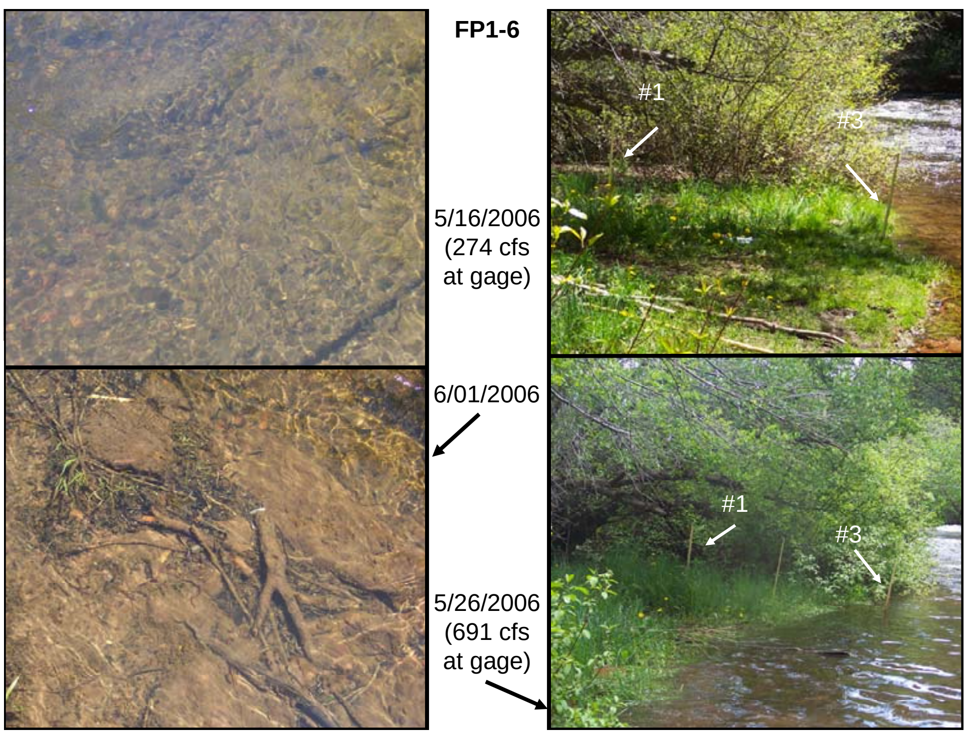

Photo Point FP1-6. Pullout at White River National Forest sign

To put this release in context of other peak flows on the lower Fryingpan River, we interpreted the magnitude, duration, and timing of this release using the period of record for this gage and also compared modeled monthly average May and June pre-developed flows to developed flows; and modeled pre-developed flows to actual stream flow gage data. A resurvey of several important habitat characteristic was conducted and compared to a survey that was done a year before to determine if habitat conditions changed as a result of the 2006 peak flow.

3. Comparison of Hydrologic Parameters

The Indicators of Hydrologic Alterations Manual (2005) outlines the ecosystem influences of individual hydrologic parameters. The magnitude of the peak flow influences the extent of the floodplain inundation. The magnitude and duration of peak flows: 1) influences the creation of sites for plant colonization; 2) balances competitive, ruderal (growing where the natural vegetational cover has been disturbed by humans), and stress-tolerant organisms; 3) structures river channel morphology and physical habitat conditions; 4) exchanges nutrient and organic matter between river and floodplain; 5) influences bed-load transport and channel sediment texture; and 6) aerates spawning beds in channel sediments. Timing of these events has to be compatible with the life cycles of organisms and provide access to special habitats during reproduction or to avoid predation.

Since initial filling of Ruedi Reservoir in May 1968 and subsequent water diversion from the Fryingpan Watershed in May 1972 as part of the Fry-Ark Project, the magnitude, timing, and duration of peak flows has been altered. USGS stream flow gage data from the Fryingpan below Ruedi were analyzed using The Nature Conservancy's Indicators of Hydrologic Alteration (IHA) software to develop graphs showing how four indicators of flow have changed since 1972 (Figure 8). The four indicators are: average monthly flow for May and June (Figures 3 and 4), seven-day maximum flow (Figure 7), and date of maximum flow (Figure 8). We chose 1972 as the date of impact, recognizing that some alteration occurred between 1968 and 1972. We used the Range of Variability Approach (RVA), which graphs the median and 33rd and 66th percentiles for data prior to 1972 and compares this to the median for post-1972 data. It should be noted that only seven years of pre-impact data are available for this gage, not the recommended 20 years. The RVA uses the pre-development (for this analysis pre-1972) natural variation of IHA parameter values as a reference for defining the extent to which natural flow regimes have been altered. Richter et al. (2006) suggest using historic or simulated flow records from a time-period in which the river was relatively unaltered (e.g. pre-dam) as part of a collaborative and adaptive process for developing environmental flow recommendations.

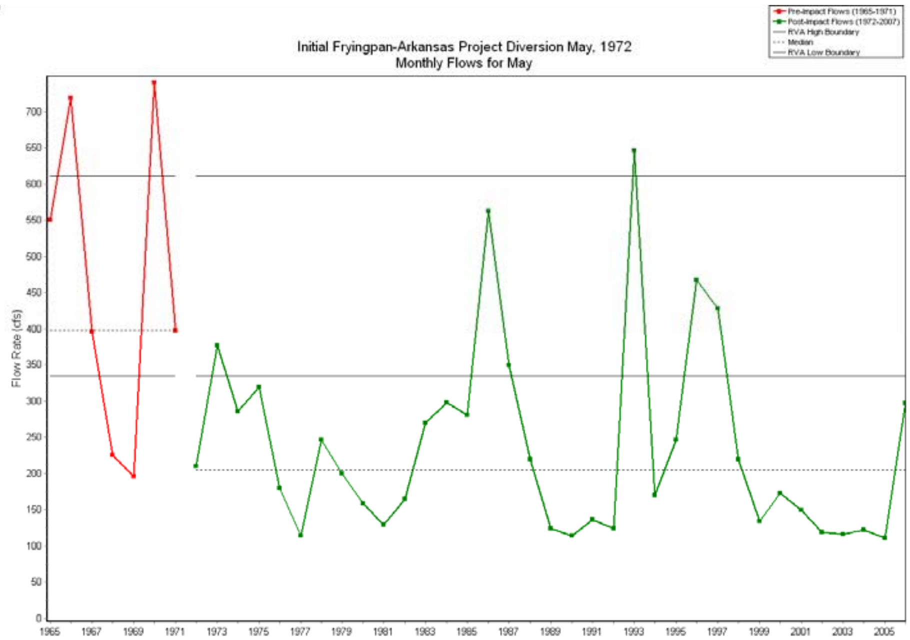

Figure 3. IHA Range of Variation Approach comparison of May monthly average flows.

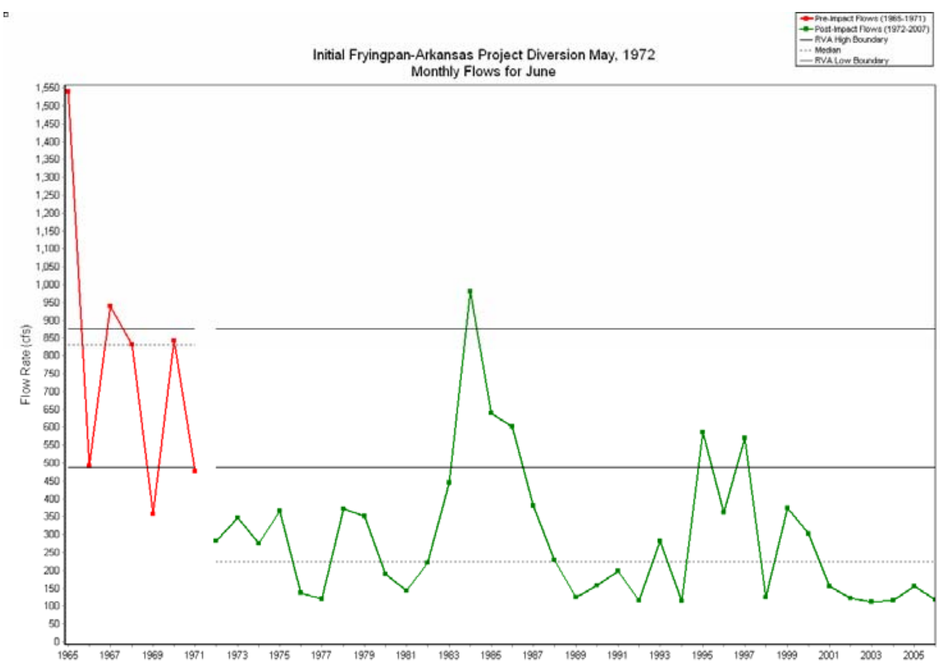

Figure 4. IHA Range of Variation Approach comparison of June monthly average flows.

Overall monthly flows in May and June have decreased since the inception of Fry-Ark diversions, although there is a lot of variability from year to year. The May median value dropped from 398 cfs to 205 cfs and the June median value dropped from 831 cfs to 224 cfs. The monthly average flow for May 2006 (297 cfs) was just below the IHA range of variability (334 cfs-611 cfs) and the monthly average flow for June 2006 (117 cfs) was well below the IHA range of variability (487 cfs-877 cfs). For the period 2000-2005, the May average flow was 129 cfs; considerably lower than the May 2006 average and the June average flow of 151 cfs exceeded that for June 2006. The average flows for both May and June 2006 were below their respective post-diversion medians.

Because the IHA range of variability values were determined using only seven years of data, and four of these years had some impact from the Fry-Ark diversions and reservoir operations they are lower than what was determined using pre-developed and developed data modeled by the state of Colorado (http://cdss.state.co.us/DNN/) for the time period 1909-1996. The pre-developed flows are flows that would have occurred without human development such as diversions and dams. Current depletions are subtracted from the pre-developed flow to obtain developed flows. The Roaring Fork Conservancy compared this modeled pre-developed and developed monthly data in the Stream Flow Survey Report (Clarke, 2006) (Table 2; Figure 5). The monthly five-year averages (2000-2005) calculated from the stream gage data are slightly lower than the modeled developed flow average values because these years were drier than average and the modeled data simulates 1909-1996 conditions.

	Average (cfs)	**Median** (cfs)	**33rd and 67th percentile** (cfs)
Pre-developed			
May	680	649	553-793
June	1179	1142	992-1346
Developed			
May	162	110	110-155
June	208	122	110-168

Table 2. Pre-developed and developed flows for Fryingpan River.

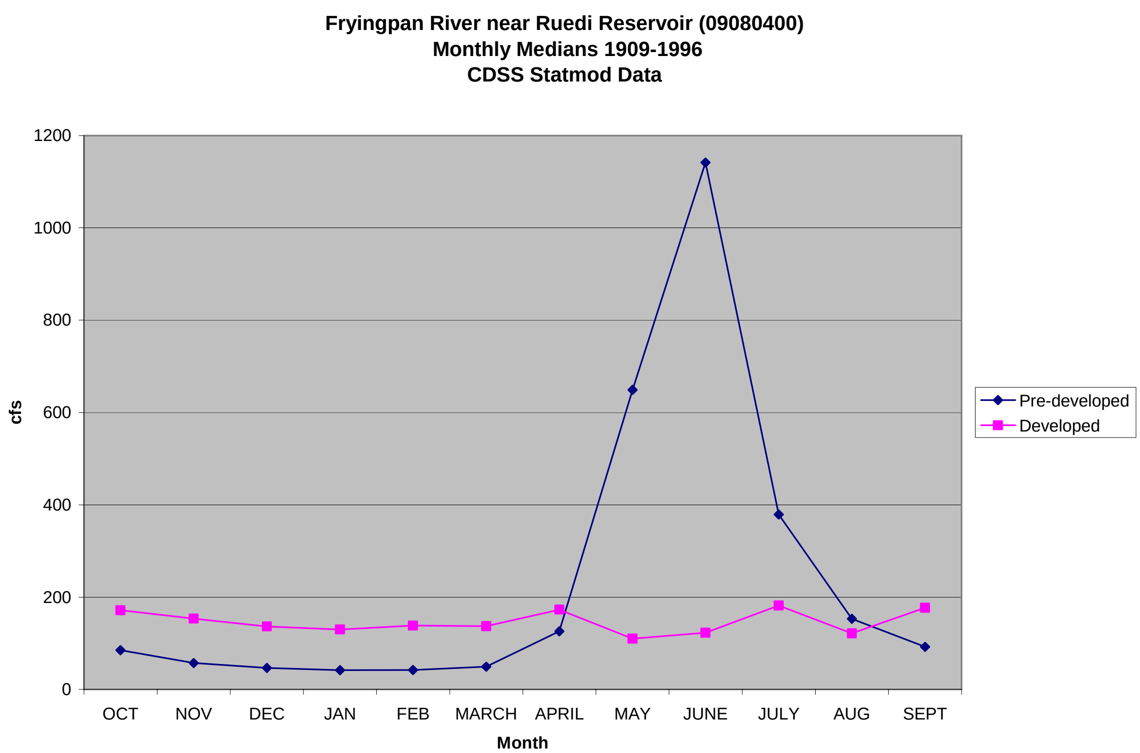

Figure 5. Comparison of modeled pre-developed flows to developed flows for the stream gage below Ruedi Reservoir.

Figure 6 shows the 2006 May and June average flows compared to these other flows. Although the average monthly flow for May 2006 was greater than the previous five year average, the 2005 average, and the modeled developed flow, it was well below the pre-developed modeled average and range of variability and the IHA range of variability. Because the 2006 peak flow occurred in May, the average monthly flow for June 2006 was below the previous five-year average, the 2005 average, and the modeled developed flow, and well below the pre-developed average and range of variability and the IHA range of variability.

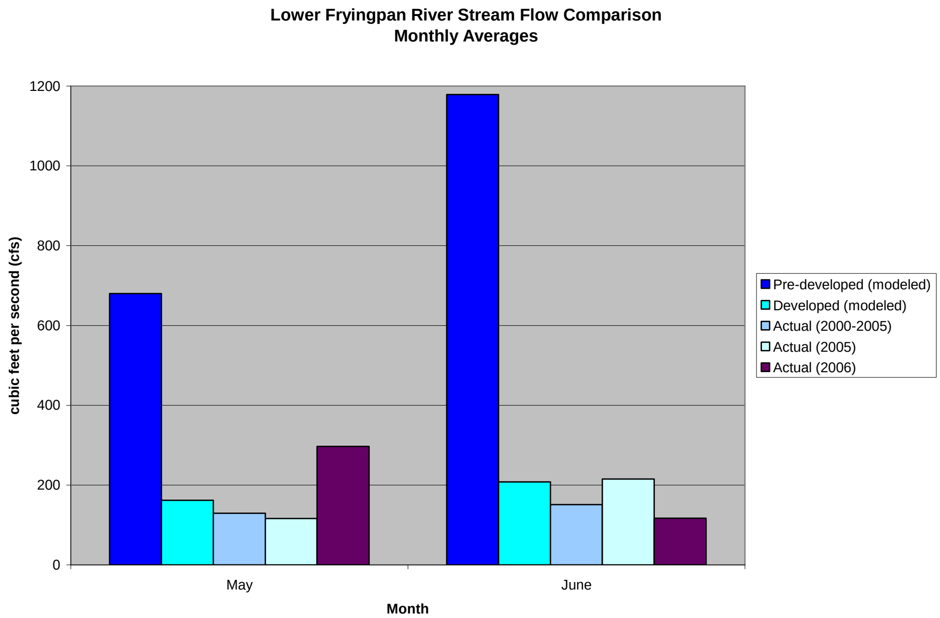

Figure 6. Comparison of modeled pre-developed and developed; actual 2000-2005, 2005, and 2006 average monthly flows for May and June.

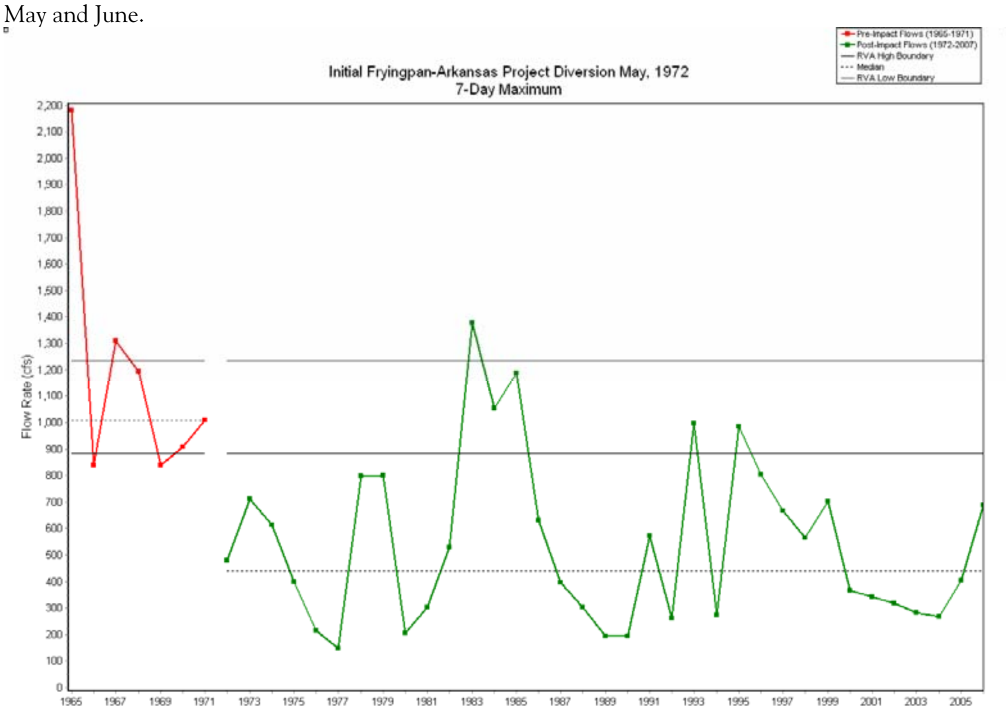

Figure 7. IHA Range of Variation Approach comparison of seven-day maximum flows.

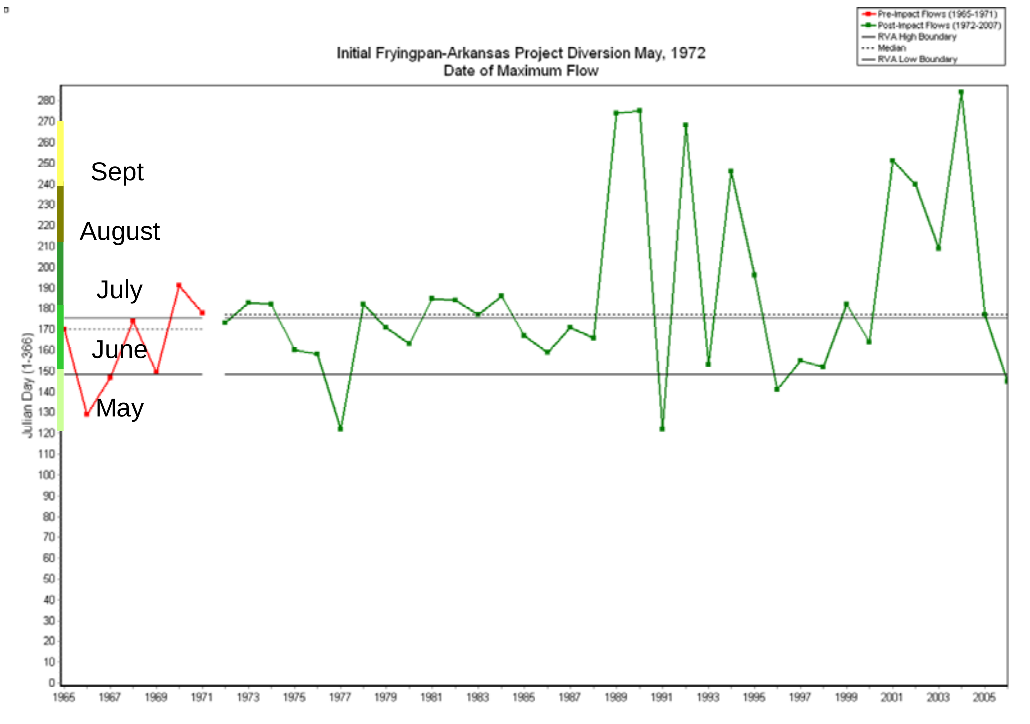

Figure 8. IHA Range of Variation Approach comparison for date of maximum flow.

The seven-day maximum flow median was 1009 cfs before diversions began in 1972. The post-diversion seven-day maximum median is now 441cfs. The seven-day maximum flow for 2006 (686 cfs) was below the IHA range of variability (883-1235 cfs). The one-day maximum flow of 814 cfs for 2006 was below the median (1140 cfs) and did not fall within the range of variability (1004-1349 cfs). The three-day maximum flow of 782 cfs was also below the median (1100 cfs) and below the range of variability (949-1306 cfs). The 2006 date of maximum flow (May 24; 145-Julian Days) was just outside the IHA range of variability (May 27-June 24; 148-175 Julian Days).

Figure 9 shows the magnitude of peak flows on the Fryingpan River below Ruedi Reservoir for the period of record 1965-2006. Table 1 is the actual peak stream flow amount as well as the date of occurrence. June, 1999 (784 cfs) was the last year that peak flows approximated the May 2006 peak flow of 814 cfs. About a quarter of the peak flows since 1972 have not occurred in the spring. From 2001 to 2003 all of the peak flows occurred in the fall. The maximum peak flow for the period of record of 2,690 cfs occurred in June 18, 1965 and the minimum peak flow for the period of record of 180 cfs occurred on May 1, 1977.

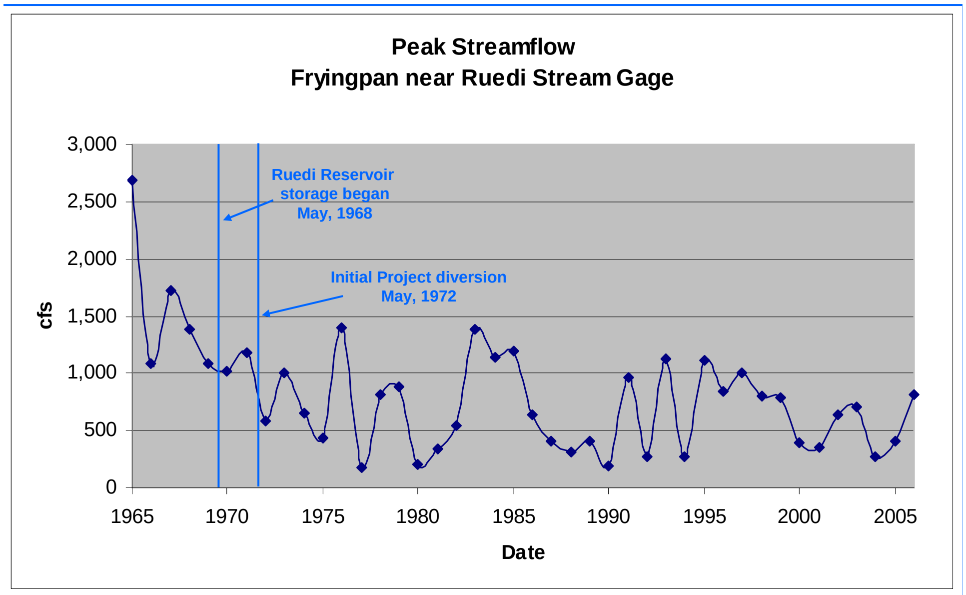

Figure 9. Peak stream flows for the Fryingpan at Ruedi stream gage.

Date	Stream Flow (cfs)
Jun. 18, 1965	MAX-2,690
May 8,1966	1,080
May 26,1967	1,720
Jun. 21, 1968	1,390
May 27, 1969	1,080
Jul. 04, 1970	1,020
Jun. 25, 1971	1,180
Jun. 21, 1972	590
Jun. 30, 1973	1,000
Jun. 29, 1974	653
Jun. 08, 1975	431
Sep. 16, 1976*	1,400
May 1, 1977	MIN-180
Jun. 30, 1978	820
Jun. 19, 1979	876
Jun. 11, 1980	207
Jul. 02, 1981	340
Jul. 02, 1982	542
Jun. 24, 1983	1,390
Jul. 04, 1984	1,140
Jun. 15, 1985	1,200

Date	Stream Flow (cfs)
Jun. 07, 1986	644
Jun. 19, 1987	403
Jun. 13, 1988	319
Feb. 23, 1989*	408
Oct. 01, 1989*	195
May 1, 1991	965
Sep. 23, 1992*	275
May 29, 1993	1,130
Sep. 01, 1994*	275
Jul. 11, 1995	1,110
May 17, 1996	846
Jun. 03, 1997	1,000
May 30, 1998	804
Jun. 29, 1999	784
Jun. 12, 2000	400
Sep. 06, 2001*	349
Nov. 14, 2001*[1]	637
Sep. 03, 2003*	710
Oct. 09, 2003*	274
Jun. 24, 2005	413
May 24, 2006	814

Bold* denotes peak flow not occurring in the spring.
[1]Outlet structure maintenance (Ptacek et al 2003)
Table 3. Date and magnitude of peak flows at the Fryingpan near Ruedi stream gage by water year (October-September).

4. Comparison of Habitat Components

The Stream Health Initiative Project surveyed the lower Fryingpan River in July of 2005 (Figure 10) (Malone and Emerick, 2006). To determine if the 2006 peak flow had an impact on in-channel conditions, a resurvey of habitat components thought to be sensitive to changes in flow was conducted after the peak flow in June and July (see Table 4 for sample dates). Data were collected on aquatic vegetation, embeddedness, sediment deposition, bank full depth, and flow status. A signed rank paired sample test was used to test for significant differences between the samples from the two dates.

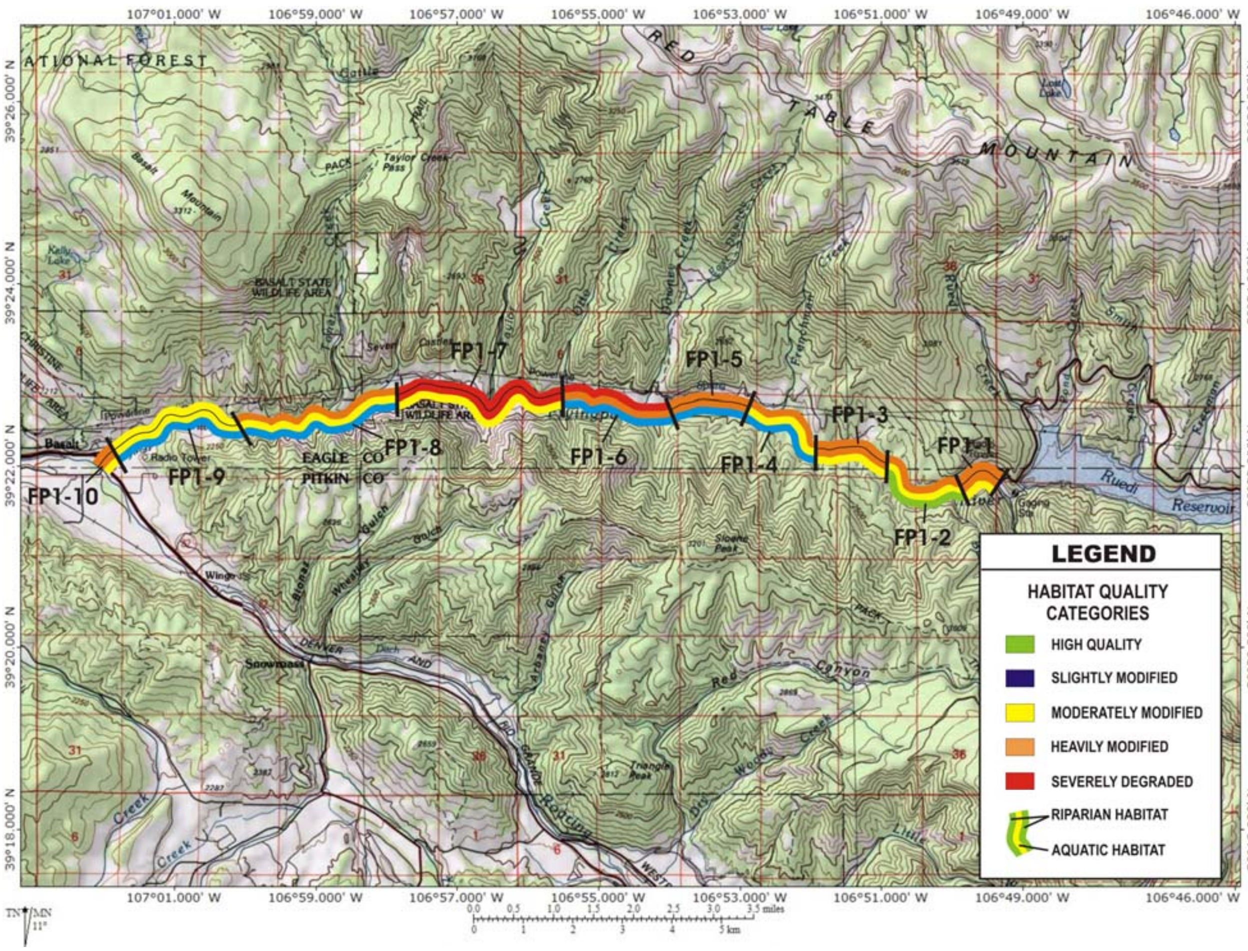

Figure 10. Stream Health Initiative survey of the lower Fryingpan River (Malone and Emerick, 2006).

Reach	SHI survey sampling dates	
	Pre-release	Post-release
FP1-1	7/16/2005	6/8/2006
FP1-2	7/16/2005	6/8/2000
FP1-3	7/17/2005	6/8/2006
FP1-4	7/18/2005	6/10/2006
FP1-5	7/18/2005	6/10/2006
Reach	SHI survey sampling dates	
	Pre-release	Post-release
FP1-6	7/19/2005	6/10/2006
FP1-7	7/19/2005	6/14/2006
FP1-8	7/20/2005	6/8/2006
FP1-9	7/21/2005	7/5/2006
FP1-10	7/23/2005	7/5/2006

Table 4. Stream Health Initiative stream survey sampling dates.

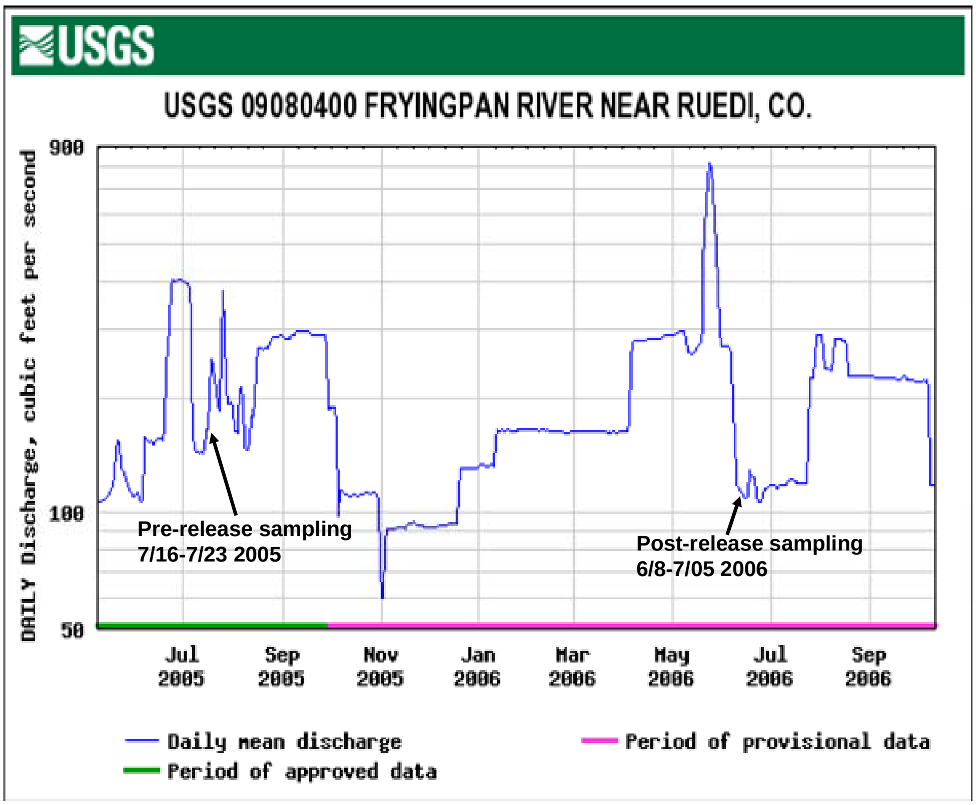

Figure 11. Dates of Stream Surveys relative to stream flows.

Figure 11 shows the flows at the Fryingpan gage near Ruedi before, during, and after the periods in 2006 and 2006 when the surveys were made. In 2005, the Fryingpan peaked on June 24 at 413 cfs and stayed around 400 cfs for 12 days. Prior to the 2006 resurvey the Fryingpan peaked at 814 cfs on May 24, about a month earlier than in 2005. According to the IHA analysis, both the spring 2005 and 2006 peak flows were below the one-, three-, and seven-day range of natural variability maximums. The spring 2005 peak flow was within and the spring 2006 peak flow was below the range of natural variability for timing of peak flow.

The following paragraphs discuss the comparison of the 2005 survey data with the 2006 resurveyed data.

4A. Aquatic Vegetation

Dominant aquatic vegetation was recorded along with a qualitative estimate of abundance for each of the surveyed reaches. Stream periphyton communities are affected by an interaction of nutrients, light, temperature, and water velocity (Pringle and Triska, 2006). Periphyton is an association/matrix of numerous algal and microbial species that grow attached to surfaces such as rocks or larger plants. They are primary producers and sensitive indicators of environmental change in moving waters. Because periphyton are attached to the substrate, this assemblage integrates physical and chemical disturbances to the stream reach (http://www.epa.gov/bioindicators/html/periphyton.html). Filamentous algae are often found in slow moving, nutrient-rich waters with little riparian shading (Kaufman et al. 1999).

	Aquatic Vegetation		
Reach	**Pre-release survey**	**Post-release resurvey**	**Change**
FP1-1	3-periphyton	3-periphyton	0
FP1-2	3-periphyton	3-periphyton	0
FP1-3	4-periphyton	4-periphyton	0
FP1-4	3-periphyton	4-periphyton	-1
FP1-5	4-periphyton	4-periphyton	0
FP1-6	3-periphyton	3-periphyton	0
FP1-7	3-periphyton	4 periphyton	-1
	2 - filamentous algae	2- filamentous algae	0
FP1-8	2-periphyton	2-periphyton	0
FP1-9	2- periphyton	3- periphyton	-1
	1-Filamentous algae	2 -Filamentous algae	-1
FP1-10	2 -Periphyton	3-Periphyton	-1
	2- Filamentous algae	2- Filamentous algae	0
Note: dominant aquatic vegetation is listed with a qualitative estimate of abundance; 0=not observed, 1=rare (0-25%), 2=common, 3=abundant, 4=dominant			

There was not a significant difference in periphyton between 2005 and 2006 surveys at the 95% confidence interval (P =.0528) although periphyton increased in reaches 4, 7, 9, and 10 (Figure 11). Filamentous algae were also recorded in three downstream reaches-7, 9 and 10 and showed an increase in reach 9. It appears that neither the velocity nor length of the 2006 release was sufficient not adequate to decrease the amount of aquatic vegetation, and that conditions influencing vegetation growth in some of the reaches favored a slight increase in aquatic vegetation before the 2006 release.

4B. Embeddedness

Embeddedness, sediment deposition, and flow status are graded according to the EPA protocol from 0-20 with 20 being high quality and 0 being poor quality (Barbour et al. 1999).

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
Embeddedness (high gradient)	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Embeddedness is the degree to which large substrate particles, typically gravels, are surrounded or covered by smaller particles of silt, sand, or small gravels. Excessive deposits of fine sediments restrict spawning habitat, reduce habitat for macroinvertebrates, and can even reduce the availability of high flow refugia (Foster et al. 2001). There was a significant difference at the 95% confidence interval (P =.03) between the degree embeddedness in 2005 and 2006, with lower scores (i.e. higher embeddedness) values in 2006. In seven of the reaches, the index score decreased and in the other three reaches it remained the same, indicating that the 2006 spring flow was not high enough or long enough to remove the deposits of fine sediments. The four reaches (2, 4, 6, and 9) that were at the lower end of the optimal category in 2005, all dropped into the suboptimal category.

	Embeddedness		
Reach	Pre-release survey	Post-release resurvey	Change
FP1-1	12	12	0
FP1-2	16	12	-4
FP1-3	15	13	-2
FP1-4	16	12	-4
FP1-5	15	15	0
FP1-6	16	15	-1
FP1-7	14 (Pool substrate)	13	-1
FP1-8	14	13	-1
FP1-9	16	11	-5
FP1-10	11	11	0

4C. Sediment Deposition

Sediment Deposition is the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition (Barbour et al. 1999). High levels of sediment deposition are indicators of an unstable and changing environment that becomes unsuitable for many organisms.

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand, or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand, or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

There was not a statistically significant difference in sediment deposition between pre- and post- release at the 95% confidence interval (P =.053) although a decline can be seen in reaches 2, 3, 4, and 5. Reach 4 went from a suboptimal to a marginal condition and reach 5 declined drastically from a suboptimal to a poor condition. Similar to aquatic vegetation and embeddedness, these results indicate that the 2006 flows were not high or long enough to remove this build-up of sediment.

	Sediment Deposition		
Reach	Pre-release survey	Post-release resurvey	Change
FP1-1	11	11	0
FP1-2	13	12	-1
FP1-3	15	11	-4
FP1-4	15	7	-8
FP1-5	15	5	-10
FP1-6	11	11	0
FP1-7	13	13	0
FP1-8	12	12	0
FP1-9	13	13	0
FP1-10	15	15	0

4D. Bankfull Depth

Bankfull depth is the height at the average bankfull flow (the high water mark that occurs on average about every 1.5 years). Comparison of width and depths describes the ability of the channel to move laterally during high flow events. There was not a significant difference in bankfull depth between pre- and post- flushing flow at the 95% confidence interval (P =.99).

The following table shows that bankfull depth decreased in the first four reaches below the reservoir and then increased downstream.

	Bank Full Depth (m)		
Reach	**Pre-release survey**	**Post-release resurvey**	**Change**
FP1-1	0.55	0.50	-0.05
FP1-2	0.60	0.40	-0.20
FP1-3	0.45	0.35	-0.10
FP1-4	0.50	0.35	-0.15
FP1-5	0.35	0.35	0.00
FP1-6	0.65	0.65	0.00
FP1-7	0.30	0.50	0.20
FP1-8	0.40	0.40	0.00
FP1-9	0.60	0.70	0.10
FP1-10	0.50	0.60	0.10

4E. Flow Status

According to Barbour et al. 1999, flow status is the degree to which the channel is filled with water. Malone and Emerick (2006) adapted this parameter by assessing hydrologic alteration and occurrence of bankfull or over-banking flows. Channel flow is useful for interpreting biological condition under abnormal flow conditions.

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

There was not a significant difference in flow status between pre- and post- release at the 95% confidence interval (P =.234). Although the channel was > 90% filled with water in all reaches post release, over-banking flows were still minimal and frequently did not occur at all, thus condition was graded as suboptimal (15) at best for reaches 3-10. The first two reaches below the reservoir were graded as optimal (16) in both years. Five reaches did see an improvement in score.

	Flow Status		
Reach	**Pre-release survey**	**Post-release resurvey**	**Change**
FP1-1	16	16	0
FP1-2	16	16	0
FP1-3	14	15	1
FP1-4	15	15	0
FP1-5	13	15	2
FP1-6	16	15	-1
FP1-7	13	15	2
FP1-8	15	15	0
FP1-9	13	15	2
FP1-10	13	15	2

5. Discussion and Conclusions

We are somewhat surprised by the lack of positive changes in aquatic habitat from the 2006 release flow. With the exception of flow status, the changes mainly reflected a decline in conditions. There was not a significant difference in periphyton between the 2005 survey and 2006 resurvey. There was a significant different between embeddedness in 2005 and 2006 with lower scores (i.e. higher embeddedness) values in 2006. Although a statistically significant difference in sediment deposition was not detected, a decline in condition was seen in three reaches. There was not a significant difference in bankfull depth and flow status between pre- and post- release surveys. However, five reaches did see an improved flow status score.

We hypothesize that the 2006 release was not long enough or perhaps not high enough to improve aquatic habitat by removing entrained sediments. In addition it is possible that flows of this magnitude are not frequent enough to remove entrained sediments. We looked at maximum flows (1, 3, and 7-day) and monthly (May and June) averages to determine how the 2006 flows compared to the historical record and modeled data. Although the 2006 release was higher than the peak flow for the previous seven years, the one-, three-, and seven-day maximum flows for 2006 were below the pre-impact medians and range of variability. Even though the average monthly flow for May 2006 was greater than the previous five year average, the 2005 average, and the modeled developed flow; it was below the IHA range of variability and well below the pre-developed modeled range of variability. Because the 2006 peak flow occurred in May, the average monthly flow for June 2006 was below the previous five-year average, the 2005 average, the modeled developed flow, and well below the IHA range of variability and the pre-developed modeled range of variability.

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