Report Title: Winter Rating Curve Survey - 2004-2005 Lower Athabasca River Habitat Surveys

Working Group: Surface Water Working Group (SWWG)

Final/Approved Report Date: 2007

Contract Number: 2005-0002

CEMA Disclaimer

Contract Name: Winter Rating Curve Survey – 2004-2005 Lower Athabasca River Habitat Surveys

Consultant Name: Northwest Hydraulics Consultants

This report was commissioned by the Instream Flow Needs Task Group of the Surface Water Working Group of the Cumulative Environmental Management Association (CEMA), in its tasks of developing a water management framework for the lower Athabasca River (LAR). Specifically, this report was intended to describe 2004-2005 LAR habitat surveys..

This report has been completed in accordance with the terms of reference issued by the Instream Flow Needs Task Group. The Surface Water Working Group has closed this project and considers this report final.

The Surface Water Working Group and its task groups does not fully endorse all of the contents of this report, nor does the report necessarily represent the views or opinions of CEMA or the Surface Water Working Group or any of its Task Groups Members.

The conclusions and recommendations contained within this report are those of the consultant, and have neither been accepted nor rejected by the Surface Water Working Group and its Task Groups.

Until such time as the Surface Water Working Group issues correspondence confirming acceptance, rejection, or non-consensus regarding the conclusions and recommendations contained in this report, they should be regarded as information only.

For more information please contact CEMA at 780-799-3947.

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Project Number: 1-6576
Contract Number: 2005-0002

May 31, 2005

Cumulative Environmental Management Association
Wood Buffalo Region
Box 5656
Fort McMurray, Alberta, T9H 3G6
Attention: Project Officer

Dear Sir or Madam:

RE: Winter Rating Curve Survey, 2004-2005
Lower Athabasca River Habitat Surveys

We have completed our winter rating curve measurements for the winter of 2004-05 as part of the Lower Athabasca River Fish Habitat Survey Program. These water level and ice thickness measurements were carried out at the upstream and downstream ends of each of the four study reaches established for the Program. The rating curves are required as boundary conditions for the flow simulations which will be carried out at these sites to evaluate fish habitat. The following report describes the data collection methodology, summarizes the results and compares the results with those from the 2003-2004 surveys.

If you have any questions or comments about this report, please call me at 780-436-5868.

Sincerely,

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Introduction

The Lower Athabasca River Fish Habitat Survey Program established four survey study reaches where two-dimensional flow simulations were to be carried out to evaluate fish habitat. Winter rating curves were required at the upstream and downstream cross sections of these reaches to establish boundary conditions for the flow simulations. Water level and ice thickness measurements were carried out previously at these eight cross section sites three times in the winter of 2003-04. This measurement program was carried out again in the winter of 2004-05.

The following report describes the data collection methodology and rating curves developed from the 2004-05 water level and ice thickness measurement program and compares the results with those from the 2003-2004 winter rating curve surveys. Data from other sources were also incorporated into the rating curve analysis.

Methodology

The data was collected at the upstream and downstream cross section sites of each of the four survey reaches during the winter of 2004-2005. Reach 2 is located near the Embarras Airstrip, Reach 3 is near the reserve land at Poplar Point, Reach 4 is near the Bitumount historical site and Reach 5 is near the Northlands Sawmill. The eight sites were visited three times over the course of the winter, during Dec 14-16, Feb 1-3, and Mar 8-10. During each site visit 9 to 11 holes were drilled through the ice across the river so that depth, water level and ice thickness could be measured. Water depth and ice thickness were established to ±0.005 m accuracy by direct reading of a submerged survey rod. Depth of the submerged portion of the ice was also measured to establish the position of the ice relative to the water level.

After these measurements were completed, the elevation difference between the water level and a benchmark was established using a survey level and rod. The existing upstream (XS01) and downstream (XS12) cross section pins established during the summer reach surveys were used as benchmarks.

Extreme conditions prevented access to the some of the sites at various times. Helicopter access to the two sites at Reach 3 (Poplar Point) in Dec 15-16, 2004 was not possible due to very poor visibility. Deep snow combined with significant amounts of water on the ice made it impossible to travel on the ice to the two Reach 4 (Bitumount) sites and the upstream site at Reach 5 (Northlands) on Feb 3, 2005

2004-05 Rating Curve Measurements

The water levels, ice thicknesses and bottom-of-ice elevations measured at the eight sites in 2004-05 are summarized in Table 1. Approximate geodetic elevations have been reported where available. These elevations are surveyed to the same datum as the bathymetric surveys. Water level changes over the winter measurement period ranged from 0.01 m at Reach 4 (Bitumount) to

0.39 m at Reach 2 (Embarras). Ice thicknesses varied from 0.38 to 0.57 m during the first set of measurements but varied from 0.66 to 0.98 m by the third set of measurements.

The discharges at the time the water level measurements were determined from direct discharge measurements reported by Water Survey of Canada (WSC) for the Athabasca River below Fort McMurray (07DA001). Flows were not adjusted for tributary inflows because discharges from gauged tributaries between the McMurray gauge and Embarras are not measured during winter. These ungauged inflows are expected to be quite small, probably only a few percent of the total flow. As well, winter discharges do not vary rapidly with time so the discharges measured at the gauge were adopted as the discharges for the associated week of measurements.

The measured discharges are listed in Table 1 along with the water level and ice data. The discharge ranged from 184 m^3/s on Dec 20 to 200 m^3/s on Mar 9. The discharge on Jan 25 was 187 m^3/s.

Bottom-of-ice Elevations from other Sources

Additional bottom-of-ice elevations were obtained from sources other than the winter rating curve measurement program. This additional data is summarized in Table 2 along the data from both years of the winter rating curve measurements. Winter survey measurements collected in 2003-04 at Reaches 4 and 5 provided some additional data; however, this data was collected at discharges similar to those which occurred during the winter water level measurement. Winter survey measurements at Reach 2 in 2004-05 also provide additional data but the discharge estimates for this period are preliminary. Other data are available from a previous study on river mixing carried out during a low flow period in the winter of 2002-03 (Trillium, 2003).

Bottom-of-ice elevations are available near the upstream section at Reach 4 (Bitumount) from the river mixing study carried out in the winter of 2002-03 (Trillium, 2003). The benchmark for this previous study was referenced to the present benchmark during the summer survey at Reach 4. The discharge at the time of the previous measurement was very low, only 88 m^3/s. The bottom-of-ice elevation corresponding to this discharge is shown in Figure 3 along with the other data and rating curves for this site.

The measured bottom-of-ice elevation from the previous study is about 0.2 m below the adopted winter rating curve developed from the survey data from the present study. This deviation is within the range of deviations from the winter rating curve for the other rating curve data but suggests that the winter rating curve may slightly over predict bottom-of-ice elevation at very low flows.

A comparison of cross section data from the two studies at the location of the cross-section from the previous study (winter section 3-7) is shown in Figure 5. This comparison indicates that while the bed elevations on the right side of the channel are similar, the bed elevations on the left side of the channel were 2.5 m lower in 2002-03 than they were in 2003-04. The significantly lower bed elevations likely contributed to the lower that predicted bottom-of-ice elevation at this

site in 2002-03. However, even with this significant change in bed elevation the bottom-of-ice elevation predicted by the rating curve is only 0.2 m above the measured bottom-of-ice elevation.

Other water level data from the river mixing study may be applicable to two other rating curves, one at Reach 3 upstream and the other at Reach 5 downstream; however, the benchmarks from the previous study must first be referenced to the present survey benchmarks. This can be done next fall or winter during the next scheduled visits to these sites.

Rating Curves

In winter, the water levels change in response to changes in ice thickness as well as changes in discharge. Rating curves in winter must, therefore, account for the growth in ice thickness over time in order to be valid for periods other than the measurement period. The bottom-of-ice elevation is independent of the ice thickness; and, thus is a better parameter than water level for developing winter rating curves. Actual water levels can then be determined by adding a given submerged ice thickness to the bottom-of-ice elevation.

The variations of bottom-of-ice elevation with discharge are shown for each reach in Figures 1 to 4 along with the other bottom-of-ice elevations available. Best-fit (least-squares) power functions of the data are provided to indicate the trends in the data. There are some significant deviations from the trend lines at some of the sites. These deviations are not related to survey error since the bed elevations are consistent for measurements on different dates in the same winter. The deviations may be due to changes in roughness of the bottom of the ice or to differences in discharge between the WSC measurements and the actual local discharge. At present, the daily discharge record from the WSC gauge is preliminary and the tributary inflows are unknown so it is not possible to refine the local discharge estimates.

The rating curves adopted for two-dimensional flow modeling at Reaches 4 and 5 are also shown in Figures 3 and 4. These rating curves were developed from a one-dimensional flow model using surveyed cross sections. Bed roughness was calibrated using 2004 summer water level measurements and ice roughness calibrated using the 2003-04 winter bottom-of-ice elevations measured during the winter surveys of the reaches. These adopted rating curves were found to provide reasonable estimates of bottom-of-ice elevations for the range of measured discharges; however, the trends indicated by the data are steeper than the trends indicated by the rating curves.

The one-dimensional flow model used to develop the rating curves was calibrated assuming no bed movement and using a constant ice roughness; however, bed elevation or ice roughness may vary with discharge. Bottom-of-ice measurements over a wider range of discharges are required before these effects can be incorporated into the one-dimensional flow model. The measurements are limited to discharges ranging from 139 to 200 m^3/s (except for one site where data was available at a discharge of 88 m^3/s) while the rating curve is used for discharges ranging from 50 to 600 m^3/s. Further measurements are required during higher and lower flow winters to extend

the data range; however, the range of measurements is constrained by the flows which occur over the winter.

Conclusions and Recommendations

The data indicates that the rating curves developed from the one-dimensional flow model provide a reasonable estimate of bottom-of-ice elevations, but these estimates may be less reliable at very low and very high flows. Further data collection is recommended to collect bottom-of-ice elevations over a wider range of discharge.

Additional data at two locations may also be obtained if benchmarks from a previous study carried out in 2002-03 can be referenced to the habitat survey benchmarks. This survey work can be carried out during scheduled site visits next fall or winter. This previous study was carried out during very flow flows so this information can help validate the rating curves at low flow.

References

Trillium, 2003. Tracer dye studies in the Lower Athabasca River. File Number 03-456. Prepared for the Cumulative Environmental Management Association (CEMA) – Wood Buffalo Region.