# Fish Passage Plan (FPP) Change Request Form

**Change Form # & Title**: 21LMN002 – Update Locked-Blade Units

**Date Submitted**: 31 December 2020

**Project**: Lower Monumental Dam

**Requester Name, Agency**: Lisa Wright, Corps RCC

**Final Action: APPROVED – 28 January 2021**

**FPP Section**:

Table LMN-5 (Unit Priority Order) and Table LMN-6 (Turbine Operating Ranges)

**Justification for Change**:

Unit 4 has been rehabbed to an adjustable-blade Kaplan and may resume operating in the full 1% range and in the normal priority order.

**Proposed Change**:

*See pages below with edits to existing Tables LMN-5 and LMN-6 in track changes.*

**Comments**:

**Record of Final Action**: Approved at the FPOM FPP meeting on 28-JAN-2021

4.2. Turbine Unit Priority Order.

**4.2.1.** From March 1 through November 30, turbine units will be operated in the order of priority defined in **Table LMN-5** in order to enhance adult and juvenile fish passage. If a turbine unit is out of service for maintenance or repair, the next unit in the priority order shall be operated. Unit priority order may be coordinated differently to allow for fish research, construction, or project maintenance activities.

**4.2.2.** Unit 1 provides the best fish passage conditions by eliminating the eddy at the juvenile fish loading dock and providing attraction flow to the North adult fish ladder. Therefore, the default priority order for fish passage starts with Unit 1, then proceeds in order from north to south. However, due to blade seal failures on Unit 5, the runner blades are hydraulically locked at a set angle which restricts the unit to a narrower operating range (**Table LMN-6-A**). To avoid excessive wear and tear from repeated starts/stops, Unit 5 is operated last-on/first-off in the priority order for all flow conditions until the unit is repaired.

Table LMN-5. Lower Monumental Dam Turbine Unit Priority Order.

| **Season** | **Unit Priority Order** |
| --- | --- |
| March 1 – November 30  Fish Passage Season | DEFAULT = 1, 2, 3, 4, 5, 6  MODIFIED ORDER for Unit 5 w/ Locked Blades\*  Start-up: 1, 2, 3, 4, 6, 5\*  Shutdown: 5\*, 6, 4, 3, 2, 1 |
| December 1 – End of February  Winter Maintenance Period | Any Order |

\* Unit 5 has hydraulically locked blades and is operated in the “MODIFIED ORDER” to minimize starts/stops. When the blade seals are replaced, the unit will resume operating in the “DEFAULT” priority order.

Table LMN-6. Lower Monumental Dam Turbine Unit Power (MW) and Flow (cfs) at ±1% of Peak Turbine Efficiency (Lower and Upper Limits of 1% Range) and Operating Limits. a, b

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Project** | **LMN Units 1, 2, and 3 – with STS** | | | | | | | **LMN Units 1, 2, and 3 – No STS** | | | | | | |
| **Head** | **1% Lower Limit** | | | **1% Upper Limit** | | **Operating Limit** | | **1% Lower Limit** | | | **1% Upper Limit** | | **Operating Limit** | |
| **(feet)** | **MW** | **cfs** | | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | | **MW** | **cfs** | **MW** | **cfs** |
| 85 | 68.6 | 11,169 | | 128.5 | 20,905 | 140.9 | 24,344 | 69.2 | 11,123 | | 125.8 | 20,216 | 140.9 | 23,569 |
| 86 | 69.4 | 11,154 | | 131.0 | 21,056 | 142.8 | 24,273 | 70.0 | 11,109 | | 128.3 | 20,363 | 142.8 | 23,542 |
| 87 | 70.2 | 11,140 | | 133.5 | 21,204 | 144.6 | 24,200 | 70.8 | 11,094 | | 130.8 | 20,506 | 144.6 | 23,513 |
| 88 | 70.9 | 11,125 | | 136.1 | 21,348 | 146.5 | 24,126 | 71.6 | 11,080 | | 133.3 | 20,645 | 146.5 | 23,482 |
| 89 | 71.7 | 11,111 | | 138.6 | 21,488 | 148.3 | 24,050 | 72.3 | 11,066 | | 135.8 | 20,781 | 148.3 | 23,450 |
| 90 | 72.4 | 11,097 | | 141.2 | 21,625 | 150.2 | 23,974 | 73.1 | 11,052 | | 138.3 | 20,913 | 150.2 | 23,415 |
| 91 | 73.3 | 11,088 | | 141.6 | 21,418 | 151.5 | 23,815 | 74.0 | 11,043 | | 138.7 | 20,714 | 151.5 | 23,268 |
| 92 | 74.1 | 11,079 | | 142.0 | 21,216 | 152.8 | 23,654 | 74.8 | 11,035 | | 139.1 | 20,518 | 152.8 | 23,119 |
| 93 | 75.0 | 11,071 | | 142.4 | 21,018 | 154.0 | 23,492 | 75.7 | 11,026 | | 139.5 | 20,327 | 154.0 | 22,968 |
| 94 | 75.8 | 11,061 | | 142.8 | 20,824 | 155.2 | 23,420 | 76.5 | 11,017 | | 139.9 | 20,140 | 155.2 | 22,850 |
| 95 | 76.7 | 11,052 | | 143.2 | 20,634 | 155.2 | 22,904 | 77.4 | 11,009 | | 140.3 | 19,956 | 155.2 | 22,409 |
| 96 | 77.7 | 11,071 | | 143.3 | 20,416 | 155.2 | 22,592 | 78.4 | 11,027 | | 140.4 | 19,746 | 155.2 | 22,125 |
| 97 | 78.8 | 11,088 | | 143.5 | 20,203 | 155.2 | 22,286 | 79.5 | 11,044 | | 140.6 | 19,540 | 155.2 | 21,847 |
| 98 | 79.8 | 11,105 | | 143.6 | 19,994 | 155.2 | 21,988 | 80.5 | 11,061 | | 140.7 | 19,338 | 155.2 | 21,576 |
| 99 | 80.8 | 11,121 | | 143.8 | 19,789 | 155.2 | 21,696 | 81.5 | 11,078 | | 140.9 | 19,141 | 155.2 | 21,309 |
| 100 | 81.8 | 11,137 | | 144.0 | 19,589 | 155.2 | 21,410 | 82.6 | 11,093 | | 141.0 | 18,947 | 155.2 | 21,049 |
| 101 | 82.7 | 11,138 | | 145.9 | 19,641 | 155.2 | 21,130 | 83.5 | 11,095 | | 142.9 | 18,998 | 155.2 | 20,798 |
| 102 | 83.6 | 11,140 | | 147.8 | 19,692 | 155.2 | 20,857 | 84.3 | 11,096 | | 144.8 | 19,047 | 155.2 | 20,553 |
| 103 | 84.5 | 11,141 | | 149.7 | 19,741 | 155.2 | 20,589 | 85.2 | 11,098 | | 146.7 | 19,095 | 155.2 | 20,312 |
| 104 | 85.4 | 11,142 | | 151.6 | 19,789 | 155.2 | 20,326 | 86.1 | 11,099 | | 148.5 | 19,142 | 155.2 | 20,077 |
| 105 | 86.2 | 11,143 | | 153.5 | 19,837 | 155.2 | 20,069 | 87.0 | 11,100 | | 150.4 | 19,188 | 155.2 | 19,846 |
|  | **LMN Units 4 and 6 – with STS** | | | | | | | **LMN Units 4 and 6 – No STS** | | | | | | |
| 85 | 89.8 | | 14,150 | 123.8 | 19,493 | 141.3 | 25,052 | 89.5 | | 13,962 | 122.5 | 19,102 | 141.3 | 24,441 |
| 86 | 91.0 | | 14,160 | 125.5 | 19,519 | 143.3 | 24,978 | 90.7 | | 13,971 | 124.2 | 19,128 | 143.3 | 24,414 |
| 87 | 92.2 | | 14,169 | 127.2 | 19,545 | 145.4 | 24,904 | 91.9 | | 13,981 | 125.9 | 19,153 | 145.4 | 24,385 |
| 88 | 93.4 | | 14,178 | 128.9 | 19,569 | 147.4 | 24,829 | 93.1 | | 13,990 | 127.6 | 19,177 | 147.4 | 24,356 |
| 89 | 94.6 | | 14,187 | 130.6 | 19,593 | 149.4 | 24,753 | 94.2 | | 13,998 | 129.3 | 19,201 | 149.4 | 24,324 |
| 90 | 95.7 | | 14,195 | 132.3 | 19,616 | 151.4 | 24,676 | 95.4 | | 14,006 | 131.0 | 19,224 | 151.4 | 24,291 |
| 91 | 96.9 | | 14,196 | 133.9 | 19,613 | 153.5 | 24,623 | 96.5 | | 14,007 | 132.5 | 19,221 | 153.5 | 24,230 |
| 92 | 98.0 | | 14,197 | 135.4 | 19,610 | 155.2 | 24,553 | 97.7 | | 14,008 | 134.0 | 19,218 | 155.2 | 24,168 |
| 93 | 99.2 | | 14,197 | 136.9 | 19,607 | 155.2 | 23,936 | 98.8 | | 14,009 | 135.5 | 19,215 | 155.2 | 23,577 |
| 94 | 100.3 | | 14,198 | 138.5 | 19,603 | 155.2 | 23,343 | 99.9 | | 14,010 | 137.1 | 19,211 | 155.2 | 23,008 |
| 95 | 101.4 | | 14,198 | 140.0 | 19,600 | 155.2 | 22,771 | 101.1 | | 14,010 | 138.6 | 19,208 | 155.2 | 22,460 |
| 96 | 102.3 | | 14,170 | 140.5 | 19,456 | 155.2 | 22,389 | 102.0 | | 13,982 | 139.1 | 19,067 | 155.2 | 21,828 |
| 97 | 103.2 | | 14,142 | 141.0 | 19,315 | 155.2 | 22,017 | 102.9 | | 13,954 | 139.6 | 18,929 | 155.2 | 21,478 |
| 98 | 104.1 | | 14,114 | 141.5 | 19,177 | 155.2 | 21,654 | 103.8 | | 13,928 | 140.1 | 18,794 | 155.2 | 21,136 |
| 99 | 105.1 | | 14,087 | 142.0 | 19,042 | 155.2 | 21,300 | 104.7 | | 13,901 | 140.5 | 18,662 | 155.2 | 20,803 |
| 100 | 106.0 | | 14,061 | 142.5 | 18,909 | 155.2 | 20,955 | 105.6 | | 13,875 | 141.0 | 18,532 | 155.2 | 20,723 |
| 101 | 107.3 | | 14,091 | 143.9 | 18,909 | 155.2 | 20,701 | 106.9 | | 13,904 | 142.5 | 18,532 | 155.2 | 20,477 |
| 102 | 108.5 | | 14,120 | 145.4 | 18,909 | 155.2 | 20,452 | 108.2 | | 13,933 | 143.9 | 18,532 | 155.2 | 20,236 |
| 103 | 109.8 | | 14,149 | 146.8 | 18,909 | 155.2 | 20,208 | 109.4 | | 13,962 | 145.3 | 18,532 | 155.2 | 19,999 |
| 104 | 111.1 | | 14,177 | 148.2 | 18,909 | 155.2 | 19,970 | 110.7 | | 13,989 | 146.7 | 18,532 | 155.2 | 19,768 |
| 105 | 112.4 | | 14,204 | 149.6 | 18,909 | 155.2 | 19,736 | 112.0 | | 14,017 | 148.1 | 18,532 | 155.2 | 19,541 |

1. Values provided by HDC (July 2003). Flow (cfs) was calculated based on turbine efficiency, project head, and power output (MW). “Operating Limit” is the maximum safe operating point based on cavitation or generator limit (added Feb 2018).
2. Unit 5 has hydraulically locked runner blades and a restricted operating range, as defined in **Table LMN-6-A**.

Table LMN-6-A. Temporary Restricted Operating Range for Lower Monumental Unit 5 with Locked Runner Blades (Non-Adjustable).a

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Project** | **LMN Unit 5 w/ Blades Locked at 25° – with STS** | | | | | |
| **Head** | **Lower Limit** | | **Peak Efficiency** | | **Upper Limit** | |
| **(feet)** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** |
| 85 | 111.2 | 17,959 | 113.5 | 18,226 | 116.3 | 18,791 |
| 86 | 112.5 | 17,951 | 114.9 | 18,223 | 117.8 | 18,794 |
| 87 | 113.9 | 17,942 | 116.3 | 18,220 | 119.3 | 18,796 |
| 88 | 115.2 | 17,933 | 117.7 | 18,216 | 120.8 | 18,798 |
| 89 | 116.6 | 17,924 | 119. 1 | 18,212 | 122.3 | 18,800 |
| 90 | 117.9 | 17,915 | 120.6 | 18,207 | 123.8 | 18,801 |
| 91 | 119.6 | 17,954 | 122.2 | 18,233 | 125.3 | 18,810 |
| 92 | 121.3 | 17,991 | 123.8 | 18,257 | 126.8 | 18,818 |
| 93 | 122.9 | 18,028 | 125.4 | 18,280 | 128.4 | 18,826 |
| 94 | 124.6 | 18,063 | 127.0 | 18,303 | 129.9 | 18,833 |
| 95 | 126.3 | 18,097 | 128.6 | 18,325 | 131.4 | 18,840 |
| 96 | 127.6 | 18,091 | 130.0 | 18,327 | 133.0 | 18,852 |
| 97 | 128.9 | 18,086 | 131.4 | 18,329 | 134.5 | 18,863 |
| 98 | 130.3 | 18,080 | 132.8 | 18,330 | 136.0 | 18,873 |
| 99 | 131.6 | 18,074 | 134.3 | 18,332 | 137.5 | 18,883 |
| 100 | 133.0 | 18,069 | 135.7 | 18,333 | 139.1 | 18,893 |
| 101 | 134.3 | 18,059 | 137. 1 | 18,339 | 140.6 | 18,918 |
| 102 | 135.5 | 18,050 | 138.5 | 18,345 | 142.2 | 18,943 |
| 103 | 136.8 | 18,041 | 140.0 | 18,351 | 143.8 | 18,967 |
| 104 | 138.1 | 18,032 | 141.4 | 18,357 | 145.4 | 18,991 |
| 105 | 139.4 | 18,024 | 142.8 | 18,362 | 147.0 | 19,014 |

1. Unit 5 has hydraulically locked (non-adjustable) runner blades due to leaking blade seals and is restricted to a smaller operating range until the blade seals are repaired or replaced. Values provided by HDC based on the abbreviated index test for Unit 5 (Feb 2020).