

Draft Bighorn Lake Operating Criteria
Changes for the 2012 Water Year
November 2, 2011

Background

In October 2009, revised operating criteria for Yellowtail Dam and Bighorn Lake were implemented for the 2010 water year, which ran from October 1, 2009 to September 30, 2010. Reclamation implemented the revised criteria on a trial basis, with a commitment that the criteria would be evaluated annually, and modified appropriately (for a period of years) based on experience and public input.

In November 2010, a formal report on the revised operating criteria (as described in the *Draft Bighorn Lake Operating Criteria Evaluation Study & Report*) was provided to the applicable natural resource management agencies in Montana and Wyoming, and to stakeholders, for review and comment. Public meetings were held in Billings, Montana and Lovell, Wyoming during January 2011 to explain the revised operating criteria, and additional discussions occurred during meetings of the Bighorn River System Issues Group held in Lovell in March 2011 and later in Billings in October 2011. Over 80 written comments were received during this period.

Reclamation has considered these comments in making changes to the operating criteria for implementation during water year 2012. The changes are summarized as follows:

General

The operating criteria is based on meeting various end-of-month target elevations in Bighorn Lake while providing sufficient releases to the Bighorn River for power generation and to meet fishery flow targets. The operating criteria also provides a procedure (based on the lake elevation targets and the forecasted November through March inflow) for establishing a fall/winter river release to the Bighorn River. Application of the criteria requires careful balance between meeting sometimes conflicting operational goals. Consequently, neither the lake elevation targets nor the river release targets are mandatory or absolute, but rather operational goals for a balanced operating plan.

In addition to the specific changes discussed below, the topics: 1) flushing flows in the Bighorn River; and, 2) gradual reduction of river releases following periods of sustained high flows, will be discussed, evaluated and deliberated at future meetings of the Bighorn River System Issues Group during this coming year.

Lake Elevation Targets

The lake elevation targets were established to meet objectives identified by reservoir recreation and fishery managers and stakeholders, and to provide a lake elevation in the early spring that will (in most years) allow the reservoir to recover to nearly full by July, while still providing

sufficient storage space in the spring to provide adequate flood control during the peak runoff. The range for the lake elevation target is dependent on water supply forecasts and the actual water supply available at specific times of the year. Below are the reservoir elevation targets for 2012 compared to those used in 2011:

<u>Date</u>	<u>Lake Elevation Target for 2012</u>	<u>Lake Elevation Target for 2011</u>
October 31	3,635 to 3,640	3,638 to 3,640
March 31	3,615 to 3,619	3,616.7 to 3,620.6
* April-July (Rule Curve)	3,592 to 3,617	3,603 to 3,618
July 31	3,640	3,640

*During the April thru July period, a rule curve (which is based on forecasted inflow and river release limitations) guides reservoir operations on a daily basis from the actual end-of-March lake elevation until the reservoir fills. The rule curve is an inflow routing procedure that determines the minimum reservoir elevation necessary, in concert with a river release schedule that will accommodate the forecasted inflow and control the reservoir rate-of-fill through the spring runoff season, to best meet the established operational objectives.

River Release Targets

River release targets were established to meet objectives identified by river fishery managers and stakeholders, and hydropower interests. No changes from the current criteria were made for these release targets, as indicated in the following table:

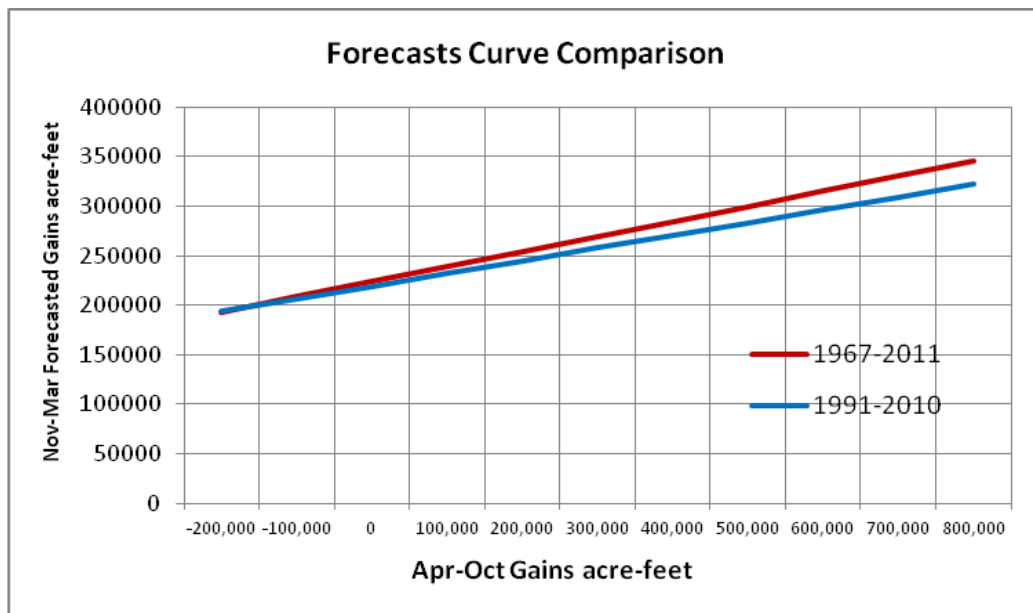
	<u>River Release Targets for 2012</u>	<u>River Release Targets for 2011</u>
Preferred flow range	2,500 cfs to 8,000 cfs	2,500 cfs to 8,000 cfs
Optimum fishery flow	2,500 cfs	2,500 cfs
Standard fishery flow	2,000 cfs	2,000 cfs
Minimum fishery flow	1,500 cfs	1,500 cfs
*Absolute minimum flow	1,000 cfs	1,000 cfs

*Under the operating criteria and the current level of water development in the basin, the need to reduce the river release below 1,500 cfs should not be necessary. However, if future water development occurs or a future drought is more severe than previously experienced, river releases as low as 1,000 cfs may be necessary to prevent full depletion of the active conservation pool and loss of power generating capability. The Definite Plan Report for Yellowtail Dam identified 1,000 cfs as the absolute minimum flow to the Bighorn River expected during operation of the project.

November thru March Operations

A stable reservoir release is desirable for the late fall and winter period to provide certainty for power generation, reliability for the river fishery during the brown trout spawn, and to minimize potential disruption to downstream ice conditions. This fall/winter release rate is set around the first of November after the irrigation season has ended, and prior to the start of significant brown trout spawning which generally occurs around the middle of November. A formal procedure for calculating this release was established in the draft criteria. Changes to this procedure are briefly described below:

Gains is the term used to describe the net water that enters the Bighorn River between the two upstream reservoirs (Boysen and Buffalo Bill) and Bighorn Lake. The procedure for forecasting the November thru March gains has been revised to expand the period of record used in the analysis from the current period (1991 thru 2010), to the full period of record (1967 thru 2011). The rationale for expanding the period is twofold: 1) it provides the full period of record in the analysis; and, 2) it includes years with higher runoff events to better correlate with the record runoff experienced in 2011. The forecasted gains under both periods of record are illustrated in the graph below:



End-of-March Lake Elevation Target

In addition to revising the method for forecasting the November thru March gains, the end-of-March lake elevation target used in this procedure was also modified. The end-of-March lake elevation target of 3,618 used previously was lowered one foot to elevation 3,617 to account for the new area-capacity table that was implemented in January of 2011. In summary, the available storage between elevations 3,617 and 3,640 under the new are-capacity table is approximately

the same as the available storage between elevations 3,818 and 3,640 under the old area-capacity table.

Further, the range between the upper and lower end-of-March lake elevation targets was adjusted slightly, and the procedure for determining which elevation target applies was simplified as follows:

First, an initial fall/winter river release is calculated using the new end-of-March lake elevation target of 3617. If this calculated release falls between 2,000 cfs and 2,500 cfs then the end-of-March lake elevation target remains at 3,617. If the calculated release is greater than 2,500 cfs then the release is re-calculated using an end-of-March lake elevation target of 3,619. Should the initial calculated release be less than 2,000 cfs then the release is re-calculated using an end-of-March lake elevation target of 3,615. These procedures provide some sharing between upstream and downstream beneficiaries and stakeholders in the risk associated with experiencing either a high or low spring runoff. The effect of these procedures is illustrated in the table below:

Initial calculated river release using March 31 Lake Elevation of 3,617	Water Year 2012 March 31 Lake Elevation Target	Water Year 2011 March 31 Lake Elevation Target
> 2,500 cfs	3,619.0	3,620.6
2,000 cfs to 2,500 cfs	3,617.0	3,618.0
< 2,000 cfs	3,615.0	3,616.7

January thru March Operations

Beginning in January each year, monthly water supply forecasts are prepared for Bighorn Lake which estimate the runoff for the April thru July period, based primarily on the water content in the mountain snowpack and normal spring precipitation. Typically, the river release rate established in early November will not be changed until after the first of April. If however, gains to the system are trending noticeably higher or lower than forecasted in early November, minor adjustments in river release rates may be necessary to bring the reservoir elevation back in line with the end-of-March target elevation. Likewise, if the April thru July inflow forecasts prepared in February or March indicate that spring runoff is expected to be either considerably higher or lower than average, adjustment to the end-of-March target elevation and the fall/winter release rate may be made prior to April 1, to prepare the reservoir for potentially high or potentially low spring runoff.

April thru July Operations (Rule Curves)

As described previously, rule curve methodology is an inflow routing procedure that has been applied to Yellowtail operations over the past couple of years. Using the Bighorn Lake Rule Curve spreadsheet and the spring runoff forecast, a rule curve is developed to identify the desired reservoir elevations during the April thru July runoff season. The rule curve is updated with each revision to the runoff forecast (revisions are normally available around the 1st and 15th of each month). Once the rule curve is established, it is used to help guide operations until the next revision is made, or through the remainder of the runoff season, whichever is applicable.

The 2012 criteria expands the rule curves for April thru July inflow forecasts up to 2,500,000 acre-feet (as compared to an upper limit of 2,000,000 acre-feet under the 2011 criteria). Below is a comparison of the 2012 target elevations with the 2011 target elevations:

<u>Runoff (acre-feet)</u>	<u>Percentile Rank</u>	<u>Percent of Average</u>	<u>2012 Minimum Target Elevation</u>	<u>2011 Minimum Target Elevation</u>
548,900	10	48%	3,617.0	3,618.0
655,000	25	58%	3,617.0	3,618.0
1,121,800	50	99%	3,613.5	3,614.7
1,584,000	75	140%	3,607.7	3,607.3
1,850,000	90	163%	3,603.7	3,604.7
1,957,300	95	173%	3,600.5	3,603.3
2,310,000	98	204%	3,594.5	3,602.7
2,500,000	Max	221%	3,591.5	3,602.7

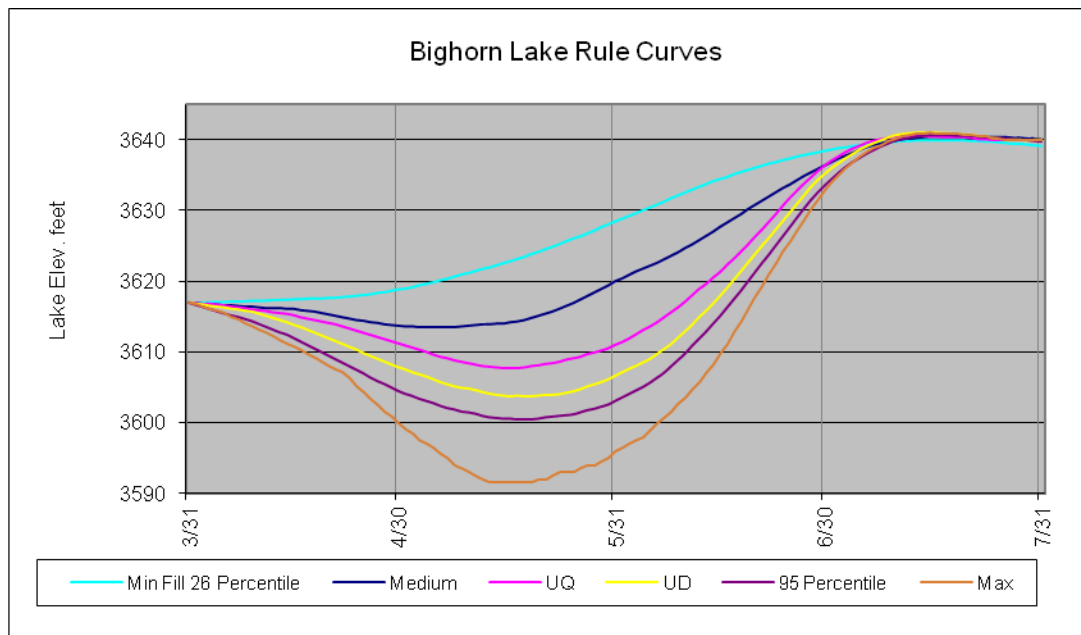
The following table provides more detail on the lake elevation targets established by the 2012 rule curves for various April thru July forecasted inflow volumes. Included are estimated maximum releases and potential flow durations for upper percentile runoff years.

<u>Percentile Rank</u>	<u>Percent of Average</u>	<u>April – July Inflow Forecast (acre-feet)</u>	<u>Rule Curve Minimum Elevation</u>	<u>Date</u>	<u>*Max. Release (cfs)</u>	<u>Duration Releases > 8,000 cfs</u>
10	48%	548,900	3,617.0	4/1	1,500	
25	58%	655,000	3,617.0	4/1	2,000	
35	84%	950,000	3,616.0	4/1	3,400	
50	99%	1,121,800	3,613.5	5/3	4,500	
60	116%	1,310,000	3,611.5	5/13	5,700	
75	140%	1,584,000	3,607.7	5/15	7,500	
90	163%	1,850,000	3,603.7	5/18	9,500	30 days
95	173%	1,957,300	3,600.5	5/17	10,000	41 days
98	204%	2,310,000	3,594.5	5/14	12,000	58 days
Max (99+)	221%	2,500,000	3,591.5	5/14	13,000	66 days

*The estimated maximum release assumes somewhat ideal runoff conditions. The actual peak releases may be higher (as much as 10 to 20 percent) due to natural variability in the spring runoff. Spring temperatures, snowpack conditions, significant rain events, and the potential for more runoff than forecast are all factors that could result in the actual peak release exceeding the estimated release.

During years when the forecasted runoff is less than 700,000 acre-feet, it may be necessary to reduce the river release below 2,000 cfs to adequately conserve storage for long-term operations. The primary goal in these low water years is to conserve storage sufficiently to provide a stable river release rate of between 1,500 cfs and 2,000 cfs while allowing storage to recover to a desired elevation near 3,617 by the end of the following March.

A graphical representation of the 2012 Rule Curves is presented below:



August thru October Operations

In years with a good water supply, river releases will be established at 2,500 cfs or more while meeting the desired end-of-October reservoir elevation target range of 3,635 to 3,640. This target range is established to provide desirable reservoir levels for: 1) reservoir-based recreation; 2) waterfowl hunting; and, 3) a water supply sufficient for allowing adequate fall/winter river releases for river fishery and power generation purposes. In runoff years when a river release of 2,500 cfs cannot be met without drafting the reservoir below elevation 3,635 by the end-of-October, operations are planned based on meeting the end-of-March target elevation of near 3,617 with a fairly uniform release throughout the late summer, fall and winter seasons.