Memo

Date:	Friday, February 27, 2015
Project:	NorthWestern Energy Operations Modeling of Hydros
To:	John Vandaveer, NorthWestern Energy
From:	Rick Miller, HDR
Subject:	Peaking Analysis

1.0 INTRODUCTION

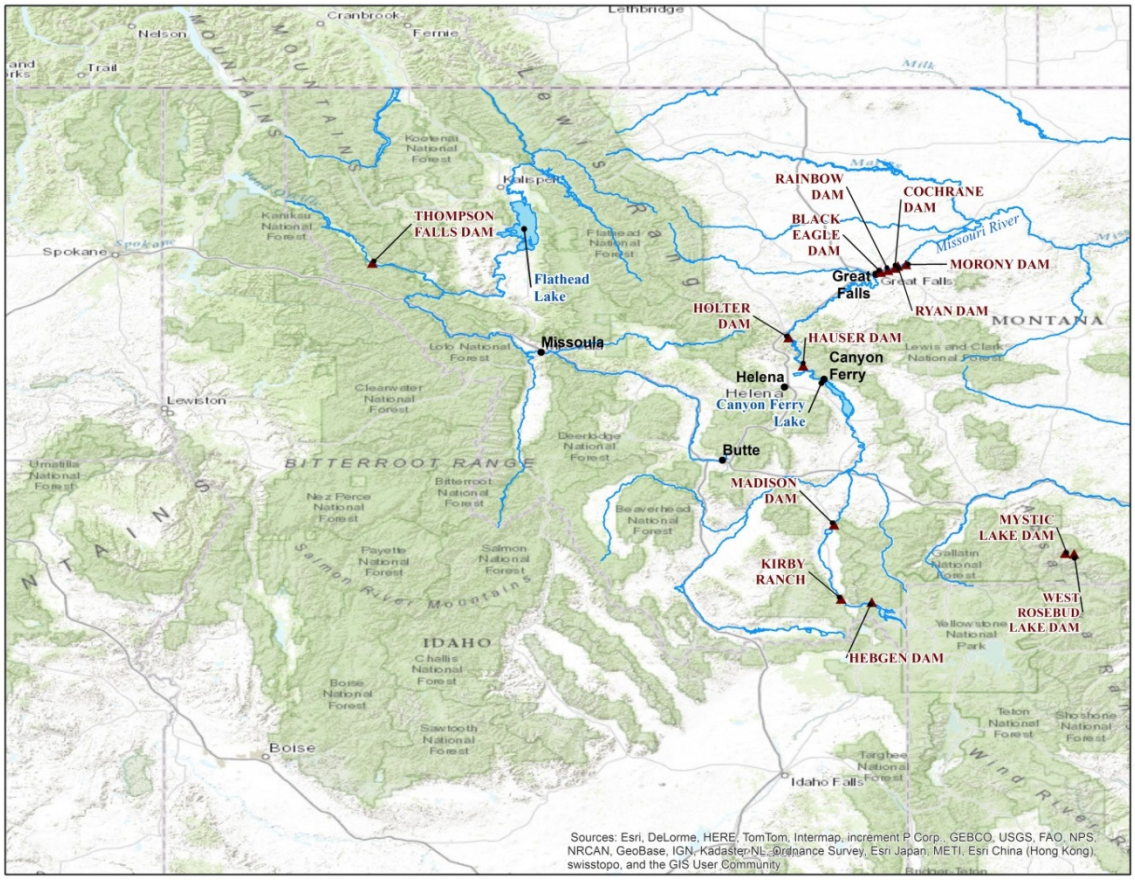
The goal of this Flexibility Operations Model Study is to simulate the potential for peaking operations and system reserves within the PPL Montana Hydro Assets (Hydros) recently acquired by NorthWestern Energy. This memo will present the results of the peaking and flexibility analysis by documenting the scenarios (model runs) that have been developed and run using the NorthWestern Energy Hydro Fleet CHEOPS Model (NWE CHEOPS Model).

NorthWestern Energy (Licensee) contracted with HDR Engineering, Inc. (HDR) to develop an operations model of the PPL Montana Hydro Assets (Hydros) recently acquired by NorthWestern Energy, including: the Missouri-Madison Hydroelectric Project (Federal Energy Regulatory Commission (FERC) Project No. 2188) on the Madison and Missouri Rivers; Thompson Falls Hydroelectric Project (FERC Project No. 1869) on the Clark Fork River; and the Mystic Hydroelectric Project (FERC Project No. 2301) on West Rosebud Creek. The U.S. Bureau of Reclamation (USBR) Canyon Ferry facility on the Missouri River is also included in the modeled plants, and these are referred to as the "modeled system." This operations model utilizes HDR's proprietary Computer Hydro Electric Operations and Planning Software (CHEOPS).

Major features of the hydro developments included in the NWE CHEOPS Model are shown in Figure 1-1. This schematic is the basis for the conceptual model that was used to develop the NWE CHEOPS Model. The NWE CHEOPS Model has thirteen nodes (the thirteen developments previously outlined) that correspond to the major hydrologic junctures in the modeled system and two flow calculation locations (Kirby Ranch downstream of Hebgen Dam and the Mystic bypass reach which is downstream of Mystic Lake Dam and upstream of Mystic Lake Powerhouse discharge) that correspond to locations of operational flow requirements. The model accounts for inflows, discharge, change in reservoir storage, and power generation at the various reservoir nodes and the flows at the two flow-only node locations. A scenario is a combination of

user-defined specific operating rules or conditions which the model logic will follow when scheduling releases. Model results presented in this memo represent the model configuration as of February, 2015.

FIGURE 1-1
NORTHWESTERN ENERGY HYDRO FLEET



2.0 SCENARIO DEFINITIONS

As outlined in the February 13, 2015, Draft NorthWestern Energy Hydro Fleet CHEOPS Model Operations/Verification Report (Draft Ops Report); NorthWestern Energy owns and operates the developments of Hebgen, Madison, Hauser, Holter, Black Eagle, Rainbow, Cochrane, Ryan, Morony, Thompson Falls, Mystic Lake, and West Rosebud Lake. The USBR owns and operates the Canyon Ferry Development. Each development is simulated within the NWE CHEOPS Model and consists of dams and multi-unit powerhouses as shown in Table 2-1. Additionally, the approximate generation,

spinning reserve, and load following capacities at rated head are listed in Table 2-2. Existing operations of each development are outlined in detail in Section 2 of the Draft Ops Report. Additionally, the Draft Ops Report documents all modeling assumptions and inputs of the Base Case scenario. This memo summarizes the Base Case scenario results as compared to scenarios where the system is operated to maximize peaking operations and to demonstrate the potential flexibility available at Black Eagle, Rainbow, Cochrane, Ryan, and Thompson Falls.

TABLE 2-1
NORTHWESTERN ENERGY CHEOPS MODEL PLANTS

Development	Upstream Reservoir	Downstream Reservoir	FERC Project No.	Drainage Area (square miles)
Hebgen	—	Madison	2188	932
Madison	Hebgen	Canyon Ferry	2188	2,208
Canyon Ferry	Madison	Hauser	—	15,908
Hauser	Canyon Ferry	Holter	2188	16,723
Holter	Hauser	Black Eagle	2188	16,977
Black Eagle	Holter	Rainbow	2188	22,909
Rainbow	Black Eagle	Cochrane	2188	22,920
Cochrane	Rainbow	Ryan	2188	22,942
Ryan	Cochrane	Morony	2188	22,947
Morony	Ryan	—	2188	23,054
Thompson Falls	—	—	1869	20,924
Mystic Lake	—	West Rosebud Lake	2301	48
West Rosebud Lake	Mystic	—	2301	65

TABLE 2-2
NORTHWESTERN ENERGY
APPROXIMATE HYDROELECTRIC STATION CAPACITIES

Development	Station Capacity (MW)	Spinning Reserve (MW)	Load Following Range (MW)
Hebgen	-	-	-
Madison	9	9	-
Hauser	16.8	16.8	-
Holter	48	48	-
Black Eagle	20.6	20.6	2.6 - 20.6
Rainbow	64.2	64.2	18.8 - 64.2
Cochrane	59.4	59.4	7.7 - 59.4
Ryan	66.6	66.6	0.8 - 66.6
Morony	50	50	-
Thompson Falls	93.1	93.1	4.3 - 93.1
Mystic Lake	10.5	10.5	0.1 - 10.5
West Rosebud Lake	-	-	-

Note: Capacities are based on rated head, all units available, and unit performance developed from historical operational data as outlined in the Draft Ops Report. Capacities will vary with available net head. Additionally, this table does not take into account operational limitations on the units, such as cavitation.

Model inputs for the Base Case and Peaking scenarios are outlined below.

2.1 BASE CASE

The Base Case scenario simulates the system as currently licensed and operated. The inputs are outlined in detail in the Draft Ops Report, and summarized further below. The following five modifications were made to the Base Case scenario since the Draft Ops Report:

- *The loadshape was modified to a single peak period to better represent historical operations.*
- *The storage curve for the Ryan reservoir was extended down to one foot below the operational minimum elevation.*
- *The storage curve for the Rainbow reservoir was extended down to zero storage*

- *The Rainbow minimum elevation was revised to be the bottom of usable storage (3211 feet). The historical minimum elevation of 3,199 feet is below the usable storage as documented in the historical operations data ("HDB RNB 198801 to 201411.xlsx").*
- *The minimum elevation of Morony was revised to reflect baseload operations.*
- *Canyon Ferry revised to run-of-river daily average operations.*

The purpose of this scenario is to simulate the existing operations, with the assumptions outlined below, at each development. The outputs of the Base Case scenario are then compared to the outputs of alternative operating scenarios to determine the incremental changes due to the modified operating rules. The Base Case scenario assumptions are summarized below and, as previously noted, in detail in the Draft Ops Report.

HEBGEN DEVELOPMENT (FERC PROJECT NO. 2188)

- There are no generating facilities at this development; discharges are released through the outlet works and a side-channel spillway.[1] Hebgen is operated as a storage facility, with releases providing head and flow to the downstream hydroelectric developments.
- For Modeling Purposes
    - Due to the infrequency, the Madison River Flushing Flow Plan flows are not included in the definition of the Base Case scenario.
    - Release requirements which are measured at USGS gage 06038800 are simulated based on Hebgen releases plus the incremental inflow to Kirby Ranch. This duplicates actual operations.
    - The model logic prioritizes the continuous flow requirement of 600 cfs at Kirby Ranch over the 10 percent per day limit to changes in outflow from Hebgen Dam.

MADISON DEVELOPMENT (FERC PROJECT NO. 2188)

- Madison is operated as a base load, run-of-river generating facility, with releases providing head and flow to the downstream hydroelectric developments.
- For Modeling Purposes
    - The bypass flow ramping rate restrictions are not simulated in the model. If desired, the bypass flow ramping rate functionality could be added to the model with additional custom coding.
    - Due to the infrequency, the Madison River Flushing Flow Plan flows are not included in the definition of the Base Case scenario.
    - Since CHEOPS does not model plant outage due to tripping, the Flow Restoration Plan is not modeled.
    - CHEOPS does not currently use temperature inputs to implement

[1] Federal Energy Regulatory Commission (FERC). 2000. Missouri-Madison Hydroelectric Project, FERC No. 2188, Order Issuing New License. September 2000.

scheduling and release logic; therefore, the Madison River Pulse Flow Protocol is not modeled. However, the Madison River Pulse Flow Protocol may be simulated through use of scheduling by month and day to allow for alternatives analysis.

CANYON FERRY DEVELOPMENT

- Canyon Ferry provides for flood control, generation, and irrigation. The Helena Valley Pumping Plant diverts water into a conveyance system which provides irrigation to the Helena Valley and the City of Helena/Helena Lake consumptive uses. Operated by the USBR, HDR understands that Canyon Ferry is operated a baseload generating facility, which provides the usable storage for providing continuous flows in the Missouri River from Lake Hauser down to the Morony tailrace.

HAUSER DEVELOPMENT (FERC PROJECT NO. 2188)

- Hauser is operated as a base load, run-of-river generating facility, with releases providing flow to the downstream hydroelectric developments.
- For Modeling Purposes
    - Since CHEOPS does not model plant outage due to tripping, the Flow Restoration Plan is not modeled.
    - If conflicts occur, the model logic will prioritize the downstream flow requirements as follows:
        1. Limit to 10 percent, the difference between the daily average flow measured just below Hauser Dam (at a USGS gauging station to be installed) and the daily average inflow to Hauser Reservoir and Lake Helena. For this purpose, the inflow to Hauser Reservoir and Lake Helena shall be calculated based on the modeled inflow to Hauser Dam.
        2. Limit changes in the hourly average flow measured at the gauging station to be installed to no more than 5 percent of the previous hour's average flow.
        3. Limit the difference between the highest hourly average flow and the lowest hourly average flow (as measured at the USGS gauging station to be installed) on any day to no more than the sum of (a) 10 percent of the previous day's average flow at the gauging station and (b) any increase or decrease in releases from Canyon Ferry Dam occurring from the day prior to the current day.

HOLTER DEVELOPMENT (FERC PROJECT NO. 2188)

- Holter is operated as a base load, run-of-river generating facility, with releases providing flow to the downstream hydroelectric developments.
- For Modeling Purposes

- The Standard Operating Plan (SOP) emergency winter flows are not included in the definition of the Base Case scenario. The SOP may be simulated through use of scheduling by month and day to allow for alternatives analysis.
- Since CHEOPS does not model plant outage due to tripping, the Flow Restoration Plan is not modeled.
- If conflicts occur, the model logic will prioritize the downstream flow requirements as follows:
  1. Limit to no more than 10 percent the difference between the daily average flow measured just below Holter Dam and the daily average inflow to Holter Reservoir.
  2. Limit changes in the hourly average flow measured below the dam to be no more than 5 percent of the previous hour's average flow.
  3. Limit the difference between the highest hourly average flow and the lowest hourly average flow on any day to no more than the sum of (a) 10 percent of the previous day's modeled average outflow and (b) any increase or decrease in releases from Canyon Ferry Dam occurring from the day prior to the current day.

BLACK EAGLE DEVELOPMENT (FERC PROJECT NO. 2188)

- Black Eagle is operated as a limited peaking generating facility, with releases providing flow to the downstream hydroelectric developments.
- For Modeling Purposes
  - Based on discussions with NorthWestern Energy operations staff, the 200 cfs minimum spill flow is performed regardless of the April–June natural runoff into Canyon Ferry Reservoir. This is likewise simulated as a requirement, regardless of the runoff, in the Base Case scenario.
  - The four hours of available short-term generation reserves (peaking ability) are not included in the definition of the Base Case scenario; this will be evaluated in the Peaking scenario. Black Eagle is operated as a run-of-river generating facility in the Base Case scenario.

RAINBOW DEVELOPMENT (FERC PROJECT NO. 2188)

- Rainbow is operated as a limited peaking generating facility, with releases providing flow to the downstream hydroelectric developments.
- For Modeling Purposes
  - Based on discussions with NorthWestern Energy operations staff, the 200 cfs minimum spill flow is performed regardless of the April–June natural runoff into Canyon Ferry Reservoir. This is likewise simulated as a requirement, regardless of the runoff, in the Base Case scenario.
  - The four hours of available short-term generation reserves (peaking ability) are not included in the definition of the Base Case scenario; this

will be evaluated in the Peaking scenario. Rainbow is operated as a run-of-river generating facility in the Base Case scenario.

COCHRANE DEVELOPMENT (FERC PROJECT NO. 2188)

- Cochrane is operated as a generating facility with the ability for discretionary peaking operations, with releases providing flow to the downstream hydroelectric developments.
- For Modeling Purposes
  - The capability of peaking operations and generation reserves are not included in the definition of the Base Case scenario; this will be evaluated in the Peaking scenario. Cochrane is operated as a run-of-river generating facility in the Base Case scenario.

RYAN DEVELOPMENT (FERC PROJECT NO. 2188)

- Ryan is operated as a generating facility with the ability for discretionary peaking operations, with releases providing flow to the downstream hydroelectric developments.
- For Modeling Purposes
  - Based on discussions with NorthWestern Energy operations staff, the 200 cfs minimum spill flow is performed regardless of the April–June natural runoff into Canyon Ferry Reservoir. This is likewise simulated as a requirement, regardless of the runoff, in the Base Case scenario.
  - The capability of peaking operations and generation reserves are not included in the definition of the Base Case scenario; this will be evaluated in the Peaking scenario. Ryan is operated as a run-of-river generating facility in the Base Case scenario.

MORONY DEVELOPMENT (FERC PROJECT NO. 2188)

- Morony is operated as a re-regulating generating facility.
- For Modeling Purposes
  - If conflicts occur, the model logic will prioritize the downstream flow requirements as follows:
    1. Limit to 10 percent, the difference between the daily average flow measured just below Morony Dam and the daily average inflow to the Great Falls Developments. For modeling purposes, to duplicate the license requirement, the inflow to the Great Falls Developments is calculated as the modeled inflow to Black Eagle plus the change in storage content of Black Eagle, Rainbow, Cochrane, Ryan, and Morony Reservoirs.
    2. Limit changes in the hourly average flow measured downstream of Morony dam to no more than 7.5 percent from the previous hour's average flow.

3. Limit the difference between the highest hourly average flow and the lowest hourly average flow measured downstream of Morony dam on any day to no more than the sum of (a) 15 percent of Morony's previous day's average outflow and (b) the greater of the sum of the differences between the modeled highest hourly average flow and the lowest hourly average flow measured as inflows to Black Eagle on the day in question or the day preceding the day in question.

THOMPSON FALLS DEVELOPMENT (FERC PROJECT NO. 1869)

- Thompson Falls is operated as a generating facility with the ability for discretionary peaking operations.
- For Modeling Purposes
  - Based on discussions with NorthWestern Energy operations staff, fish ladder flows of typically 80 cfs from mid-March through late October are released. Supplemental attraction flows are sometimes released through spillway gates for test purposes but have not been standardized. The Base Case scenario is configured to release 80 cfs from March 15 through October 25 annually. Other options are available as sensitivity analyses.
  - The capability of peaking operations is included in the definition of the Base Case scenario.

MYSTIC LAKE DEVELOPMENT (FERC PROJECT NO. 2301)

- Mystic Lake is operated as a storage and generating facility with the ability for discretionary peaking operations.
- For Modeling Purposes
  - The capability of peaking operations is included in the definition of the Base Case scenario.

WEST ROSEBUD LAKE DEVELOPMENT (FERC PROJECT NO. 2301)

- There are no generating facilities at this development; West Rosebud Lake is operated as a storage facility.

2.2 BASE CASE_PEAK1

The Base Case_Peak 1 scenario is the same as the Base Case scenario with the addition of 4 hours of up to maximum capacity discharge at Black Eagle and Rainbow for each day of the run, and the addition of unrestricted peaking operations at Cochrane and Ryan (assuming existing reservoir target elevations). The Morony minimum elevation is revised to reflect the maximum reregulation drawdown of 2,878 feet for Cochrane/Ryan peaking operations.

The purpose of this scenario is to simulate the peaking capabilities of the Great Falls facilities under normal operations. The Base Case_Peak1 scenario assumptions are summarized below.

HEBGEN, MADISON, CANYON FERRY, HAUSER, HOLTER, THOMPSON FALLS, MYSTIC LAKE, and WEST ROSEBUD LAKE DEVELOPMENTS

- No change from the Base Case scenario.

BLACK EAGLE DEVELOPMENT

- Black Eagle is operated as a limited peaking generating facility with four hours of increased generation up to maximum capacity for each day.

RAINBOW DEVELOPMENT

- Rainbow is operated as a limited peaking generating facility with four hours of increased generation up to maximum water rights capacity for each day.

COCHRANE DEVELOPMENT

- Cochrane is operated as a flexible generating facility, with the ability to prioritize peak generation. Cochrane operations are set to target peak period generation without causing avoidable spills at Ryan and without causing violations of the flow requirements at Morony.

RYAN DEVELOPMENT

- Ryan is operated as a flexible generating facility, with the ability to prioritize peak generation. Ryan operations are set to target peak period generation without causing violations of the flow requirements at Morony.

MORONY DEVELOPMENT

- Minimum reservoir elevation lowered to 2,878 feet to reflect maximum reregulation flexibility for Cochrane/Ryan peaking operations.

2.3 BASE CASE-PEAK2

The Base Case_Peak2, Base Case_Peak2a, Base Case_Peak2b, and Base Case_Peak2c scenarios are the same as the Base Case_Peak1 scenario with the exception being the target elevation of the Cochrane reservoir is lowered by 1, 2.5, 5, and 8 feet respectively. The purpose of these scenarios is to determine the potential for additional peak generation by utilizing more of the usable storage by lowering the end of day reservoir target elevation, thus allowing for more reservoir utilization. The Base Case_Peak2, Base Case_Peak2a, Base Case_Peak2b, and Base Case_Peak2c scenario assumptions are summarized below.

HEBGEN, MADISON, CANYON FERRY, HAUSER, HOLTER, BLACK EAGLE, RAINBOW, RYAN, MORONY, THOMPSON FALLS, MYSTIC LAKE, and WEST ROSEBUD LAKE DEVELOPMENTS

- No change from the Base Case_Peak1 scenario.

COCHRANE DEVELOPMENT

- Base Case_Peak2 - Reservoir target elevation lowered to 3118.8 feet.
- Base Case_Peak2a - Reservoir target elevation lowered to 3117.3 feet.
- Base Case_Peak2b - Reservoir target elevation lowered to 3114.8 feet.
- Base Case_Peak2c - Reservoir target elevation lowered to 3111.8 feet.

2.4 BASE CASE_PEAK3

The Base Case_Peak 3, Base Case_Peak3a, and Base Case_Peak3b scenarios are the same as the Base Case scenario with the exception being the target elevation of the Thompson Falls reservoir is lowered by 1 foot, 2 feet and 3 feet respectively. The purpose of these scenarios is to determine the potential for additional peak generation by utilizing more of the usable storage by lowering the end of day reservoir target elevation, thus allowing for more reservoir utilization. The Base Case_Peak3, Base Case_Peak3a, and Base Case_Peak3b scenarios assumptions are summarized below.

HEBGEN, MADISON, CANYON FERRY, HAUSER, HOLTER, BLACK EAGLE, RAINBOW, COCHRANE, RYAN, MORONY, MYSTIC LAKE, and WEST ROSEBUD LAKE DEVELOPMENTS

- No change from the Base Case scenario.

THOMPSON FALLS DEVELOPMENT

- Base Case_Peak3 - Reservoir target elevation lowered to 2,395 feet.
- Base Case_Peak3a - Reservoir target elevation lowered to 2,394 feet.
- Base Case_Peak3b - Reservoir target elevation lowered to 2,393 feet.

3.0 MODEL RESULTS DISCUSSION

The purpose of the Base Case scenario is to simulate the existing operations and to serve as the baseline to assess the relative impacts between scenarios. To determine the incremental short-term energy and system reserves potential of the Missouri-Madison developments, the Base Case_Peak1 scenario is compared against the Base Case scenario. The Base Case_Peak1 scenario includes four-hours of increased generation, simulating generation reserves, at Black Eagle and Rainbow, as well as peaking operations at Cochrane and Ryan. The operational requirements of Black Eagle and Rainbow limit their operations to 4 hours of reserve generation in accordance with their FERC license. To provide full calendar year results, all scenarios are simulated for the period 1/1/1988 through 12/31/2013. The average annual generation for each of the Hydros for both the Base Case and Base Case_Peak1 scenarios is shown Table 3-1.

TABLE 3-1
BASE CASE AND BASE CASE_PEAK1 AVERAGE ANNUAL TOTAL GENERATION SUMMARY (1988 THROUGH 2013)

Powerhouse	Base Case Total Annual Generation (MWh)	Base Case_Peak1 Total Annual Generation (MWh)	Difference (Base Case_Peak1 less Base Case, MWh)	Percent Difference (Base Case_Peak1 less Base Case/Base Case, %)
Madison	72,000	72,000	0	0.0%
Hauser	130,106	130,106	0	0.0%
Holter	290,902	290,902	0	0.0%
Black Eagle	156,941	154,360	-2,581	-1.6%
Rainbow	399,027	390,438	-8,588	-2.2%
Cochrane	312,889	297,444	-15,445	-4.9%
Ryan	479,477	461,255	-18,222	-3.8%
Morony	315,008	304,455	-10,553	-3.4%
Thompson Falls	538,931	538,931	0	0.0%
Mystic	51,545	51,545	0	0.0%
NWE Total	***2,746,826***	***2,691,436***	***-55,389***	***-2.0%***
Missouri-Madison Total	***2,156,350***	***2,100,961***	***-55,389***	***-2.6%***

The change to average annual long term generation, shown in Table 3-1, is a reduction of approximately -2,581 MWh and -8,588 MWh at Black Eagle and Rainbow respectively when compared to the Base Case scenario. The incremental loss in average annual total generation is a result of less efficient operation of the developments, for example, the greater fluctuation in reservoir elevations results in a loss in operational net head.

The reduction in annual generation though is offset by the increase of approximately 3,544 MWh and 17,708 MWh of annual average incremental short-term (4 hour) generation reserves over the Base Case scenario at Black Eagle and Rainbow, respectively as shown in Table 3-2.

TABLE 3-2
BASE CASE AND BASE CASE_PEAK1 AVERAGE ANNUAL PEAK GENERATION SUMMARY (1988 THROURH 2013)

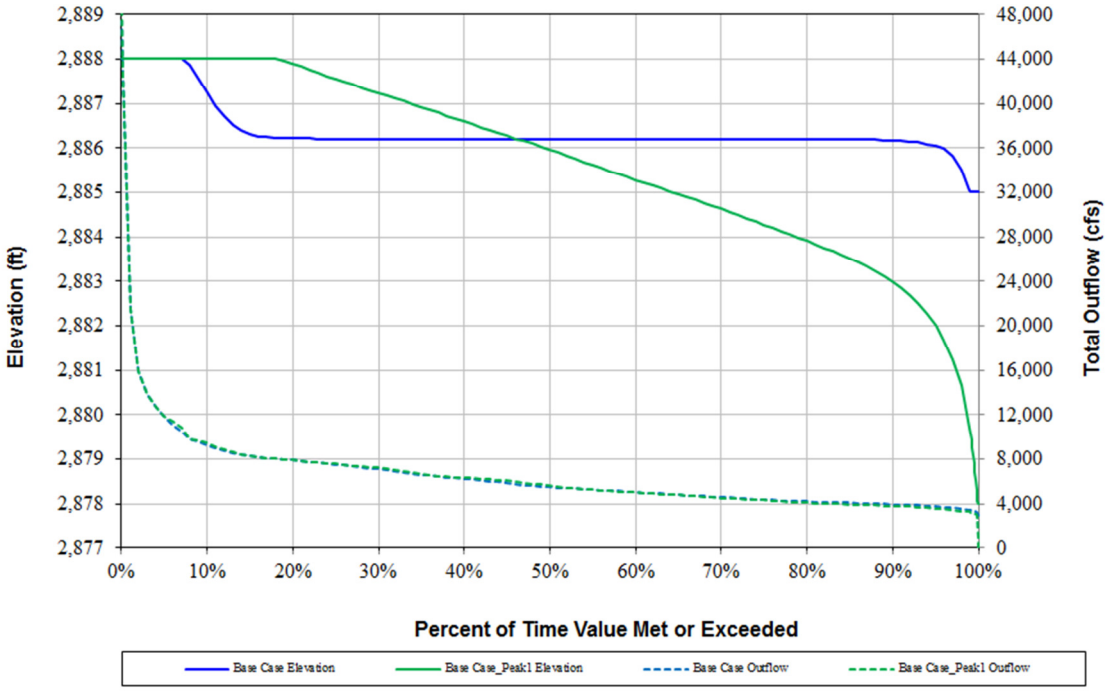
Powerhouse	Base Case Annual Peak Generation (MWh)	Base Case_Peak1 Annual Peak Generation (MWh)	Difference (Base Case_Peak1 less Base Case, MWh)	Percent Difference (Base Case_Peak1 less Base Case/Base Case, %)
Black Eagle (4 hours)	26,153	29,697	3,544	13.6%
Rainbow (4 hours)	66,499	84,207	17,708	26.6%
Cochrane (16 hours)	208,592	211,181	2,588	1.2%
Ryan (16 hours)	319,650	321,548	1,898	0.6%

Assuming a sixteen-hour daily peaking period, Table 3-2 shows the Base Case_Peak1 scenario has the potential for approximately 2,588 MWh and 1,898 MWh of annual average peak period generation over the Base Case scenario at Cochrane and Ryan, respectively. Table 3-1 shows the average annual long term generation is reduced by approximately -15,445 MWh and -18,222 MWh at Cochrane and Ryan, respectively. The Madison-Missouri system total average annual generation is reduced by -55,389 MWh when generation reserves and peaking operations are implemented.

Morony Discussion

As shown in Figure 3-1 the Morony reservoir operations fluctuate significantly during the Base Case_Peak1 operations when compared to the Base Case operations. This is due to the increased operational band allowed during upstream peaking operations, and the reregulation of the peaking flows of the Base Case_Peak1 scenario when compared to the run-of-river type flows of the Base Case scenario.

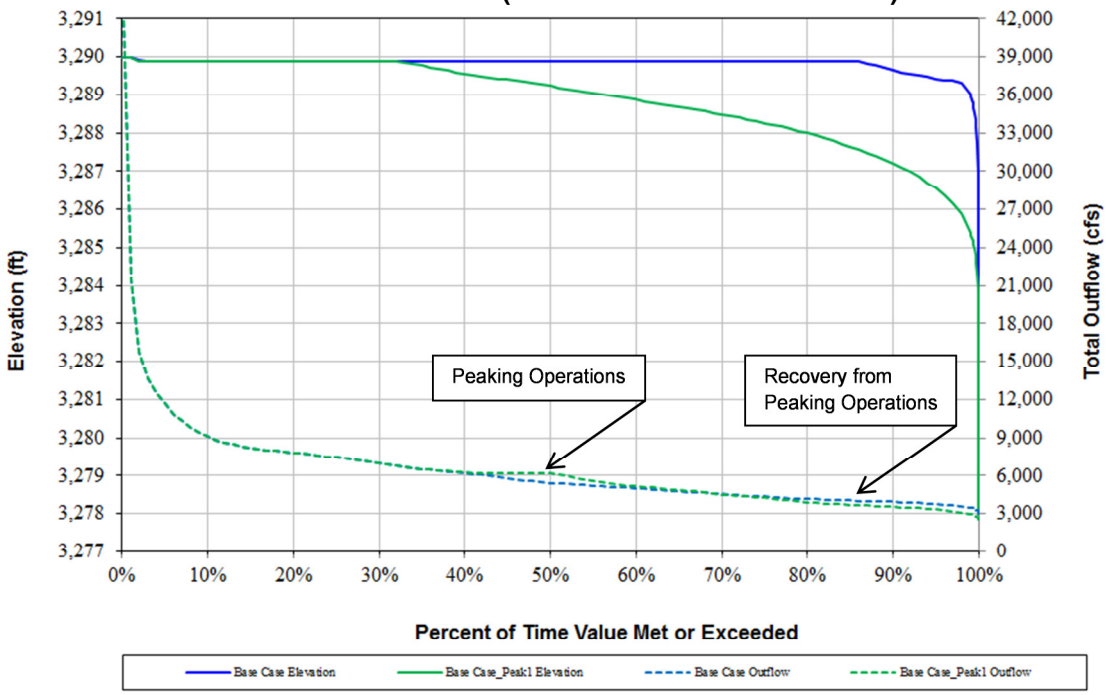
FIGURE 3-1
MORONY OPERATIONS COMPARISON
DETAILED SUMMARY (15-MIN DETAILED OUTPUT)



Black Eagle Discussion

The operation of Black Eagle to maximize generation (provide generation reserves) for four hours within the day results in an hourly gain in generation for the specific hours targeted; however, due to the refilling of the reservoir, the four hours of increased generation may result in an overall decrease in generation. There is minimal storage at Black Eagle to compensate for the period of increased generation, and a significant head change of over four feet over four hours of full plant discharge results in less efficient utilization of the same volume of flow. Additionally, the flows in the system are such that the station capacity is exceeded approximately 40 percent of the time, which results in a reduction in the percent of time this operation may be achieved as the station would already be at full station capacity(Figure 3-2).

FIGURE 3-2
BLACK EAGLE OPERATIONS COMPARISON
DETAILED SUMMARY (15-MIN DETAILED OUTPUT)

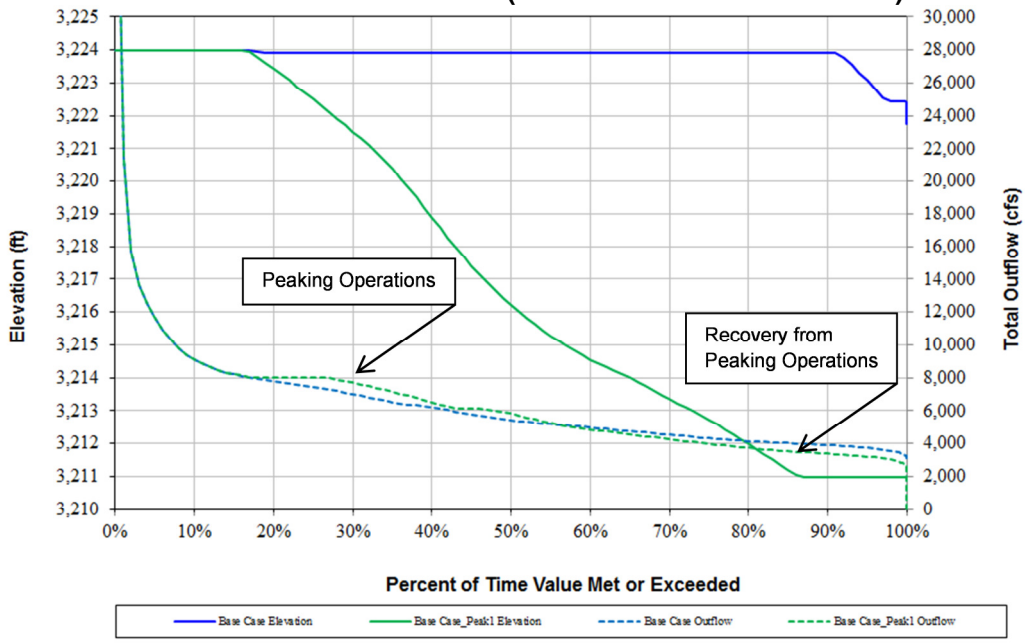


Rainbow Discussion

Similarly, the operation of Rainbow to generate for four-hours (provide generation reserves) is limited by the outflows from Black Eagle, plus incremental accretions to Rainbow, and Rainbow usable storage. Black Eagle maximum powerhouse hydraulic capacity of approximately 6,150 cfs, plus incremental accretions into Rainbow, generally only permits about one hour of maximum Rainbow output of approximately 8,000 cfs before Rainbow reservoir reaches the minimum elevation and has to reduce outflows to match inflows.

Figure 3-3 shows that Rainbow reservoir usable storage is significantly utilized during peaking operations. Approximately 20 percent of the time the reservoir is at or near top of pool, and approximately 15 percent of the time the reservoir is at or near the bottom of the operating pool. During low pool operations, the powerhouse may be releasing all inflow received from Black Eagle to provide as much peaking power as possible.

FIGURE 3-3
RAINBOW OPERATIONS COMPARISON
DETAILED SUMMARY (15-MIN DETAILED OUTPUT)



SUMMARY OF PEAKING OPERATIONS ASSUMING ALTERNATIVE OPERATIONS

The purpose of these scenarios is to determine the potential for additional peak generation by utilizing more of the usable storage by allowing for additional reservoir flexibility.

SENSITIVTY ANALYSIS COCHRANE RESERVOIR OPERATIONS

The Base Case_Peak2, Base Case_Peak2a, Base Case_Peak2b, and Base Case_Peak2c scenarios were developed to compare the potential changes in peak generation by modifying reservoir operations at Cochrane and the resulting impact to overall generation throughout the Great Falls system. Figure 3-4 presents the peak (assuming a sixteen hour peak duration) and total generation resulting from changes in reservoir operations at Cochrane, and the cascading impact to Ryan. Figure 3-5 shows a comparison of the Cochrane reservoir elevation exceedance curves resulting from the alterative operations.

Assuming a sixteen-hour daily peaking period, the Base Case_Peak2c (8 foot target elevation reduction) scenario shows the potential for a maximum of approximately

30,469 MWh annual average incremental peak generation at Cochrane. However, assuming a sixteen-hour peaking period, the Base Case_Peak2b (5 foot target elevation reduction) scenario shows the greatest potential for a maximum incremental peak generation of approximately 48,930 MWh at Cochrane and Ryan combined. This operation also results in a corresponding reduction of in average annual long term generation at Cochrane and Ryan of approximately -38,821 MWh, from the Base Case scenario due to generation at lower reservoir levels.

FIGURE 3-4
COCHRANE OPERATIONS SENSITIVITY
GENERATION SUMMARY

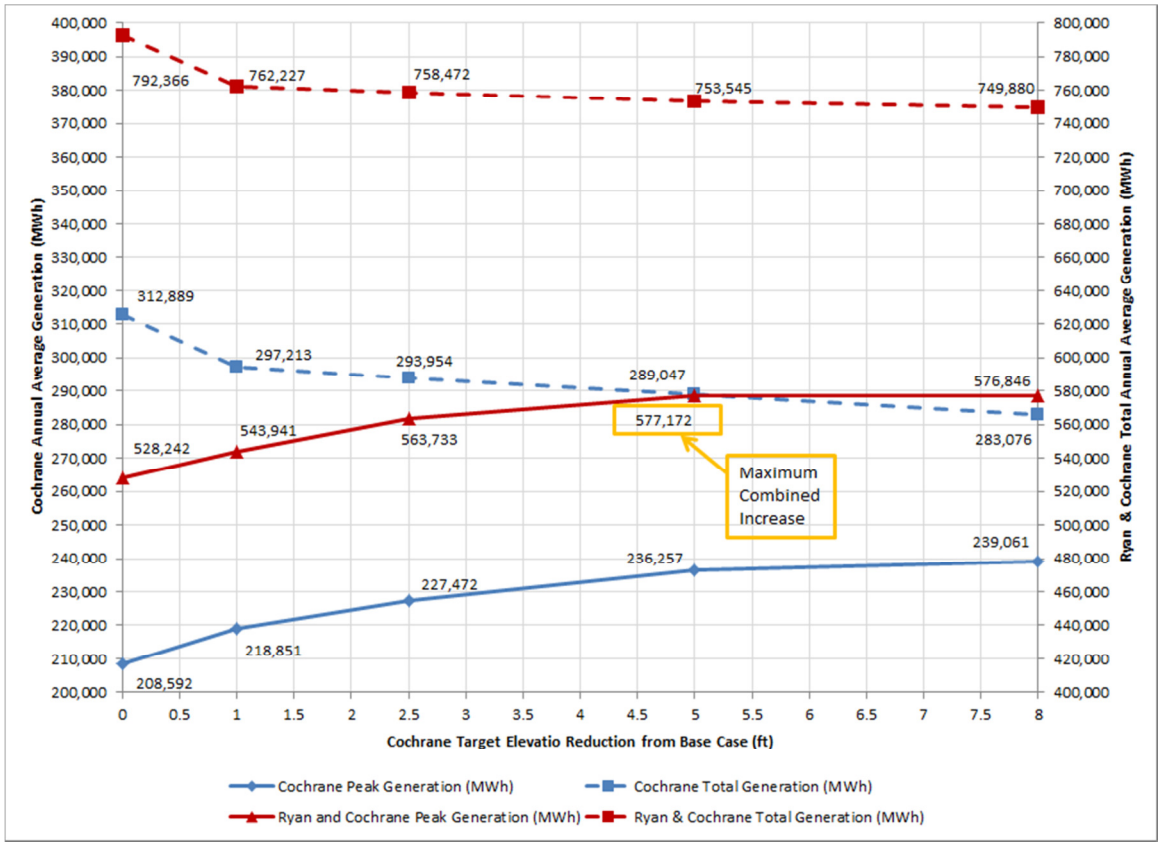
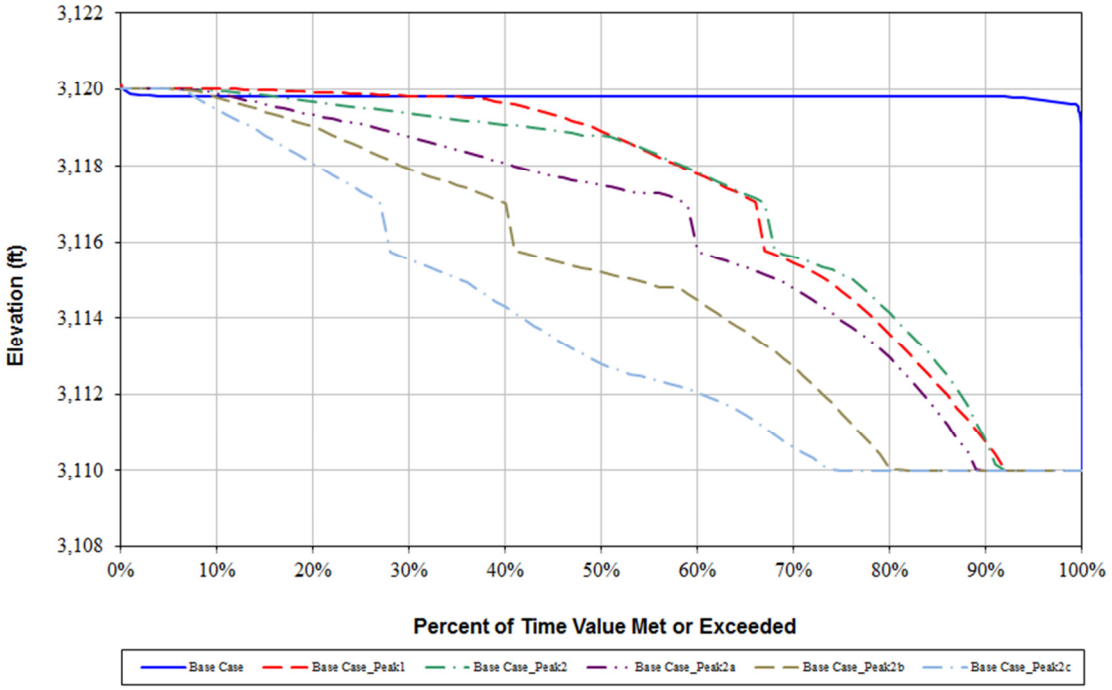


FIGURE 3-5
COCHRANE OPERATIONS SENSITIVITY
DETAILED ELEVATION SUMMARY (15-MIN DETAILED OUTPUT)



SENSITIVITY ANALYSIS THOMPSON FALLS RESERVOIR OPERATIONS

The Base Case_Peak3, Base Case_Peak3a, and Base Case_Peak3b scenarios were developed to compare the potential increases in peak generation and the resulting impacts to overall generation by modifying reservoir end of day target elevations. Figure 3-6 shows a comparison of the approximate potential increase in peak period generation at Thompson Falls and the corresponding percent decrease in total generation resulting from changes in reservoir operations. As shown, there is a diminishing return as the reservoir target elevation approaches the minimum drawdown elevation. Figure 3-7 shows a comparison of the Thompson Falls reservoir elevation exceedance curves resulting from the alterative operations.

Assuming a sixteen-hour peaking period, of the alternatives simulated, the Base Case_Peak3a scenario (with a target elevation drawdown of 2 feet) shows the potential for a maximum of approximately 13,311 MWh of annual average incremental peak generation at Thompson Falls, with a corresponding reduction of the total annual generation by approximately -15,357 MWh when compared to the Base Case scenario (Table 3-3).

TABLE 3-3
BASE CASE AND BASE CASE_PEAK3, 3A, AND 3B AVERAGE ANNUAL GENERATION SUMMARY (1988 THROURH 2013)

Scenario	Annual Peak Generation (MWh)	Annual Total Generation (MWh)
Base Case	**379,777**	**538,931**
Base Case_Peak3	**389,697**	**531,425**
Difference (Base Case_Peak3 less Base Case, MWh)	9,920	-7,505
Percent Difference (Base Case_Peak3 less Base Case/Base Case, %)	2.6%	-1.4%
Base Case_Peak3a	**393,087**	**523,573**
Difference (Base Case_Peak3a less Base Case, MWh)	13,311	-15,357
Percent Difference (Base Case_Peak3a less Base Case/Base Case, %)	3.5%	-2.8%
Base Case_Peak3b	**387,411**	**518,508**
Difference (Base Case_Peak3b less Base Case, MWh)	7,634	-20,423
Percent Difference (Base Case_Peak3b less Base Case/Base Case, %)	2.0%	-3.8%

FIGURE 3-6
THOMPSON FALLS OPERATIONS SENSITIVITY GENERATION SUMMARY

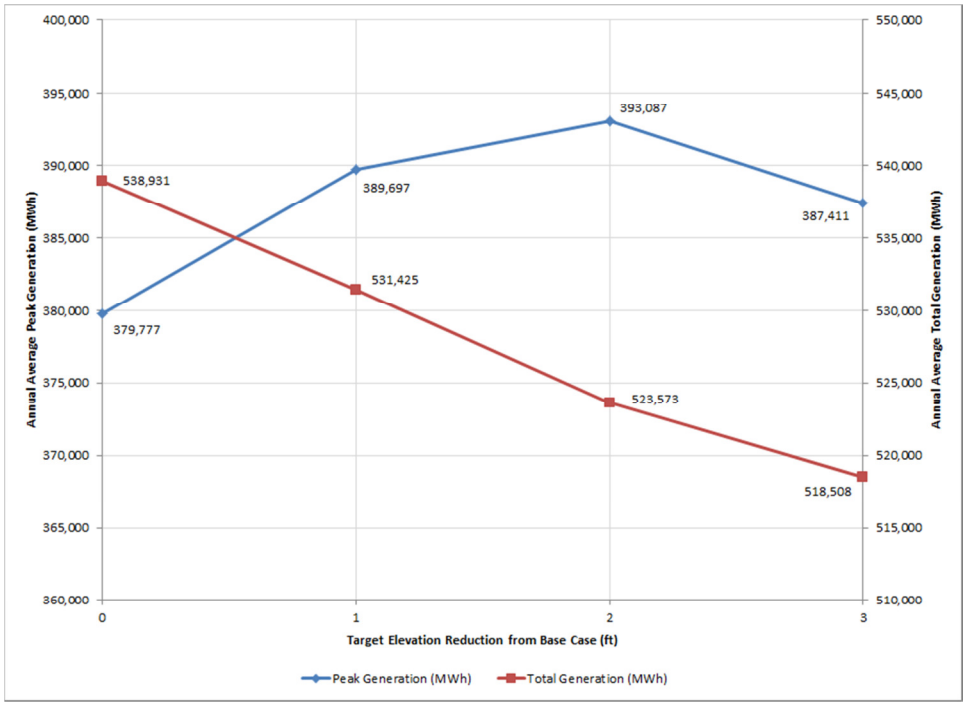
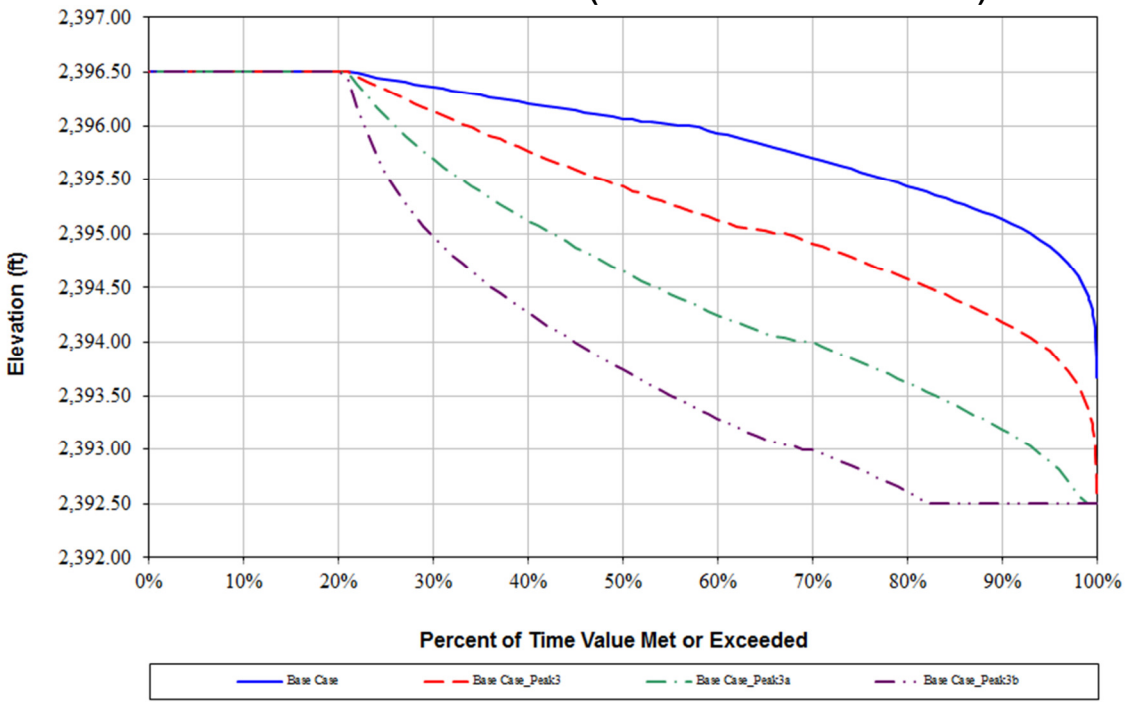


FIGURE 3-7
THOMPSON FALLS OPERATIONS SENSITIVITY
DETAILED ELEVATION SUMMARY (15-MIN DETAILED OUTPUT)



GENERAL CONCLUSIONS

Reviewing the results of all of the scenarios documented in this report leads to the following observations:

1. Where operational limitations allow, there is ability to provided short-term generation reserves; however the operations required to provide these reserves will likely lead to a reduction in long-term generation.
2. The Hydros are very sensitive to the targeted reservoir elevation. Decreasing end of day target reservoir elevations, even at plants operating in run-of-river mode, may result in higher peak period generation for the NWE plants; however there is a resulting decrease in overall long-term generation from the Hydros.
3. There appear to be opportunities throughout the Hydro fleet to optimize the hydraulic flexibility of the system and potentially increase total annual generation as well as the reserves capability, for example:

    a. Addition of generation capability at Hebgen.
    b. Additional capacity at Black Eagle and Ryan. On average, the station capacity at both Black Eagle and Ryan is exceeded approximately 40 percent of the time.
    c. Modifications to the units at Morony to optimize performance against the hydrology. The ability to take advantage of additional hydraulic capacity may be impacted by the hourly and daily fluctuation limits on the discharge from Morony.