Manitoba Hydro

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wvpenner@hydro.mb.ca

2013 05 30

Our file: 00184-07310-0166_00

Mr. R. Matthews, P.Geo.
Manager, Water Use Licensing
Manitoba Conservation &
Water Stewardship
Box 16, 200 Saulteaux Crescent
Winnipeg, MB R3J 3W3

Dear Mr. Matthews:

Re: **2012 WUSKWATIM ANNUAL WATER LEVELS REPORT**

On behalf of the Wuskwatim Power Limited Partnership, enclosed is the first annual Wuskwatim Water Levels Report. The report contains information on data collection, verification, and reporting related to the Water Power Act and Environment Act licenses, as well as a summary of deviations from licence conditions during the year. Please note that full control of Wuskwatim Lake water levels was not attained until September 1st, therefore the 2012 reporting period applies to the last four months of the year only. Subsequent annual reports will span the full length of the year.

If you have any questions or require additional information, please call me at 204-360-3018.

Yours truly,

Original signed by: Wes Penner

W.V. Penner, P.Eng.
Manager
Hydraulic Operations Department

ASK/ljm/00184-07310-0166_00.docx
Encl.

cc: K.R.F. Adams, Chair of the general partner of Wuskwatim Power Limited Partnership

Hydraulic Operations Department, Manitoba Hydro
On behalf of: **Wuskwatim Power Limited Partnership**

WATER POWER ACT & ENVIRONMENT ACT LICENCES 2012 ANNUAL WATER LEVELS REPORT FOR WUSKWATIM GENERATING STATION

Original signed by: Agnieszka Kotula

PREPARED BY: Original signed by: Agnieszka Kotula
A. S. KOTULA

REVIEWED BY: Original signed by: Brian Giesbrecht
B. W. GIESBRECHT

APPROVED BY: Original signed by: Wes Penner
W. V. PENNER

DATE: 2013-05-30

REPORT NO: PS&O 13-02

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EXECUTIVE SUMMARY

During the 2012 reporting period from September 1 to December 31, Wuskwatim Generating Station (GS) licence constraints were met 98.36% of the time.

The reporting period start date of September 1, 2012 marks the completion of channel improvements between Wuskwatim Lake and the Wuskwatim GS and the achievement of Wuskwatim Lake level control. All references to water levels on Wuskwatim Lake or Birchtree Lake during 2012 pertain to this reporting period.

Manitoba Hydro operates the Wuskwatim GS on behalf of Wuskwatim Power Limited Partnership in accordance with the Water Power Act and Environment Act licences issued by the Province of Manitoba. These licences constrain the water level on Wuskwatim Lake, and the rate of change in water level on Birchtree Lake.

Environment Act Licence No. 2699 for Wuskwatim GS requires an annual water level report for each calendar year. This report addresses all water level constraints imposed by both the Water Power Act and Environment Act licences. The report contains information on data collection, validation, and reporting, as well as a summary of licence compliance violations during the year.

Manitoba Hydro obtained all necessary water level data from the hydrometric databases to prepare this report. Data were processed to analyze water conditions at licence specific locations during the 2012 reporting period. Licence limit violations were identified by evaluating water levels against licence limits.

There were two recorded instances of licence limit violations during 2012. The maximum mean daily water level on Wuskwatim Lake exceeded the licence limit of 234.0 m on October 15 and 16 by 0.01 m. The reason for the occurrence of these events was an error in station alarms setting. Station alarm settings were corrected and the events reported in to Manitoba Conservation and Water Stewardship.

In summary, water levels deviated outside the licence limits 1.64% of the time as follows.

Date	Location	Constraint	Variable
October 15, 2002	Wuskwatim Lake	Max Elevation	Mean Daily Water Level
October 16, 2002	Wuskwatim Lake	Max Elevation	Mean Daily Water Level

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APPENDICES

1.0 INTRODUCTION

1.1 Background

Wuskwatim Power Limited Partnership (WPLP) is a legal entity involving Nisichawayasihk Cree Nation (NCN) and Manitoba Hydro, which developed and now owns the Wuskwatim Generating Station (GS). Manitoba Hydro operates the station as part of the Manitoba power grid on behalf of WPLP.

WPLP received licences under the Water Power Act and the Environment Act for the development of the Wuskwatim GS. The Interim Water Power Act licence stipulates a maximum and minimum allowable water level on Wuskwatim Lake. The Environment Act Licence No. 2699 stipulates a maximum and minimum water level on Wuskwatim Lake, a maximum daily change in water level on Birchtree Lake, as well as monthly and annual reporting requirements. This report fulfills the annual reporting requirement of Environment Act Licence No. 2699.

Manitoba Hydro, in collaboration with Manitoba Conservation and Water Stewardship, prepared the Wuskwatim GS Licence Implementation Guide for Water Levels to establish and document the water regime terms specified by the Wuskwatim licences. The Licence Implementation Guide forms the basis for content of this report, is included as Appendix II, and provides the following details:

- calculation methodology to be used for determining critical levels,
- protocol for reporting to meet licence requirements, and
- manner in which compliance will be defined and assessed.

1.2 Objective

The objective of this report is to report on Wuskwatim GS licence compliance by summarizing the Water Power Act and Environment Act licence requirements and providing the relevant water level data for the 2012 reporting period. In the case of any licence violation, this report provides the reason for the violation, actions taken to prevent such an event from occurring in the future, and proof of regulator notification.

1.3 Outline

Section 1.0 contains the introduction to the report, including background information on licence and reporting requirements, objective and outline of the report. Following the introduction is section 2.0, which provides the Wuskwatim GS project location and description. Section 3.0 summarizes the water level data collection process including data transfer, storage and validation. Section 4.0 includes information about data sources, definition of compliance, and compliance reporting. Section 5.0 describes the data analysis used to prepare this report, includes a summary table of deviations from licence constraints during the 2012 calendar year, and provides reasons for any licence deviations. Section 6.0 summarizes major system upgrades

or changes during the 2012 calendar year, and finally Section 7.0 provides conclusions and closure to the report.

Appendix I provides copies of relevant correspondence with Manitoba Conservation and Water Stewardship related to licence violations and the compliance report issued during the 2012 reporting period. Appendix II contains a copy of the Licence Implementation Guide, which contains all required background information related to the definitions of compliance and compliance reporting.

The enclosed CD contains final water level data for Wuskwatim Lake and Birchtree Lake used in the preparation of this report.

2.0 WUSKWATIM GENERATING STATION

2.1 Project Location

The Wuskwatim Generating Station is located on the Burntwood River, in the Nelson House Resource Management Area, approximately 56 km southwest of Thompson, 35 km southeast of Nelson House, or approximately 830 km north by road from Winnipeg. The geographical location of the station is shown in Figure 1. A photograph of the station is shown in Figure 2. A general arrangement of the site is shown in Figure 3.

2.2 Project Description

The Wuskwatim Generating Station consists of a 3-unit powerhouse with a nameplate capacity of 209 MW, gravity dams and embankment structures, and a 3-bay spillway with heated gates. Tables 1 and 2 summarize the operating parameters and construction specifications of the Wuskwatim Generating Station.

Wuskwatim units were commissioned between June and October of 2012, making it the newest generating station in Manitoba and the first in operation on the Burntwood River.

Table 1: Construction Specifications and Operating Parameters of the Wuskwatim Generating Station

Construction Period	2006 to 2012
Licensed Capacity	210 MW
2012 Generation	556 million kW-h
Waterfall Drop (head)	21.4 m
Maximum Licence Forebay Elevation	234.0 m
Minimum Licence Forebay Elevation	233.75 m

Table 2: Principal Structures for the Wuskwatim Generating Station

Powerhouse	Number of Units	3
	Length	75 m
	Discharge Capacity (at full gate)	1,100 m^3/s
	Power Production	3 units @ 69.7 MW/unit TOTAL = 209 MW
Spillway	Number of Bays	3
	Total Length	43.0 m
	Discharge Capacity (Wuskwatim L. @ 234.0 m)	2,310 m^3/s
Dams	Material	Impervious fill and granular fill
	Crest Elevation	236.69 – 237.80 m

The reservoir at Wuskwatim Generating Station has a total area of 88.41 km^2 and a fetch length of approximately 1.88 km. There is a 0.1 m drop between the reservoir level on Wuskwatim Lake and the forebay level of the station. The reservoir normal maximum water level is 234.0 m while the forebay normal maximum water level is 233.9 m. The incremental flooded area due to the project is 0.37 sq. km allowing the majority of the reservoir and forebay to be contained by natural river banks and minimizing the need for dykes.

As the only generating station on the Burntwood River, Wuskwatim's inflow is largely dependent on the Churchill River Diversion, as controlled by the Notigi Control Structure. The generating station operates in a daily cycling mode within the allowed 0.25 m water level range on Wuskwatim Lake.

The operators and maintenance personnel of the Wuskwatim Generating Station are located on site. Support and technical services are also located in the nearby city of Thompson.

3.0 DATA COLLECTION

3.1 Water Level Gauges

Hydraulic Operations staff compiled data from 5 remote water level gauges located on Wuskwatim Lake, and 4 remote water level gauges located on Birchtree Lake to evaluate licence compliance for the 2012 reporting period. The locations of the water level gauges as well as the gauge description sheets are contained in the Licence Implementation Guide appendices. Manitoba Hydro uses the recorded water level data to measure compliance with the licence conditions as they apply to hourly and mean daily water levels (with wind and wave effects eliminated) on Wuskwatim Lake, and daily average water level changes on Birchtree Lake.

3.2 Data Transmission and Storage

Manitoba Hydro remote gauges on Wuskwatim and Birchtree Lakes, use pressure transducers and data loggers to send water level data to satellites operated by the National Oceanic and Atmospheric Administration (NOAA). NOAA sends the signal to DOMSAT, a domestic communications satellite operated by NOAA. Manitoba Hydro servers retrieve the data from DOMSAT using a data collection system (DCS) Toolkit. The DCS Toolkit is auto-collection software that sends the data to the hydrometric database operated by Hydraulic Operations. The hydrometric database is accessible to all internal departments within Manitoba Hydro.

Water level data from remote locations is collected and published according to the procedures and Quality Control Assurance processes established by Water Survey of Canada. Real-time data is available but it is not recognized as official. Final data, or published data is generated through several levels of reviews to verify compliance with applicable standards and includes recognition of the impact of other related environmental and contextual factors.

Figure 4 shows the data transmission and storage process for remote gauge water level data used in the preparation of this report.

4.0 WATER POWER ACT AND ENVIRONMENT ACT DATA REPORTING

4.1 Monitoring & Reporting Process

As required by Clause 33 of Environment Act Licence No. 2699, an annual water level report for each calendar year, must be provided to Manitoba Conservation and Water Stewardship. This report uses final data only from the required water level gauges based on three levels of internal review. The annual report also contains any compliance reports issued in the 2012 reporting period. Due to the quality assurance processing time, this report is issued by June 1 of the following year.

4.2 Data Sources

The water level data used in preparing this report was obtained from the Manitoba Hydro hydrometric database which contains water level data of various time steps including real-time (5-minute interval), hourly, daily average and mean daily (with wind and wave effects eliminated) data. Hourly water level and flow data from Wuskwatim can be used in determining the operational impact of the project on Birchtree Lake in case the Birchtree Lake daily change in water level exceeds the licence limit.

4.3 Compliance

Section 4.2 of the Wuskwatim Interim Water Power Act licence states that:

> *The Licensee shall not raise the headwaters of its development above an elevation of 234.0 metres ASL as measured on Wuskwatim Lake, except as ordered by the Minister under Clause 72(b) of the Water Power Regulation or as fixed by the Minister under Clause 72(c) of the Water Power Regulation.*

Clause 30(a) of Environment Act Licence No. 2699 states that the Licensee shall operate the Development within the following parameters:

> *Maintain the mean daily water level on Wuskwatim Lake (wind and wave effects eliminated) between 233.75 meters and 234.0 meters Above Sea Level (ASL), as determined by measurements from a minimum of three water level monitoring stations on Wuskwatim Lake.*

Clause 30(b) of Environment Act Licence No. 2699 states that the Licensee shall operate the Development within the following parameters:

> *Maintain mean daily water levels on Birchtree Lake such that the daily water level variations shall be less than 0.10 meters and 0.15 meters in open water and winter conditions (wind and wave effects eliminated) respectively. Any exceptions to these fluctuations shall be reported within one week to Manitoba Water Stewardship.*

4.4 Compliance Reporting

Compliance for Wuskwatim GS has been defined, and agreed upon with Manitoba Conservation and Water Stewardship using the maximum and minimum water level limits stated by the Water Power Act and Environment Act licences. More precisely the Wuskwatim Lake water level shall be in compliance with the upper limit defined by both licences if:

1. The Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated) does not exceed 234.0 meters, and
2. The Wuskwatim Hourly Water Level does not exceed 234.1 meters more than two times for two consecutive hours each time in any 24 hour period.

Furthermore, the Wuskwatim Lake water level is in compliance with the lower limit defined by both licences if:

1. The Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated) does not recede below 233.75 meters, and
2. The Wuskwatim Hourly Water Level does not recede below 233.65 meters more than two times for two consecutive hours each time in any 24 hour period.

For the purpose of licence compliance at Birchtree Lake, open water will refer to the period from May 1 to October 31 and winter will refer to the period from November 1 to April 30. The Birchtree Lake Daily Change in water level is in compliance when:

1. The Birchtree Lake Daily Change is below these seasonal limits, or
2. The Birchtree Lake Daily Change is above these seasonal limits but the change attributable to Wuskwatim Generating Station is below these seasonal limits.

In the event that the Wuskwatim Lake or Birchtree Lake water levels are not in compliance with the licence limits as described above, notification will be made to Manitoba Conservation and Water Stewardship within one week of the incident. A follow up compliance report on causes contributing to the event and changes to operations, if any will also be provided.

WPLP publishes monthly and annual compliance reports on its web site at www.wuskwatim.ca.

5.0 SUMMARY OF FINDINGS

5.1 Data Analysis

Water level data was analyzed to prepare charts outlining water conditions at Wuskwatim Lake and Birchtree Lake during the 2012 reporting period. All readings were evaluated against licence limits to identify violations based on the definition of licence compliance given in Section 4.4.

Wuskwatim Lake Hourly Water Level, Wuskwatim Lake Mean Daily Water Level, and Birchtree Lake Daily Water Level Change is shown in Figure 5, 6, and 7 respectively, for the 2012 reporting period. The reporting period start date of September 1 marks the completion of channel improvements between Wuskwatim Lake and the Wuskwatim GS and the achievement of Wuskwatim Lake level control. As of September 1, 2012, only 2 out of the station's 3 generating units were commissioned and operational. The third unit was commissioned and operational on October 6, 2012.

5.2 Licence Violations

During the 2012 reporting period, there were 2 (out of a possible 3172) recorded instances of water levels outside of the licence limits that were reported to Manitoba Conservation and Water Stewardship. The maximum number of possible instances was calculated as the sum of instances pertaining to each licence constraint and was based the station operating from September 1 to December 31. Each licence constraint yields the following number of possible instances:

- Maximum/Minimum Mean Daily Water Level on Wuskwatim Lake – 122 days of possible instances,
- Maximum/Minimum Hourly Water Level on Wuskwatim Lake – 122 days * 24 hours = 2928 possible instances, and
- Maximum Daily Water Level Change on Birchtree Lake – 122 days.

Table 3 shows a breakdown of licence limit violations for Wuskwatim Lake and Birchtree Lake for the 2012 reporting period. The Hydraulic Operations Department investigated the licence violations to determine the reasons for their occurrence. Copies of correspondence notifying Manitoba Conservation and Water Stewardship of these events are included in Appendix I of this report.

Table 3: Wuskwatim Generating Station, Water Power Act and Environment Act Licences: Summary of Events for the reporting period of 2012

Date	Location	Constraint	Variable
October 15, 2002	Wuskwatim Lake	Max Elevation	Mean Daily Water Level
October 16, 2002	Wuskwatim Lake	Max Elevation	Mean Daily Water Level

5.3 Licence Violations Explanation

The Wuskwatim mean daily water level (with wind and wave effects eliminated) exceeded the upper licence limit of 234.0 m on October 15 and 16, 2012 by 0.01 m. There is a 0.1 m difference in water level between Wuskwatim Lake and Wuskwatim Generating Station forebay that was not accounted for in the station alarm setting. Wuskwatim GS adjusted the alarms to account for the water level difference in order to better track water levels on Wuskwatim Lake and to prevent this event from occurring again.

6.0 MAJOR SYSTEM UPGRADES/CHANGES

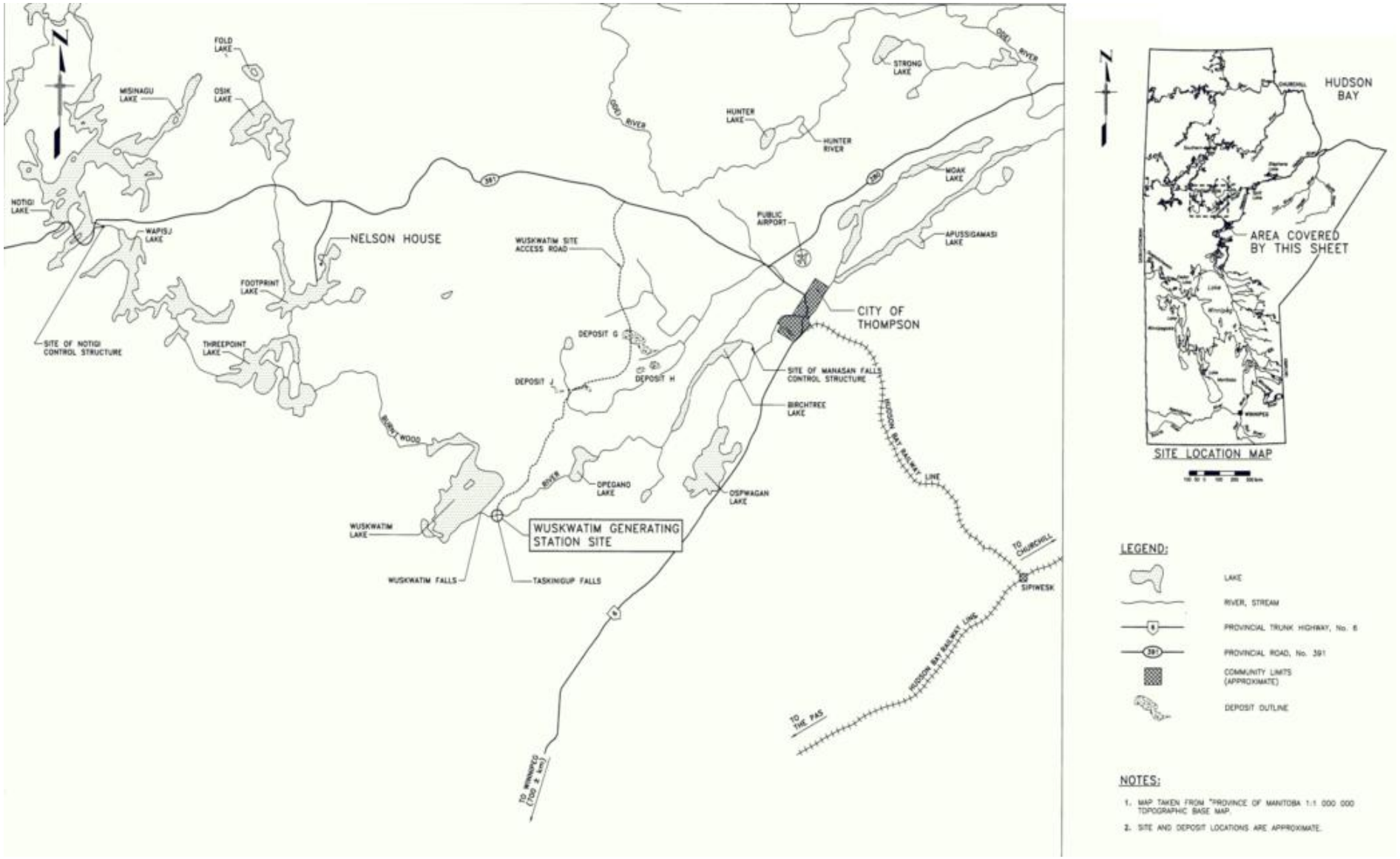
Maintenance and construction activities that occurred during the 2012 calendar year include:

- Unit #1 was commissioned and put into commercial service on June 22, 2012 with a nameplate rating of 69.7 MW.
- Unit #3 was commissioned and put into commercial service on August 22, 2012 with a nameplate rating of 69.7 MW.
- Unit #2 was commissioned and put into commercial service on October 6, 2012 with a nameplate rating of 69.7 MW.

7.0 CONCLUSIONS & CLOSURE

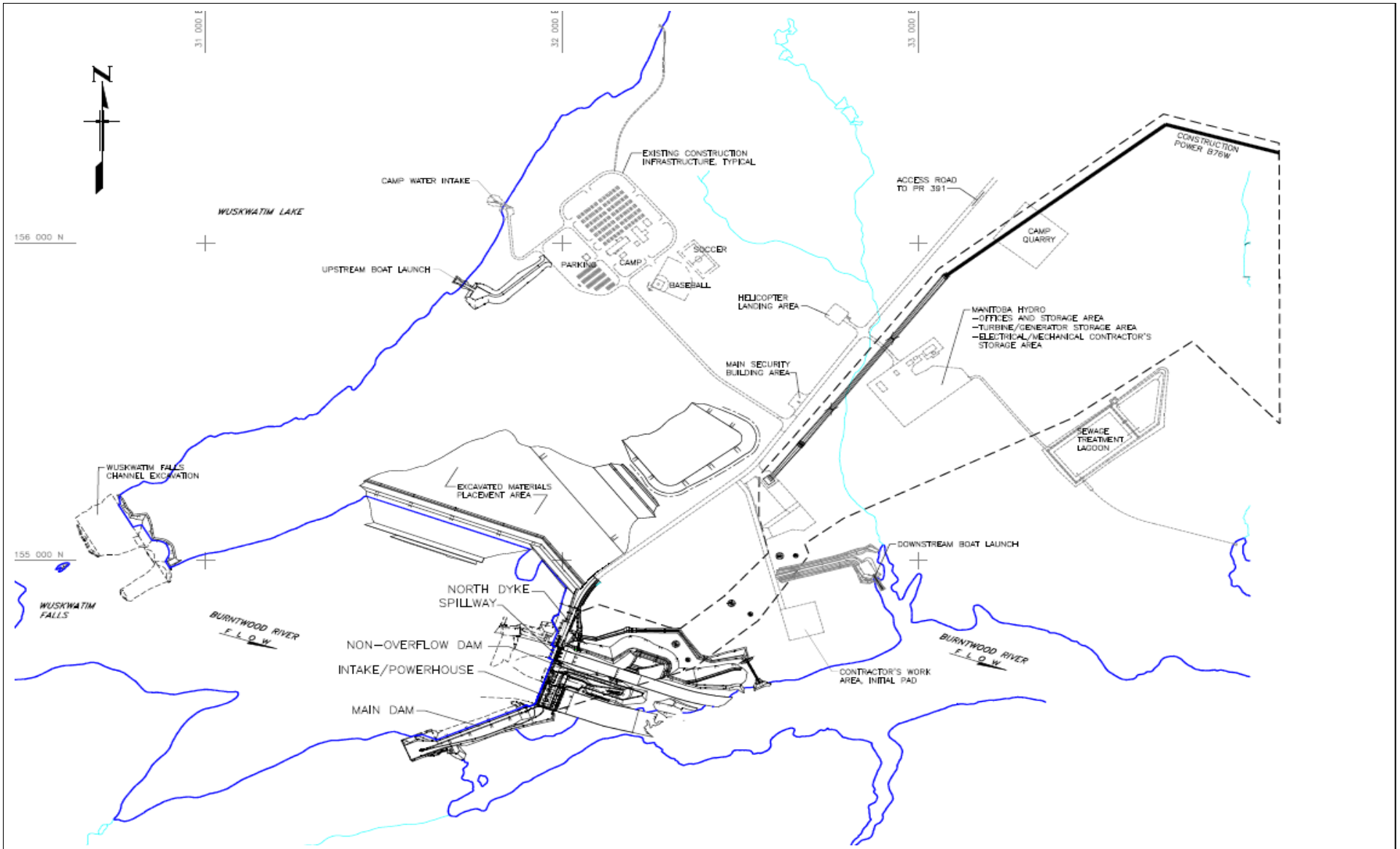
During the September 1 to December 31, 2012 reporting period, there were 2 instances when water levels deviated from the Water Power Act and Environment Act licence limits. Water levels were in compliance with the licences 98.36% of the time.

Manitoba Hydro continues to operate the Wuskwatim Generating Station in accordance with the Interim Licence under the Water Power Act for the development of water power at the Wuskwatim Site on the Burntwood River and Environment Act Licence No. 2699.

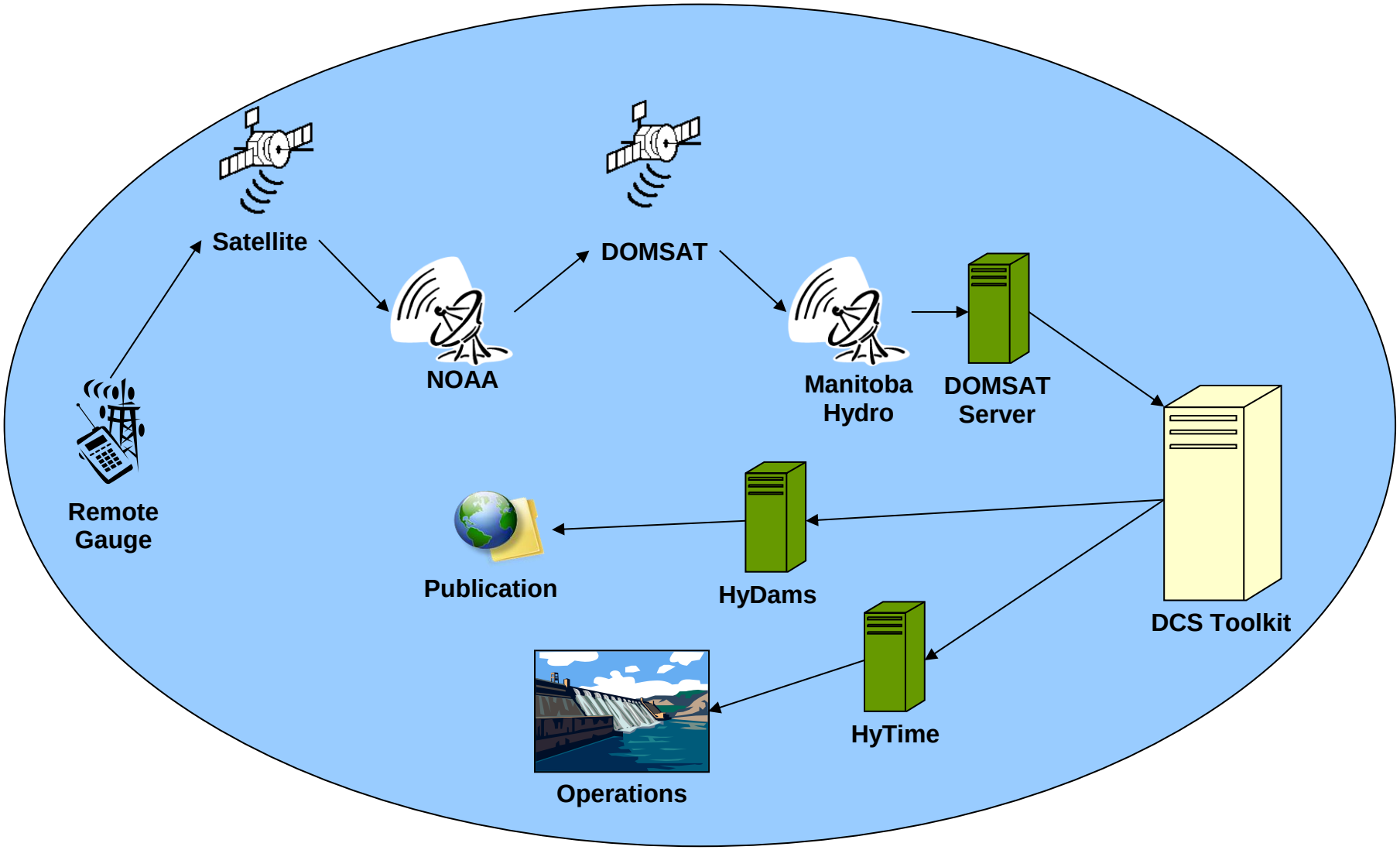


Manitoba Hydro	MANITOBA HYDRO	
	HYDRAULIC OPERATIONS DEPARTMENT	
	WUSKWATIM GENERATING STATION	
DRAWN BY ASK	LOCATION MAP	
YEAR 2013	PROJECT ANNUAL WATER LEVEL REPORT	FIGURE 1

Manitoba Hydro	MANITOBA HYDRO	
	HYDRAULIC OPERATIONS DEPARTMENT	
	WUSKWATIM GENERATING STATION	
DRAWN BY ASK	PHOTOGRAPH OF GENERATING STATION	
YEAR 2013	PROJECT ANNUAL WATER LEVEL REPORT	FIGURE 2

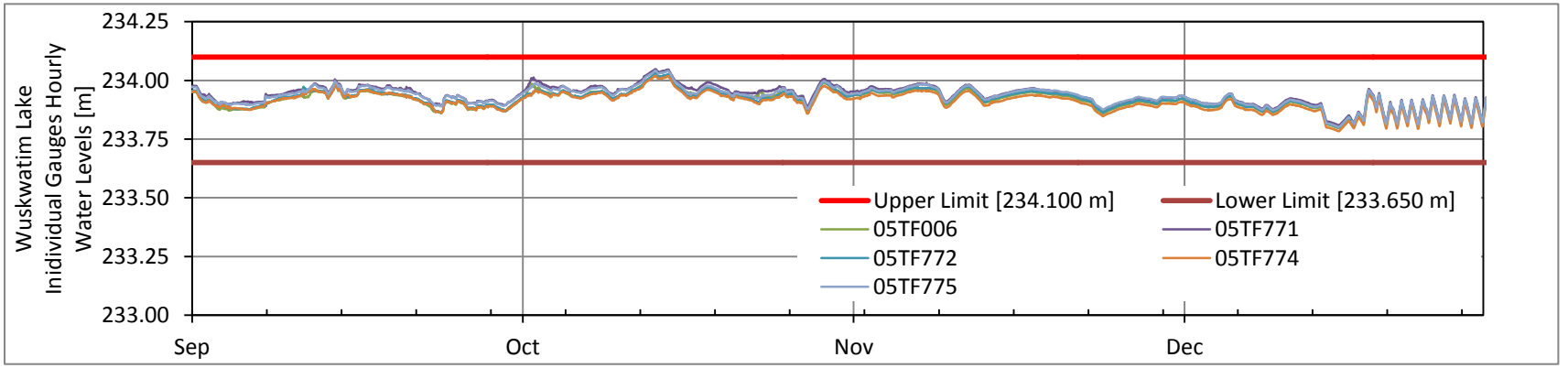


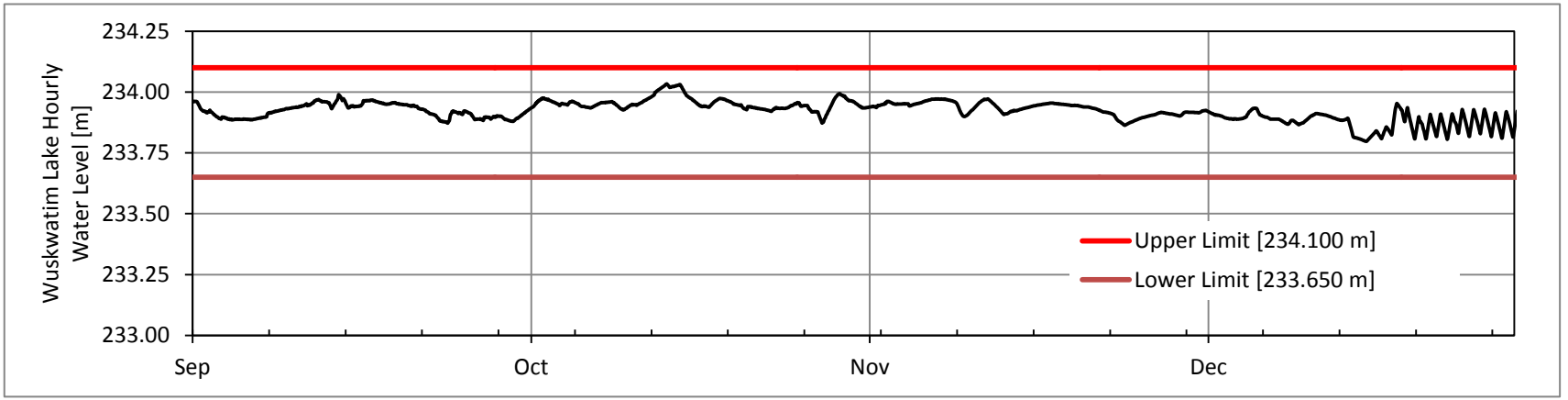
Manitoba Hydro	MANITOBA HYDRO	
	HYDRAULIC OPERATIONS DEPARTMENT	
	WUSKWATIM GENERATING STATION	
DRAWN BY ASK	GENERAL ARRANGEMENT	
YEAR 2013	PROJECT ANNUAL WATER LEVEL REPORT	FIGURE 3



Manitoba Hydro	MANITOBA HYDRO
	HYDRAULIC OPERATIONS DEPARTMENT
	HYDROLOGIC DATA ACQUISITION AND MANAGEMENT SYSTEM
	REMOTE DATA PROCESS MAP
YEAR 2013	PROJECT ANNUAL WATER LEVEL REPORT — FIGURE 4

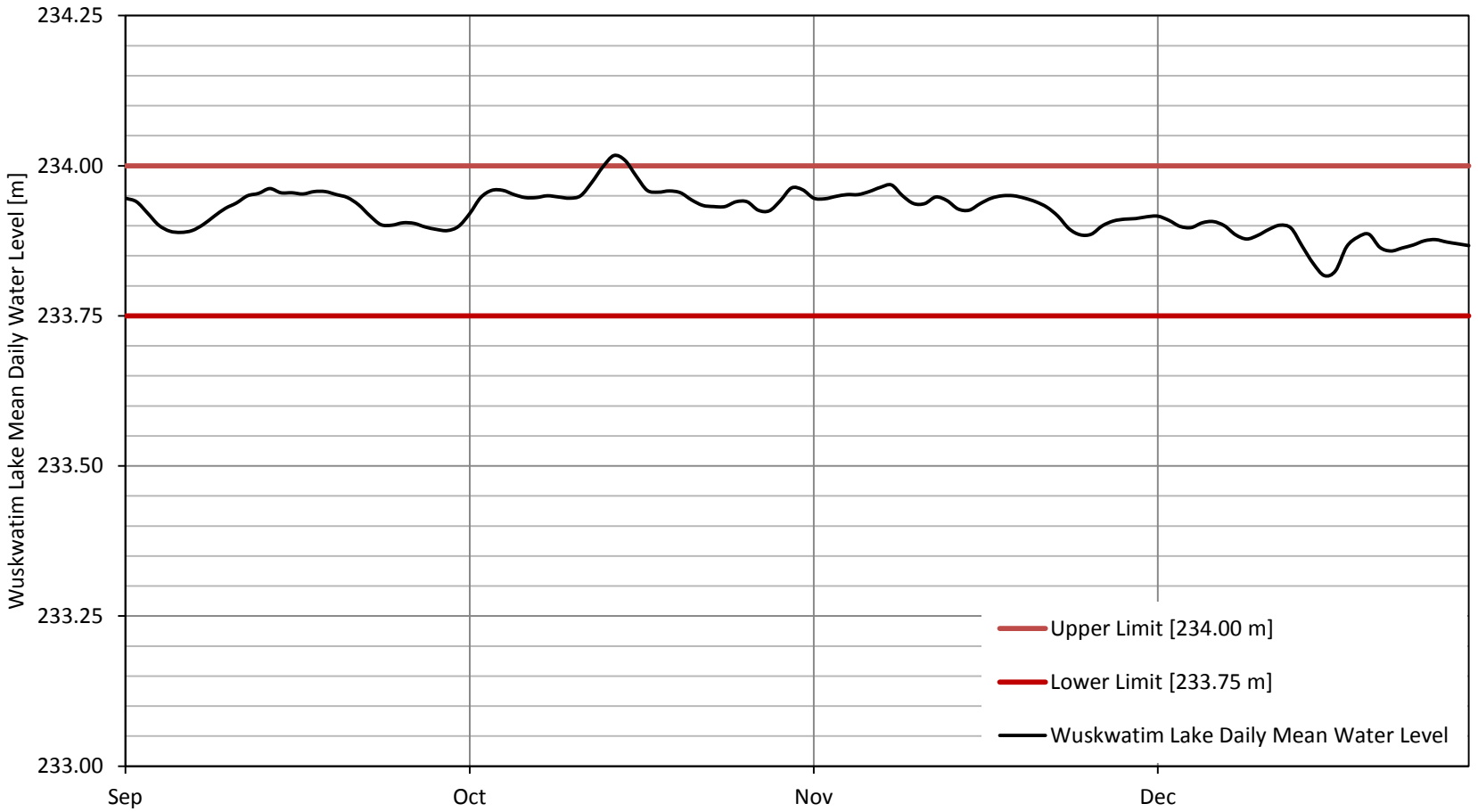
Wuskwatim Generating Station - Wuskwatim Lake Hourly Water Levels
Compliance Report for 2012





Manitoba Hydro	MANITOBA HYDRO	
	HYDRAULIC OPERATIONS DEPT.	
	WUSKWATIM GENERATING STATION	
DRAWN BY ASK	WUSKWATIM LAKE HOURLY WL (2012)	
YEAR 2013	PROJECT ANNUAL WATER LEVEL REPORT	FIGURE 5

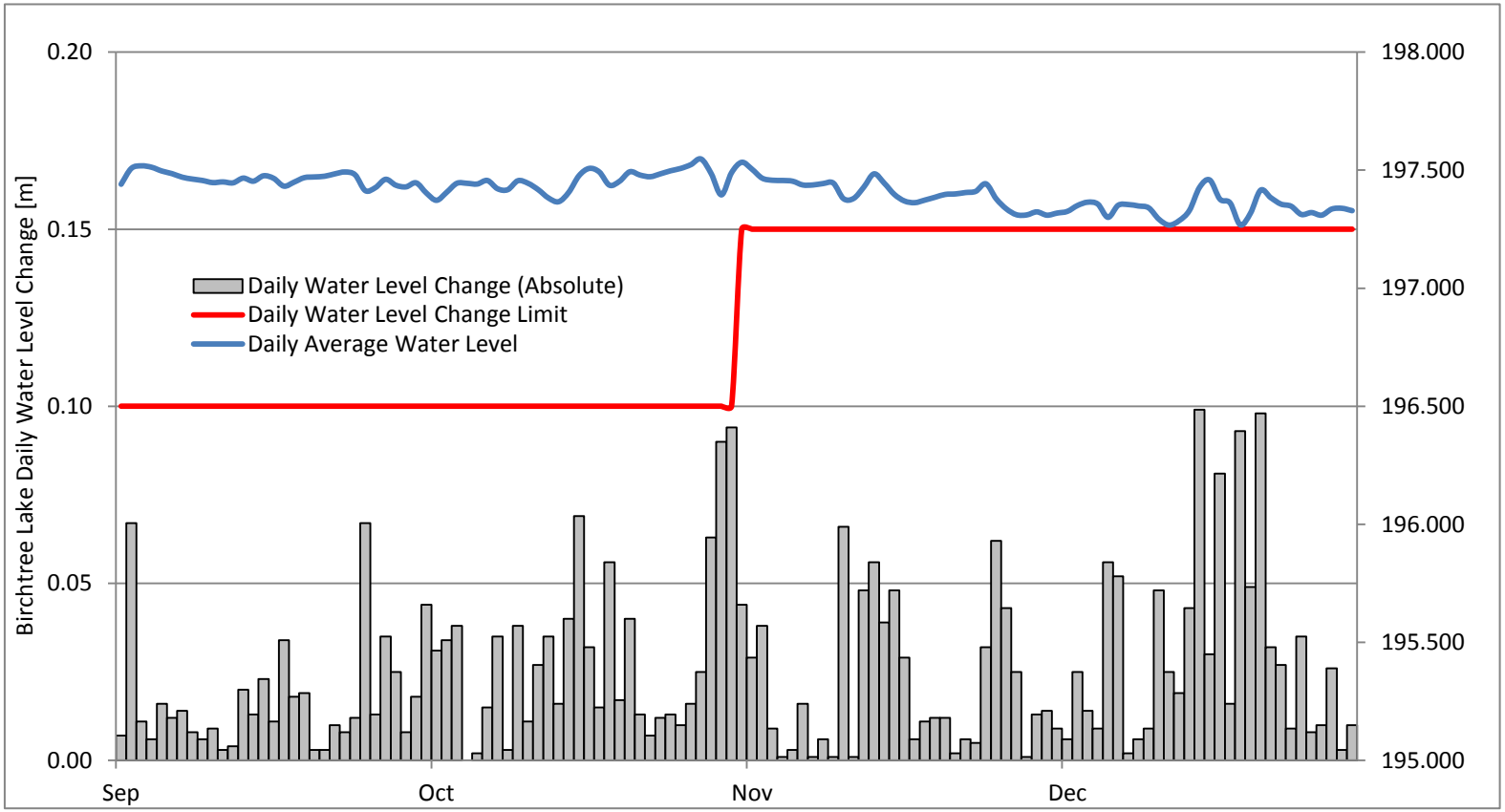
Wuskwatim Generating Station - Wuskwatim Lake Mean Daily Water Level Compliance Report for 2012



Note:
Wuskwatim Lake Mean Daily Water Level is calculated using Wuskwatim Lake gauges 05TF006, 05TF771, 05TF772, 05TF774, & 05TF775

Manitoba Hydro	MANITOBA HYDRO	
	HYDRAULIC OPERATIONS DEPT.	
	WUSKWATIM GENERATING STATION	
DRAWN BY ASK	WUSKWATIM LAKE MEAN DAILY WL (2012)	
YEAR 2013	PROJECT ANNUAL WATER LEVEL REPORT	FIGURE 6

Wuskwatim Generating Station - Birchtree Lake Daily Water Level Change Compliance Report for 2012



Note:
The Birchtree Lake Daily Water Level Change is calculated using Birchtree Lake gauges 05TG701, 05TG707, 05TG746, & 05TG747
The daily water level change limit is equal to 0.1 m in open water conditions (May 1 to October 31) and 0.15 m in winter conditions

Manitoba Hydro	MANITOBA HYDRO	
	HYDRAULIC OPERATIONS DEPT.	
	WUSKWATIM GENERATING STATION	
DRAWN BY ASK	BIRCHTREE LAKE DAILY WL CHANGE (2012)	
YEAR 2013	PROJECT ANNUAL WATER LEVEL REPORT	FIGURE 7

APPENDIX I

CORRESPONDANCE WITH MANITOBA CONSERVATION AND WATER STEWARDSHIP REGARDING LICENCE LIMIT VIOLATIONS

Manitoba Hydro

P.O. Box 815 • Winnipeg Manitoba Canada • R3C 2P4
Telephone / *Nº de téléphone :* (204) 360-3018 • Fax / *Nº de télécopieur :* (204) 360-6136
wvpenner@hydro.mb.ca

2012 11 09

Our file: 00184-07311-0010_00

Mr. R. Matthews, P. Geo.
Manager, Water Use Licensing
Manitoba Conservation and Water Stewardship
Box 11 - 200 Saulteaux Crescent
Winnipeg, MB R3J 3W3

Dear Mr. Matthews:

Re: **WUSKWATIM GENERATING STATION – WATER POWER AND ENVIRONMENTAL ACT LICENCES – DAILY AVERAGE LAKE LEVEL ABOVE LICENCE LIMIT**

The following is an explanation of the events that caused the level of Wuskwatim Lake to rise above the licence limit specified in Article 4 of the Wuskwatim Water Power Act Licence and Clause 30 of the Environmental Act Licence No. 2699 for two days.

The Wuskwatim mean daily water level (with wind and wave effects eliminated) exceeded the upper licence limit of 234.0 metres on October 15 and 16, 2012 by 0.01 metres (Figure 1). Wuskwatim hourly water levels remained within the licence compliance limits (Figure 2). There is a 0.1 metre difference between Wuskwatim Lake and Wuskwatim Generating Station forebay water levels that was not accounted for in the station alarms (Figure 2). Station high and low water level alarms are based on the forebay water level measured at the station. Wuskwatim Generating Station has adjusted the alarms to account for the water level difference in order to prevent these circumstances from occurring again.

If you have any further questions related to this incident, please call me at 204-360-3018.

Yours truly,

Original signed by: *Wesley Penner*

W.V. Penner, P.Eng.
Manager
Hydraulic Operations Department

JST/ljm/00184-07311-0010_00.docx
Att.

bc: G.W. Ratushniak
T.J. Armstrong

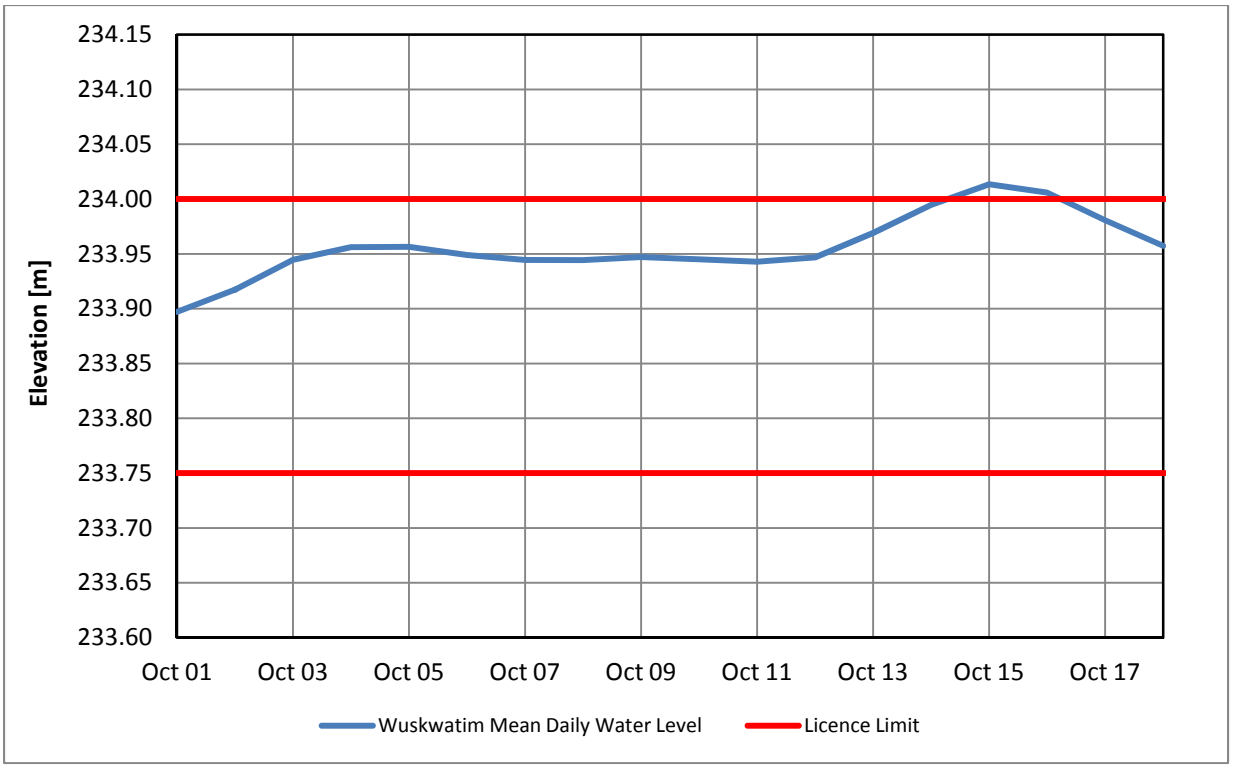


Figure 1: Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated)

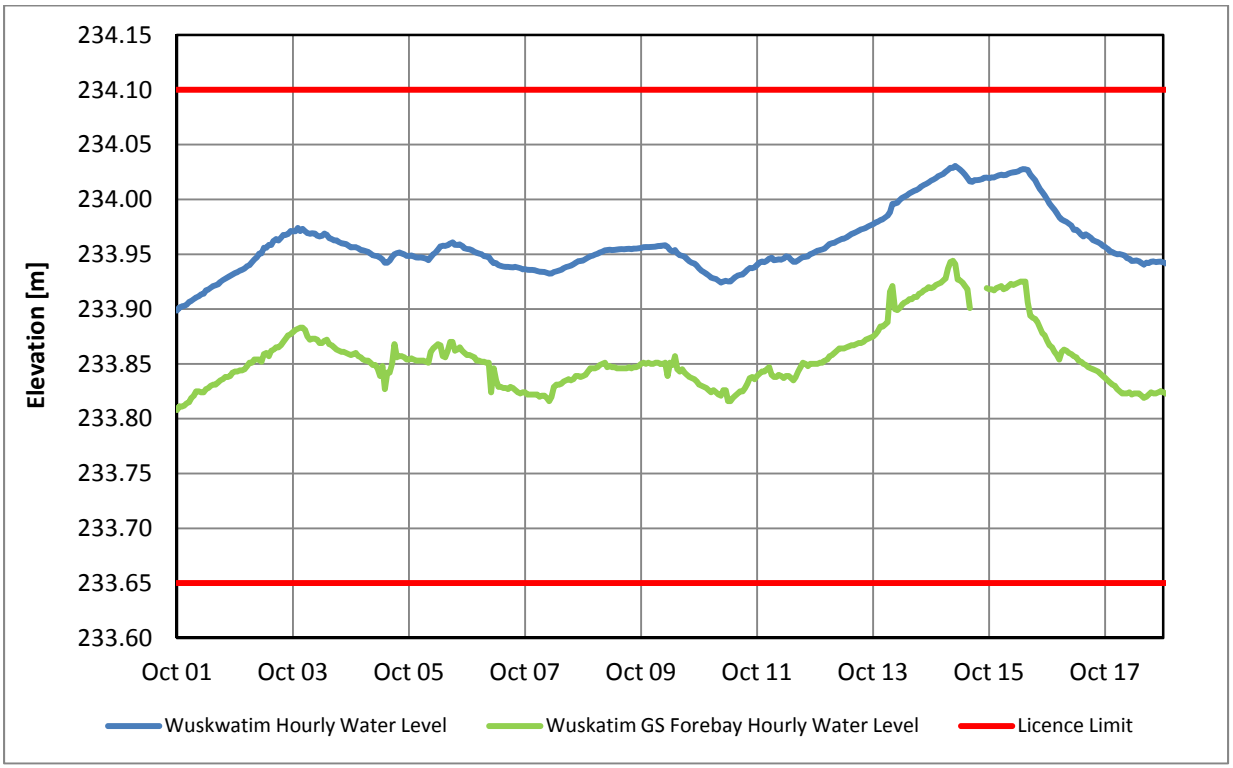


Figure 2: Wuskwatim Hourly Water Levels and GS Forebay Hourly Water Levels

Manitoba
Conservation and Water Stewardship

Box 16, 200 Saulteaux Crescent
Winnipeg MB R3J 3W3
CANADA

http://www.gov.mb.ca/waterstewardship/

December 3, 2012

File: 53.1.5

	WVP	
	MPB	
	KDG	
✓	BWG	
✓	MJD	
✓	PGC	
✓	HJE	
	LJM	
✓	File	184

0731

Mr. W. V. Penner, P. Eng.
Manager
Hydraulic Operations Department
Manitoba Hydro
P.O. Box 815
Winnipeg, MB R3C 2P4

RECEIVED
DEC 0 6 2012
HYDRAULIC OPERATIONS DEPARTMENT

Dear Mr. Penner:

Re: WUSKWATIM GENERATING STATION
Water Power and Environmental Act Licences – Daily Average Wuskwatim Lake Level Above Licence Limit

This correspondence is in response to your letter dated November 9, 2012 (with attachment) regarding an explanation of the events that occurred on October 15 and 16, 2012 which resulted in a rise in the forebay water level at the Wuskwatim Generating Station above the upper limit as specified in the station's Interim Water Power Licence.

I understand that the Wuskwatim mean daily water level rose above the licence limit of elevation 234.0 m for two consecutive days, peaking at an elevation of 234.01 m. This excursion occurred because a 0.1 metre difference between Wuskwatim Lake and the forebay was not accounted for. I note that necessary adjustments were made to the high and low water level alarms to prevent this from occurring again.

Thank you for providing an explanation of why forebay levels at the station exceeded the licence limit and for the chart attached to your letter. Please include a reference to this event in your 2012 Annual Water Levels and Flows Report.

If you have any questions, please feel free to contact Puru Singh any time at 204-945-3613, or email at Purushottam.Singh@gov.mb.ca.

Yours Truly,

Rob Matthews
Manager
Water Use Licensing Section

c: D. Williamson, P. Singh

APPENDIX II

WUSKWATIM GENERATING STATION LICENCE IMPLEMENTATION GUIDE FOR WATER LEVELS

Wuskwatim Power Limited Partnership
Wuskwatim Generating Station
Licence Implementation Guide for Water Levels

Prepared for:
Manitoba Water Stewardship
200 Saulteaux Crescent
Winnipeg, Manitoba R3J 3W3

Prepared by:
Hydraulic Operations Department
Manitoba Hydro
820 Taylor Avenue
Winnipeg, Manitoba R3C 2P4

On behalf of:
Wuskwatim Power Limited Partnership
820 Taylor Avenue
Winnipeg, Manitoba R3C 2P4

July 2007

Report No. PS&O 07/03

Wuskwatim Power Limited Partnership
Wuskwatim Generating Station
Licence Implementation Guide for Water Levels

PREPARED BY: B.W. GIESBRECHT

REVIEWED BY: W.V. PENNER

NOTED BY: T.M. MILES

DATE: 2007 07 03

REPORT NO: PS&O 07/03

APEGM
Certificate of Authorization
Manitoba Hydro
No. 38 Date: 2007 07 05

Foreword

Wuskwatim Power Limited Partnership (WPLP) has been issued licences under the Environment Act and The Water Power Act for the development of the Wuskwatim Generating Project.

The WPLP is a limited partnership of which 5022649 Manitoba Ltd., a wholly owned subsidiary of Manitoba Hydro, is the general partner and Manitoba Hydro and Taskinigahp Power Corporation, wholly owned by Nisichawayasihk Cree Nation, are limited partners.

The WPLP has entered in contracts with Manitoba Hydro for the management, construction and operation of the Wuskwatim generating station in accordance with the provisions of the applicable agreements as set out in the Project Development Agreement between Nisichawayasihk Cree Nation and Manitoba Hydro. Consistent with responsibilities set out in these agreements, Manitoba Hydro has prepared this report on behalf of the WPLP.

Executive Summary

Introduction
In collaboration with Manitoba Water Stewardship, Manitoba Hydro prepared this guideline to document a common understanding of the water regime terms of the Wuskwatim licences. Environment Act Licence No. 2699 and an Interim Water Power Act licence specify operating limits and reporting requirements that must be met for compliance with the licences. As such, this document sets out the mutually understood and agreed to:

- calculation methodology to be used for determining critical levels,
- protocol for reporting to meet licence requirements, and
- manner in which compliance will be defined and assessed.

Wuskwatim Lake
As required by licence, data from a minimum of three water level gauges will be used to determine the Wuskwatim Lake level. A set of averaging and weighting techniques are employed to remove immediate operational effects and the effects of wind and waves.

Birchtree Lake
As required by licence, data from a minimum of two water level gauges will be used to calculate the daily change on Birchtree Lake. Weighting and averaging techniques are used to remove the effect of wind and waves.

Compliance
Compliance with the licence on Wuskwatim Lake will be measured against both hourly water levels and wind-eliminated water levels. In the event that the Birchtree Lake daily change licence constraint is exceeded, a hydraulic model of the Burntwood River will be

used to determine the change attributable to Wuskwatim operations. Compliance with the Environment Act licence will be measured against the model output.

Monthly and annual reports will be issued to Manitoba Water Stewardship in accordance with the Environment Act licence. Special compliance reports will be issued as necessitated by deviations from licence conditions.

Change Management

Revisions to this Implementation Guide are anticipated to accommodate the change from pre-project monitoring to construction to plant operation. Proposed revisions will be discussed with Manitoba Water Stewardship from time to time. Following review and approval of revisions by Manitoba Water Stewardship, a revised copy of this Implementation Guide will be produced and distributed by Wuskwatim Power Limited Partnership.

A five year window is included in the Environment Act licence to review the appropriateness of the included water level parameters. This review window recognizes that the licence parameters are based on model simulations and that measured data may differ from what was anticipated.

Table of Contents

1. Introduction

1.1 Definitions

For the purposes of this implementation guide, unless the context otherwise requires, the following terms shall have the respective meanings set out below and grammatical variations of such terms shall have corresponding meanings:

ASL means above sea level;

Controlling Benchmarks means:

(a) Manitoba Hydro benchmark BM L20A-1 (85MH2H) for Wuskwatim Lake. This benchmark is a brass cap set in bedrock located along the south shore of Wuskwatim Lake approximately 250 metres northeast of the centre of Wuskwatim Falls. The elevation of this benchmark was established by precise spirit leveling methods from GSC benchmark 69M592 located near Taskinigup Falls. The elevation of benchmark BM L20A-1 is 247.380 metres, GSC CGVD28, 1969 local adjustment

(b) Birchtree Lake benchmarks were established by static GPS methods constrained on GSC benchmarks 69M587 (205.226 metres) located just west of Birchtree Lake at Pipe Lake mine, on 69M575 (208.656 metres) located west of Birchtree Lake along PTH #6 and on Hydro 2 located on the Burntwood River upstream of Opegano Lake. This geodetic control effectively surrounds Birchtree Lake and allows for accurate benchmarks to be established on Birchtree Lake.

Birchtree Lake Gauges means the water level gauges established on Birchtree Lake for the purpose of collecting data used in calculating the **Birchtree Lake Hourly Water Level**;

Birchtree Lake Daily Average Water Level means the arithmetic mean of all hourly water levels recorded at the **Birchtree Lake Gauges** for a calendar day;

Birchtree Lake Daily Change means the difference in the **Birchtree Lake Daily Average Water Level** between one calendar day and the previous calendar day;

Wuskwatim Lake Gauges means the water level gauges established on Wuskwatim Lake for the purpose of collecting data used in calculating the **Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated)**;

Wuskwatim Hourly Water Level means the weighted average of available readings of water levels recorded from the top of one hour to the top of the following hour at the **Wuskwatim Lake Gauges,** calculated as set forth in Section 2.2;

Wuskwatim Daily Average Water Level means the arithmetic mean of all **Wuskwatim Hourly Water Level**s for a calendar day;

Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated) means a three day moving mean of the **Wuskwatim Daily Average Water Level**.

1.2 Datum

In accordance with Clause 30(d) of Environment Act Licence No. 2699 and Section 10.3 of the Wuskwatim Site, Burntwood River Interim Water Power Act licence, water level information for the operation of the Wuskwatim Project is based upon Geodetic Survey of Canada (GS of C), Canadian Government Vertical Datum (CGVD) 1928, 1971 Local Adjustment (also referred to as GS of C CGVD28, 1969 Local Adjustment).

1.3 Water Levels and Water Level Fluctuations

All water levels referenced in this implementation guide are to be inferred as measured in terms of elevations **ASL**, GS of C CGVD28 1971 Local Adjustment. All water levels and water level fluctuations referenced in this implementation guide are to be inferred as measured excluding the effects of wind and waves.

1.4 Quality Control

1.4.1 Benchmarks

Vertical control surveys have been performed to establish appropriate local benchmarks around Wuskwatim Lake and Birchtree Lake at hydrometric gauging stations.

Wuskwatim Lake benchmarks were established by water level transfer from **Controlling Benchmarks** using spirit leveling methods and staff gauge readings. These benchmarks are accurate to ± 10mm.

Vertical control on Birchtree Lake did not meet the required standards for long term water level monitoring. Therefore, elevations for the new benchmarks were established using static GPS methods from **Controlling Benchmarks** in the region. The Birchtree Lake benchmarks are accurate to ± 50 mm, a typical error associated with using GPS survey methods.

1.4.2 Direct water level measurements

Field staff will visit the **Wuskwatim Lake Gauges** and the **Birchtree Lake Gauges** on a two month cycle as a minimum. Additional site visits will be conducted as necessary to maintain gauge performance. Direct water level measurements are taken during these visits and compared to the level indicated by the water level sensor. Direct water level measurements for lakes of this size are typically accurate to within ±5 mm with the instrument error accounting for ±0.8 mm.

1.4.3 Gauge readings

Manitoba Hydro uses pressure transducers to determine water levels at its existing hydrometric gauging stations and at the **Wuskwatim Lake Gauges** and the **Birchtree Lake Gauges**. The error in the reading provided by the pressure transducer is ±0.75 mm given the scale setting that is typically used by Manitoba Hydro. The transducers are temperature corrected, however, if the temperature correction malfunctions, the reading can drift between site visits by up to 0.1 metres, although drift of this magnitude is rare. If the technician visiting the site determines that the transducer reading is more than ±5 mm different from the direct water level measured in accordance with Subsection 1.4.2, the transducer is reset to the direct water level measurement. If the transducer reading is less than ±5 mm different from the direct water level measured in accordance with Subsection 1.4.2, no change is made to the transducer setting.

1.5 Quality assurance procedure for water level data

Water level data exists in three degrees of quality assurance – raw, provisional and final.

Raw data is real-time data that has been transmitted from the field. The only level of quality assurance is that built in to the data collection system, described in Section 1.4. This level of data is used in the daily operation of the Wuskwatim Generating Station. This level of data is also reported monthly in accordance with Subsection 4.3.3 of this guide.

Provisional data is data processed by a qualified data assurance technician who reviews the field data and corrects obvious errors. The data is compared to all available relevant data in the area to verify its accuracy.

Final data has been through two levels of review by qualified technicians and a final review by a professional engineer. This data is considered publishable and has met the quality assurance standards of the National Hydrometric Program. This data will be used for annual reporting described in Subsection 4.3.4 of this guide

2. Wuskwatim Lake

2.1 Gauge location criteria

In accordance with Clause 30(a) of Environment Act Licence 2699, a minimum of three water level gauges will be used in determining the water level of Wuskwatim Lake. Six test locations for the **Wuskwatim Lake Gauges**, shown in Figure 1, have gauges installed temporarily for the purpose of collecting and analyzing water level data. Detailed gauge descriptions are included in Appendix A. From the six test locations, final locations will be selected for the **Wuskwatim Lake Gauges**. Final gauge locations will be in spots that exhibit a minimum variation in water level due to wind speed and direction.

2.2 Wuskwatim Wind-Eliminated Water Level calculation procedure

Clause 30(a) of Environment Act Licence No. 2699 and Section 4.2 of the Interim Water Power Act licence place limits on Wuskwatim Lake water levels. Wuskwatim Lake water levels will be influenced by Wuskwatim operations. Water levels will also be affected by local meteorological events and non-project hydraulic effects. Significant local weather impacts can result from heavy precipitation, the movement of high and low pressure cells and large wind events. Non-project hydraulic impacts may result from upstream storage and release of water caused by changing ice conditions, operation of Notigi Control Structure, rapid spring runoff. To properly evaluate the wind-eliminated water level, averaging techniques are used to remove these effects. Small, short-term weather and hydraulic events can be smoothed out using multiple gauges, gauge weighting and a daily average water level. Larger, long-term events require a longer duration averaging technique. For a lake of this size, a three-day moving mean is appropriate.

In order to ensure that the Licensee's operations remain within the constraints of its licences, compliance will be measured against both the **Wuskwatim Hourly Water Level** and the **Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated)**.

2.2.1 Hourly averaging and weighting

The **Wuskwatim Lake Gauges** will be set to record spot water levels from which the hourly average water level at each gauge location will be calculated. The hourly average water levels from each of the **Wuskwatim Lake Gauges** will be used to determine the **Wuskwatim Hourly Water Level** as shown in Equation 1. The **Wuskwatim Hourly Water Level** is one measure of compliance with Environment Act Licence 2699 and the Interim Water Power Act licence as discussed in Section 4.1, below.

$$HAWL = \sum_{n} \left(W_n G_n \right) \qquad [1]$$

where

$HAWL$ = **Wuskwatim Hourly Water Level**
G_n = hourly average water level for **Wuskwatim Lake Gauge** n
W_n = weighting factor for **Wuskwatim Lake Gauge** n

and

$$\sum_n W_n = 1$$

Weights are assigned in inverse proportion to the standard deviation of each **Wuskwatim Lake Gauge**'s recorded water levels from the **Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated)**. Tables of current weighting factors are included in Appendix B.

Weights will be reviewed regularly and a table of current weights will be included in each annual compliance report.

2.2.2 Three-day moving average

As an intermediate step in determining the **Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated)**, the **Wuskwatim Daily Average Water Level** will be calculated as the arithmetic mean of the **Wuskwatim Hourly Water Level**s as shown in Equation 2.

$$DAWL = \frac{\sum_{i=1}^{n} HAWL_i}{n} \qquad [2]$$

where

$DAWL$ = the **Wuskwatim Daily Average Water Level**
$HAWL_i$ = the **Wuskwatim Hourly Water Level** for hour i
n = the number of available hourly readings for that calendar day

A three-day moving average as shown in Equation 3, will be applied to the **Wuskwatim Daily Average Water Level** data stream to produce the **Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated)**.

$$WEWL_i = \frac{DAWL_{i-2} + DAWL_{i-1} + DAWL_i}{3} \qquad [3]$$

where

$WEWL_i$ = **Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated)** for day i
$DAWL_i$ = **Wuskwatim Daily Average Water Level** for day i

3. Birchtree Lake

3.1 Gauge location criteria

In accordance with Clause 30(c) of Environment Act Licence 2699, a minimum of two water level gauges will be used in determining the **Birchtree Lake Daily Change** for the purpose of licence compliance. In addition to Manitoba Hydro gauge 05TG701 already located on Birchtree Lake, three more test locations for the **Birchtree Lake Gauges**, shown in Figure 2, have gauges installed temporarily for the purpose of collecting and analyzing water level data. Detailed gauge descriptions are located in Appendix A. The final **Birchtree Lake Gauges** will be the ones that exhibit a minimum variation in water level due to wind speed and direction.

3.2 Method to determine magnitude of project impacts on Birchtree Lake Daily Change

Clause 30(b) of Environment Act Licence No. 2699 limits mean daily water level variations on Birchtree Lake to 0.10 metres under open water conditions and 0.15 metres under winter conditions. Water level changes on Birchtree Lake will be affected by Wuskwatim Generating Station operations. Water level changes are also influenced by local meteorological events and by non-project hydraulic effects. The **Birchtree Lake Daily Change** is calculated using the method described in 3.2.1 which attempts to eliminate the effect of wind-driven waves. If the **Birchtree Lake Daily Change** exceeds the limits in Clause 30(b), hydraulic modeling will be completed to estimate the project impact and meteorological and non-project hydraulic impacts will be assessed.

3.2.1 Birchtree Lake Daily Change calculation

Wind and wave effect elimination will be accomplished by calculating a weighted daily average of the water levels recorded by the **Birchtree Lake Gauges** as shown in Equations 4 and 5.

$$BL = \sum_n W_n BG_n \qquad [4]$$

where:

BL = Birchtree Lake hourly water level
W_n = weighting factor for **Birchtree Lake Gauge** n
BG_n = hourly average water level for **Birchtree Lake Gauge** n

and

$$\sum_n W_n = 1$$

$$BLDA = \frac{\sum_{i=1}^{m} BL_i}{m} \qquad [5]$$

where:

BLDA = **Birchtree Lake Daily Average Water Level**
BL_i = Birchtree Lake hourly water level for hour *i*
m = the number of available hourly readings for that calendar day

Weights are assigned in inverse proportion to the standard deviation of each **Birchtree Lake Gauge**'s recorded water levels from the **Birchtree Lake Daily Average Water Level**. Tables of current weighting factors are included in Appendix B.

Weights will be reviewed regularly and a table of current weights will be included in each annual compliance report.

The **Birchtree Lake Daily Change** will be calculated as the absolute difference in **Birchtree Lake Daily Average Water Level** between that calendar day and the previous calendar day as shown in Equation 6.

$$BLDC_j = \left| BLDA_j - BLDA_{j-1} \right| \quad [6]$$

where:

$BLDC_j$ = **Birchtree Lake Daily Change** for calendar day *j*
BLDAj = the **Birchtree Lake Daily Average Water Level** for calendar day *j*

3.2.2 Wuskwatim operational impact determination

As part of the preparation of the Environmental Impact Statement for the Wuskwatim Generating Station, a hydraulic model was developed for the Burntwood River from Wuskwatim Generating Station to First Rapids. In the event that the **Birchtree Lake Daily Change** exceeds 0.10 metres under open water conditions or 0.15 metres under winter conditions, such a model will be used to determine the magnitude of the **Birchtree Lake Daily Change** that is attributable to Wuskwatim Generating Station operations. Actual Wuskwatim outflows preceding such an event will be used as the input hydrograph for the model. The model output will show the impact of Wuskwatim operations on the water level changes recorded on Birchtree Lake.

3.2.3 Meteorological impacts

Local weather can cause an impact on the **Birchtree Lake Daily Change** that is not attributable to Wuskwatim Generating Station operations. Local precipitation can result in a rapid rise of Birchtree Lake water level. The passage of pressure cells can temporarily raise or lower the lake level. Large wind events may produce an effect on water levels that cannot be removed using the weighting technique described in Subsection 3.2.1. Local precipitation data is available from the Environment Canada weather station at Thompson Airport, the Manitoba Hydro weather station at Wuskwatim Generating Station and the Manitoba Hydro weather station at Birchtree Lake. These same weather stations provide atmospheric pressure data and wind speed and direction data. An estimate of the magnitude of the meteorological impact on the **Birchtree Lake**

Daily Change will be made using the model when the **Birchtree Lake Daily Change** exceeds the licence limit.

3.2.4 Non-project hydraulic impacts

Hydraulic impacts caused by factors other than Wuskwatim Generating Station operations can impact the **Birchtree Lake Daily Change**. Such factors include but are not limited to varying upstream storage and release of water caused by ice conditions, varying ice conditions at Manasan Control Structure, operation of the Manasan control structure fuse plug and rapid spring runoff. An estimate of the magnitude of such an impact on the **Birchtree Lake Daily Change** will be made using the model when the **Birchtree Lake Daily Change** exceeds the licence limit.

4. Compliance

4.1 Wuskwatim Lake

Clause 30(a) of Environment Act Licence No. 2699 states that the Licensee shall operate the Development within the following parameters:

> *maintain the mean daily water level on Wuskwatim Lake (wind and wave effects eliminated) between 233.75 meters and 234.0 meters Above Sea Level (ASL), as determined by measurements from a minimum of three water level monitoring stations on Wuskwatim Lake*

Section 4.2 of the Wuskwatim Interim Water Power Act licence states that:

> *The Licensee shall not raise the headwaters of its development above an elevation of 234.0 metres ASL as measured on Wuskwatim Lake, except as ordered by the Minister under Clause 72(b) of the Water Power Regulation or as fixed by the Minister under Clause 72(c) of the Water Power Regulation.*

The forebay level shall be in compliance with the upper limit described above if:

1. The **Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated)** does not exceed 234.0 metres, and
2. The **Wuskwatim Hourly Water Level** does not exceed 234.1 metres more than two times for two consecutive hours each time in any 24 hour period .

The forebay level shall be in compliance with the lower limit described above if:

1. The **Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated)** does not recede below 233.75 metres, and
2. The **Wuskwatim Hourly Water Level** does not recede below 233.65 metres more than two times for two consecutive hours each time in any 24 hour period.

4.2 Birchtree Lake

Clause 30(b) of Environment Act Licence No. 2699 states that the Licensee shall operate the Development within the following parameters:

> *maintain mean daily water levels on Birchtree Lake such that the daily water level variations shall be less than 0.10 meters and 0.15 meters in open water and winter conditions (wind and wave effects eliminated) respectively. Any exceptions to these fluctuations shall be reported within one week to Manitoba Water Stewardship*

For the purposes of licence compliance, open water will refer to the period from May 1 to October 31 and winter will refer to the period from November 1 to April 30. The **Birchtree Lake Daily Change** shall be deemed to be in compliance when:

1. The **Birchtree Lake Daily Change** is below these seasonal limits, or
2. The **Birchtree Lake Daily Change** is above these seasonal limits but the change attributable to Wuskwatim Generating Station is below these seasonal limits.

4.3 Reporting

4.3.1 Compliance Reporting

In the event that the Wuskwatim Generating Station forebay level is not in compliance with the licence limits as described in Section 4.1 above, notification shall be made to Manitoba Water Stewardship within one week of the incident. A follow-up report on causes contributing to the event and changes to operations, if any are needed to prevent such an event in the future, will be provided to Manitoba Water Stewardship.

When the **Birchtree Lake Daily Change** exceeds the open water or winter limit, notification shall be made to Manitoba Water Stewardship within one week of the incident in accordance with Clause 30(b) of Environment Act Licence No. 2699. A follow-up report containing the modeled Wuskwatim-based contribution to the **Birchtree Lake Daily Change** and a discussion of other factors affecting the **Birchtree Lake Daily Change** shall be provided to Manitoba Water Stewardship.

4.3.2 Regular Monthly Reporting

Clause 33 of Environment Act Licence No. 2699 states that:

> *The Licensee shall report, to Manitoba Water Stewardship, on a monthly and annual basis, the water levels monitored pursuant to Clauses 30 (a) and (c) of this Licence including other relevant station and related system operating characteristics. These reports shall also be provided to the Nelson House Resource Management Board, all communities on the Manitoba Hydro Churchill River Diversion Augmented Flow Program notification list and posted on the Manitoba Hydro web site.*

Monthly water level reports will be provided in accordance with Clause 33 of Environment Act Licence No. 2699. These reports will use raw data from the **Wuskwatim Lake Gauges** and the **Birchtree Lake Gauges**. The reports will contain the **Wuskwatim Hourly Water Level** and the **Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated)** calculated in accordance with Section 2.2 and the **Birchtree Lake Daily Change** calculated in accordance with Subsection 3.2.1.

4.3.3 Regular Annual Reporting

An annual water level report for each calendar year will be provided in accordance with Clause 33 of Environment Act Licence No. 2699. This report will use final data from the **Wuskwatim Lake Gauges** and the **Birchtree Lake Gauges.** The report will contain the final **Wuskwatim Hourly Water Level**, the final **Wuskwatim Mean Daily Water Level (with wind and wave effects eliminated)** and the final **Birchtree Lake Daily Change**. The annual report will also contain any compliance reports issued in that year. Due to the quality assurance processing time, this report will be issued by June 1 of the following year.

5. Change Management

5.1 Regular Updates

Revisions to this Implementation Guide are anticipated to accommodate the change from pre-project monitoring to construction to plant operation. Proposed revisions to this Implementation Guide will be reviewed with Manitoba Water Stewardship from time to time. Following review and approval of revisions by Manitoba Water Stewardship, a revised copy of this Implementation Guide will be produced and distributed by Wuskwatim Power Limited Partnership.

5.2 Comprehensive Review

Clause 34 of Environment Act Licence No. 2699 states that:

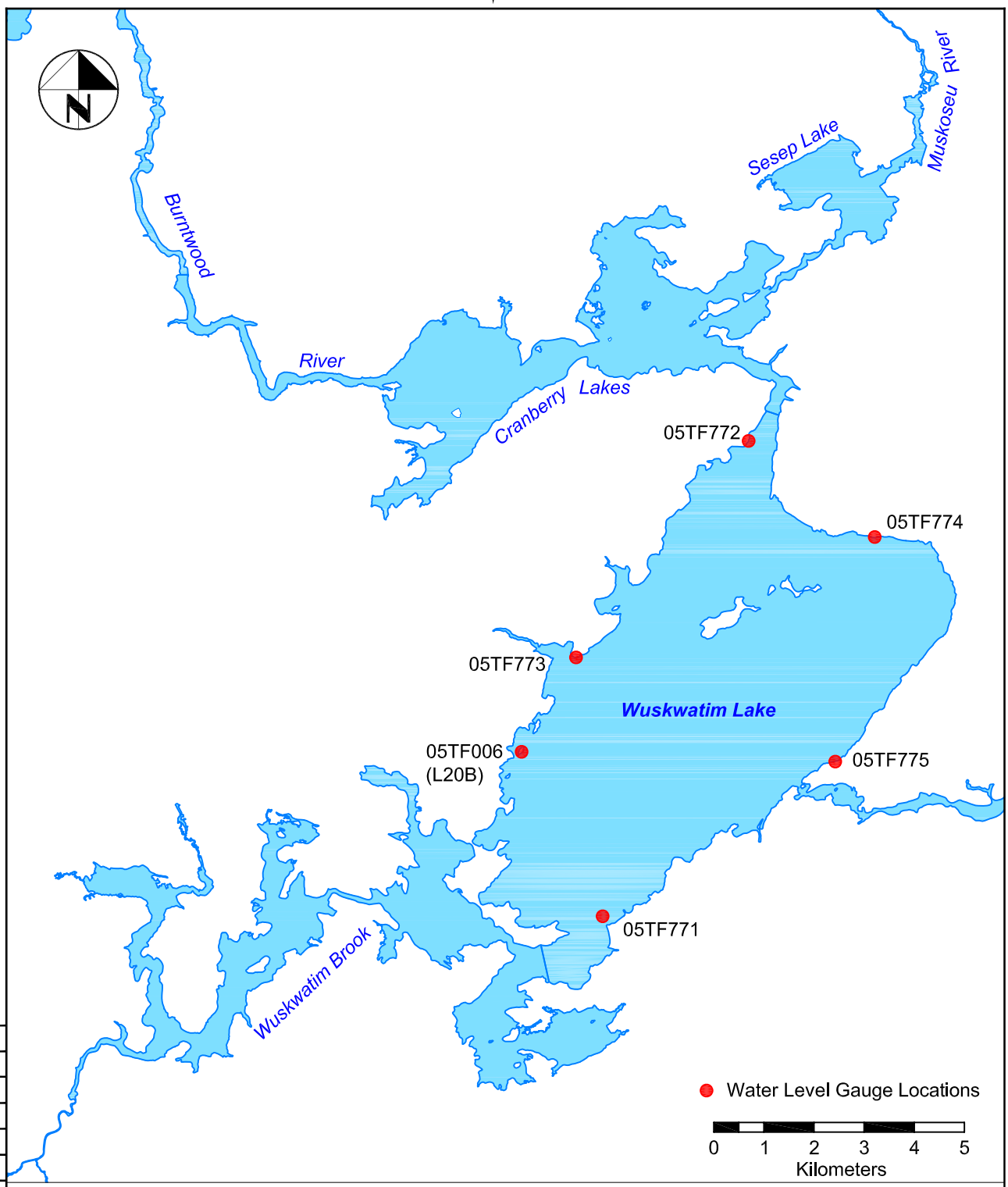
> *The Licensee shall at the commencement of the operation of the Development and for a period of fiver years, unless otherwise directed by the Minister, monitor daily water level variations and the frequency and magnitude of exceedances for the purpose of confirming the appropriateness of the parameters prescribed in Clause 30 of this Licence or the need for adjustments to reflect local hydrological conditions.*

The limits placed on water level and water level fluctuations in Environment Act Licence No. 2699 were based on hydraulic modeling results. This review period provided in Clause 34 was established to corroborate the modeling results with data collected after the generating station becomes operational. At the start of year four of Wuskwatim operation, a licence parameter review process will be initiated by Wuskwatim Power Limited Partnership in collaboration with Manitoba Water Stewardship.

Figures

Appendix A

Water level gauge description sheets



A SIZE – 184 X 279

FOR MICROFILMING USE ONLY

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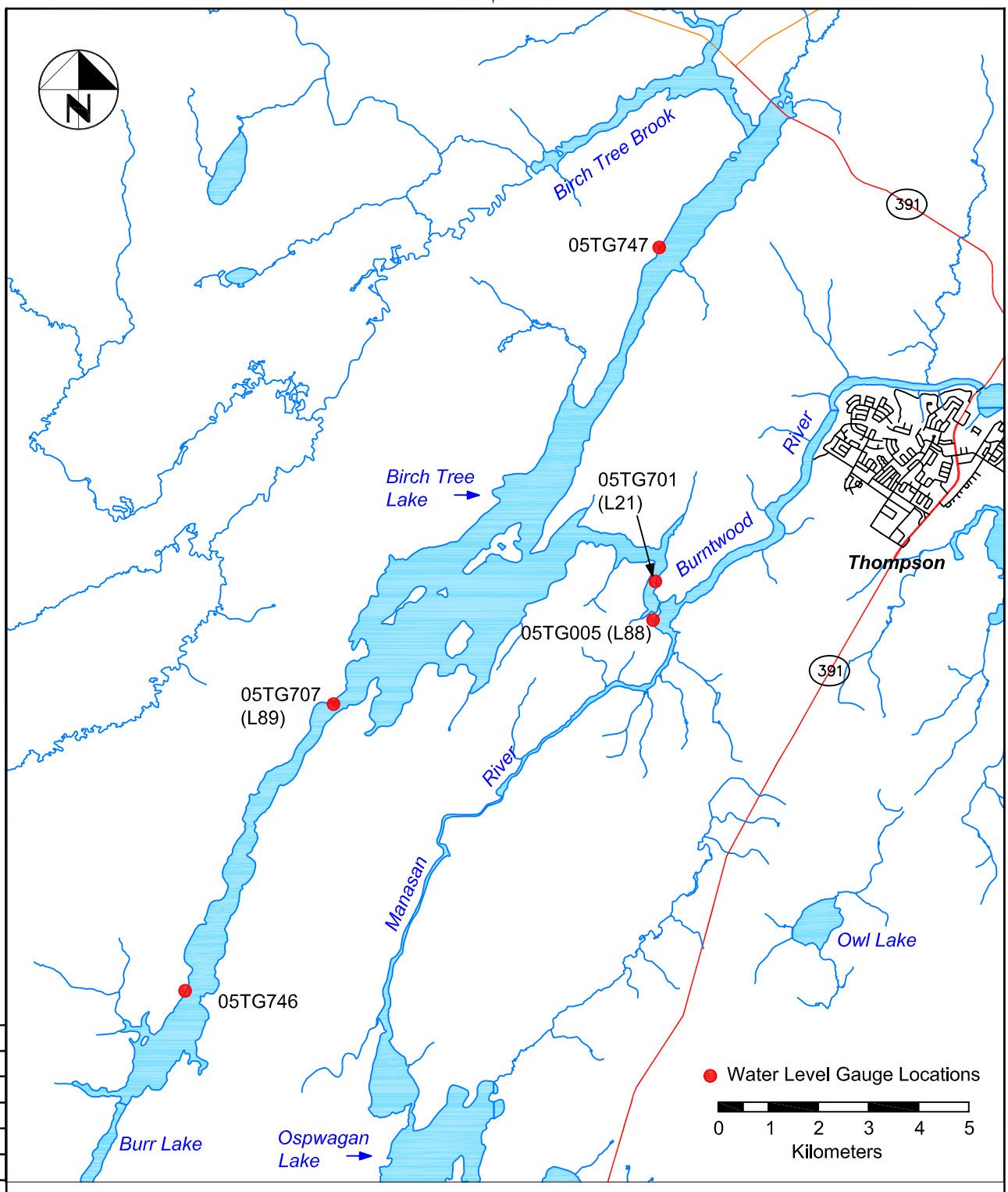
ELECTRICAL			WATER LEVEL GAUGE TEST LOCATIONS ON WUSKWATIM LAKE			
F.P. ENGINEER						
MECHANICAL	DRAWN	K.R.				
DISTRIBUTION	DESIGN	BG				
PROJECT	DSCALE	AS SHOWN				
CONSTRUCTION	PSCALE	1/8"=1'-0"				
MANAGER	DATE	07/04/02				

SHT. 0001 REV. 00

AUTOCAD ORIGINAL

✳ REDUCED SIZED PLOT



A SIZE - 184 X 279

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NOTED	NO.	DATE	REVISIONS	BY	CKD.	APP.
DESIGN						
TELEPHONE						
ELECTRICAL						
F.P. ENGINEER						
MECHANICAL						
DISTRIBUTION						
PROJECT						
CONSTRUCTION						
MANAGER						

DRAWN	K.R.
DESIGN	BG
DSCALE	AS SHOWN
PSCALE	1/8"=1'-0"
DATE	07/03/30

MANITOBA HYDRO

WUSKWATIM GENERATING STATION

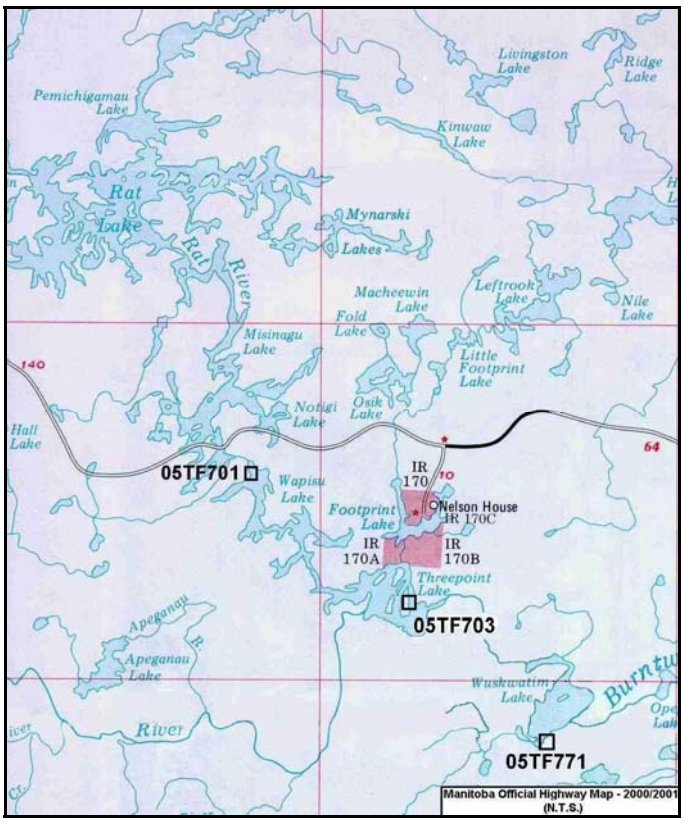
WATER LEVEL GAUGE TEST LOCATIONS ON BIRCHTREE LAKE

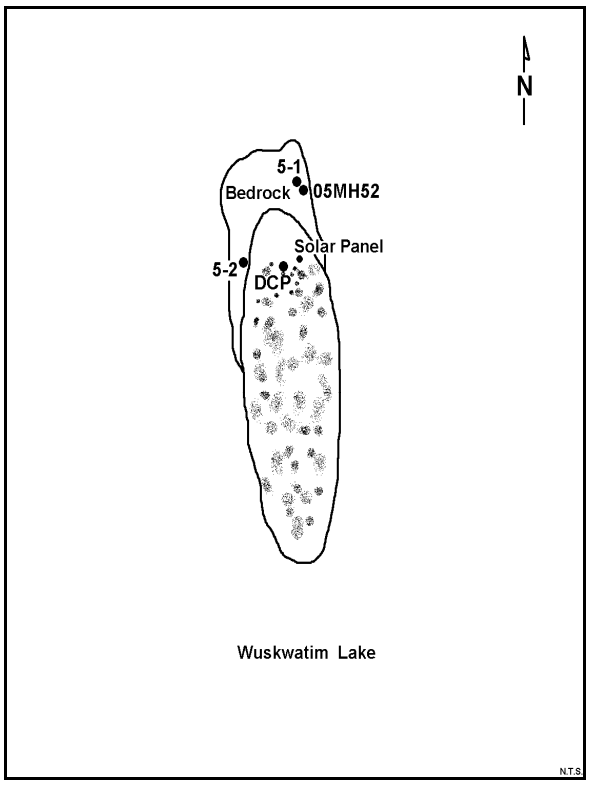
SHT.	REV.
0001	00

AUTOCAD ORIGINAL

✳ REDUCED SIZED PLOT

Wuskwatim Lake Site #5





Number: **05TF771**

Name: **Wuskwatim Lake Site #5**

DCP Id: Drainage Area (km2):

Latitude: 55° 31' 06" Longitude: -98° 34' 42"

Operator: Manitoba Hydro, Thompson

Established: September 2005

Location: On the SE side of Wuskwatim Lake on a small island approx. 3.5 km S of the exit.

Equipment: A Campbell Scientific CR10X data logger, firmware version 1.21, with an SDI-12 Keller pressure transducer in a Campbell Scientific fiberglass enclosure. Solar panel and an external 12 volt gel cell battery in a cooler.

Metering:

Access: Helicopter and boat.

Station Status: Active

Datum: GSC CGVD28 1969 Manitoba Hydro local adjustment

Bench Marks:

05MH52 - Elevation – 234.305 m. A Manitoba Hydro brass cap set in bedrock near water's edge marked with a 3/8" diameter rebar. It is approx. 23.5 m NW of hilti bolt 5-2 and 0.65 m SE of hilti bolt 5-1.

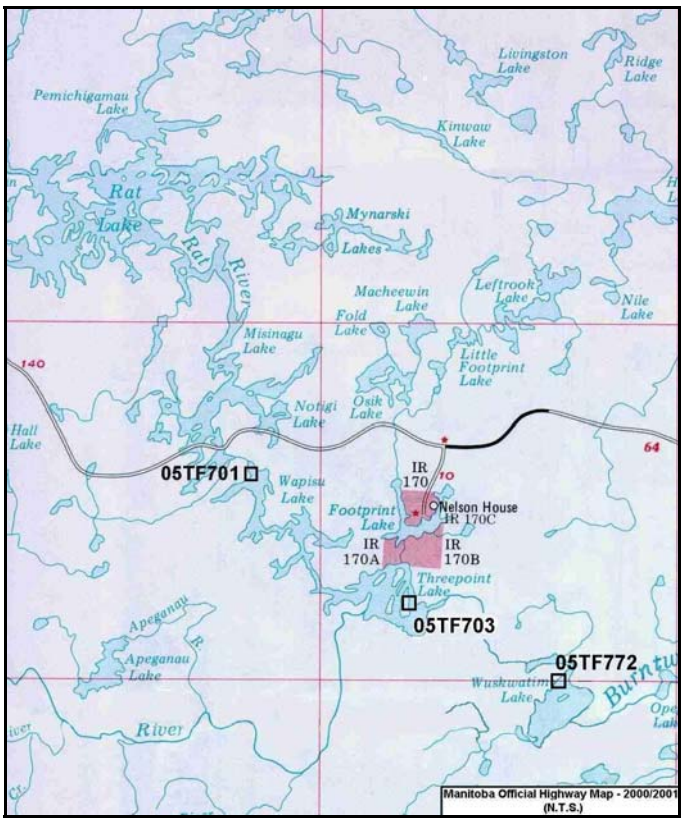
5-2 - Elevation – 234.264 m. A Manitoba Hydro brass cap set in bedrock near water's edge. Brass cap is 11.9 m W from DCP and marked with a 5/8" diameter rebar. Brass cap is 24.1 m SW of hilti bolt 5-1.

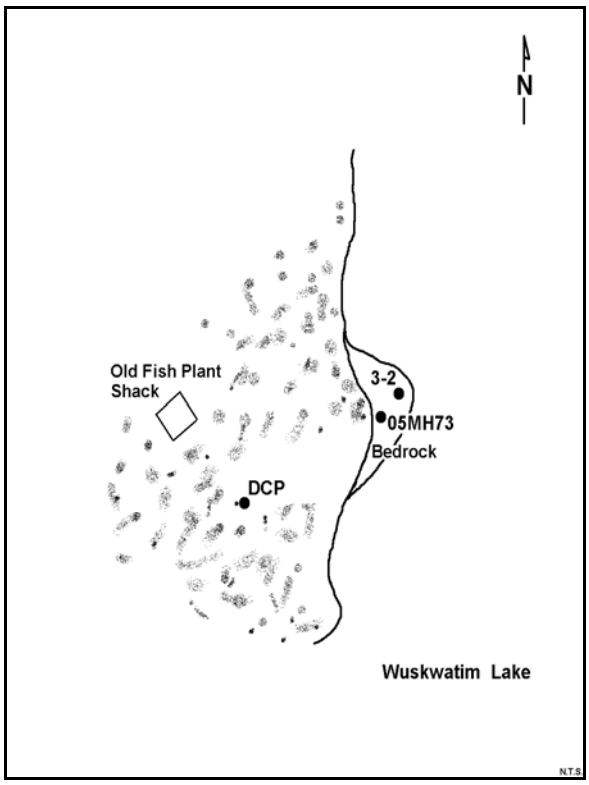
5-1 - Elevation – 234.389 m. A hilti bolt drilled into bedrock near water's edge and marked with a flagged tripod 7.6 m from NE edge of the island and 0.65 m NW of BM 05MH52.

Additional Information:

Source file to PDF: **2007-01-17** Source file last modified: **2007-01-17** Compiled By: A.L. Janier Checked By:

Wuskwatim Lake Site #3





Number: **05TF772**

Name: **Wuskwatim Lake Site #3**

DCP Id: Drainage Area (km2):

Latitude: 55° 36' 12" Longitude: -98° 31' 54"

Operator: Manitoba Hydro, Thompson

Established: September 2005

Location: At the entrance to Wuskwatim Lake on the NW shore at the old fish plant site.

Equipment: A Campbell Scientific CR10X data logger, firmware version 1.21, with an SDI-12 Keller pressure transducer in a Campbell Scientific fiberglass enclosure. Solar panel and an external 12 volt gel cell battery in a cooler.

Metering:

Access: Helicopter and boat.

Station Status: Active

Datum: GSC CGVD28 1969 Manitoba Hydro local adjustment

Bench Marks:

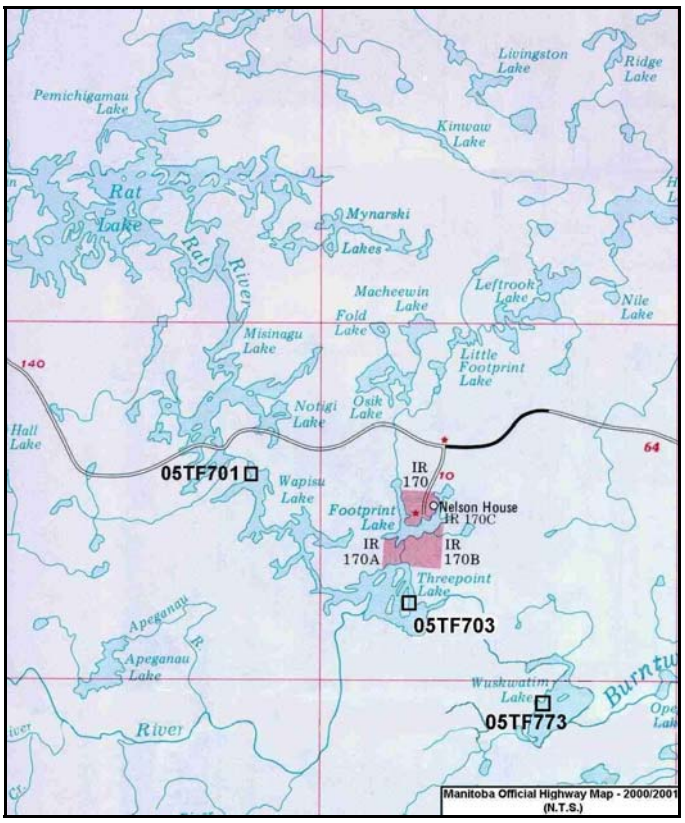
05MH73 – Master - Elevation – 234.183 m. A Manitoba Hydro brass cap stamped 05MH73 set in bedrock near water's edge. Brass cap is 12.2 m NE from DCP and approx. 2 m SW of hilti bolt and marked with a 5/8" diameter rebar.

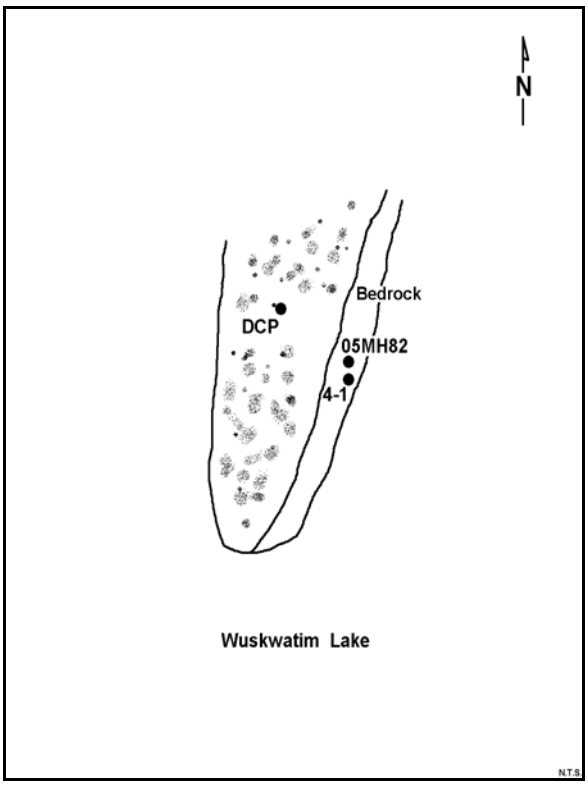
3-2 - Elevation – 233.709 m. A hilti bolt drilled into bedrock near water's edge on the edge of the same rock outcrop as BM 05MH73 and approx. 2 m NE of BM 05MH73.

Additional Information: Shef Codes: TW, HG, ZT, VB

Source file to PDF: **2006-06-15** Source file last modified: **2006-06-15** Compiled By: A.L. Janier Checked By:

Wuskwatim Lake Site #4





Number: **05TF773**

Name: **Wuskwatim Lake Site #4**

DCP Id: Drainage Area (km2):

Latitude: 55° 33' 53" Longitude: -98° 35' 12"

Operator: Manitoba Hydro, Thompson

Established: August 2005

Location: On a point of land on the W shore of Wuskwatim Lake NW of the exit.

Equipment: A Campbell Scientific CR10X data logger, firmware version 1.21, with an SDI-12 Keller pressure transducer in a Campbell Scientific fiberglass enclosure. Solar panel and an external 12 volt gel cell battery in a cooler.

Metering:

Access: Helicopter and boat.

Station Status: Active

Datum: GSC CGVD28 1969 Manitoba Hydro local adjustment

Bench Marks:

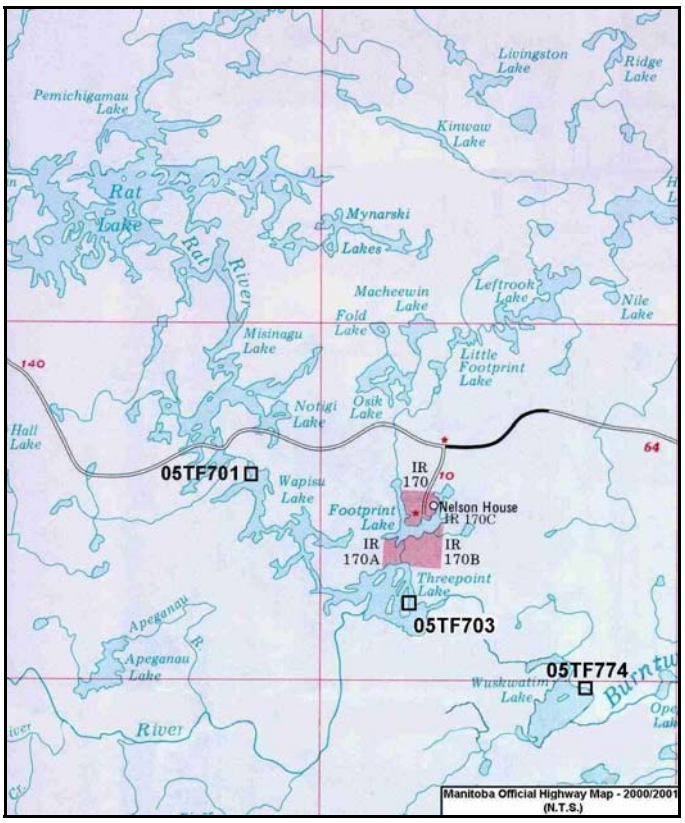
05MH82 (4-2) – Master - Elevation – 234.458 m. A Manitoba Hydro brass cap stamped 05MH82 set in bedrock near water's edge. Brass cap is 11.0 m SE from DCP marked with a 3/8" diameter rebar and is 0.25 m N of hilti bolt 4-1.

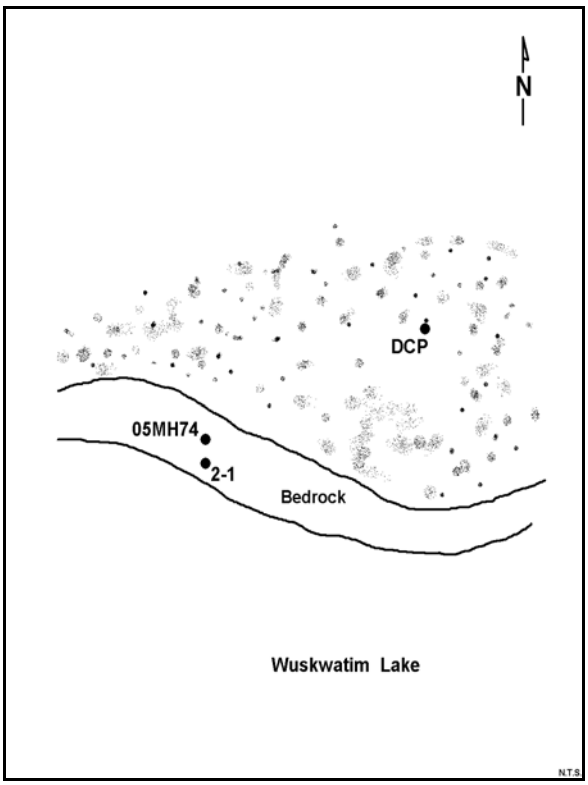
4-1 - Elevation – 234.475 m. A hilti bolt drilled into bedrock near water's edge. Hilti bolt is 11.0 m SE from DCP and marked with a 3/8" diameter rebar 0.25 m S of BM 05MH82.

Additional Information:

Source file to PDF: **2006-04-07** Source file last modified: **2006-04-07** Compiled By: A.L. Janier Checked By:

Wuskwatim Lake Site #2





Number: **05TF774**

Name: **Wuskwatim Lake Site #2**

DCP Id: Drainage Area (km2):

Latitude: 55° 35' 09" Longitude: -98° 29' 31"

Operator: Manitoba Hydro, Thompson

Established: August 2005

Location: On N shore of Wuskwatim Lake approx. 3 km E of the inlet and approx. 3.5 km N of exit .

Equipment: A Campbell Scientific CR10X data logger, firmware version 1.21, with an SDI-12 Keller pressure transducer in a Campbell Scientific fiberglass enclosure. Solar panel and an external 12 volt gel cell battery in a cooler.

Metering:

Access: Helicopter and boat.

Station Status: Active

Datum: GSC CGVD28 1969 Manitoba Hydro local adjustment

Bench Marks:

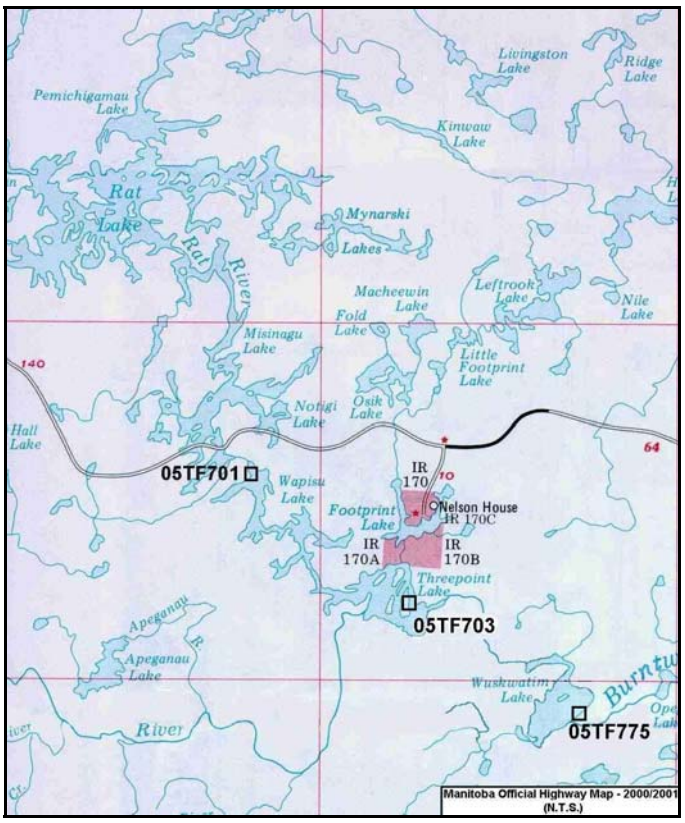
05MH74 – Master - Elevation – 234.374 m. A Manitoba Hydro brass cap set in bedrock near water's edge. Brass cap is 15.2 m SW from the DCP marked with a 5/8" diameter rebar and is 16 cm N of hilti bolt 2-1.

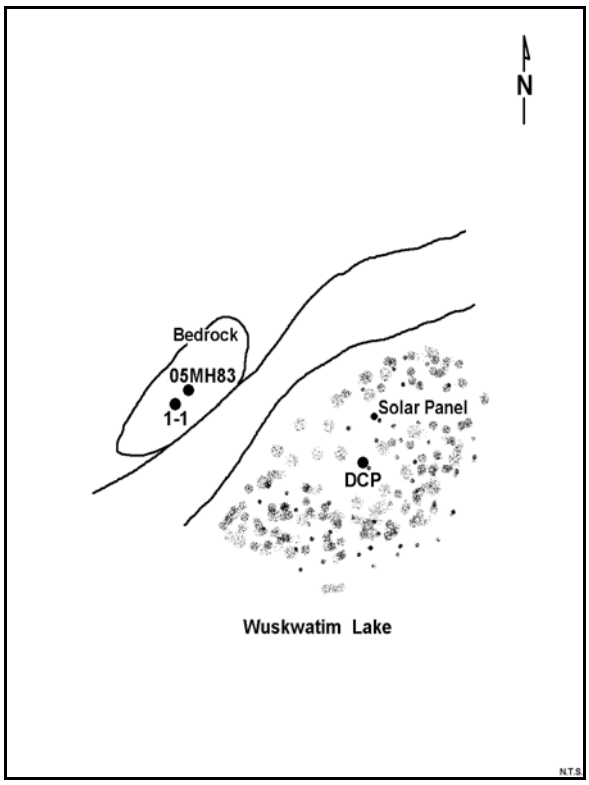
2-1 - Elevation – 234.377 m. A flagged hilti bolt, drilled in to bedrock near water's edge marked with a 0.05 m diameter flagged poplar tree 15.2 m SW of the DCP and 0.16 m S of the BM 05MH74.

Additional Information:

Source file to PDF: **2006-05-25** Source file last modified: **2006-05-25** Compiled By: A.L. Janier Checked By:

Wuskwatim Lake Site #1





Number: **05TF775**

Name: **Wuskwatim Lake Site #1**

DCP Id: Drainage Area (km2):

Latitude: 55° 32' 45" Longitude: -98° 30' 17"

Operator: Manitoba Hydro, Thompson

Established: August 2005

Location: On the SE shore of Wuskwatim Lake approx. 1.5 km NE of Wuskwatim Lake outlet.

Equipment: A Campbell Scientific CR10X data logger, firmware version 1.21, with an SDI-12 Keller pressure transducer in a Campbell Scientific fiberglass enclosure. Solar panel and an external 12 volt gel cell battery in a cooler.

Metering:

Access: Helicopter and boat.

Station Status: Active

Datum: GSC CGVD28 1969 Manitoba Hydro local adjustment

Bench Marks:

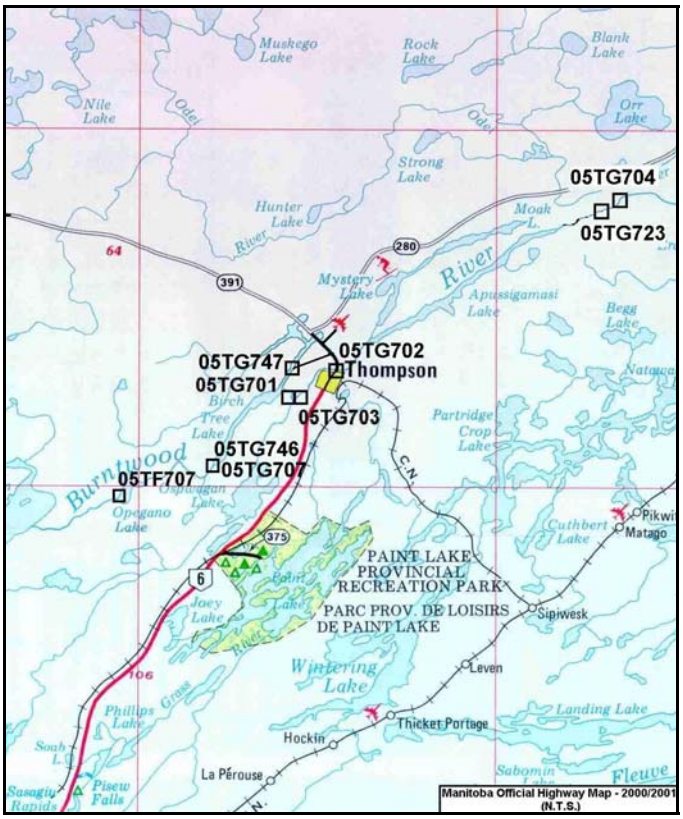
05MH83 – Master - Elevation – 234.736 m. A Manitoba Hydro brass cap set in a bedrock outcrop near water's edge marked with 3/8" diameter rebar and a flagged tripod. The brass cap is 8.2 m W of the DCP 0.2 m NE of the hilti bolt and 2 m W of an eroded bank.

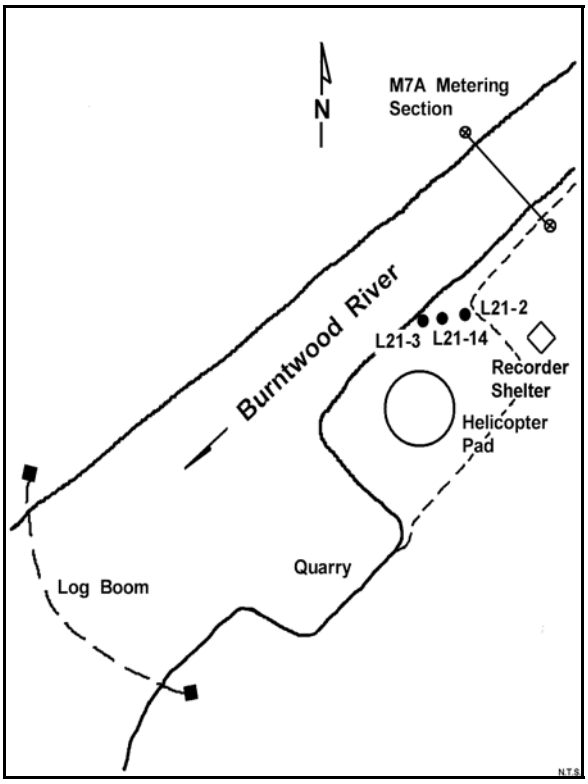
1-1 - Elevation – 234.730 m. A hilti anchor bolt drilled into bedrock near water's edge marked with a flagged tripod. The hilti bolt is 0.2 m SW of BM 05MH83 and 8.2 m WNW of the DCP.

Additional Information:

Source file to PDF: **2006-08-22** Source file last modified: **2006-08-22** Compiled By: A.L. Janier Checked By:

Burntwood River above Manasan Falls





Number: **05TG701**

Name: **Burntwood River above Manasan Falls**

DCP Id: 48225410 Drainage Area (km2):

Latitude: 55° 43' 11" Longitude: 97° 56' 48"

Operator: Manitoba Hydro, Thompson

Established: 1978

Location: On the SE shore 0.5 km above of Manasan Falls.

Equipment: A Valcom EDAS, firmware version 3.09, SDI-12 Sutron pressure transducer in a plywood shelter with an antenna. Real time data is obtained by EDAS unit powered by a 12-volt battery on a 20 watt solar panel.

Metering: M7A discharge section. Discharge measurements are by boat, tagline and ice cover.

Access: Boat or helicopter.

Station Status: Active

Datum: GSC CGVD28 1969 Manitoba Hydro local adjustment

Bench Marks:

L21-2 – Master - Elevation - 199.504 m. Brass cap on high rock outcrop 1.0 m from bank edge and 13.7 m from corner of recorder shack.

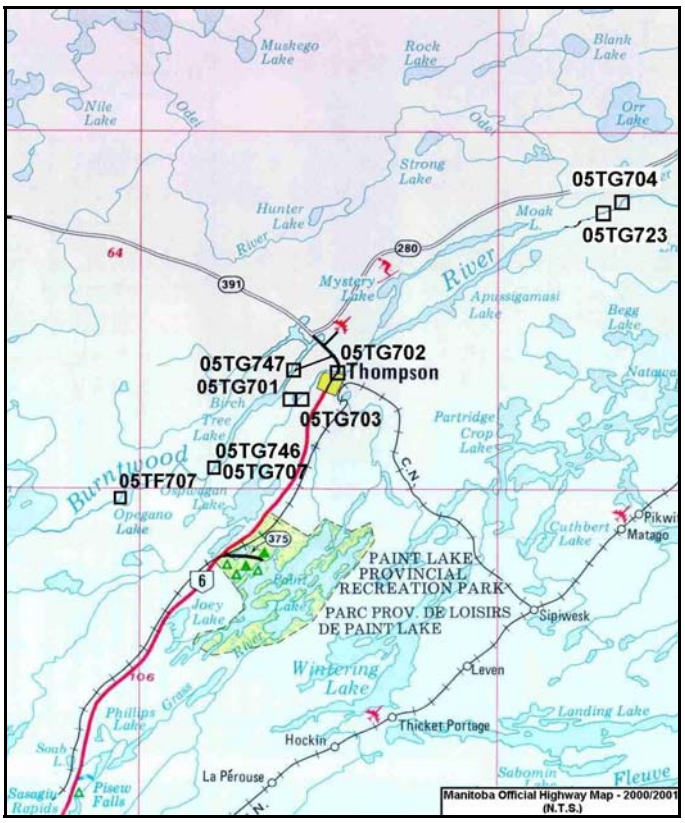
L21-3 - Elevation - 198.320 m. Brass cap on low rock outcrop 1.0 m from bank edge and 5.5 m from L21-2.

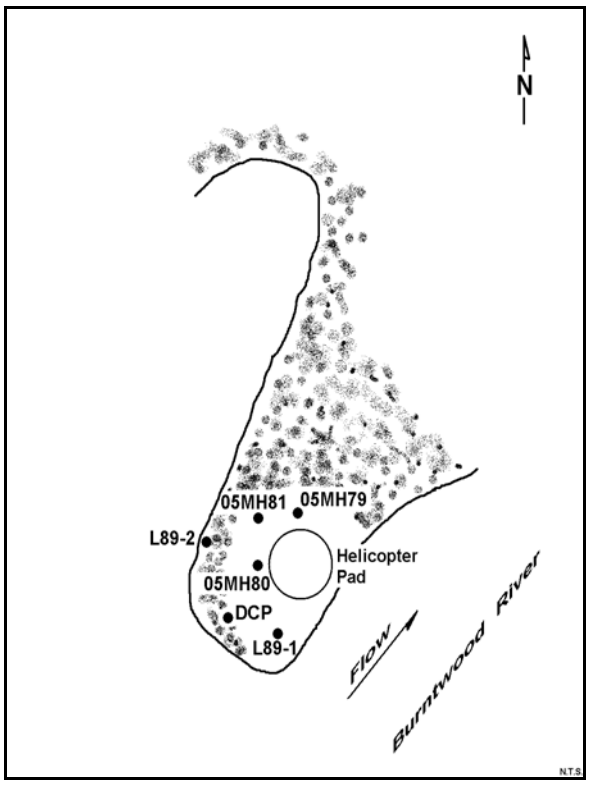
L21-14 - Elevation - 199.309 m. Brass cap in bedrock 1.5 m from the water's edge and 2.2 m E of L21-3.

Additional Information:
Time slot - 00:16, Satellite azimuth - 222.4, Antenna angle - 18.5 degrees.
Shef Codes: HG, TW, VB, ZT, ZD

Source file to PDF: **2006-06-23** Source file last modified: **2006-06-23** Compiled By: A.L. Janier Checked By:

Burntwood River above Birchtree Lake





Number: **05TG707**

Name: **Burntwood River above Birchtree Lake**

DCP Id: Drainage Area (km2):

Latitude: 55° 41' 56.8" Longitude: -98° 02' 57.1"

Operator: Manitoba Hydro, Thompson

Established: September 2005

Location: Left bank of Burntwood River approx. 10 km above Manasan Falls near the entrance to Birchtree Lake at the water level profile site L89.

Equipment: A Campbell Scientific CR10X data logger, firmware version 1.21, with an SDI-12 Keller pressure transducer in a Campbell Scientific fiberglass enclosure. Solar panel and an external 12 volt gel cell battery in a cooler.

Metering:

Access: Helicopter, boat and snowmobile.

Station Status: Active

Datum: GSC CGVD28 1969 Manitoba Hydro local adjustment

Bench Marks:

05MH79 - Elevation – 199.147 m. A Manitoba Hydro brass cap stamped 05MH79 on a ground rod drilled into ground 5.8 m, located approx. 29.5 m NE of the DCP and marked by a steel bar painted green. The most northerly of three brass caps it is 13 m NE of BM 05MH80.

05MH80 – Master - Elevation – 199.068 m. A Manitoba Hydro brass cap stamped 05MH80 on a ground rod drilled into ground 9.1 m, located approx. 16.5 m NE of the DCP and marked by a steel bar painted green. The middle brass cap of three brass caps it is 13 m SW of BM 05MH79.

05MH81 - Elevation – 199.541 m. A Manitoba Hydro brass cap stamped 05MH81 on a ground rod drilled into ground 8.2 m, located 23.4 m NNE of the DCP and marked by a steel bar painted green. The most westerly cap of the three brass caps it is 6.9 m NNE of BM 05MH80. It is farther W than both 05MH80 and 05MH79.

L89-1 - Elevation – 198.767 m. A spike in a 1 m high poplar stump approx. 6.5 m from the river bank.

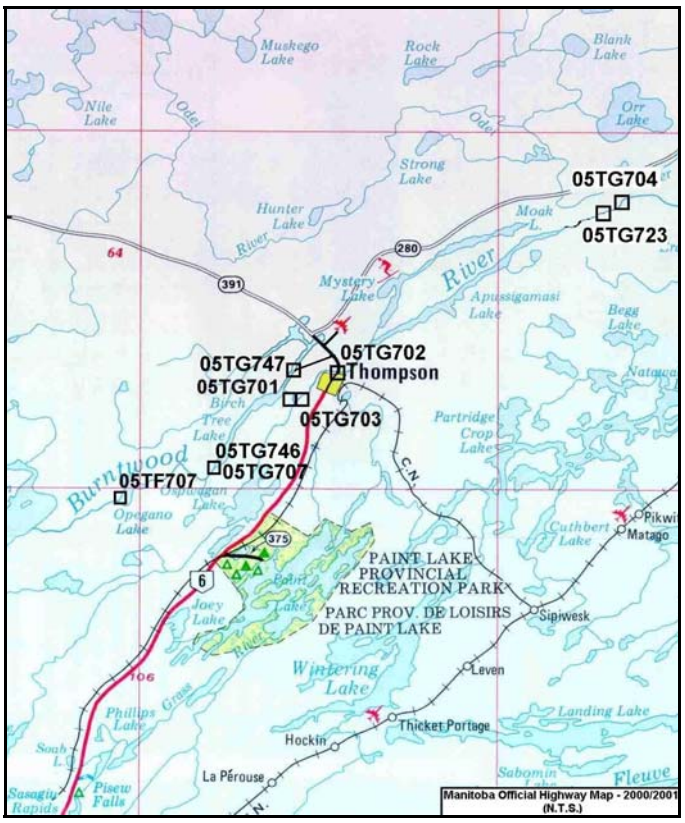
L89-2 - Elevation – 199.498 m. A spike in a 1.5 m high spruce stump at the top of the helicopter pad at entrance to Birchtree Lake. BM is approx. 10.5 km above Manasan Falls on the Burntwood River.

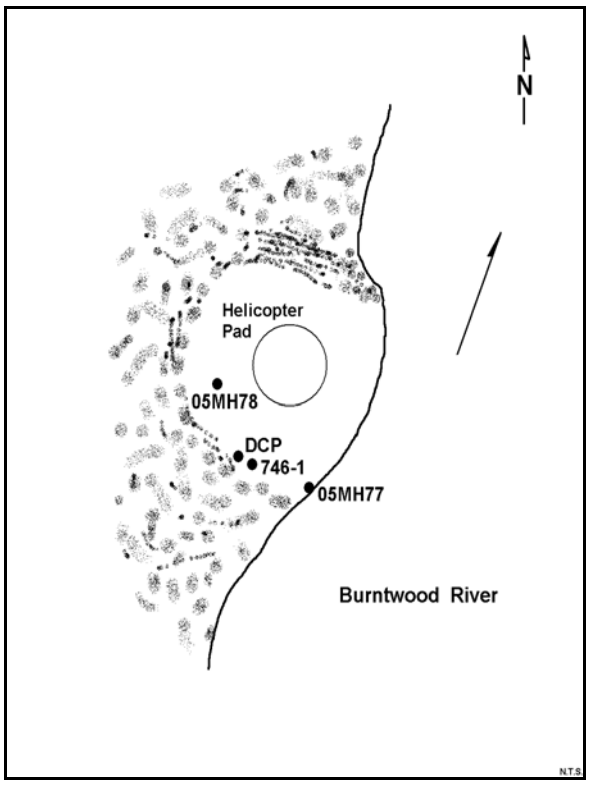
Additional Information:

Source file to PDF: **2006-05-24** Source file last modified: **2006-05-24**

Compiled By: A.L. Janier Checked By:

Birchtree Lake





Number: **05TG746**

Name: **Birchtree Lake**

DCP Id: Drainage Area (km2):

Latitude: 55° 38' 52" Longitude: -98° 05' 49"

Operator: Manitoba Hydro, Thompson

Established: October 2005

Location: Left bank of the Burntwood River above Birchtree Lake approx. 5.0 km below Kepuche Falls.

Equipment: A Campbell Scientific CR10X data logger, firmware version 1.21, with an SDI-12 Keller pressure transducer in a Campbell Scientific fiberglass enclosure. Solar panel and an external 12 volt gel cell battery in a cooler.

Metering:

Access: Helicopter, boat and snowmobile.

Station Status: Active

Datum: GSC CGVD28 1969 Manitoba Hydro local adjustment

Bench Marks:

05MH77 (05-746-1) – Master - Elevation - 197.748 m. A Manitoba Hydro brass cap stamped 05MH77, set in bedrock near water's edge, located approx. 9.3 m SE of the DCP. It is approx. 17 m SE of BM 05MH78 located at the top and W of the helicopter pad.

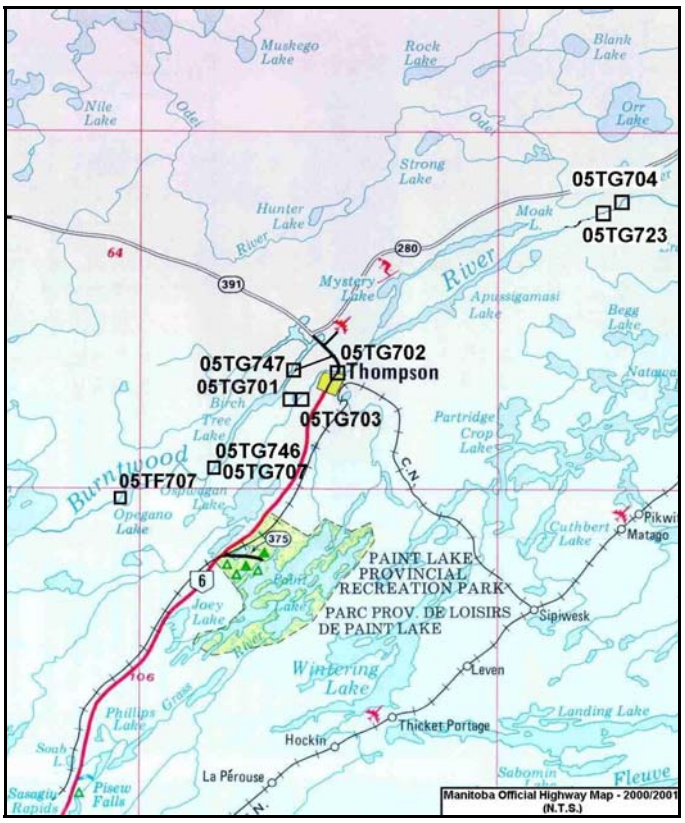
05MH78 (05-746-2) - Elevation – 201.761 m. A Manitoba Hydro brass cap stamped 05MH78, on a ground rod drilled into the ground 4.0 m, marked with a steel rod painted green. It is approx. 8.6 m NNW of the DCP and approx. 17 m NW of BM 05MH77.

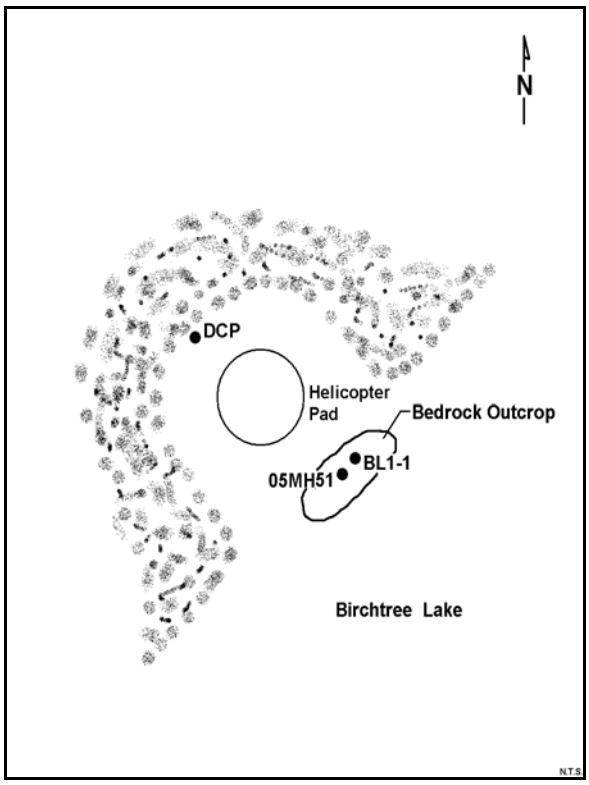
746-1 – Elevation – 202.287 m. Vertical nail in 1.5' high spruce stump SE of and near the DCP on left side of helicopter pad.

Additional Information:

Source file to PDF: **2006-05-24** Source file last modified: **2006-05-24** Compiled By: A.L. Janier Checked By:

Birchtree Lake above Birchtree Brook





Number: **05TG747**

Name: **Birchtree Lake above Birchtree Brook**

DCP Id: Drainage Area (km2):

Latitude: 55° 46' 48" Longitude: -97° 56' 38"

Operator: Manitoba Hydro, Thompson

Established: September 2005

Location: Left bank of Birchtree Lake above Birchtree Brook directly across from a dirt road that extends from the airport runway.

Equipment: A Campbell Scientific CR10X data logger, firmware version 1.21, with an SDI-12 Keller pressure transducer in a Campbell Scientific fiberglass enclosure. Solar panel and an external 12 volt gel cell battery in a cooler.

Metering:

Access: Helicopter, boat and snowmobile.

Station Status: Active

Datum: GSC CGVD28 1969 Manitoba Hydro local adjustment

Bench Marks:

05MH51(05-747-1) – Master - Elevation – 198.115 m. A Manitoba Hydro brass cap set in bedrock, marked with a 5/8 " diameter rebar painted fluorescent orange. It is located approx. 0.190 m SW of a hilti bolt BL1-1 (05-747-2) drilled into the same bedrock outcrop and approx. 22.6 m SE of the DCP near water's edge.

BL1-1 - Elevation – 198.103 m. A hilti bolt drilled into bedrock and marked with a 5/8" diameter rebar painted fluorescent orange. The hilti bolt is 0.19 m NE of brass cap 05MH51 and 22.6 m SE of the DCP in the same bedrock outcrop near water's edge.

Additional Information: Shef Codes: HG, TW, VB, ZT

Source file to PDF: **2006-06-14** Source file last modified: **2006-06-14** Compiled By: A.L. Janier Checked By:

Appendix B

Water Level Gauge Weighting Factors

B.1. Wuskwatim Lake Gauges

Weights are assigned in inverse proportion to the standard deviations of each **Wuskwatim Lake Gauge**'s recorded levels from the **Wuskwatim Lake Mean Daily Water Level (with wind and wave effects eliminated)** based on the individual period of record at each gauge. The weighting factors are determined using the following equations:

$$X\left(\frac{1}{S_1}+\frac{1}{S_2}+\ldots\frac{1}{S_i}\right)=1.0 \qquad \text{[B-1]}$$

$$W_1=\frac{X}{S_1};\quad W_2=\frac{X}{S_2};\quad W_i=\frac{X}{S_i} \qquad \text{[B-2]}$$

where:

X = a computational constant
S_i = standard deviation for **Wuskwatim Lake Gauge** i
W_i = weighting factor for **Wuskwatim Lake Gauge** i

Initial weighting factors have been estimated as 1/n where n is the number of **Wuskwatim Lake Gauge**s.

Gauge	Weighting Factor
05TF006	0.167
05TF771	0.167
05TF772	0.167
05TF773	0.167
05TF774	0.167
05TF775	0.167

Weighting Factors for 6 gauges operating

B.2. Birchtree Lake Gauges

Weights are assigned in inverse proportion to the standard deviations of each **Birchtree Lake Gauge**'s recorded levels from the **Birchtree Lake Daily Average Water Level** based on the individual period of record at each gauge. The weighting factors are determined using the following equations:

$$X\left(\frac{1}{S_1}+\frac{1}{S_2}+\ldots\frac{1}{S_i}\right)=1.0 \qquad \text{[B-1]}$$

$$W_1=\frac{X}{S_1};\quad W_2=\frac{X}{S_2};\quad W_i=\frac{X}{S_i} \qquad \text{[B-2]}$$

where:

X = a computational constant
S_i = standard deviation for **Birchtree Lake Gauge** i
W_i = weighting factor for **Birchtree Lake Gauge** i

Initial weighting factors have been estimated as 1/n where n is the number of **Birchtree Lake Gauge**s.

Gauge	Weighting Factor
05TG701	0.250
05TG707	0.250
05TG746	0.250
05TG747	0.250

Weighting Factors when 4 gauges operating