

RECLAMATION

Managing Water in the West

Flaming Gorge Technical Working Group

April 11, 2016 Hydrology Summary

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For the purposes of discussions related to implementing the ROD in 2016, an evaluation has been made of the current hydrologic conditions in the Upper Green River (*i.e.* above Flaming Gorge Dam) and Yampa River Basins. The evaluation centered on the historical unregulated inflow statistics for Flaming Gorge Dam during the period from 1963 through 2015. Based on these statistics and the April 1, 2016 final forecast of 740,000 acre-feet for Flaming Gorge, the hydrologic classification will be moderately dry (70% to 90% exceedance) for spring 2016.

The combined April through July forecast of the Yampa River at Maybell and Little Snake at Lily is 1,130,000 acre-feet. This forecast would fall into the average (below median) hydrologic classification of the ROD.

Snow water equivalent (SWE) as of April 11, 2016, for the Upper Green River and Yampa/White River Basins are 93 and 97 percent of median, respectively. Flaming Gorge SWE is similar to 1995 and 2005, while Deerlodge SWE is similar to 2000 and 2010.

Snowstorms over the last few weeks assisted in accumulation in the Upper Green and Yampa River Basins to a greater extent than other areas in the Colorado River Basin system. The Upper Green snowpack, however, accumulated in noncontributing or less contributing runoff areas and the forecast is still below average at 76 percent of average. The Yampa River Basin did see significant snow accumulation that will assist in runoff. Weather patterns between now and May will determine the peak flows seen on the Green River at Jensen, Utah.

Basin Hydrology

Green River Basin Hydrology

The April 1, 2016, final forecast of April through July unregulated inflow (current forecast) for Flaming Gorge Reservoir is 740,000 acre-feet (AF) (76% of 30-year average). This forecast falls at approximately 72% exceedance (an increase from 77% exceedance) based on the historic unregulated inflow record (1963-2015).

Figure 1 illustrates the Upper Green River SWE as of April 7, 2016 and compares it against water years 1995 and 2007. Figures 2 and 3 show the spatial extent of significant areas of modeled snow accumulation for the Upper Green River Basin and how this is incorporated into the water supply forecasts. Figure 3 indicates that the forecast for Flaming Gorge Reservoir has increased and the April 11, 2016, estimated forecast has increased from 740 kaf to 874 kaf from one week ago.

Figure 4 illustrates the current forecast in relation to the historic unregulated inflow volumes. Figure 5 illustrates Flaming Gorge Reservoir April final forecast probability (percent exceedance).

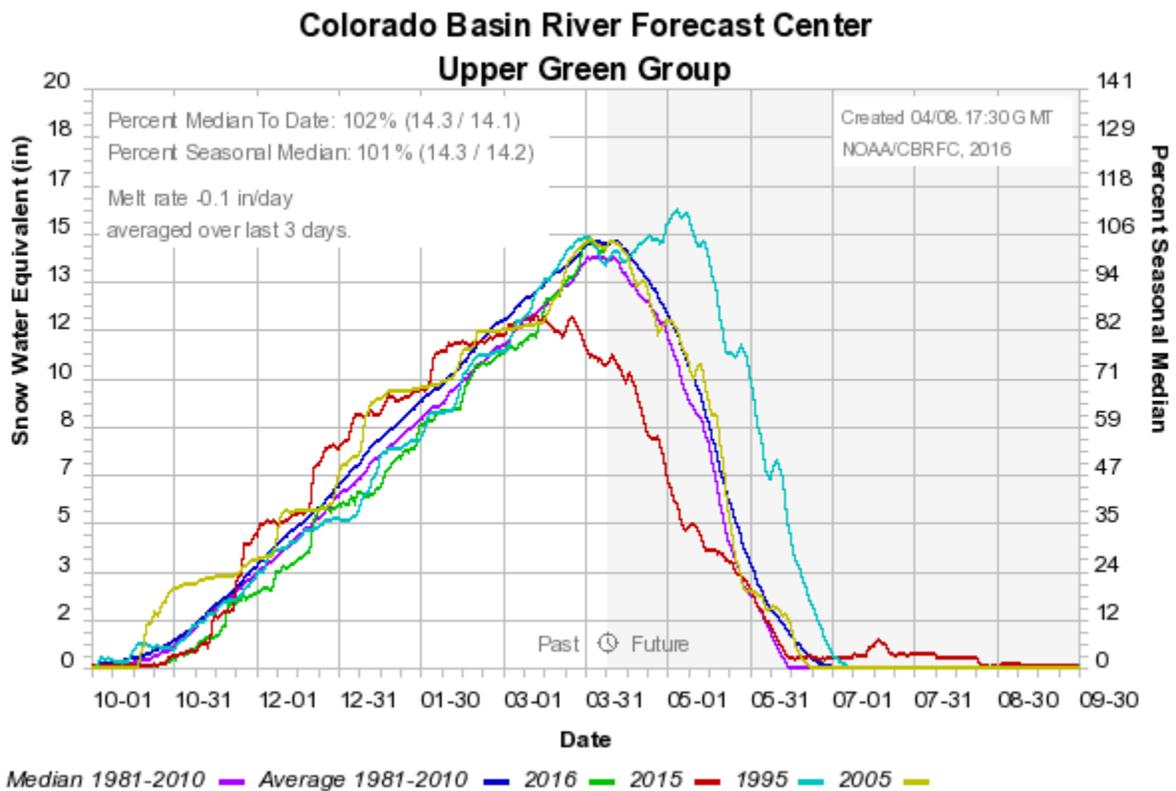


FIGURE 1. Upper Green River Basin Snotel Tracking. 1981-2010 percent of median compared against 2016 YTD Snow Water Equivalent (SWE) and 1995, 2005 and 2015 percent of average SWE

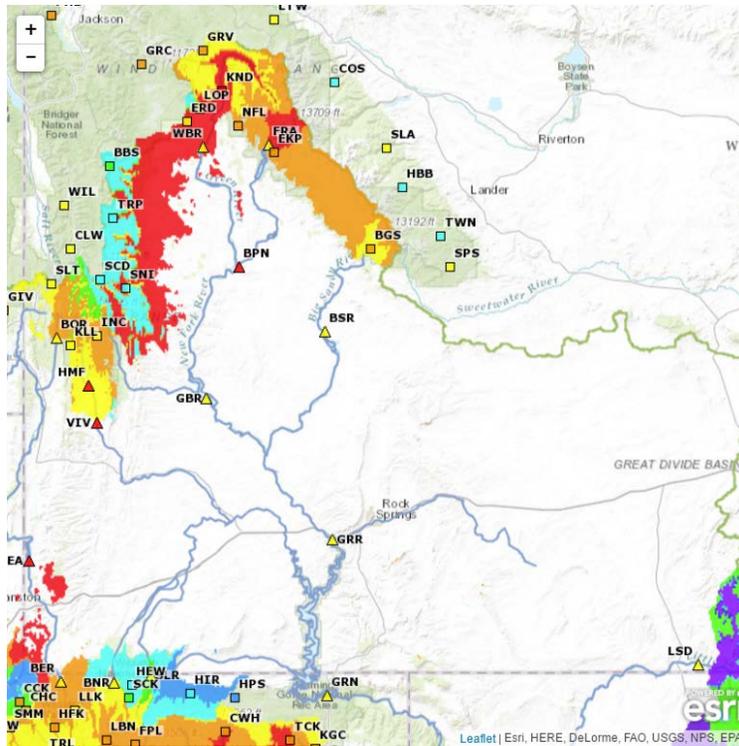


FIGURE 2. Upper Green River Basin modeled SWE significant areas as of April 8, 2016.

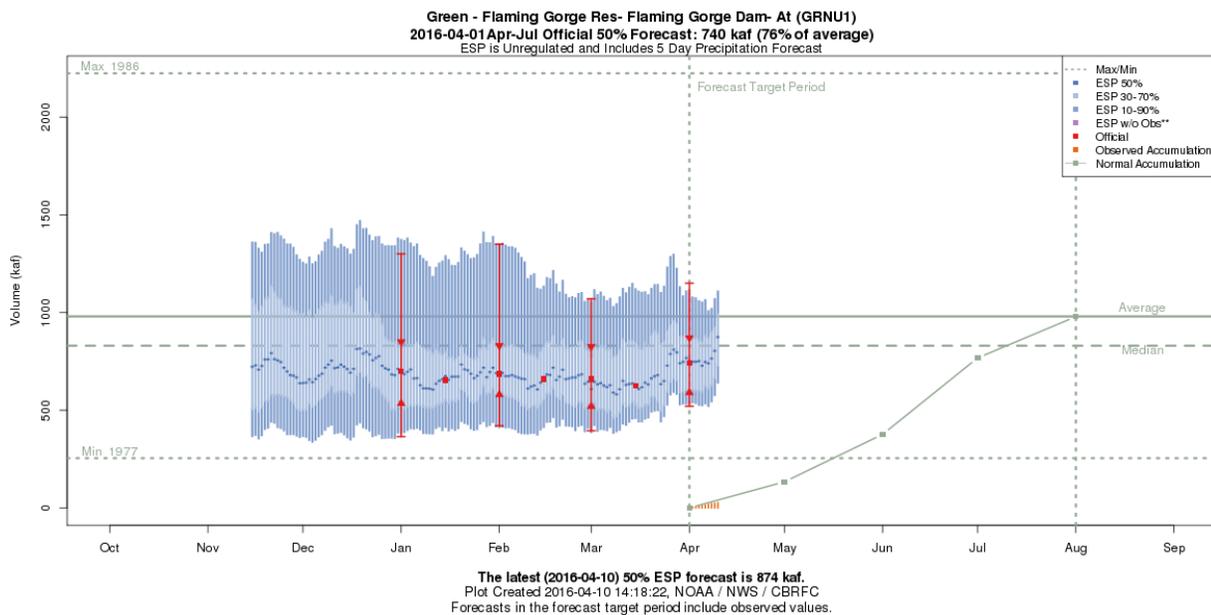


FIGURE 3. Upper Green River Basin Water Supply Forecast as of April 8, 2016.

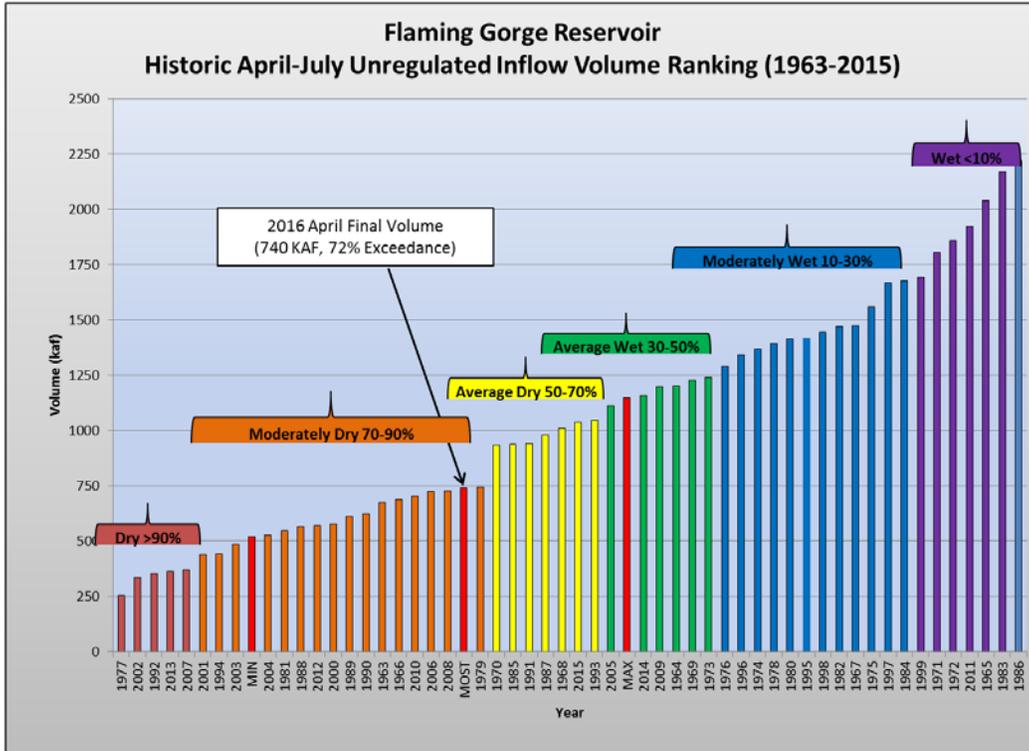


FIGURE 4. Flaming Gorge Reservoir April final forecast and ranked historic April-July unregulated inflow volume for years 1963-2015

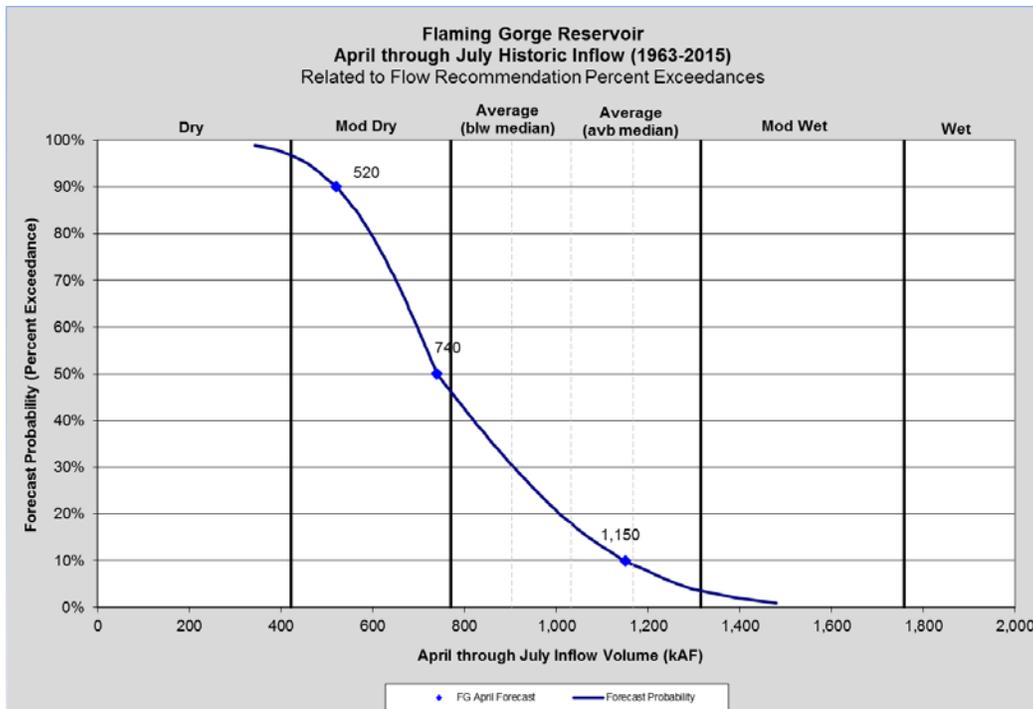


FIGURE 5. Flaming Gorge Reservoir April final forecast probability (percent exceedance) and historic April-July unregulated inflow volume for years 1963-2015

Yampa River Basin Hydrology

The combined current forecast for the Little Snake at Lily plus Yampa River at Maybell is 1,130,000 AF (91% of 30-year average). This forecast falls at approximately 58% exceedance (up from 66% exceedance) based on a ranking of the historic record (1922-2015).

Figure 6 illustrates the Yampa River at Deerlodge Park SWE as of April 8, 2016 and compares it against water years 2000 and 2010.

Figures 7 and 8 show the spatial extent of significant areas of modeled snow accumulation for the Yampa River Basin and how this is incorporated into the water supply forecasts. Figure 8 indicates that the forecast for the Yampa River at Deerlodge has continued to decrease and the April 11, 2016, estimated forecast has decreased from 1,130 kaf to 1,059 kaf from one week ago.¹

Figure 9 below shows the current forecast in relation to historic flow volumes. Figure 10 illustrates the Yampa River at Maybell plus Lily April final forecast probability (percent exceedance).

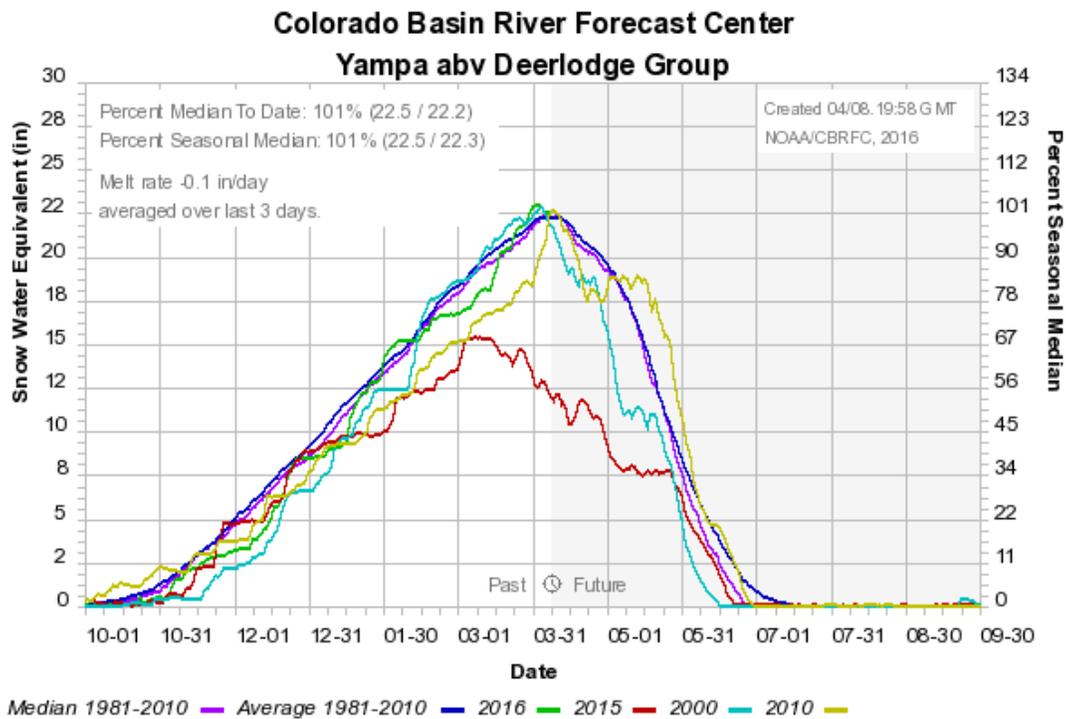


FIGURE 6. Yampa River above Deerlodge SNOTEL Group. 1981-2010 percent of average SWE compared against 2016 YTD, and analog years 2000, 2010 and 2015 percent of median SWE

¹ The Yampa River at Deerlodge forecast volume differs from the Yampa River – Maybell Plus Lily volume. The historic gage record to calculate the Maybell plus Lily forecast volume is significantly longer than the Deerlodge dataset. The forecast volumes will be close, but the actual volume may differ due to routing in the CBRFC forecast model.

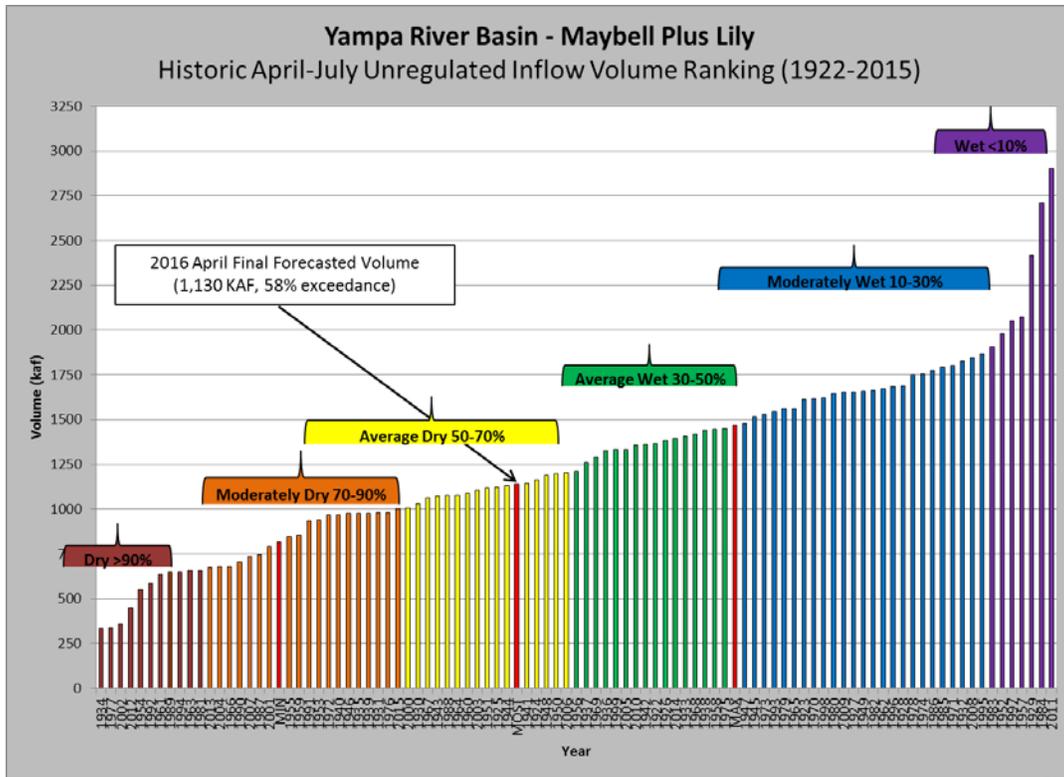


FIGURE 9. Yampa River Basin (Maybell plus Lily) April forecast and ranked April-July unregulated inflow volume for years 1922-2015

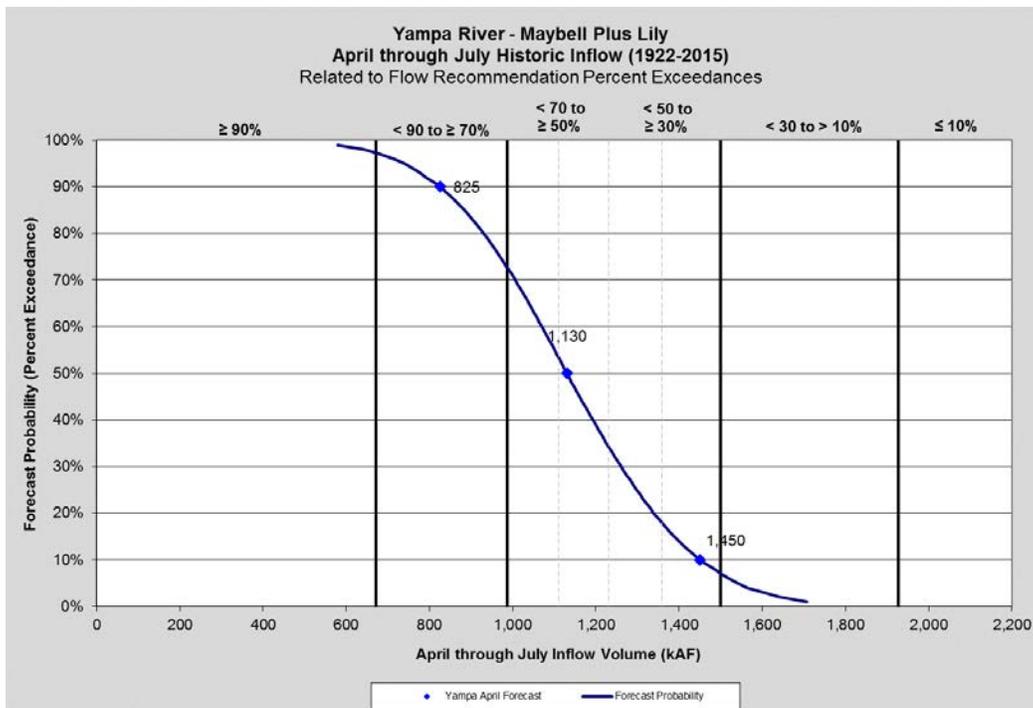


FIGURE 10. Yampa River – Maybell Plus Lily April final forecast probability (percent exceedance) and historic April-July unregulated inflow volume for years 1963-2015

Probabilities of Flow Events for Spring 2016

The Flaming Gorge unregulated inflow and Yampa River forecasts are moderately dry and average (below median), respectively, and trending wetter. Conditions this year are wetter than last year and similar to 2005 and 2010. An analysis was completed to assist in the determination of appropriate flow objectives for spring and summer 2016. The ten most similar historic years for the Yampa River Basin (Maybell plus Lily) compared to the current forecast (Table 1) were analyzed assuming a normal distribution.

Table 2 presents the percent exceedance of cumulative days greater than or equal to various flow levels at Yampa River (Maybell plus Lily). The current analysis indicates that it is likely Yampa River flows above 10,000 cfs may be achieved this year.

Table 1
Yampa River (Maybell plus Lily) – April through July Unregulated Volume
Ten Similar Years to the April 1, 2016 Final Forecast
Thousand Acre-Feet (KAF)

Year	April-July Unreg Inflow Volume (KAF)
MIN	825
1960	1,089
2003	1,108
1951	1,116
1925	1,121
1944	1,131
MOST	1,140
1941	1,141
1924	1,165
1948	1,188
1950	1,198
2006	1,202
MAX	1,450

Table 2
Spring 2016 – Days above Specific Flow Thresholds in the Yampa River
(Maybell plus Lily)
Based on the April 1, 2016, Final Forecast
Percent Exceedance (%)

April Final Forecast	% Exceed	Days above 7500 cfs	Days above 8500 cfs	Days above 9500 cfs	Days above 10000 cfs	Days above 12000 cfs	Days above 14000 cfs	Days above 15000 cfs
YAMPA	25%	34	26	19	17	7	3	0
	50%	28	21	12	9	2	1	0
	75%	23	18	5	4	0	0	0
	90%	21	9	3	2	0	0	0

Colorado Basin River Forecast Center Yampa River Analysis

The Colorado Basin River Forecast Center (RFC) calculates percent exceedance based on thirty years of historic temperature and precipitation data (1981-2010) using a modified Monte Carlo method to provide projections of flow. The RFC provides projections based upon (1) strict observance to the historic dataset and (2) incorporation of the ten-day quantitative precipitation forecast (QPF). QPF is the expected amount of melted precipitation over the ten-day climate forecast period.

The RFC provides a synopsis of the current seasonal outlook for the Yampa River at Deerlodge. This synopsis is provided below:

This outlook is based on flows from ESP with model states as of April 4. Seasonal precipitation is average in the Yampa River Basin at 98 percent of normal. Precipitation was above average for the month of January followed by an extremely dry February. The weather pattern for March was active over the Yampa River basin which resulted in above average monthly precipitation and some improvement to snowpack conditions.

March precipitation was 130 percent of normal and the current snow water equivalent as of April 1 was 100 percent of median. Mean maximum temperatures were near normal for March while mean minimum temperatures were above average. Periods of snow melt have occurred at lower and middle elevations.

The ridge of high pressure will bring warm and dry conditions through the end of week before a storm system arrives for the weekend. This the first storm in what looks to be a progressive weather pattern over the next week. However, this storm will be warm and any precipitation will be in the form of rain rather than snow. Models differ on the details for late in the weekend and early next week but expect to see an active weather pattern.

As a result of the warm temperatures and possible rain for the weekend, the 10-day streamflow forecasts are showing flows increasing over the next 10 days. The increases are a result of snow melt and rain.

The RFC provides updated Yampa River April through July seasonal exceedance probabilities for both the river flows and daily maximum peak flow. Table 3 presents the RFC projections based on current information. Figures 11 and 12 illustrate the probabilities of the Yampa River at Deerlodge river flows exceeding certain thresholds and exceedance probabilities over the April through July spring period.

Table 3
Maximum Peak Daily Flow on the Yampa River at Deerlodge
Based on the April 5, 2016, RFC Analysis
Percent Exceedance (%)

CBRFC April 5, 2016 Projections	% Exceed	Maximum Daily Peak (cfs)	Number of Days to Peak from 04/01/15	Number of Days Above 10,000 cfs	Number of Days above 14,000 cfs
YAMPA	10%	15,841	70	23	5
	25%	12,269	64	12	0
	50%	10,954	56	3	0
	75%	10,087	47	1	0
	90%	8,743	42	0	0

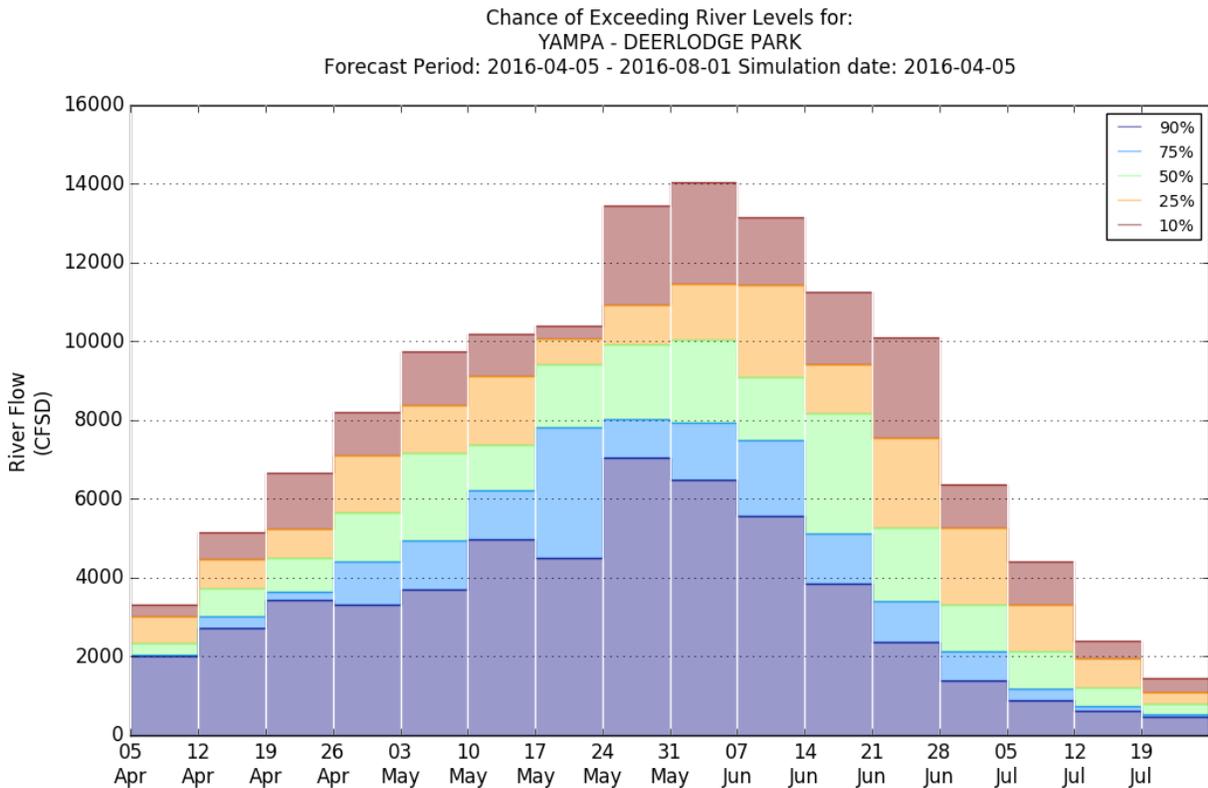


FIGURE 11. RFC April 5, 2016 projection of Yampa River at Deerlodge flows exceeding thresholds for various percent exceedance for the 2016 April through July spring period.

Exceedance Probabilities for
 YDLC2L_F: YAMPA - DEERLODGE PARK
 Forecast Period: 2016-04-05 - 2016-08-01 Simulation date: 2016-04-05

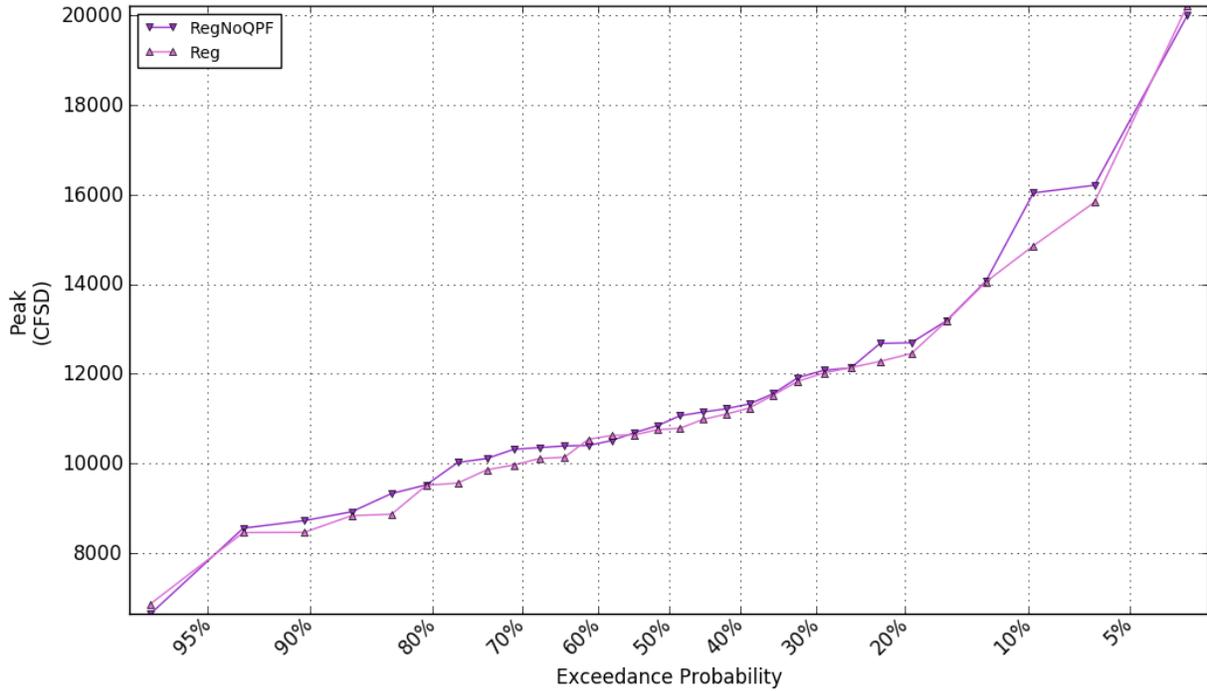


FIGURE 12. RFC April 5, 2016 projection of Yampa River at Deerlodge flow exceeding thresholds for based on the historic observed, simulation of historic climate with current initial conditions and simulation of historic climate including the ten-day QPF with initial conditions.

Larval Trigger Study Plan Projected Operations

Previous to the implementation of the ROD, the U.S. Fish and Wildlife Service issued a Biological Opinion in 1992 that timed releases from Flaming Gorge to occur during the spring peak of the Yampa River. Under the ROD, Flaming Gorge releases are timed during the Yampa River spring peak and immediate post peak.

The Larval Trigger Study Plan (LTSP) experimental protocol alters Flaming Gorge releases to occur after razorback sucker larvae have been observed in the Green River below Flaming Gorge Dam. This modification in timing of spring peak releases alters projected operations from Flaming Gorge as compared against historic releases.

Table 4 outlines the LTSP matrix used to determine the peak flow measured at Jensen, targeted study wetlands, number of days exceeded for each hydrologic classification. Figure 13 below illustrates one potential Flaming Gorge release utilizing a similar hydrologic year that synchronizes both the Upper Green and Yampa River Basins to the current one.

**Table 4
Larval Trigger Study Plan Table 2 Matrix**

TABLE 2. Matrix to Be Used in Studying the Effectiveness of a Larval Trigger

Peak Flow (x) as Measured at Jensen, Utah	Proposed Study Wetlands ^(a, b)	Number of Days (x) Flow to Be Exceeded and Corresponding Hydrologic Conditions ^(c)		
		$1 \leq x < 7$	$7 \leq x < 14$	$x \geq 14$
$8,300 \leq x < 14,000$ cfs	Stewart Lake (f), Above Brennan (f), Old Charley Wash (s)	Dry	Moderately dry	Moderately dry and average (below median)
$14,000 \leq x < 18,600$ cfs	Same as previous plus Thunder Ranch (f), Bonanza Bridge (f), Johnson Bottom (s), Stirrup (s), Leota 7 (s)	Average (below median)	Average (below median)	Average (below median)
$18,600 \leq x < 20,300$ cfs	Same as previous	Average (above median)	Average (above median)	Average (above median)
$20,300 \leq x < 26,400$ cfs	Same as previous plus Baeser Bend (s), Wyasket (s), additional Leota units (7a and 4), Sheppard Bottom (s)	Moderately wet	Moderately wet	Moderately wet
$x \geq 26,400$ cfs	Same as previous	Wet	Wet	Wet

(a) f = flow-through wetland, s = single-breach wetland

(b) Up to eight wetlands would be sampled in a given year with the three in the lowest flow category being sampled in all years.

(c) Refer to Table 1 for exceedance percentages and peak flow recommendations for each hydrologic condition. Note that the hydrologic conditions presented are the driest that could support a particular combination of peak flow magnitude and duration. For any combination, wetter hydrology could also support an experiment.

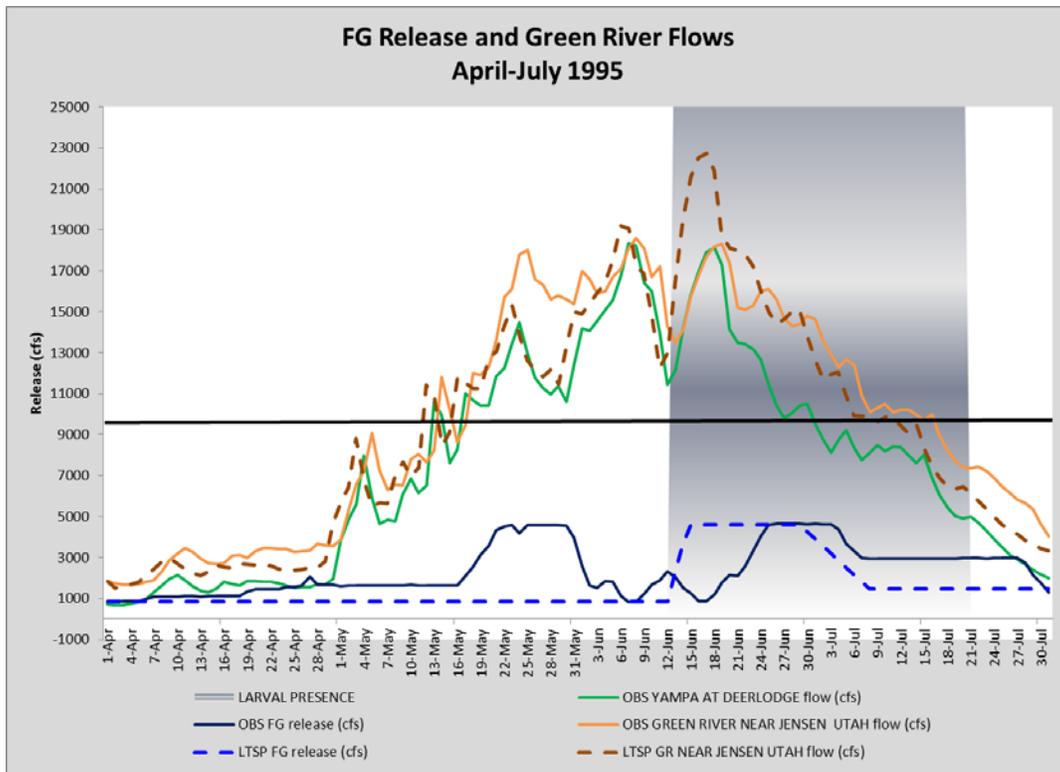


FIGURE 13. Flaming Gorge release, Yampa and Jensen flows for WY1995 and projected operations under LTSP using 1995 flows. Shaded grey area indicates larval presence.

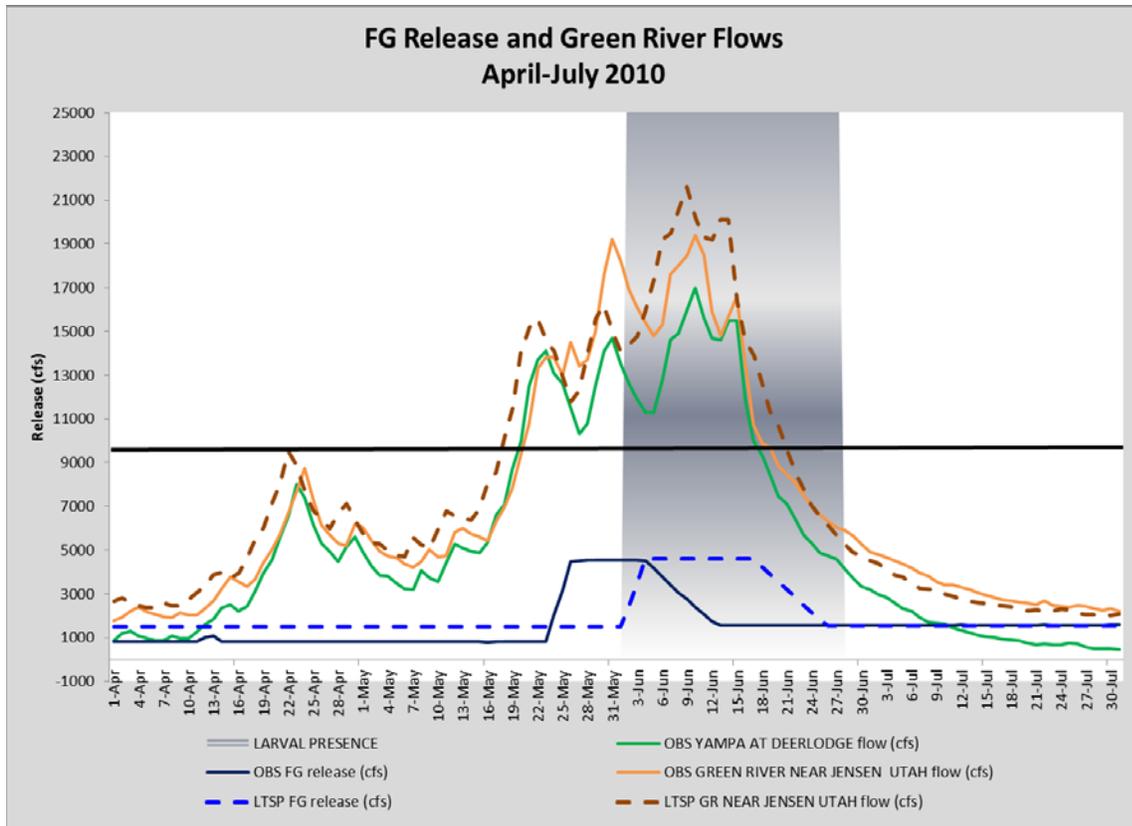


FIGURE 14. Flaming Gorge release, Yampa and Jensen flows for WY2010 and projected operations under LTSP using 2010 flows. Shaded grey area indicates larval presence.

Record of Decision Spring Flow Objectives

This hydrologic update provides information regarding current conditions and how it relates to the Operating Plan detailed in the 2005 Flaming Gorge Final Environmental Impact Statement (FEIS) in Section 2.5.3.1. The operating plan is to describe the current hydrologic classification of the Green River and Yampa River Basins, including the most probable runoff patterns for the two basins. The operating plan is also to identify the most likely Reach 2 flow magnitudes and durations that are to be targeted for the upcoming spring release. It further specifies that “[b]ecause hydrologic conditions often change during the April through July runoff period; the operations plan would contain a range of operating strategies that could be implemented under varying hydrologic conditions. Flow and duration targets for these alternate operating strategies would be limited to those described for one classification lower or two classifications higher than the classification for the current year.”

The potential classifications for 2016 are as follows:

Moderately Dry Classification

If the April through July unregulated inflow into Flaming Gorge Reservoir remains in the range from 422,000 AF to 770,000 AF the hydrological classification would be moderately dry. It is recommended to operate Flaming Gorge within the moderately dry hydrologic classification.

The peak flow as measured at Jensen, Utah this year would correspond with the moderately dry hydrologic condition. The LTSP outlines moderately dry flows between 8,300 cfs and 14,000 cfs at Jensen for a period between 7 to 14 days, and minimum seven-day duration above 8,300 cfs during larval drift. These flows provide connection at Stewart Lake, Above Brennan and Old Charley Wash.

The ROD spring flow objectives for moderately dry years are:

Table 5 – Moderately Dry Spring Flow Objectives

Reach	Spring Peak Magnitude (cfs)	Spring Peak Duration
Reach 1	≥ 4,600 cfs	That necessary to achieve duration target in Reach 2
Reach 2	≥ 8,300 cfs	1 week (i.e. 7 days)

Flow Recommendations and FEIS

Dry Classification

It is likely that hydrologic conditions into Flaming Gorge Reservoir will change before implementation of the proposed 2016 flow objectives. In the event conditions become drier and the Flaming Gorge Reservoir unregulated inflow forecast for April through July falls below 422,000 AF, the hydrological classification would be dry.

The peak flow as measured at Jensen, Utah this year would correspond with the dry hydrologic condition. The LTSP outlines moderately dry flows between 8,300 cfs and 14,000 cfs at Jensen for a period between 1 to 7 days, and minimum seven-day duration above 8,300 cfs during larval drift. These flows provide connection at Stewart Lake, Above Brennan and Old Charley Wash.

The ROD spring flow objectives for dry years are:

Table 6 –Dry Spring Flow Objectives

Reach	Spring Peak Magnitude (cfs)	Spring Peak Duration
Reach 1	≥ 4,600 cfs	That necessary to achieve duration target in Reach 2
Reach 2	≥ 8,300 cfs	2 days or more (except in extremely dry years (≥ 98% exceedance))

Flow Recommendations and FEIS

Average (Below Median) Classification

It is likely that hydrologic conditions into Flaming Gorge Reservoir will change before implementation of the proposed 2016 flow objectives. In the event conditions become wetter and the Flaming Gorge Reservoir unregulated inflow forecast for April through July falls between 770,000 AF to 1,033,000 AF, the hydrological classification would be average (below median).

The peak flow as measured at Jensen, Utah, would correspond with the average (below median) hydrologic condition with targeted flows between 14,000 and 18,600 cfs for a period between 1 to 14 days in Reach 2. These flows provide connection at the Stewart Lake, Above Brennan, Old Charley Wash, Thunder Ranch, Bonanza Bridge, Johnson Bottom, Stirrup and Leota 7 floodplains.

ROD spring flow objectives for average (below median) years are:

Table 7 – Average (Below Median) Spring Flow Objectives

Reach	Spring Peak Magnitude (cfs)	Spring Peak Duration
Reach 1	≥ 4,600 cfs	That necessary to achieve duration target in Reach 2
Reach 2	≥ 8,300 cfs in 50% of average years	One week (i.e. 7 days) in 50% of average years

Flow Recommendations and FEIS

Average (Above Median) Classification

If conditions become wetter than the current forecast at Flaming Gorge Reservoir and the April through July forecast increases between 1,033,000 AF and 1,315,000 AF, the hydrological classification would be average (above median).

The peak flow as measured at Jensen, Utah, would correspond with the average (above median) hydrologic condition with targeted flows between 18,600 and 20,300 cfs for a period between 1 to ≥14 days in Reach 2. These flows provide connection at the Stewart Lake, Above

Brennan, Old Charley Wash, Thunder Ranch, Bonanza Bridge, Johnson Bottom, Stirrup and Leota 7 floodplains.

ROD spring flow objectives for average (above median) wet years are:

Table 8 – Average (Above Median) Spring Flow Objectives

Reach	Spring Peak Magnitude (cfs)	Spring Peak Duration
Reach 1	≥ 4,600 cfs	That necessary to achieve duration target in Reach 2
Reach 2	≥ 18,600 cfs in 50% of average years	Two weeks (<i>i.e.</i> 14 days) in 25% of all average years

Flow Recommendations and FEIS