

Columbia River Water Use Plan

Arrow Lakes Reservoir Operations Management Plan

Monitoring Program

Annual Report: 2017

Implementation Period: June 2016 – May 2017

- **CLBMON-31 Arrow Lakes Reservoir: Burbot Life History Study**
- **CLBMON-32 Arrow Lakes Reservoir: Tributary Fish Migration Study**
- **CLBMON-36 Kinbasket and Arrow Lakes Reservoir: Nest Mortality of Migratory Birds due to Reservoir Operations**
- **CLBMON-37 Kinbasket and Arrow Lakes Reservoir: Amphibian and Reptile Life History and Habitat Use Assessment**
- **CLBMON-39 Arrow Lakes Reservoir: Neotropical Migrant Use of the Drawdown Zone**
- **CLBMON-40 Arrow Lakes Reservoir: Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Program**
- **CLBMON-41 Arrow Lakes Reservoir: Recreational Demand Study**
- **CLBMON-58 Monitoring of Impacts on Amphibians and Reptiles from Mica Units 5 and 6 in Kinbasket Reservoir**

Conditional Water Licences for Kinbasket storage (27068 and 39432), Mica diversion (39431), Revelstoke diversion and storage (47215), and Arrow storage (27066)

June 28, 2017

BC Hydro Columbia River Project Water Use Plan Arrow Lakes Reservoir Operations Management Plan Monitoring Programs Annual Report: 2017

1 Introduction

This document represents a summary of the status and the results of the Arrow Lakes Reservoir Operations Management Plan Water Use Plan (WUP) monitoring programs to May 31, 2017, as per the Columbia River Order under the *Water Act*, dated January 26, 2007. There are eight monitoring programs.

2 Status

The following table outlines the dates that Terms of Reference (TOR) for the Arrow Lakes Reservoir Operations Management Plan WUP monitoring programs were submitted to and approved by the Comptroller of Water Rights (CWR).

Table: 2-1: Dates of Arrow Lakes Reservoir Operations Management Plan WUP TOR Submissions and Approvals by the Comptroller of Water Rights

| Monitoring Program | Order Clause | Original ToR Submission | | Most Recent ToR Resubmission | |
|--|--|-------------------------|---------------|------------------------------|---------------|
| | | Date Submitted | Date Approved | Date Submitted | Date Approved |
| CLBMON-31 Arrow Lakes Reservoir: Burbot Life History Study | Schedule D: 5.a | Oct 24, 2007 | Dec 03, 2007 | | |
| CLBMON-32 Arrow Lakes Reservoir: Tributary Fish Migration Study | Schedule D: 5.b | Oct 24, 2007 | Dec 03, 2007 | | |
| CLBMON-36 Kinbasket and Arrow Lakes Reservoir: Nest Mortality of Migratory Birds due to Reservoir Operations | Schedule A: 6.a Schedule C: 5.c | Jan 25, 2008 | Mar 03, 2008 | Dec 18, 2014 | Feb 04, 2015 |
| CLBMON-37 Kinbasket and Arrow Lakes Reservoir: Amphibian and Reptile Life History and Habitat Use Assessment | Schedule A: 6.b Schedule C: 5.d | Jan 25, 2008 | Mar 03, 2008 | Jan 04, 2011 | Apr 12, 2011 |
| CLBMON-39 Arrow Lakes Reservoir: Neotropical Migrant Use of the Drawdown Zone | Schedule C: 5.f | Jan 25, 2008 | Mar 17, 2008 | Jun 22, 2015 | Jul 16, 2015 |
| CLBMON-40 Arrow Lakes Reservoir: Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Program | Schedule C: 5.e, 5.g | Jan 25, 2008 | Mar 03, 2008 | Dec 23, 2015 | Jan 26, 2016 |
| CLBMON-41 Arrow Lakes Reservoir: Recreational Demand Study | Clause 6.c Ordered Jan 26, 2007 and Clause 6.c Ordered by CWR Apr 24, 2007 | Jul 31, 2008 | Sep 11, 2008 | | |
| CLBMON-58 Monitoring of Impacts on Amphibians and Reptiles from Mica Units 5 and 6 in Kinbasket Reservoir | Augment to Schedule A: 6.b Schedule C: 5.d | Jan 04, 2011 | Apr 12, 2011 | | |

3 Schedule

The following table outlines the current schedule for the monitoring programs being delivered for the Arrow Lakes Reservoir Operations Management Plan WUP.

Table 3-1: Monitoring Programs Schedule as of May 31, 2017

| Monitoring Programs | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|--|---------|---------|---------|---------|---------|---------|---------------------------|---------|---------|----------|----------|----------|----------|
| | WLR YR1 | WLR YR2 | WLR YR3 | WLR YR4 | WLR YR5 | WLR YR6 | WLR YR7 Interim Review | WLR YR8 | WLR YR9 | WLR YR10 | WLR YR11 | WLR YR12 | WLR YR13 |
| CLBMON-31 Arrow Lakes Reservoir: Burbot Life History Study | | ✓ | ✓ | ✓ | ✓ | ✓F | | | | | | | |
| CLBMON-32 Arrow Lakes Reservoir: Tributary Fish Migration Study | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓F | | | | | | |
| CLBMON-36 Kinbasket and Arrow Lakes Reservoir: Nest Mortality of Migratory Birds due to Reservoir Operations | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | u/w | | |
| CLBMON-37 Kinbasket and Arrow Lakes Reservoir: Amphibian and Reptile Life History and Habitat Use Assessment | | ✓ | ✓ | ✓ | | ✓ | | ✓ | | ✓ | | ■ | |
| CLBMON-39 Arrow Lakes Reservoir: Neotropical Migrant Use of the Drawdown Zone | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | u/w | | |
| CLBMON-40 Arrow Lakes Reservoir: Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Program | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | u/w | | |
| CLBMON-41 Arrow Lakes Reservoir: Recreational Demand Study | | | ✓ | ✓ | ✓ | ✓ | ✓F | | | | | | |
| CLBMON-58 Mica Addendum to CLBMON 37 Amphibians and Reptiles | | | | | ✓ | | ✓ | | ✓ | | u/w | | |

Legend:

- = Program to be undertaken/initiated in identified year
- u/w = Project is underway
- ✓ = Program completed for the year
- x = Program started, but encountered operational or hydrological delays
- ✓F = All field work for this project is complete. No further field work is planned.
- PCR = Project Completion Report submitted

4 Monitoring Programs Terms of Reference

The monitoring programs being implemented under the Arrow Lakes Reservoir Operations Management Plan WUP are described in Terms of Reference. These Terms of Reference and the reports for work completed to date can be found here:

http://www.bchydro.com/about/sustainability/conservation/water_use_planning/southern_interior/columbia_river/arrow-operations.html

5 Status of Monitoring Programs

5.1 CLBMON-31 Arrow Lakes Reservoir: Burbot Life History Study

The objective of this study was to assess the potential effects of winter drawdown of Arrow Lakes Reservoir to spawning Burbot. This monitoring program was initiated in 2008 and was completed in 2013. All reports have been submitted.

5.2 CLBMON-32 Arrow Lakes Reservoir: Tributary Fish Migration Study

The objective of this study was to assess passage conditions for fish at tributaries to Arrow Lakes Reservoir under a range of operating levels and streamflow conditions. This monitoring program was initiated in 2008 and was completed in 2014. All reports have been submitted.

5.3 CLBMON-36 Kinbasket and Arrow Lakes Reservoir: Nest Mortality of Migratory Birds due to Reservoir Operations

This monitoring program researches the impacts that reservoir operations have on the productivity of birds breeding in the reservoir drawdown zones of Kinbasket and Arrow Lakes Reservoirs. The study was initiated in 2008 and will be carried out annually over ten years.

In Year 9, the Kinbasket Reservoir had above average water levels during the early- to mid-part of the breeding season, causing early nest flooding. The rate of inundation slowed down so that levels were relatively normal towards the end of the breeding season. The Arrow Lakes Reservoir filled to a relatively low and early peak level of just 437.2 MASL on June 12, 2016.

The Year 9 report will be submitted with the 2018 Annual Report.

5.4 CLBMON-37 Kinbasket and Arrow Lakes Reservoir: Amphibian and Reptile Life History and Habitat Use Assessment

This monitoring program is intended to address the relative influence and importance of the current reservoir operating regime on the life history and habitat use of amphibians and reptiles occurring in the drawdown zones of each reservoir. The study was initiated in 2008 and will be carried out every other year for eleven years.

The influence of the abnormally early increase in reservoir levels in both Kinbasket and Arrow Lakes Reservoirs in 2016 led to less habitat being available for amphibians in June however more than usual habitat was available later in the summer (August and September).

Radio-telemetry was used in 2016 to determine how Common Garter Snake use habitats in the drawdown zone and the locations of any overwintering sites in the Valemount Peatland area of Kinbasket Reservoir.

Attached is the report for Year 6 dated May 14, 2017. The final implementation (Year 12) is 2018.

5.5 CLBMON-39 Arrow Lakes Reservoir: Neotropical Migrant Use of the Drawdown Zone

This monitoring program was designed to determine the effects of reservoir operations on neotropical migrant songbirds in Revelstoke Reach during fall migration. The study was initiated in 2008 and will be carried out annually over ten years.

In 2016, mist net surveys were conducted at two sites in the drawdown zone (Airport Islands and Machete Island) and one site outside of the drawdown zone (Jordan River).

Attached is the report for Year 9 dated May 14, 2017.

5.6 CLBMON-40 Arrow Lakes Reservoir: Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Program

This monitoring program studies the use of the Revelstoke Reach wetlands during spring and fall migration, the importance of these wetlands for breeding

waterbirds, and how ecological functions are impacted by reservoir operations. The study was initiated in 2008 and will be carried out annually over ten years.

In 2016, the wetlands thawed early relative to previous years. The Arrow Lakes Reservoir spring storage operation was also early, with increasing water surface elevation being several meters higher than historic norms, especially in May.

Year 9 report is in process of being finalized and will be submitted with the 2018 Annual Report.

5.7 CLBMON-41 Arrow Lakes Reservoir: Recreational Demand Study

This monitoring program was initiated in 2009 and field work was completed in 2013. The objective of this study is to establish a functional link between recreational use and water levels on Arrow Lakes Reservoir. As reported in last year's Annual Report, a secondary analysis of the full study results was completed to ensure that BC Hydro operations have a minimal effect on recreation use of the Arrow Lakes Reservoir.

The secondary analysis was completed on February 23, 2017 by StatMathComp Consulting and determined that an increase in reservoir elevation by 1 m results in a 2% to 3% increase in the number of boats launched. However, this relationship may depend on the temperature or year of the survey and these additional effects are difficult to disentangle because reservoir elevation and temperature are highly related. The secondary analysis also determined that there is a clear preference for intermediate reservoir levels (i.e., 434.0 m to 437.5 MASL; even after adjusting for temperature) and this finding was consistent across the different categories of users (e.g., beach goer or angler or camper, etc.).

Attached is the Year 5 report dated February 23, 2017.

5.8 CLBMON-58 Monitoring of Impacts on Amphibians and Reptiles from Mica Units 5 and 6 in Kinbasket Reservoir

This monitoring program addresses the potential predicted impacts of the installation of Units 5 and 6 (and the consequential increase of 0.6 m in maximum reservoir elevation) at Mica Dam on amphibian and reptile populations in Kinbasket Reservoir. The study was initiated in 2011 and will be carried out every other year over seven years (2018 is the final year).

Implementation did not occur in 2016.

6 Monitoring Programs Costs

The following table summarizes the Arrow Lakes Reservoir Operations Management Plan WUP monitoring programs approved by the Comptroller and the Actual Costs to May 31, 2017.

Table 6-1: Arrow Lakes Reservoir Operations Management Plan WUP Monitoring Programs Costs

| Monitoring Programs | Costs approved by CWR | Life to Date Actuals (LTD) | Estimated to Complete (Forecast) | Total Forecast (LTD and Forecast) | Variance Total to Approved | Explanation | Corrective Action |
|--|-----------------------|----------------------------|----------------------------------|-----------------------------------|----------------------------|--|-------------------|
| CLB MP6 Arrow Res Ops Annual Report | \$13,457 | \$9,055 | \$3,108 | \$12,162 | \$1,295 | | |
| C06M31A ARROW: Burbot Life - ONR | \$114,277 | \$116,683 | | \$116,683 | (\$2,406) | Project is complete. Final completion report is outstanding. | |
| C06M31A ARROW: Burbot Life - ONR DM | \$0 | \$73 | | \$73 | (\$73) | | |
| C06M31A ARROW: Burbot Life - ONR Imp | \$114,277 | \$116,610 | | \$116,610 | (\$2,333) | | |
| C06M31A ARROW: Burbot Life - OR | \$970,525 | \$857,802 | \$778 | \$858,580 | \$111,945 | Project is complete. Final completion report is outstanding. | |
| C06M31A ARROW: Burbot Life - OR DM | \$67,022 | \$56,092 | \$778 | \$56,870 | \$10,152 | | |
| C06M31A ARROW: Burbot Life - OR Imp | \$903,503 | \$801,710 | | \$801,710 | \$101,793 | | |
| C06M32A ARROW:Tributary Fish | \$439,574 | \$368,344 | \$778 | \$369,122 | \$70,452 | Project is complete. Final completion report is outstanding. | |
| C06M32A ARROW:Tributary Fish - OR DM | \$81,842 | \$45,132 | \$778 | \$45,910 | \$35,932 | | |
| C06M32A ARROW:Tributary Fish - OR Imp | \$357,732 | \$323,212 | | \$323,212 | \$34,520 | | |
| C06M36A ARROW & KIN: Nest | \$4,256,071 | \$3,542,144 | \$397,171 | \$3,934,315 | \$321,756 | Efficiencies found in the project | |
| C06M36A ARROW & KIN: Nest - OR DM | \$204,722 | \$125,233 | \$28,845 | \$149,078 | \$55,644 | | |
| C06M36A ARROW & KIN: Nest - OR Imp | \$4,051,349 | \$3,416,911 | \$368,326 | \$3,785,237 | \$266,112 | | |
| C06M37A ARROW & KIN: Amphib | \$1,166,608 | \$932,071 | \$179,903 | \$1,111,974 | \$54,634 | Efficiencies found in the project | |
| C06M37A ARROW & KIN: Amphib - OR DM | \$127,889 | \$78,212 | \$20,453 | \$98,665 | \$29,224 | | |
| C06M37A ARROW & KIN: Amphib - OR Imp | \$1,038,719 | \$853,859 | \$159,450 | \$1,013,309 | \$25,410 | | |
| C06M39A ARROW: Neotropical | \$2,150,992 | \$1,776,898 | \$233,630 | \$2,010,528 | \$140,464 | Efficiencies found in the project | |
| C06M39A ARROW: Neotropical - OR DM | \$189,932 | \$129,265 | \$4,815 | \$134,081 | \$55,851 | | |
| C06M39A ARROW: Neotropical - OR Imp | \$1,961,060 | \$1,647,633 | \$228,815 | \$1,876,448 | \$84,612 | | |
| C06M40A ARROW: Shore&Wat | \$2,890,326 | \$2,306,225 | \$280,063 | \$2,586,288 | \$304,038 | Efficiencies found in the project | |
| C06M40A ARROW: Shore&Wat - OR DM | \$189,388 | \$148,021 | \$7,554 | \$155,575 | \$33,813 | | |
| C06M40A ARROW: Shore&Wat - OR Imp | \$2,700,938 | \$2,158,203 | \$272,510 | \$2,430,713 | \$270,225 | | |
| C06M41A ARROW: Recreation | \$755,561 | \$707,513 | \$9,000 | \$716,513 | \$39,048 | Project is complete. Final completion report is outstanding. | |
| C06M41A ARROW: Recreation - OR DM | \$71,661 | \$45,729 | | \$45,729 | \$25,932 | | |
| C06M41A ARROW: Recreation - OR Imp | \$683,900 | \$661,784 | \$9,000 | \$670,784 | \$13,116 | | |
| C06M58A ARROW Amphibs & Rep | \$497,676 | \$349,578 | \$93,574 | \$443,152 | \$54,524 | Efficiencies found in the project | |
| C06M58A ARROW Amphibs & Rep - ONR DM | \$68,894 | \$18,555 | \$19,477 | \$38,032 | \$30,862 | | |
| C06M58A ARROW Amphibs & Rep - ONR Imp | \$428,782 | \$331,023 | \$74,097 | \$405,120 | \$23,662 | | |

OR - Ordered Remissible
ONR - Ordered Non-Remissible

* Red values in parentheses denote overage.