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MEMORANDUM

TO: Ed Bowles, ODFW

FROM: Michele DeHart, FPC

DATE: February 7, 2007

RE: Water Travel Time through JDA Pool at Minimum Irrigation Pool and at Minimum Operating Pool at Various Flows and the Impact of the Montana Plan as Outlined in the Proposed Action

This memorandum is a follow-up to the February 6, 2007 memorandum from FPC to ODFW titled "Water Travel Time through JDA Pool at Minimum Irrigation Pool and at Minimum Operating Pool at Various Flows and the Impact of the Montana Plan." The February 6th, 2007 memorandum assumed the flow impact of the MT Plan to be 7 Kcfs, taken directly from Montana's System Operation Request dated July 6, 2005. It is our understanding that the MT Operations outlined in the Proposed Action are somewhat different than that presented in Montana's 2005 SOR. This memorandum utilizes the Proposed Action to determine the potential flow impacts of Montana Operations to the Lower Columbia River.

The Reservoir Replacement Method was used for calculating water travel times through a reservoir.

This formula is:

$$\text{WTT (s)} = \text{Reservoir Volume (ft}^3\text{)} / \text{Flow (ft}^3\text{/s)}$$

This method was suggested by personnel from the US Army Corps of Engineers. In particular, Lester Cunningham from the COE in Walla Walla, Washington suggested using the storage replacement method for calculating water particle transit time between respective pools based on the fact that the average water transit time is the same as the time that it takes to completely replace the volume of water contained in a reservoir. An "average" particle of water starting at the upstream end of the pool will "theoretically" exit at the downstream end when the volume of water that was in the pool has exited from the downstream end of the pool.

Furthermore, the use of the storage replacement method was validated by computer program HEC-2 developed by the U.S. Army Corps of Engineers Hydrological Engineering Center over the Lower Snake River.

The storage replacement method is relatively simple if the following are known: flow rate exiting the pool, pool elevation, and pool storage/elevation rating curve.

Reservoir volumes for this analysis were taken form Reservoir Storage Tables developed by the Corps of Engineers. For this analysis, the elevation at John Day under MIP was assumed to be 262 feet with a gross storage volume of 2217.8 Kaf. The elevation at John Day under MOP was assumed to be 257 feet with a gross storage volume of 1989.9 Kaf.

Calculations were performed under three flow scenarios for the summer season (see Table 1), 100 Kcfs, 150 Kcfs, and 200 Kcfs.

For this analysis, the Proposed Action was utilized to determine the potential flow impacts of Montana Operations to the Lower Columbia River. The Proposed Action (PA) states,

> "Consistent with the 2003 Council's Mainstem Amendments, an experimental operation consisting of interim summer reservoir drafting limits at Hungry Horse and Libby should be 10 feet from full pool by the end of September (elevations 3550 and 2449, respectively) in all years except the lowest 20th percentile water supply (drought years) when the draft limit is increased to 20 feet from full pool by the end of September."

The end of August draft elevations for Libby and Hungry Horse Reservoirs were not specified in the PA. It was assumed that under each operation outlined in the PA that the August 31st draft elevation could be determined by either: 1.) Linear interpolation between the July 1st and September 30th elevations and, or, 2.) That one-half of the draft would occur in July and August and the other half would occur in September. This resulted in four potential Montana Operations:

1. Operation #1: 20-foot linear draft by the end of September, with an August 31st elevation of 2445.6 at Libby and 3546.6 at Hungry Horse.
2. Operation #2: 20-foot draft by the end of September with 10 feet drafted by the end of August and another 10 feet drafted by the end of September, with August 31st elevations of 2449 at Libby and 3550 at Hungry Horse.
3. Operation #3: 10-foot linear draft by the end of September, with an August 31st elevation of 2452.3 at Libby and 3553.3 at Hungry Horse.
4. Operation #4: 10-foot draft by the end of September with 5 feet drafted by the end of August and another 5 feet drafted by the end of September, with August 31st elevations of 2454 at Libby and 3555 at Hungry Horse.

For each Montana Operation, we calculated the amount of flow augmentation volume that was lost over July and August relative to an operation where 20-feet were drafted out at each project by the end of August (2004 BIOP). These calculations were determined using the Reservoir Storage Tables for Libby and Hungry Horse. Each lost flow augmentation volume was converted to a loss in flow over the 62 days between July and August. The following are the flow calculated flow losses:

1. MT Operation #1: 20-foot linear draft by the end of September, with an August 31st elevation of 2445.6 at Libby and 3546.6 at Hungry Horse. Resulted in a ***3.6 Kcfs*** loss in flow relative to an operation that drafted 20 feet at both projects by the end of August.
2. MT Operation #2: 20-foot draft by the end of September with 10 feet drafted by the end of August and another 10 feet drafted by the end of September, with August 31st elevations of 2449 at Libby and 3550 at Hungry Horse. Resulted in a ***5.5 Kcfs*** loss in flow relative to an operation that drafted 20 feet at both projects by the end of August.
3. MT Operation #3: 10-foot linear draft by the end of September, with an August 31st elevation of 2452.3 at Libby and 3553.3 at Hungry Horse. Resulted in a ***7.3 Kcfs*** loss in flow relative to an operation that drafted 20 feet at both projects by the end of August.
4. MT Operation #4: 10-foot draft by the end of September with 5 feet drafted by the end of August and another 5 feet drafted by the end of September, with August 31st elevations of 2454 at Libby and 3555 at Hungry Horse. Resulted in a ***8.3 Kcfs*** loss in flow relative to an operation that drafted 20 feet at both projects by the end of August.

Calculations of water travel times through John Day Pool under MOP and MIP conditions were calculated under five scenarios. The water travel times under the Base case were calculated at all three flow levels, 100,150, and 200 Kcfs. Because the Proposed Action only drafts Libby and Hungry Horse 20 feet by the end of September in the lowest 20th Percentile water years, calculations of water travel times under MT Operations #1 and #2 were only calculated with a flow level of 100 Kcfs (assumed to be 20th Percentile flow). Under all other water years, the Proposed Action drafts Libby and Hungry Horse 10 feet by the end of September, therefore, calculations of water travel times under MT Operations #3 and #4 were calculated with flow levels of 150 and 200 Kcfs (assumed to be greater than the 20th Percentile flow). The following outline each calculation:

1. The Base Case: This was the “normal scenario,” was simple calculation of the water travel time (in days) through John Day Pool under MIP and MOP at summer flow levels of 100 Kcfs, 150 Kcfs, and 200 Kcfs.
2. MT Operation #1: This scenario was similar to the Base Case, however reduced the base flow by 3.6 Kcfs, the estimated flow impact of the MT Operation #1. Essentially, this scenario was a calculation of the water travel time (in days) through the John Day Pool under MIP and MOP at a summer flow level of 96.4 Kcfs.
3. MT Operation #2: This scenario was similar to the Base Case, however reduced the base flow by 5.5 Kcfs, the estimated flow impact of the MT Operation #2. Essentially, this

scenario was a calculation of the water travel time (in days) through the John Day Pool under MIP and MOP at a summer flow level of 94.5 Kcfs.

4. MT Operation #3: This scenario was similar to the Base Case, however reduced each base flow by 7.3 Kcfs, the estimated flow impact of the MT Operation #3. Essentially, this scenario was a calculation of the water travel time (in days) through the John Day Pool under MIP and MOP at summer flow levels of 142.7 Kcfs and 192.7 Kcfs.
5. MT Operation #4: This scenario was similar to the Base Case, however reduced each base flow by 8.3 Kcfs, the estimated flow impact of the MT Operation #4. Essentially, this scenario was a calculation of the water travel time (in days) through the John Day Pool under MIP and MOP at summer flow levels of 141.7 Kcfs, and 191.7 Kcfs.

Table 1 displays the results of this analysis.

Table 1. Water travel times at various flow rates through JDA Pool at Minimum Irrigation Pool (MIP) and at Minimum Operating Pool (MOP) and the impact the Montana (MT) Plan would have on these water travel times.

Summer Flows						
	JDA at MIP			**JDA at MOP**		
	WTT through JDA at MIP at 100,000 cfs	WTT through JDA at MIP at 150,000 cfs	WTT through JDA at MIP at 200,000 cfs	WTT through JDA at MOP at 100,000 cfs	WTT through JDA at MOP at 150,000 cfs	WTT through JDA at MOP at 200,000 cfs
Base	11.2	7.5	5.6	10.0	6.7	5.0
MT Operation #1, (3600 cfs reduction)	11.6	na	na	10.4	na	na
MT Operation #2, (5500 cfs reduction)	11.8	na	na	10.6	na	na
MT Operation #3 (7300 cfs reduction)	na	7.8	5.8	na	7.0	5.2
MT Operation #4 (8300 cfs reduction)	na	7.9	5.8	na	7.1	5.2

The following are the main points of Table 1:

1. Under a flow scenario of 100 Kcfs (assumed to be lowest 20th Percentile flow), the water travel time through John Day Pool at MIP was 11.2 days and at MOP was 10.0 days, a decrease in water travel time of 1.2 days. When the base flow was reduced by

3.6 Kcfs and 5.5 Kcfs (MT Plans), the water travel times through John Day Pool under MOP conditions was 10.4 to 10.6 days. Therefore, the decrease in flow resulting under the MT Operations would negate 33-50% of the water travel time benefit seen when JDA was operated under MOP instead of MIP under normal base conditions.

2. Under a flow scenario of 150 Kcfs (assumed to be greater than the 20th Percentile flow), the water travel time through John Day Pool at MIP was 7.5 days and at MOP was 6.7 days, a decrease in water travel time of 0.8 days. When the base flow was reduced by 7.3 Kcfs and 8.3 Kcfs (MT Plans), the water travel time through John Day Pool under MOP conditions was 7.0 to 7.1 days. Therefore, the decrease in flow resulting under the MT Plan would negate 38-50% of the water travel time benefit seen when JDA was operated under MOP instead of MIP under normal base conditions.
3. Under a flow scenario of 200 Kcfs (assumed to be greater than the 20th Percentile flow), the water travel time through John Day Pool at MIP was 5.6 days and at MOP was 5.0 days, a decrease in water travel time of 0.6 days. When the base flow was reduced by 7.3 Kcfs, and 8.3 Kcfs (MT Plans), the water travel time through John Day Pool under MOP conditions was 5.2 days. Therefore, the decrease in flow resulting under the MT Plan would negate 33% of the water travel time benefit seen when JDA was operated under MOP instead of MIP under normal base conditions.

In summary, this simple analysis indicates that implementing the Montana Plan after the John Day Reservoir has been drawn down from MIP to MOP negates 33-50% of the benefit in water travel time at flows of 100 Kcfs, 38-50% of the benefit in water travel time at flows of 150 Kcfs, and 33% of the benefit in water travel time at flows of 200 Kcfs.