# Fish Passage Plan (FPP) Change Form

**Change Form # & Title**: 23JDA003 – Unit 13 Fixed-Blade Operating Range

**Date Submitted**: 20-Oct-2023

**Project**: John Day Dam

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

**Final Action: FINALIZED 9-NOVEMBER-2023**

**FPP Section**:

Chapter 4 - John Day, Table JDA-7-A. Operating Range for Units with Locked Blades.

**Justification for Change**:

Unit 13 runner blades were mechanically pinned at an angle of 29° due to several linkage pins that failed inspection. HDC conducted an index test on June 28, 2023, to determine the operating range. Fish screens were installed during testing. Results were consistent with the operating range of Unit 14 with welded blades, thus HDC recommends that Unit 13 use the same operating table as Unit 14.

**Proposed Change**:

See following pages for edits to existing FPP text in “Track Changes.”

**Comments**:

**Record of Final Action**:

**Coordinated and finalized at FPOM 9-NOVEMBER-2023.**

Table JDA-7. John Day 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

|  |  |  |
| --- | --- | --- |
| **Project**  | **JDA Units 1–16 With STS (see footnote b for exceptions)** | **JDA Units 1–16 No STS (see footnote b for exceptions)** |
| **Head** | **1% Lower Limit** | **1% Upper Limit**  | **Operating Limit c** | **1% Lower Limit** | **1% Upper Limit**  | **Operating Limit c** |
| **(feet)** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** |
| **80** | 67.6 | 11,608 | 98.9 | 17,000 | 120.9 | 21,451 | 67.9 | 11,615 | 103.1 | 17,649 | 123.9 | 21,880 |
| **81** | 68.3 | 11,573 | 102.2 | 17,333 | 123.2 | 21,563 | 68.7 | 11,595 | 106.3 | 17,950 | 126.4 | 22,036 |
| **82** | 68.9 | 11,530 | 105.6 | 17,667 | 125.6 | 21,702 | 69.4 | 11,567 | 109.7 | 18,275 | 129.0 | 22,218 |
| **83** | 69.5 | 11,479 | 109.1 | 18,017 | 128.1 | 21,845 | 70.2 | 11,539 | 113.1 | 18,589 | 131.6 | 22,402 |
| **84** | 70.1 | 11,430 | 112.5 | 18,336 | 130.8 | 22,013 | 70.9 | 11,506 | 116.4 | 18,888 | 134.0 | 22,550 |
| **85** | 70.7 | 11,381 | 115.6 | 18,597 | 133.2 | 22,131 | 71.7 | 11,477 | 119.5 | 19,144 | 136.5 | 22,746 |
| **86** | 71.3 | 11,332 | 118.5 | 18,817 | 135.1 | 22,131 | 72.4 | 11,445 | 122.5 | 19,367 | 138.5 | 22,792 |
| **87** | 71.9 | 11,283 | 121.0 | 18,986 | 136.4 | 22,009 | 73.1 | 11,414 | 125.3 | 19,577 | 139.8 | 22,674 |
| **88** | 72.5 | 11,231 | 123.6 | 19,148 | 137.7 | 21,876 | 73.8 | 11,383 | 128.1 | 19,760 | 141.2 | 22,589 |
| **89** | 73.1 | 11,186 | 125.7 | 19,237 | 139.1 | 21,766 | 74.5 | 11,353 | 130.7 | 19,919 | 142.5 | 22,446 |
| **90** | 73.6 | 11,136 | 127.8 | 19,337 | 140.6 | 21,679 | 75.2 | 11,327 | 133.0 | 20,030 | 143.6 | 22,176 |
| **91** | 74.2 | 11,091 | 129.7 | 19,389 | 141.8 | 21,536 | 75.9 | 11,297 | 135.3 | 20,129 | 144.8 | 21,985 |
| **92** | 74.8 | 11,042 | 131.6 | 19,442 | 142.9 | 21,372 | 76.6 | 11,269 | 137.2 | 20,174 | 146.1 | 21,864 |
| **93** | 75.3 | 10,992 | 133.6 | 19,512 | 143.9 | 21,231 | 77.4 | 11,241 | 138.9 | 20,187 | 147.1 | 21,727 |
| **94** | 75.8 | 10,945 | 135.6 | 19,567 | 145.0 | 21,107 | 78.1 | 11,213 | 140.5 | 20,176 | 148.0 | 21,556 |
| **95** | 76.4 | 10,903 | 137.6 | 19,627 | 145.9 | 20,968 | 78.8 | 11,191 | 141.8 | 20,132 | 148.8 | 21,369 |
| **96** | 77.1 | 10,867 | 139.7 | 19,701 | 146.7 | 20,819 | 79.7 | 11,176 | 142.7 | 20,026 | 149.6 | 21,182 |
| **97** | 77.7 | 10,837 | 141.9 | 19,782 | 147.5 | 20,683 | 80.5 | 11,165 | 143.5 | 19,909 | 150.4 | 21,017 |
| **98** | 78.5 | 10,812 | 144.1 | 19,858 | 148.3 | 20,541 | 81.4 | 11,158 | 144.6 | 19,820 | 151.0 | 20,855 |
| **99** | 79.1 | 10,785 | 146.5 | 19,967 | 149.1 | 20,378 | 82.3 | 11,153 | 145.8 | 19,758 | 151.6 | 20,699 |
| **100** | 79.8 | 10,757 | 149.1 | 20,087 | 149.7 | 20,194 | 83.2 | 11,146 | 147.4 | 19,759 | 152.3 | 20,551 |
| **101** | 80.5 | 10,732 | 151.4 | 20,180 | 150.4 | 20,017 | 84.0 | 11,139 | 149.3 | 19,792 | 153.0 | 20,401 |
| **102** | 81.2 | 10,709 | 153.7 | 20,270 | 151.0 | 19,852 | 84.9 | 11,135 | 151.1 | 19,817 | 153.6 | 20,245 |
| **103** | 81.9 | 10,682 | 156.2 | 20,377 | 151.7 | 19,691 | 85.8 | 11,133 | 153.1 | 19,858 | 154.2 | 20,059 |
| **104** | 83.0 | 10,717 | 155.7 | 20,104 | 152.3 | 19,593 | 86.6 | 11,119 | 155.3 | 19,940 | 154.7 | 19,819 |
| **105** | 84.0 | 10,741 | 155.5 | 19,877 | 152.9 | 19,489 | 87.3 | 11,095 | 158.2 | 20,098 | 155.2 | 19,575 |
| **106** | 85.0 | 10,752 | 155.8 | 19,714 | 153.5 | 19,374 | 88.2 | 11,095 | 158.8 | 19,985 | 155.6 | 19,438 |
| **107** | 85.9 | 10,769 | 155.9 | 19,537 | 154.0 | 19,258 | 89.0 | 11,087 | 159.6 | 19,886 | 156.1 | 19,299 |
| **108** | 86.8 | 10,780 | 156.1 | 19,374 | 154.5 | 19,145 | 89.8 | 11,079 | 160.2 | 19,776 | 156.5 | 19,168 |
| **109** | 87.8 | 10,794 | 156.1 | 19,193 | 155.0 | 19,038 | 90.6 | 11,072 | 161.1 | 19,693 | 157.0 | 19,045 |
| **110** | 88.7 | 10,809 | 156.1 | 19,030 | 155.5 | 18,935 | 91.4 | 11,068 | 162.0 | 19,629 | 157.4 | 18,936 |

1. Values provided by HDC (May 2022). Flow (cfs) is a calculated value based on turbine efficiency, project head, and power output (MW).
2. Units 3, 8, 9, 10, 11, 13, and 14 have locked runner blades and are restricted to an operating range of approximately 17-19 kcfs, as defined below in **Table JDA-7-A**. *Unit 4 is out of service for rehab and will be a fully adjustable Kaplan when it returns to service (estimated RTS 2024).*
3. “Operating Limit” (added Feb 2018) is the maximum safe operating point based on cavitation or generator limit. JDA units have a generator limit that restricts turbine output at higher heads. Values shaded in gray indicate the Operating Limit is below the 1% Upper Limit.

Table JDA-7-A. Operating Range Values for John Day Turbine Units 3, 8, 9, 10, 11, 13, and 14 with Locked Runner Blades

(Non-Adjustable). a

|  |  |  |
| --- | --- | --- |
| **Project Head (feet)** | **Unit 3 w/ Blades Hydraulically Locked at 29.1° (Dec 2020)** | **Unit 8 w/ Blades Welded at 29.4° (March 2017)** |
| **With STS** | **No STS** | **With STS** | **No STS** |
| **Lower Limit** | **Upper Limit** | **Lower Limit** | **Upper Limit** | **Lower Limit** | **Upper Limit** | **Lower Limit** | **Upper Limit** |
| **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** |
| 80 | 103.5 | 18,039 | 107.7 | 18,769 | 103.5 | 17,961 | 107.7 | 18,688 | 106.3 | 18,435 | 110.9 | 19,239 | 106.3 | 18,435 | 110.9 | 19,239 |
| 81 | 104.8 | 18,010 | 109.0 | 18,728 | 104.8 | 17,932 | 109.0 | 18,653 | 107.7 | 18,413 | 112.2 | 19,186 | 107.7 | 18,417 | 112.2 | 19,190 |
| 82 | 106.1 | 17,979 | 110.2 | 18,685 | 106.1 | 17,906 | 110.3 | 18,609 | 109.1 | 18,392 | 113.5 | 19,133 | 109.1 | 18,400 | 113.5 | 19,141 |
| 83 | 107.4 | 17,949 | 111.5 | 18,648 | 107.5 | 17,881 | 111.6 | 18,568 | 110.5 | 18,371 | 114.8 | 19,086 | 110.5 | 18,383 | 114.8 | 19,098 |
| 84 | 108.6 | 17,919 | 112.9 | 18,616 | 108.8 | 17,855 | 113.0 | 18,539 | 111.9 | 18,350 | 116.1 | 19,042 | 112.0 | 18,367 | 116.2 | 19,058 |
| 85 | 109.9 | 17,891 | 114.2 | 18,589 | 110.1 | 17,830 | 114.3 | 18,513 | 113.3 | 18,328 | 117.5 | 19,005 | 113.4 | 18,348 | 117.6 | 19,025 |
| 86 | 111.7 | 17,933 | 115.9 | 18,615 | 111.9 | 17,872 | 116.0 | 18,541 | 115.0 | 18,355 | 119.2 | 19,025 | 115.1 | 18,380 | 119.3 | 19,048 |
| 87 | 113.4 | 17,969 | 117.6 | 18,643 | 113.6 | 17,914 | 117.8 | 18,572 | 116.7 | 18,381 | 120.9 | 19,041 | 116.9 | 18,410 | 121.0 | 19,068 |
| 88 | 115.1 | 18,005 | 119.4 | 18,676 | 115.3 | 17,949 | 119.5 | 18,601 | 118.3 | 18,404 | 122.5 | 19,055 | 118.6 | 18,437 | 122.7 | 19,086 |
| 89 | 116.8 | 18,037 | 121.1 | 18,704 | 117.0 | 17,985 | 121.3 | 18,636 | 120.0 | 18,427 | 124.2 | 19,067 | 120.3 | 18,464 | 124.4 | 19,102 |
| 90 | 118.5 | 18,070 | 122.8 | 18,736 | 118.8 | 18,021 | 123.0 | 18,665 | 121.7 | 18,448 | 125.9 | 19,078 | 122.0 | 18,489 | 126.1 | 19,117 |
| 91 | 119.8 | 18,058 | 124.3 | 18,743 | 120.1 | 18,012 | 124.5 | 18,674 | 122.9 | 18,411 | 127.1 | 19,040 | 123.2 | 18,457 | 127.4 | 19,083 |
| 92 | 121.1 | 18,043 | 125.8 | 18,750 | 121.5 | 18,002 | 126.1 | 18,684 | 124.2 | 18,375 | 128.4 | 19,004 | 124.5 | 18,425 | 128.7 | 19,051 |
| 93 | 122.4 | 18,029 | 127.3 | 18,755 | 122.8 | 17,989 | 127.6 | 18,694 | 125.4 | 18,341 | 129.7 | 18,970 | 125.8 | 18,394 | 130.1 | 19,020 |
| 94 | 123.7 | 18,013 | 128.8 | 18,762 | 124.1 | 17,976 | 129.1 | 18,701 | 126.7 | 18,306 | 131.0 | 18,938 | 127.0 | 18,363 | 131.4 | 18,993 |
| 95 | 124.9 | 17,994 | 130.3 | 18,770 | 125.4 | 17,962 | 130.6 | 18,710 | 127.9 | 18,271 | 132.4 | 18,909 | 128.3 | 18,332 | 132.8 | 18,968 |
| 96 | 126.5 | 18,018 | 131.9 | 18,782 | 127.0 | 17,988 | 132.3 | 18,725 | 129.6 | 18,294 | 134.0 | 18,919 | 130.0 | 18,359 | 134.4 | 18,982 |
| 97 | 128.1 | 18,041 | 133.5 | 18,797 | 128.7 | 18,013 | 133.9 | 18,741 | 131.2 | 18,317 | 135.6 | 18,926 | 131.7 | 18,386 | 136.1 | 18,993 |
| 98 | 129.8 | 18,064 | 135.1 | 18,813 | 130.3 | 18,037 | 135.6 | 18,761 | 132.9 | 18,337 | 137.3 | 18,940 | 133.4 | 18,410 | 137.8 | 19,010 |
| 99 | 131.4 | 18,085 | 136.8 | 18,837 | 132.0 | 18,061 | 137.3 | 18,786 | 134.6 | 18,359 | 139.0 | 18,954 | 135.2 | 18,437 | 139.5 | 19,028 |
| 100 | 133.0 | 18,107 | 138.6 | 18,868 | 133.6 | 18,085 | 139.0 | 18,819 | 136.2 | 18,376 | 140.7 | 18,975 | 136.8 | 18,458 | 141.3 | 19,053 |
| 101 | 134.6 | 18,134 | 140.2 | 18,890 | 135.3 | 18,115 | 140.7 | 18,843 | 137.8 | 18,395 | 142.4 | 18,998 | 138.4 | 18,473 | 142.9 | 19,072 |
| 102 | 136.2 | 18,159 | 141.9 | 18,915 | 136.9 | 18,143 | 142.4 | 18,869 | 139.4 | 18,411 | 144.1 | 19,024 | 140.0 | 18,485 | 144.6 | 19,095 |
| 103 | 137.9 | 18,187 | 143.6 | 18,938 | 138.6 | 18,172 | 144.1 | 18,894 | 141.0 | 18,427 | 145.8 | 19,052 | 141.6 | 18,497 | 146.3 | 19,119 |
| 104 | 139.5 | 18,209 | 145.3 | 18,967 | 140.2 | 18,195 | 145.9 | 18,925 | 142.6 | 18,443 | 147.6 | 19,081 | 143.1 | 18,509 | 148.0 | 19,143 |
| 105 | 141.1 | 18,230 | 147.0 | 18,997 | 141.9 | 18,218 | 147.6 | 18,957 | 144.2 | 18,456 | 149.3 | 19,111 | 144.7 | 18,518 | 149.8 | 19,170 |
| 106 | 142.3 | 18,217 | 148.6 | 19,030 | 143.1 | 18,203 | 149.2 | 18,986 | 145.5 | 18,447 | 151.0 | 19,147 | 145.9 | 18,505 | 151.4 | 19,202 |
| 107 | 143.4 | 18,197 | 150.3 | 19,064 | 144.2 | 18,182 | 150.8 | 19,015 | 146.7 | 18,434 | 152.7 | 19,187 | 147.2 | 18,487 | 153.1 | 19,238 |
| 108 | 144.5 | 18,171 | 151.9 | 19,097 | 145.3 | 18,154 | 152.5 | 19,046 | 147.9 | 18,415 | 154.5 | 19,229 | 148.3 | 18,464 | 154.9 | 19,276 |
| 109 | 145.5 | 18,137 | 153.5 | 19,132 | 146.3 | 18,119 | 154.1 | 19,077 | 149.1 | 18,393 | 155.3 | 19,149 | 149.5 | 18,438 | 155.3 | 19,149 |
| 110 | 146.5 | 18,096 | 155.2 | 19,168 | 147.3 | 18,077 | 155.7 | 19,109 | 150.2 | 18,365 | 155.3 | 18,978 | 150.6 | 18,406 | 155.3 | 18,978 |

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| **Project Head (feet)** | **Unit 9 w/ Blades Welded at 29.0° (Sep 2015)** | **Unit 10 w/ Blades Welded at 29.1° (Dec 2020)** |
| **With STS** | **No STS** | **With STS** | **No STS** |
| **Lower Limit** | **Upper Limit** | **Lower Limit** | **Upper Limit** | **Lower Limit** | **Upper Limit** | **Lower Limit** | **Upper Limit** |
| **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** |
| 80 | 106.0 | 18,388 | 110.6 | 19,182 | 106.0 | 18,388 | 110.6 | 19,182 | 104.1 | 18,013 | 108.4 | 18,747 | 104.1 | 18,013 | 108.4 | 18,747 |
| 81 | 107.3 | 18,354 | 111.9 | 19,126 | 107.4 | 18,358 | 111.9 | 19,130 | 105.4 | 17,984 | 109.6 | 18,696 | 105.4 | 17,988 | 109.6 | 18,699 |
| 82 | 108.7 | 18,322 | 113.1 | 19,070 | 108.7 | 18,330 | 113.2 | 19,078 | 106.7 | 17,954 | 110.8 | 18,642 | 106.8 | 17,963 | 110.9 | 18,647 |
| 83 | 110.0 | 18,291 | 114.4 | 19,018 | 110.1 | 18,302 | 114.5 | 19,030 | 108.0 | 17,924 | 112.1 | 18,596 | 108.1 | 17,936 | 112.1 | 18,603 |
| 84 | 111.4 | 18,260 | 115.7 | 18,970 | 111.5 | 18,275 | 115.8 | 18,986 | 109.4 | 17,895 | 113.4 | 18,555 | 109.5 | 17,911 | 113.5 | 18,565 |
| 85 | 112.7 | 18,226 | 117.0 | 18,930 | 112.8 | 18,246 | 117.2 | 18,950 | 110.7 | 17,868 | 114.7 | 18,517 | 110.8 | 17,888 | 114.8 | 18,530 |
| 86 | 114.3 | 18,245 | 118.7 | 18,949 | 114.5 | 18,269 | 118.9 | 18,973 | 112.4 | 17,905 | 116.4 | 18,534 | 112.6 | 17,930 | 116.5 | 18,549 |
| 87 | 115.9 | 18,262 | 120.4 | 18,964 | 116.1 | 18,290 | 120.6 | 18,992 | 114.1 | 17,940 | 118.0 | 18,550 | 114.3 | 17,968 | 118.1 | 18,569 |
| 88 | 117.5 | 18,275 | 122.1 | 18,977 | 117.7 | 18,307 | 122.3 | 19,009 | 115.8 | 17,971 | 119.7 | 18,568 | 116.0 | 18,004 | 119.8 | 18,588 |
| 89 | 119.1 | 18,287 | 123.7 | 18,985 | 119.4 | 18,323 | 123.9 | 19,021 | 117.5 | 18,002 | 121.4 | 18,587 | 117.8 | 18,038 | 121.5 | 18,610 |
| 90 | 120.8 | 18,302 | 125.3 | 18,985 | 121.0 | 18,342 | 125.6 | 19,025 | 119.2 | 18,030 | 123.0 | 18,605 | 119.5 | 18,071 | 123.2 | 18,631 |
| 91 | 121.9 | 18,258 | 126.6 | 18,948 | 122.2 | 18,301 | 126.9 | 18,993 | 120.6 | 18,013 | 124.4 | 18,595 | 120.8 | 18,058 | 124.6 | 18,624 |
| 92 | 123.1 | 18,215 | 127.8 | 18,912 | 123.4 | 18,262 | 128.2 | 18,960 | 121.9 | 17,995 | 125.9 | 18,586 | 122.2 | 18,044 | 126.1 | 18,617 |
| 93 | 124.3 | 18,172 | 129.1 | 18,877 | 124.6 | 18,223 | 129.5 | 18,929 | 123.1 | 17,976 | 127.3 | 18,576 | 123.5 | 18,028 | 127.5 | 18,610 |
| 94 | 125.5 | 18,129 | 130.4 | 18,843 | 125.8 | 18,184 | 130.8 | 18,900 | 124.4 | 17,956 | 128.7 | 18,567 | 124.8 | 18,013 | 128.9 | 18,604 |
| 95 | 126.6 | 18,086 | 131.7 | 18,811 | 127.0 | 18,145 | 132.1 | 18,872 | 125.7 | 17,935 | 130.1 | 18,560 | 126.1 | 17,996 | 130.4 | 18,599 |
| 96 | 128.2 | 18,099 | 133.3 | 18,817 | 128.6 | 18,161 | 133.7 | 18,881 | 127.3 | 17,957 | 131.6 | 18,564 | 127.8 | 18,021 | 131.9 | 18,605 |
| 97 | 129.8 | 18,112 | 134.9 | 18,819 | 130.3 | 18,178 | 135.3 | 18,888 | 129.0 | 17,977 | 133.2 | 18,569 | 129.4 | 18,045 | 133.5 | 18,614 |
| 98 | 131.4 | 18,122 | 136.5 | 18,828 | 131.9 | 18,193 | 137.0 | 18,901 | 130.6 | 17,998 | 134.8 | 18,579 | 131.1 | 18,070 | 135.1 | 18,625 |
| 99 | 132.9 | 18,133 | 138.1 | 18,839 | 133.5 | 18,208 | 138.7 | 18,916 | 132.2 | 18,017 | 136.4 | 18,593 | 132.8 | 18,093 | 136.8 | 18,642 |
| 100 | 134.5 | 18,141 | 139.8 | 18,856 | 135.1 | 18,220 | 140.4 | 18,936 | 133.8 | 18,036 | 138.1 | 18,614 | 134.4 | 18,117 | 138.5 | 18,666 |
| 101 | 136.2 | 18,169 | 141.5 | 18,882 | 136.7 | 18,243 | 142.1 | 18,959 | 135.5 | 18,060 | 139.7 | 18,626 | 136.1 | 18,144 | 140.1 | 18,681 |
| 102 | 137.8 | 18,194 | 143.2 | 18,911 | 138.3 | 18,264 | 143.8 | 18,984 | 137.1 | 18,084 | 141.3 | 18,638 | 137.8 | 18,173 | 141.7 | 18,696 |
| 103 | 139.5 | 18,219 | 145.0 | 18,941 | 140.0 | 18,286 | 145.5 | 19,010 | 138.7 | 18,105 | 142.9 | 18,654 | 139.4 | 18,198 | 143.4 | 18,714 |
| 104 | 141.1 | 18,243 | 146.7 | 18,973 | 141.6 | 18,306 | 147.2 | 19,038 | 140.3 | 18,125 | 144.6 | 18,670 | 141.1 | 18,222 | 145.0 | 18,733 |
| 105 | 142.7 | 18,265 | 148.5 | 19,006 | 143.2 | 18,324 | 149.0 | 19,067 | 141.9 | 18,142 | 146.2 | 18,691 | 142.7 | 18,243 | 146.7 | 18,756 |
| 106 | 144.1 | 18,266 | 150.2 | 19,046 | 144.5 | 18,321 | 150.7 | 19,103 | 143.2 | 18,132 | 147.9 | 18,728 | 143.9 | 18,229 | 148.4 | 18,791 |
| 107 | 145.4 | 18,262 | 152.0 | 19,090 | 145.8 | 18,313 | 152.4 | 19,143 | 144.4 | 18,116 | 149.6 | 18,767 | 145.1 | 18,209 | 150.1 | 18,828 |
| 108 | 146.7 | 18,253 | 153.7 | 19,135 | 147.0 | 18,300 | 154.1 | 19,184 | 145.5 | 18,093 | 151.3 | 18,807 | 146.2 | 18,182 | 151.7 | 18,865 |
| 109 | 147.9 | 18,240 | 155.3 | 19,147 | 148.2 | 18,283 | 155.3 | 19,147 | 146.6 | 18,065 | 153.0 | 18,847 | 147.3 | 18,150 | 153.4 | 18,903 |
| 110 | 149.1 | 18,221 | 155.3 | 18,975 | 149.4 | 18,260 | 155.3 | 18,975 | 147.7 | 18,030 | 154.7 | 18,890 | 148.3 | 18,111 | 155.1 | 18,943 |

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| **Project Head (feet)** | **Unit 11 w/ Blades Welded at 29.9° (April 2012)** | **Unit 13 w/ Blades Pinned at 29.5° (Jun 2023) and Unit 14 w/ Blades Welded at 29.6° (Aug 2019)** |
| **With STS** | **No STS** | **With STS** | **No STS** |
| **Lower Limit** | **Upper Limit** | **Lower Limit** | **Upper Limit** | **Lower Limit** | **Upper Limit** | **Lower Limit** | **Upper Limit** |
| **MW** | **MW** | **MW** | **MW** | **MW** | **MW** | **MW** | **MW** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** |
| 80 | 106.0 | 18,379 | 110.5 | 19,171 | 106.0 | 18,379 | 110.5 | 19,171 | 104.8 | 18,154 | 109.2 | 18,914 | 104.8 | 18,154 | 109.2 | 18,914 |
| 81 | 107.4 | 18,360 | 111.9 | 19,130 | 107.4 | 18,364 | 111.9 | 19,134 | 106.2 | 18,130 | 110.5 | 18,870 | 106.2 | 18,133 | 110.5 | 18,873 |
| 82 | 108.8 | 18,343 | 113.2 | 19,087 | 108.9 | 18,350 | 113.3 | 19,095 | 107.6 | 18,108 | 111.8 | 18,824 | 107.6 | 18,114 | 111.8 | 18,830 |
| 83 | 110.2 | 18,326 | 114.6 | 19,048 | 110.3 | 18,338 | 114.7 | 19,060 | 108.9 | 18,088 | 113.1 | 18,778 | 109.0 | 18,097 | 113.2 | 18,787 |
| 84 | 111.7 | 18,310 | 116.0 | 19,013 | 111.8 | 18,325 | 116.1 | 19,030 | 110.3 | 18,066 | 114.4 | 18,741 | 110.4 | 18,078 | 114.5 | 18,753 |
| 85 | 113.1 | 18,291 | 117.4 | 18,986 | 113.2 | 18,311 | 117.5 | 19,007 | 111.7 | 18,045 | 115.8 | 18,711 | 111.8 | 18,060 | 115.9 | 18,726 |
| 86 | 114.8 | 18,326 | 119.2 | 19,019 | 115.0 | 18,349 | 119.3 | 19,044 | 113.4 | 18,082 | 117.5 | 18,738 | 113.5 | 18,100 | 117.7 | 18,757 |
| 87 | 116.6 | 18,358 | 120.9 | 19,048 | 116.7 | 18,385 | 121.1 | 19,077 | 115.2 | 18,118 | 119.3 | 18,764 | 115.3 | 18,139 | 119.4 | 18,785 |
| 88 | 118.3 | 18,386 | 122.7 | 19,074 | 118.5 | 18,417 | 122.9 | 19,107 | 116.9 | 18,151 | 121.0 | 18,788 | 117.0 | 18,175 | 121.2 | 18,812 |
| 89 | 120.0 | 18,413 | 124.4 | 19,096 | 120.2 | 18,448 | 124.7 | 19,133 | 118.6 | 18,184 | 122.7 | 18,805 | 118.8 | 18,211 | 122.9 | 18,833 |
| 90 | 121.7 | 18,444 | 126.1 | 19,110 | 122.0 | 18,482 | 126.4 | 19,151 | 120.4 | 18,216 | 124.4 | 18,825 | 120.6 | 18,246 | 124.6 | 18,855 |
| 91 | 123.0 | 18,414 | 127.5 | 19,087 | 123.3 | 18,457 | 127.8 | 19,132 | 121.7 | 18,196 | 125.8 | 18,813 | 121.9 | 18,229 | 126.0 | 18,846 |
| 92 | 124.3 | 18,386 | 128.9 | 19,064 | 124.6 | 18,433 | 129.2 | 19,114 | 123.0 | 18,177 | 127.2 | 18,801 | 123.2 | 18,213 | 127.5 | 18,838 |
| 93 | 125.6 | 18,358 | 130.3 | 19,043 | 125.9 | 18,408 | 130.6 | 19,097 | 124.3 | 18,157 | 128.7 | 18,791 | 124.6 | 18,195 | 128.9 | 18,830 |
| 94 | 126.9 | 18,330 | 131.6 | 19,024 | 127.2 | 18,384 | 132.0 | 19,081 | 125.6 | 18,136 | 130.1 | 18,780 | 125.9 | 18,178 | 130.4 | 18,823 |
| 95 | 128.1 | 18,302 | 133.0 | 19,005 | 128.5 | 18,360 | 133.5 | 19,067 | 126.9 | 18,115 | 131.5 | 18,771 | 127.2 | 18,160 | 131.8 | 18,816 |
| 96 | 129.8 | 18,330 | 134.7 | 19,024 | 130.3 | 18,391 | 135.2 | 19,090 | 128.6 | 18,141 | 133.1 | 18,783 | 128.9 | 18,189 | 133.5 | 18,831 |
| 97 | 131.6 | 18,358 | 136.4 | 19,040 | 132.0 | 18,424 | 136.9 | 19,110 | 130.3 | 18,167 | 134.8 | 18,796 | 130.6 | 18,217 | 135.1 | 18,847 |
| 98 | 133.3 | 18,384 | 138.2 | 19,063 | 133.8 | 18,453 | 138.7 | 19,137 | 131.9 | 18,192 | 136.4 | 18,813 | 132.3 | 18,246 | 136.8 | 18,867 |
| 99 | 135.0 | 18,410 | 139.9 | 19,087 | 135.5 | 18,483 | 140.5 | 19,166 | 133.6 | 18,215 | 138.2 | 18,835 | 134.0 | 18,272 | 138.6 | 18,893 |
| 100 | 136.7 | 18,433 | 141.8 | 19,117 | 137.3 | 18,511 | 142.4 | 19,200 | 135.3 | 18,240 | 139.9 | 18,861 | 135.7 | 18,300 | 140.4 | 18,922 |
| 101 | 138.2 | 18,446 | 143.4 | 19,130 | 138.8 | 18,519 | 144.0 | 19,209 | 137.0 | 18,266 | 141.6 | 18,881 | 137.4 | 18,329 | 142.1 | 18,945 |
| 102 | 139.8 | 18,456 | 145.0 | 19,147 | 140.3 | 18,526 | 145.6 | 19,221 | 138.6 | 18,294 | 143.2 | 18,899 | 139.1 | 18,361 | 143.7 | 18,966 |
| 103 | 141.4 | 18,467 | 146.7 | 19,163 | 141.9 | 18,533 | 147.2 | 19,233 | 140.3 | 18,319 | 144.9 | 18,921 | 140.8 | 18,389 | 145.4 | 18,991 |
| 104 | 142.9 | 18,476 | 148.4 | 19,181 | 143.4 | 18,538 | 148.9 | 19,247 | 142.0 | 18,342 | 146.6 | 18,945 | 142.5 | 18,414 | 147.2 | 19,019 |
| 105 | 144.4 | 18,482 | 150.0 | 19,201 | 144.9 | 18,540 | 150.5 | 19,263 | 143.6 | 18,364 | 148.3 | 18,969 | 144.2 | 18,440 | 148.9 | 19,046 |
| 106 | 145.7 | 18,469 | 151.7 | 19,228 | 146.1 | 18,523 | 152.1 | 19,286 | 144.8 | 18,349 | 150.0 | 19,002 | 145.4 | 18,421 | 150.6 | 19,076 |
| 107 | 146.9 | 18,449 | 153.3 | 19,258 | 147.3 | 18,500 | 153.8 | 19,312 | 146.0 | 18,330 | 151.6 | 19,034 | 146.6 | 18,399 | 152.2 | 19,104 |
| 108 | 148.0 | 18,425 | 155.0 | 19,290 | 148.4 | 18,471 | 155.3 | 19,322 | 147.2 | 18,305 | 153.3 | 19,068 | 147.7 | 18,371 | 153.9 | 19,136 |
| 109 | 149.2 | 18,397 | 155.3 | 19,146 | 149.5 | 18,439 | 155.3 | 19,146 | 148.3 | 18,273 | 155.0 | 19,104 | 148.8 | 18,336 | 155.3 | 19,135 |
| 110 | 150.2 | 18,362 | 155.3 | 18,975 | 150.6 | 18,401 | 155.3 | 18,975 | 149.3 | 18,236 | 155.3 | 18,963 | 149.8 | 18,296 | 155.3 | 18,963 |

**a.** Units 3, 8, 9, 10, 11, 13, and 14 have runner blades that are locked at a fixed angle (non-adjustable) and are restricted to a smaller operating range until the unit is repaired. Values updated by HDC in May 2022 and June 2023 (Unit 13).