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REPORT ON

LEASE 13 SURFACE WATER HYDROLOGY
1997 WINTER DATA COLLECTION PROGRAM

Submitted to:

Shell Canada Limited
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P.O. Box 100, Station M
Calgary, Alberta
T2P 2H5

May 31, 1997 **972-2221**

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May 30, 1997

Proj. No. 972-2221

Dr. Doug Mead
Senior Environmental Scientist
Safety and Environmental Resources
Shell Canada Limited.
400 - 4th Avenue SW
P.O. Box 100, Station M
Calgary, AB T2P 2H5

RE: Lease 13 Winter Work Program - Final Report for Surface Water Hydrology

Dear Doug:

Attached is the final report for the Lease 13 Surface Water Hydrology - 1997 Winter Data Collection Program. This report provides a review of the Hydrology Winter Work program completed for Shell in 1997. It includes details on: a) topographic surveys for the Muskeg River and Jackpine Creek; b) snow surveys; c) streamflow monitoring stations (particularly the new station established on Mills Creek); d) winter streamflow measurements; and e) snowmelt flow measurements.

The data collected during the winter of 1996-1997 will provide valuable information to allow completion of the hydrology component of the Lease 13 Environmental Impact Assessment.

Should you have any questions about this report, please contact me at 299-5640.

Yours very truly,

GOLDER ASSOCIATES LTD.

John R. Gulley
Oil Sands Project Director

attachment

cc. Ian Mackenzie (EIA Project Manager)

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1. INTRODUCTION

This surface water hydrology component of the winter work program for the period from February to May, 1997 was commissioned by Shell Canada Limited (Shell) to obtain additional baseline hydrologic data for an environmental impact assessment (EIA) and to provide a sound basis for future design of the proposed Shell Mine development on Lease 13. These additional data will be used to expand the existing surface water hydrologic database, that has been collected for the Syncrude's Aurora Mine Project and continues to be developed under a cooperation agreement between Syncrude Canada Ltd. and Shell.

Previous detailed surface hydrologic studies of the oil sands region were conducted for Syncrude's Mildred Lake mine in Leases 17 and 22, west of the Athabasca River and the proposed Aurora Mine development in Leases 10, 12, 13, 31, and 34, east of the Athabasca River. The present study was designed based on a thorough understanding of the existing hydrologic databases available for the Shell leases from the following baseline studies and the regional climate and hydrometric stations:

- **Alsands Baseline Data Collection Program (1979):**
  This program has collected limited stream cross-sectional survey data and contour maps covering part of the Shell East Mine area. The program also collected miscellaneous streamflow and water quality data between 1980 and 1983, and one year of climate data at the Alsands study area.

- **OSLO Baseline Data Collection Program (1989):**
  This program has collected limited stream cross-sectional survey data, two years of streamflow data on five small streams in the OSLO baseline study area, and one year of climate data in 1988 at the abandoned OSLO airstrip located by Jackpine Creek.

- **Aurora Mine Development (1995):**
  Syncrude Canada Ltd. operates five streamflow gauging stations on the Alsands Drain, Jackpine Creek, Iyinimin Creek, Blackfly Creek and Muskeg River in the study area. These stations have been operational since 1995. To provide some continuation to the

OSLO 1988 data collection program, Syncrude constructed a climate station at the abandoned OSLO airstrip in May 1995.

- **Water Survey of Canada (WSC):**
  WSC operates a regional hydrometric monitoring network, which includes the Muskeg River, Jackpine Creek and many other gauging stations on creeks and rivers in the region.

- **Atmospheric Environment Service (AES):**
  AES operates two continuous year-round climate monitoring stations in the region, one at Mildred Lake located 30 km south of the Shell lease, and one at the airport of Fort McMurray located 70 km south of the Shell lease. The Fort McMurray Airport station has a long period of climate record from 1943 to present.

The scope of the Shell winter work program included the collection of essential hydrologic and hydraulic data to supplement what has been collected by Syncrude for the Aurora Mine project, installation of one new streamflow gauging station to measure flows on the Mills Creek, and streamflow monitoring at the new Mills Creek Station and existing five streamflow gauging stations in the Muskeg River basin area. The specific objectives of this winter work program included the following:

- Conduct a survey of 17 selected river cross sections, along study reaches of the Muskeg River (10 cross-sections) and Jackpine Creek (7 cross-sections). This was needed for evaluating the potential impact of river flooding on the proposed mine development in Lease 13.

- Design, install and operate one new streamflow gauging station, located on Mills Creek (S6), that would be used to monitor Mills Creek streamflow to Isadore's Lake (also known as Creeburn Lake). This streamflow monitoring was needed because the proposed mine development in Lease 13 will eventually cut off most of the natural flow to Mills Creek basin and Isadore's Lake

- Measure, process and compile winter lowflows at the five existing streamflow gauging stations (S1 to S5) and at the proposed new station (S6). These manual winter lowflow measurements were needed to monitor the stream water levels because the existing gauging stations cannot be operated in winter.

- Conduct snow course surveys on major topographic and vegetation terrain types dominant in the mine development area. The snow course surveys were required to correlate with winter snowfall data and to provide a better estimate of snowmelt runoff processes.

- Measure, process and compile the 1997 snowmelt flows at the five existing streamflow gauging stations and at the proposed new station (S6). This snowmelt monitoring program was needed to fill the existing streamflow data gaps, identified in the Aurora baseline data collection program.

This report documents topographic survey data obtained for Muskeg River and Jackpine Creek and the design and operation of the new streamflow gauging station on Mills Creek installed in May 1997. It presents the results of the winter low flow measurements at the six streamflow gauging stations and the snow course survey data on the major terrain types dominant in the area. The report also presents the analyses of snowmelt flow hydrographs for the study area.

2. PHYSICAL SETTING

This study addresses the hydrologic characteristics of the Shell's Lease 13, which is in close proximity to the proposed Aurora Mine oilsands development of Syncrude (Leases 10, 12, 31, 34) and the proposed Mobil prospect (Lease 36). Figure 1 presents the location map of these lease areas situated approximately 70 kilometres north of Fort McMurray, Alberta.

The Shell Lease 13 lies on the east side of the Athabasca River near Fort Mackay. The Muskeg River is the most significant drainage system in the local study area. Major tributaries of the Muskeg River draining through Lease 13 and adjacent Leases 10, 12, 31, 34, and 36 include Jackpine Creek (formerly Hartley Creek), Shelley Creek and Muskeg Creek, which drains the Kearl Lake watershed.

The terrain within the Muskeg River basin is mostly flat with slopes less than 0.5% ground slope, except for the area east of Lease 31. Elevations range from 280 metres to 340 metres within the local study area. However, the elevations of headwaters of Jackpine and Iyinimin creeks entering Leases 13 and 31 range from 480 metres to 510 metres. Ground slopes range from 1 to 3% in areas at elevations above 340 metres.

The topography has a dominant effect on the surface hydrology conditions and therefore the terrain has been defined in terms of two hydrologic zones, namely lowland and upland areas. Lowland areas are poorly drained and permanently wet, with less than 0.5% ground slopes. Upland areas are well drained, with greater than 0.5% ground slopes.

The dominant surficial soil type within the local study area is moss bog or peat soils. These types of soils are highly absorbent and poorly drained. They are characterized by a high water table, at or near the ground surface following the springmelt. The thickness of the moss bog in lowland areas can range from 0.5 to over 3.0 meters. The thickness of the peat in upland areas ranges from 0.3 to 1.0 metre.

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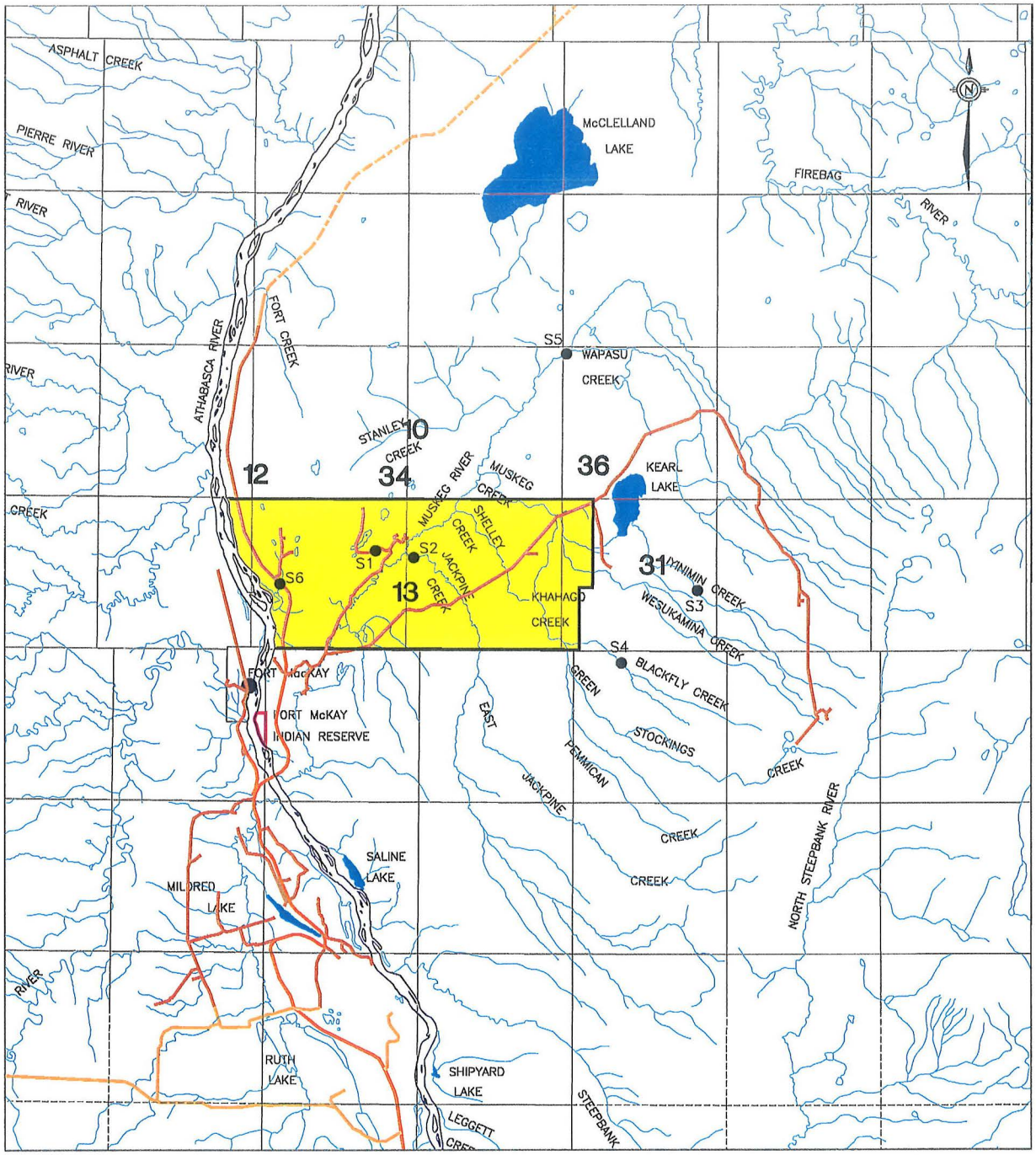

LEGEND

- STREAMFLOW MONITORING STATIONS
- LEASE 13

REFERENCE

DRAWING FROM AGRA EARTH AND ENVIRONMENTAL LIMITED
FIG.1435–A3 CATCHMENT BOUNDARIES OF LOCAL STUDY AREA
JAN, 1996.

Golder Associates

SHELL CANADA LIMITED

LOCATION MAP FOR LOCAL LEASES AND STREAMFLOW MONITORING STATIONS

13 MAY 97	FIGURE 1	REV NO A

3. TOPOGRAPHIC SURVEY

3.1 Survey Design

The Shell Lease 13 project will involve mine development along a 13 km reach of the Muskeg River and a 8 km reach of the Jackpine Creek, with a proposed development setback of 100m from the outside edge of the stream meander belts. With such an encroachment into the wide floodplains of the Muskeg River and Jackpine Creek, the Shell oil sands development has the potential to affect river flood levels and flow velocities. River floods might also govern the erosion protection and flood protection measures required for the proposed mine development. Evaluation of these potential impacts required topographic survey at regular intervals along the Muskeg River and Jackpine Creek.

A topographic survey was carried out by McMurray Resources (Research & Testing) Ltd. (MRRT) and CAN-AM Survey Ltd., with direct supervision from Golder Associates Ltd. (Golder). The survey included 17 selected cross-sections along the study reaches of the Muskeg River and Jackpine Creek. The locations of the selected cross-sections on Muskeg River (10 cross-sections) and Jackpine Creek (7 cross-sections) are shown on Figure 2.

The lengths of the cross-sectional transacts were determined based on the following criteria, to cover the outside edge of the proposed mine development area:

- The maximum length of each survey transact should be 1000 m; and,
- The transect length can be reduced but can not be less than 200 m, if the elevations end of a transect are approximately 4 m above the river bank.

The surveyed cross-sectional elevations were referenced to the geodetic datum.

3.2 Survey Program and Results

The cross-sectional survey was conducted in early March 1997, when the ground was frozen and the rivers were covered with thick ice. The surveys had to be conducted in winter because the

wet muskeg floodplain composed of saturated peat and covered by wetlands vegetation such as swamp spruce and tamaracks, is difficult to access during the open-water season.

The frozen river channels provided a pathway for accessing all of the survey locations, except the cross-sections located along the upstream reach of the Muskeg River. Those cross-sections were accessed using the existing seismic lines, because of the thin ice condition along the upstream reach of the Muskeg River. The survey of the river cross sections involved drilling holes through the ice cover by ice auger, and measuring water depths.

The Real-time Global Positioning System (GPS) technology was used to survey the cross-sections and reference the elevations of the cross-sections to the geodetic datum. The GPS method enabled the cross-section survey to be conducted safely and efficiently, and with minimal damage to the environment by avoiding line cutting and using the existing seismic lines.

The horizontal positions (x and y coordinates) of the cross-sectional data were referenced to the NE33-TWP96- RG9 - W4. The elevations (z coordinates) of the cross-sectional data were referenced to the geodetic datum based on ASCM Monument No. 157735. Appendix I includes a table and a drawing presenting the topographic survey data of the river cross-sections and the x, y, and z coordinates of each cross-section.

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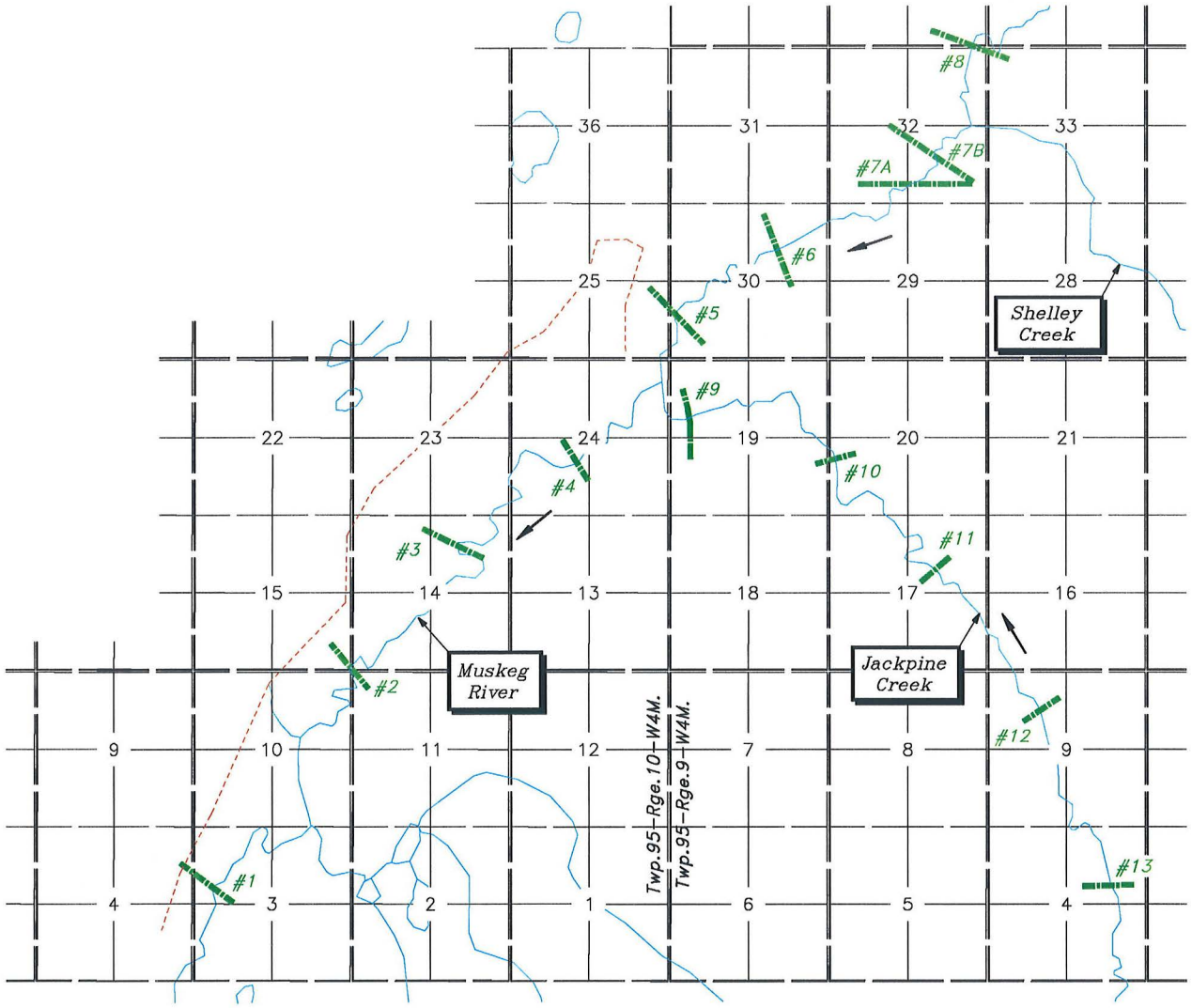


LOCATION PLAN
SCALE = 1 : 75,000

REFERENCE

DRAWING FROM CAN–AM SURVEYS LTD.
FIGURE A1, APRIL 8, 1997

LEGEND

#1 CROSS–SECTION

Golder Associates

SHELL CANADA LIMITED

SURVEY CROSS-SECTION LOCATIONS ON MUSKEG RIVER AND JACKPINE CREEK

20 MAY 97	FIGURE 2	REV NO

4. SNOW COURSE SURVEY

4.1 Snowpack and Terrain Types

Snowpack accumulation is dependent on terrain type, which is a function of both topography and vegetation. In the Muskeg River basin, vegetation is the dominant feature dictating classification of the terrain types. The main terrain types defined for the 1997 snow course survey included:

- Flat low lying areas (with a mix of willow and shrub vegetation);
- Mixed deciduous areas (with a mix of aspen, spruce, etc.);
- Open land areas (such as harvested areas with little vegetation);
- Jack pine areas; and
- Open lake areas.

Sixteen snow course survey plots were selected based on this terrain classification. Plots were identified by a visual assessment of the site.

4.2 Snow Course Measurements

The water equivalent of a snowpack (the equivalent depth of water, if the snowpack was melted) is a product of snow depth and snow density. At each snow course survey plot, snow depths and snow densities were measured as follows:

- **Snow Depth Measurements**:
  At each plot, 30 depth measurements were made at randomly selected locations on a large circle. These depth measurements were taken by inserting a sharp rebar into the snowpack, reading the snowline mark and then measuring it with a tape.

- **Snow Density Measurement**:
  Three density measurements were taken at each plot, using an Atmospheric Environment Services (AES) density sampler. The AES sampler was inserted carefully into the snowpack. Snow depth was read on the tube, when the corer reached the soil surface. The corer was then inserted/twisted more deeply into the ground to get a plug of soil to

prevent the granular snow falling out of the bottom of the snow profile. The tube weight was measured (with and without snow) using the spring scale. The units of the spring scale directly provided the snow water equivalent (SWE) of the snowpack in centimetres.

Additional notes were taken on vegetation cover type, colour of snow surface, and snow consistency. Appendix II presents the terrain type, snow cover information and snowpack measurement data collected during the period from March 17 to 19, 1997.

4.3 Summary of Snow Course Data

The snow course survey data collected are summarized in Table 1 and on Figure 3. The data in Table 1 shows that the snow density is consistent throughout the five different terrain types surveyed. Therefore, the relative differences of snow depth between terrain types, are directly reflected in variations in snow water equivalent (SWE) as described below.

- The two terrain types, jack pine and mixed deciduous, have similar snow-water-equivalent depths (88 and 96 mm). Forest canopies intercept a percentage of precipitation (for both rain or snow) before it reaches the ground. The interception rate is proportional to the canopy coverage. Mixed deciduous tree sites, without leaves, have a more open canopy than jack pine sites and, hence, a greater snow-water-equivalent.

- Flat low lying areas feature a dense shrub coverage, which has a low interception rate, yet provides a wind-sheltered, calm area that maximizes snow accumulation potential (112 mm).

- Open lake areas have the smallest snow-water-equivalent depth (31 mm), due to the wind swept, open nature of the site.

- Open land areas (clearings) have snow-water-equivalent similar to that of the forest covers (85 mm). The original survey design called for only one category of open area. Separate categories were not intended for "open-lake" and "open-land". However, the survey results indicate that these two types of sites have distinctively

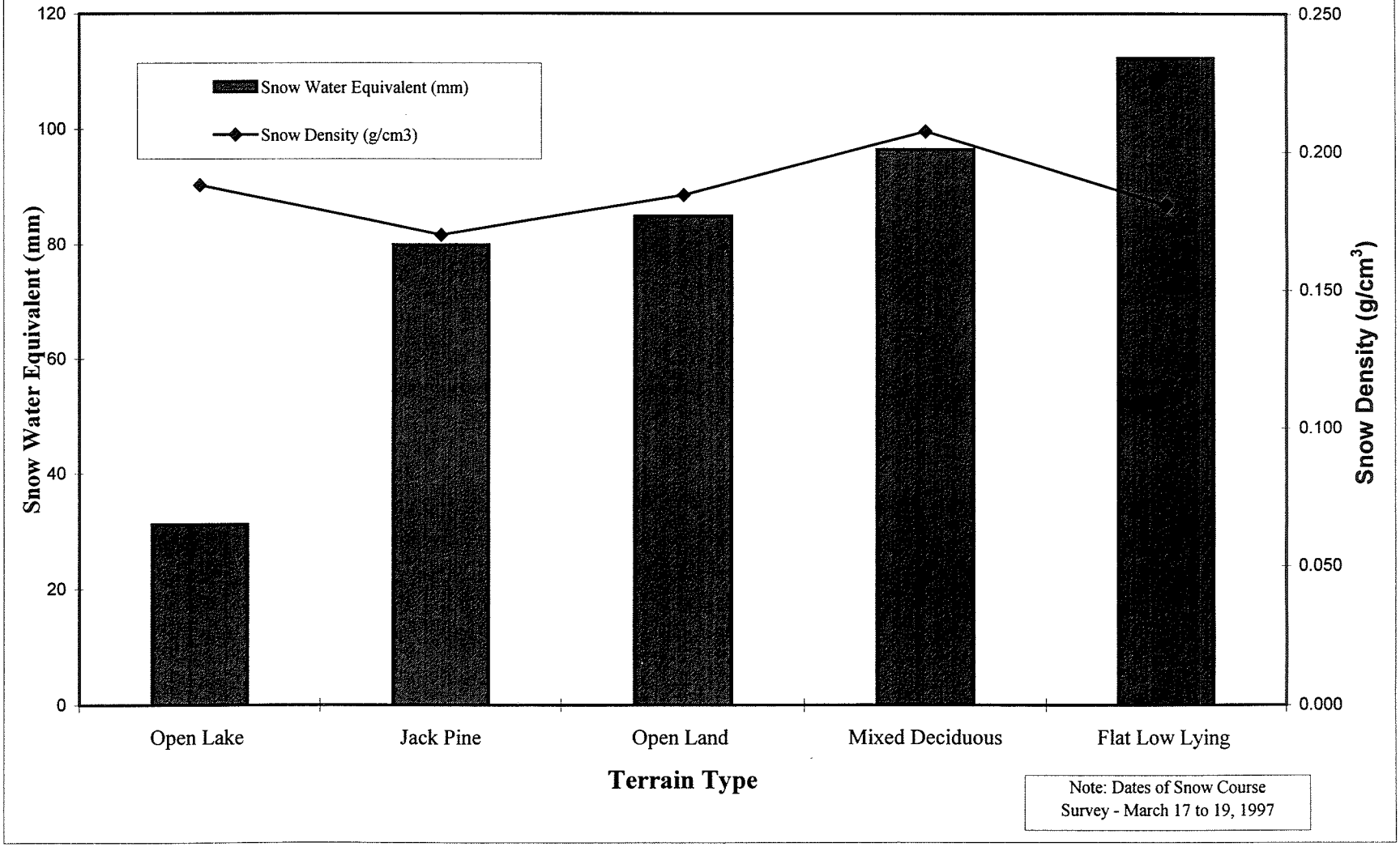
different snow accumulations. Interception at the two sites is zero and the difference between the sites is likely due to differences in wind exposure.

Table 1

Summary of Snow Course Survey Data

Terrain Type	Survey Plot No.	Snow Density (g/cm^3)	Snow Depth (cm)	Snow-Water Equivalent (mm)
Flat Low Lying	FL #1	0.187	54.2	101.9
	FL #2	0.169	50.4	85.6
	FL #3	0.189	76.5	144.6
	FL #4	0.178	65.6	117.2
		0.181	**61.7**	**112.3**
Open Land	OP #2	0.184	44.3	81.6
	OP #3	0.185	47.6	88.2
		0.185	**46.0**	**84.9**
Open Lake	OP #1	0.175	14.6	25.6
	OP #4	0.201	18.2	36.7
		0.188	**16.4**	**31.2**
Mixed Deciduous	MD #1	0.204	54.7	111.7
	MD #2	0.205	37.4	77.0
	MD #3	0.181	44.0	80.1
	MD #4	0.240	48.6	117.1
		0.208	**46.2**	**96.5**
Jack Pine	JP #1	0.170	44.9	76.5
	JP #2	0.165	48.5	80.2
	JP #3	0.167	51.1	85.8
	JP #4	0.178	43.2	77.1
		0.170	**46.9**	**79.9**

Figure 3. Snow Water Equivalent of Various Terrain Types



5. STREAMFLOW MONITORING STATIONS

5.1 Background

There were five streamflow gauging stations installed for the Syncrude's Aurora Mine development as shown on Figure 4. The streamflow data obtained from these stations (S1 to S5) are believed to be representative of the Shell East Lease area. However, there was no streamflow gauging station on Mills Creek, which drains much of the west side of the Shell Lease area and supplies surface water inflow to the Isadore's Lake. Therefore, a new streamflow gauging station was installed on Mills Creek (S6) as shown on Figure 4. A description of the existing stations (S1 to S5) and the newly installed station (S6) is presented in the following sections.

5.2 Description of Existing Stations

Station S1 was located on the Alsands Drain just upstream of its confluence with Muskeg River to gather surface runoff data from a cleared muskeg watershed. Station S1 is the only discharge monitoring station located within the Muskeg River basin to monitor discharges from a cleared basin with drains. Station S2 was located at the site of the former Water Survey Canada (WSC) monitoring gauge on Jackpine Creek (formerly Hartley Creek), which was dismantled in 1993. Station S2 provides continuity to the existing 18 year period of record at this station.

Two stations, S3 and S4, were located on Iyinimin and Blackfly Creeks, respectively, at the sites of former OSLO monitoring stations. Stations S3 and S4 extend the available periods of record for these stations. Station S5 was located on the Muskeg River upstream of the mine development area to provide data on river discharges entering the Aurora Mine area.

Table 2 summarizes the physical data of the existing streamflow gauging stations (S1 to S5) installed in 1995 and the new gauging station (S6) installed in May 1997. Appendix II shows the photographs of streamflow gauging stations (S1 to S6) taken during the 1997 field visits for the winter lowflow conditions and snowmelt conditions.

Table 2

Description of the Streamflow Monitoring Stations

Station No.	Creek / River Name	Station Location		Basin Area (km^2)	Date of Installation
		Latitude (North)	Longitude (East)		
S1	Alsands Drain	57° 15' 20"	111° 29' 30"	15.8	May 1995
S2	Jackpine Creek	57° 15' 33"	111° 27' 53"	358	May 1995
S3	Iyinimin Creek	57° 14' 58"	111° 10' 21"	24.5	May 1995
S4	Blackfly Creek	57° 12' 11"	111° 15' 21"	38.2	May 1995
S5	Muskeg River	57° 21' 13"	111° 20' 11"	434	May 1995
S6	Mills Creek	57° 15' 13"	111° 29' 49"	23.8	May 1997

5.3 Mills Creek Gauging Station

Golder undertook the design, permitting, installation and operation of the Mills Creek streamflow gauging station for Shell. The required permit was obtain from Water Resources Administration Division of Alberta Environmental Protection on behalf of Shell. The copy of the permit to install and operate the streamflow gauging station on Mills Creek is provided in Appendix IV.

Mills Creek streamflow gauging station (S6) was selected to monitor surface runoff from Shell West Lease area that flows into the Isadore's Lake. The streamflow monitoring station comprises of the following components, as detailed in Appendix IV:

- a datalogger, housed in a sealed container and placed inside a steel equipment shelter designed to provide bullet proof protection;
- a 10 metre long, submersible pressure transducer (0-8 psi), connected to the datalogger;
- a 1.5 metre long, 300 mm diameter perforated steel pipe buried horizontally and anchored beneath the channel bed;

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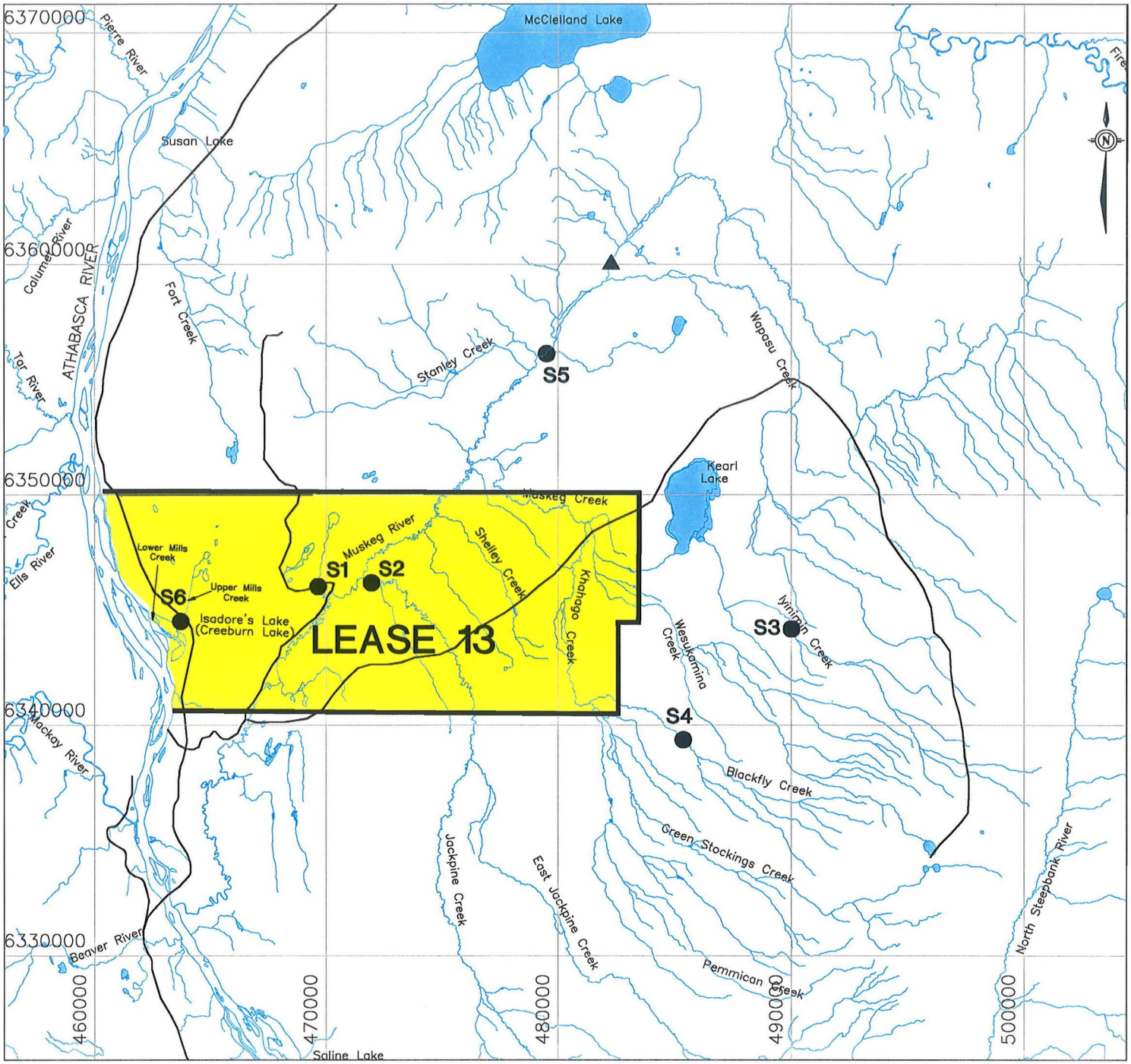


LEGEND

- **S1** ALSANDS DRAIN (15.8km^2)
- **S2** JACKPINE CREEK (358km^2)
- **S3** IYINIMIN CREEK (24.5km^2)
- **S4** BLACKFLY CREEK (38.2km^2)
- **S5** MUSKEG RIVER (434km^2)
- **S6** MILLS CREEK (23.8km^2)
- LEASE 13

REFERENCE

DRAWING FROM AGRA EARTH AND ENVIRONMENTAL LIMITED
FIG.1435–A3 CATCHMENT BOUNDARIES OF LOCAL STUDY AREA
JAN, 1996.

Golder Associates

SHELL CANADA LIMITED

DETAILED LOCATION PLAN FOR STREAMFLOW MONITORING STATIONS

20 MAY 97	FIGURE 4	REV NO A

- a 50 mm diameter thick-walled ABS pipe buried horizontally and anchored beneath the channel bed and connected to the perforated steel pipe; and

- a lockable, bullet proof steel equipment shelter placed on top of the gauging station.

At the Mills Creek Station (S6), depths of water flow are typically less than 0.2 metres. Therefore, a composite weir (a combination of 90° V-notch and rectangular weir) was installed to increase the accuracy of the flow measurements. The dimensions and the other details of the constructed weir are also provided in Appendix IV. A survey datum was installed at the station, with an arbitrary elevation of 100.000 metres.

6. WINTER STREAMFLOW MEASUREMENTS

6.1 Need for Winter Lowflow Measurements

The combined effects of several oil sands developments can seriously affect the quality of water of the receiving streams in the area. Therefore, a more comprehensive water quality analysis is required, taking account of critical lowflow conditions of the development area streams. The existing hydrologic database includes only the open-water season streamflow data. Therefore, the winter season streamflow measurements became important for the Shell EIA, because the lowflow conditions occur during the winter season.

6.2 Streamflow Measurements Under Ice Cover

Winter lowflow measurements under ice cover are similar in most respects to those carried out in open water conditions. The difference is that the effective depth at each vertical is measured from the bottom surface of the ice to the channel bottom. Effective depth is measured by subtracting the distance from the bottom of the ice to the water surface from the total water depth measured on a wading rod.

Ice thickness and the distance from the bottom of the ice to the water surface were measured with the ice thickness gauge, which consists of a meter stick attached to a perpendicular bracket which can be hooked under the ice. The depth and velocity measurements were made through holes cut in the ice at prescribed intervals. For effective depths less than 0.75m, the velocity was measured at 60% of the distance between the bottom surface of the ice and the stream bottom. For depths greater than 0.75m the velocity was measured at 20% and 80% of the depth.

6.3 Summary of Measurements

Measurements of winter lowflows were conducted between March 15 and 28, 1997 at the five existing streamflow gauging stations (S1 to S5) located for the Aurora Mine development and at the new station (S6) on the Mills Creek. Table 3 summarizes the measured winter lowflow data. Appendix V presents the detailed streamflow measurements collected during this period.

Table 3

Summary of Winter Streamflow Measurements

Station No	Creek / River Name	Discharge (m^3/s)	Measurement Date
S1	Alsands Drain	0.084	March 17, 1997
		0.074	March 28, 1997
S2	Jackpine Creek	0.023	March 16, 1997
		0.098	March 28, 1997
S3	Iyinimin Creek	No Flow	March 18, 1997
		No Flow	March 27, 1997
S4	Blackfly Creek	No Flow	March 18, 1997
		No Flow	March 27, 1997
S5	Muskeg River	0.159	March 18, 1997
		0.218	March 27, 1997
S6	Mills Creek	0.034	March 15, 1997
		0.044	March 28, 1997

7. SNOWMELT FLOW MEASUREMENTS

7.1 Need for Snowmelt Flow Measurements

The existing hydrologic database has limited snowmelt flow data, that could be used to characterize snowmelt runoff process of small watersheds in the study area. Therefore, measurements of snowpack and snowmelt flow data are required to calibrate the snowmelt process of a hydrologic model, which would be used to derive the simulated flow series including snowmelt and summer flows based on the available long-term climate data. These simulated flow data are required for the assessments of impacts on both the water quantity and quality in the proposed Shell EIA study.

7.2 Streamflow Measurements

Snowmelt flow measurements were carried out at the five existing stream gauging stations (S1 to S5) and at the new Mills Creek station (S6) between April 16 and May 8, 1997. Manual flow measurements were conducted once per week at these stations. In addition, except at Iyinimin Creek (S3), the water levels at these stations were continuously monitored using pressure transducers and dataloggers during the entire snowmelt period.

Table 4 summarizes the snowmelt flows measured during the four-week period from April 16 to May 8, 1997. The streamflow measurements collected during this period are presented in Appendix V.

7.3 Snowmelt Stage Hydrographs

The pressures transducers installed at the streamflow monitoring stations were used to measure the water levels by recording them in dataloggers at 15 minute intervals. Figures 5 to 9 and Appendix V present the recorded stage hydrographs at the five gauging stations (S1, S2, S4, S5, and S6), during the 1997 snowmelt period from April 16 to May 08. These stage hydrographs can be used to derive streamflow hydrographs, based on rating curves to be developed using the manual streamflow measurements conducted during the snowmelt period.

Table 4

Summary of Snowmelt Flow Measurement data

Station No	Creek / River Name	Discharge (m^3/s)	Measurement Date
S1	Alsands Drain	0.125	April 16, 1997
		0.159	April 23, 1997
		0.076	April 30, 1997
		0.059	May 8, 1997
S2	Jackpine Creek	0.120	April 16, 1997
		3.907	April 25, 1997
		6.019	May 1, 1997
		4.503	May 8, 1997
S3	Iyinimin Creek	No Flow	April 17, 1997
		0.500	April 23, 1997
		0.786	May 1, 1997
		0.957	May 8, 1997
S4	Blackfly Creek	No Flow	April 17, 1997
		1.504	April 23, 1997
		1.258	May 1, 1997
		1.107	May 8, 1997
S5	Muskeg River	0.648	April 17, 1997
		3.997	April 23, 1997
		4.207	May 1, 1997
		4.239	May 8, 1997
S6	Mills Creek	0.111	April 16, 1997
		0.169	April 23, 1997
		0.095	April 30, 1997
		0.084	May 8, 1997

Figure 5. Snowmelt - Stage Hydrograph at Alsands Drain Station (S1)

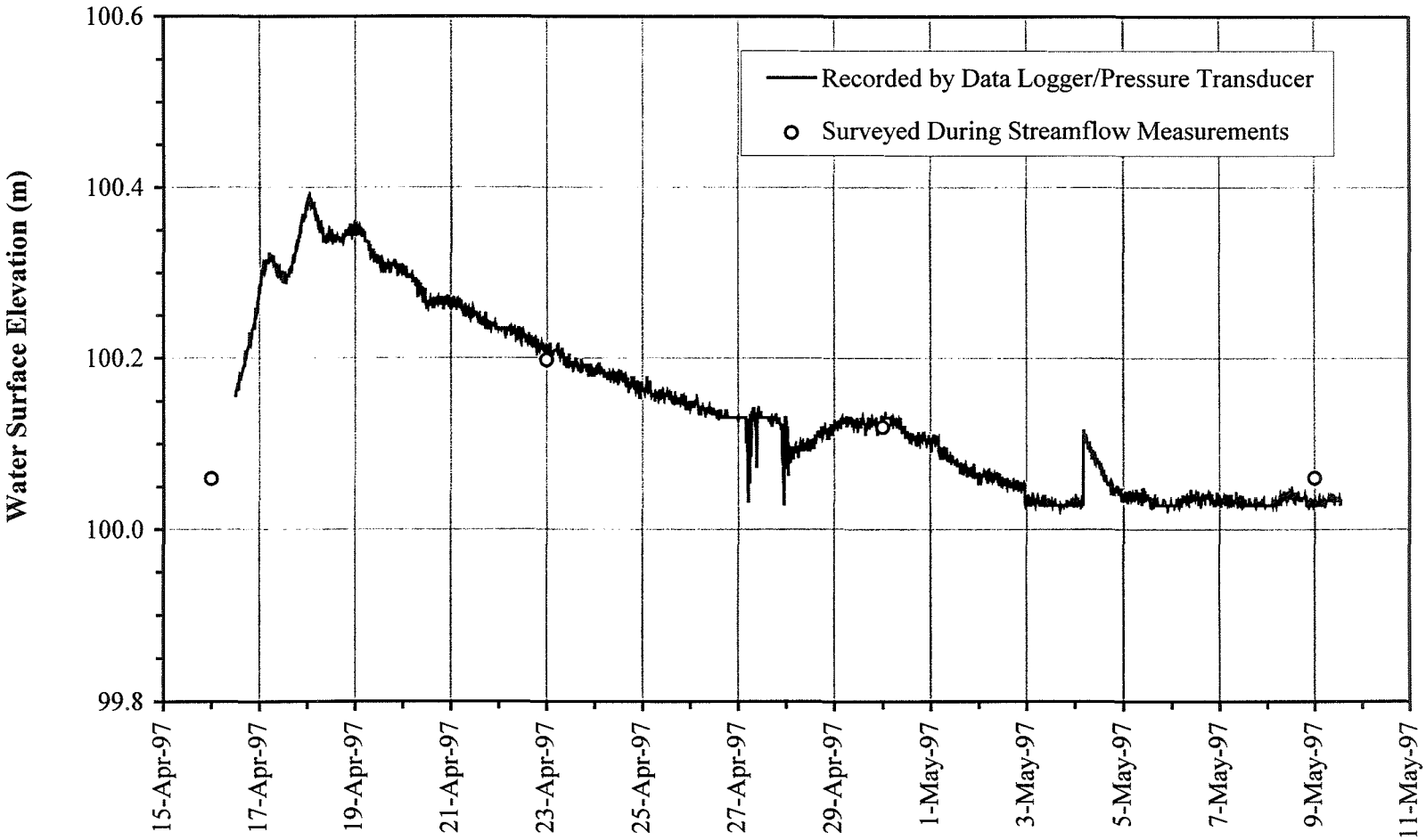


Figure 6. Snowmelt - Stage Hydrograph at Jackpine Creek Station (S2)

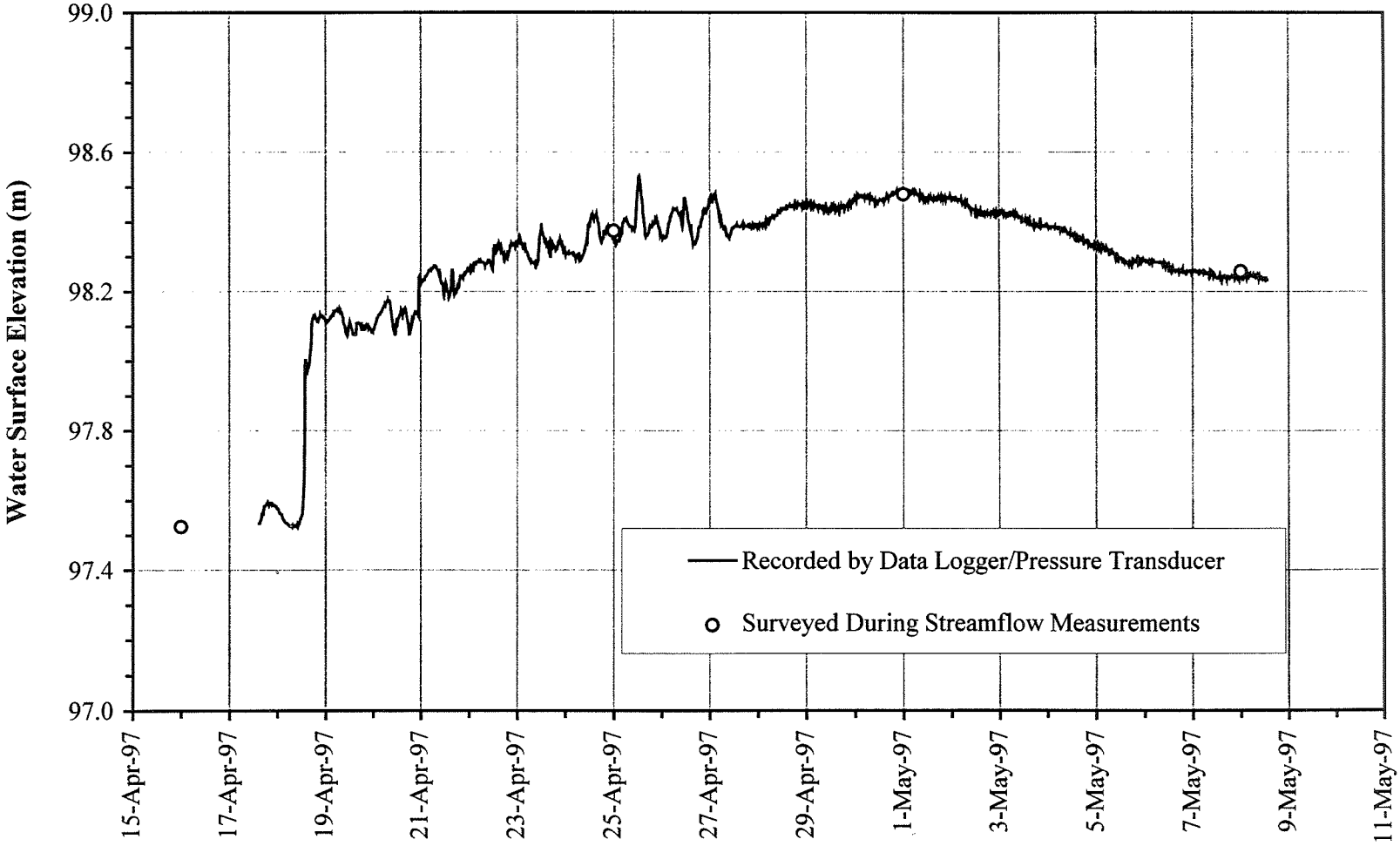


Figure 7. Snowmelt - Stage Hydrograph at Blackfly Creek Station (S4)

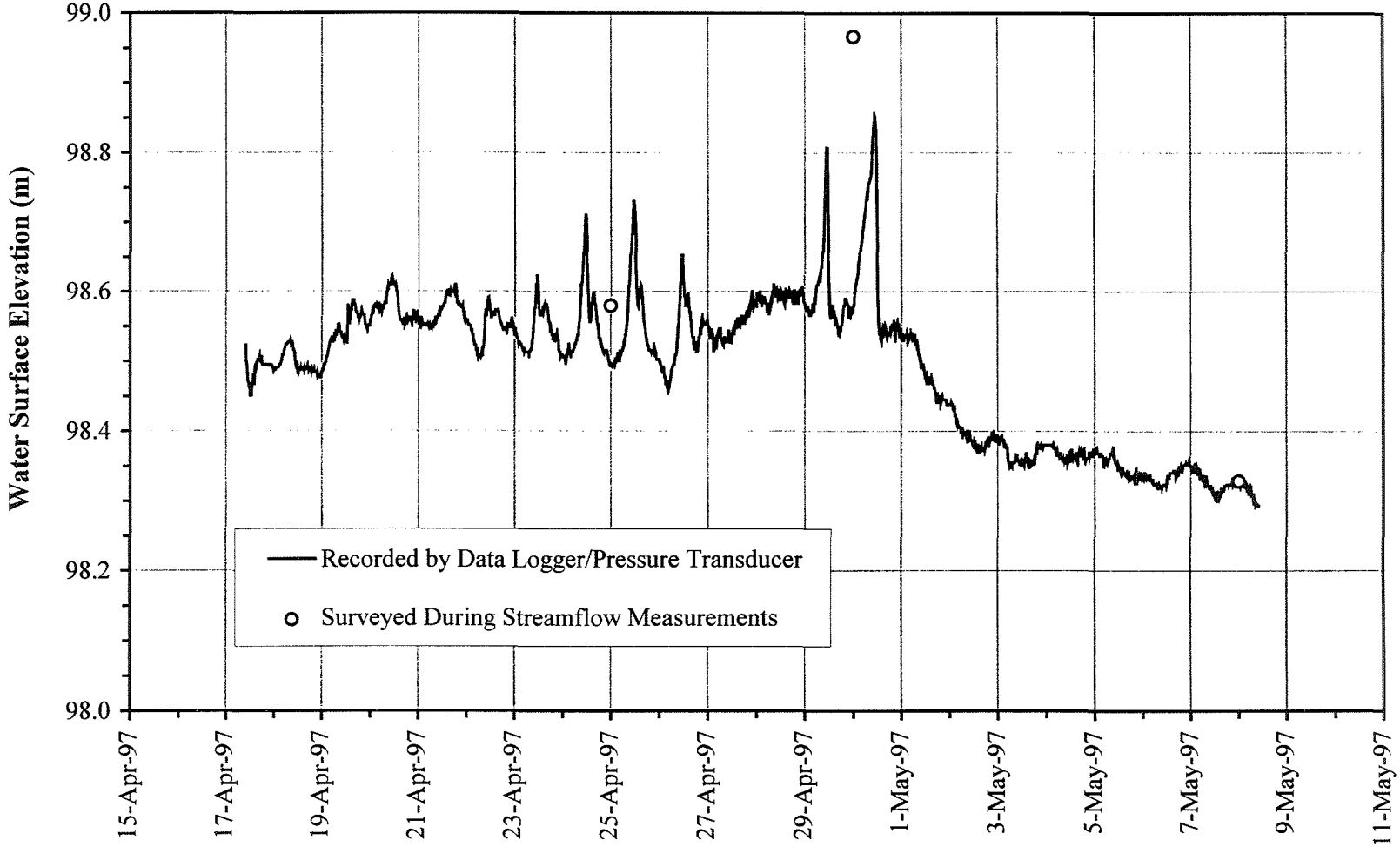


Figure 8. Snowmelt - Stage Hydrograph at Muskeg River Station (S5)

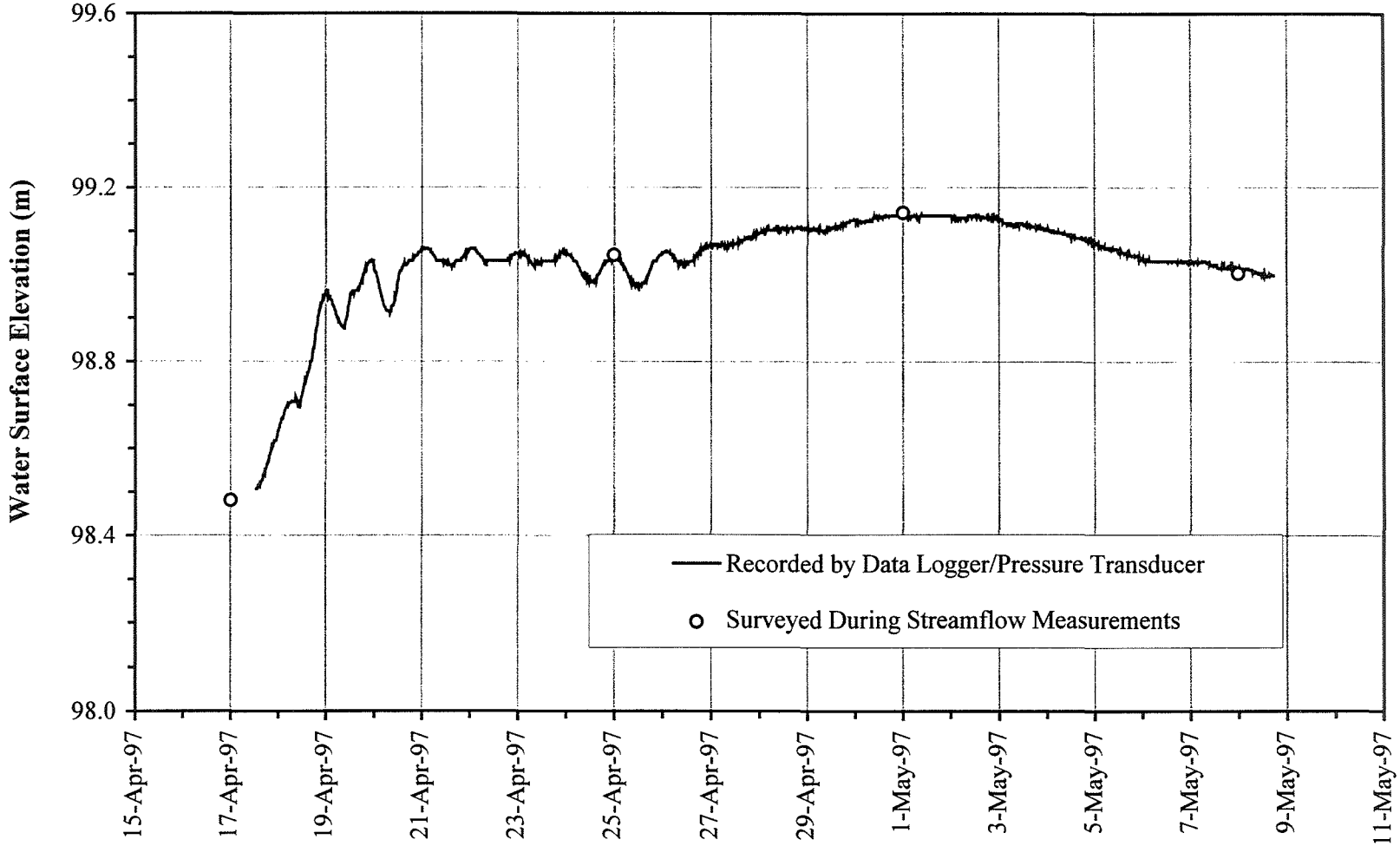
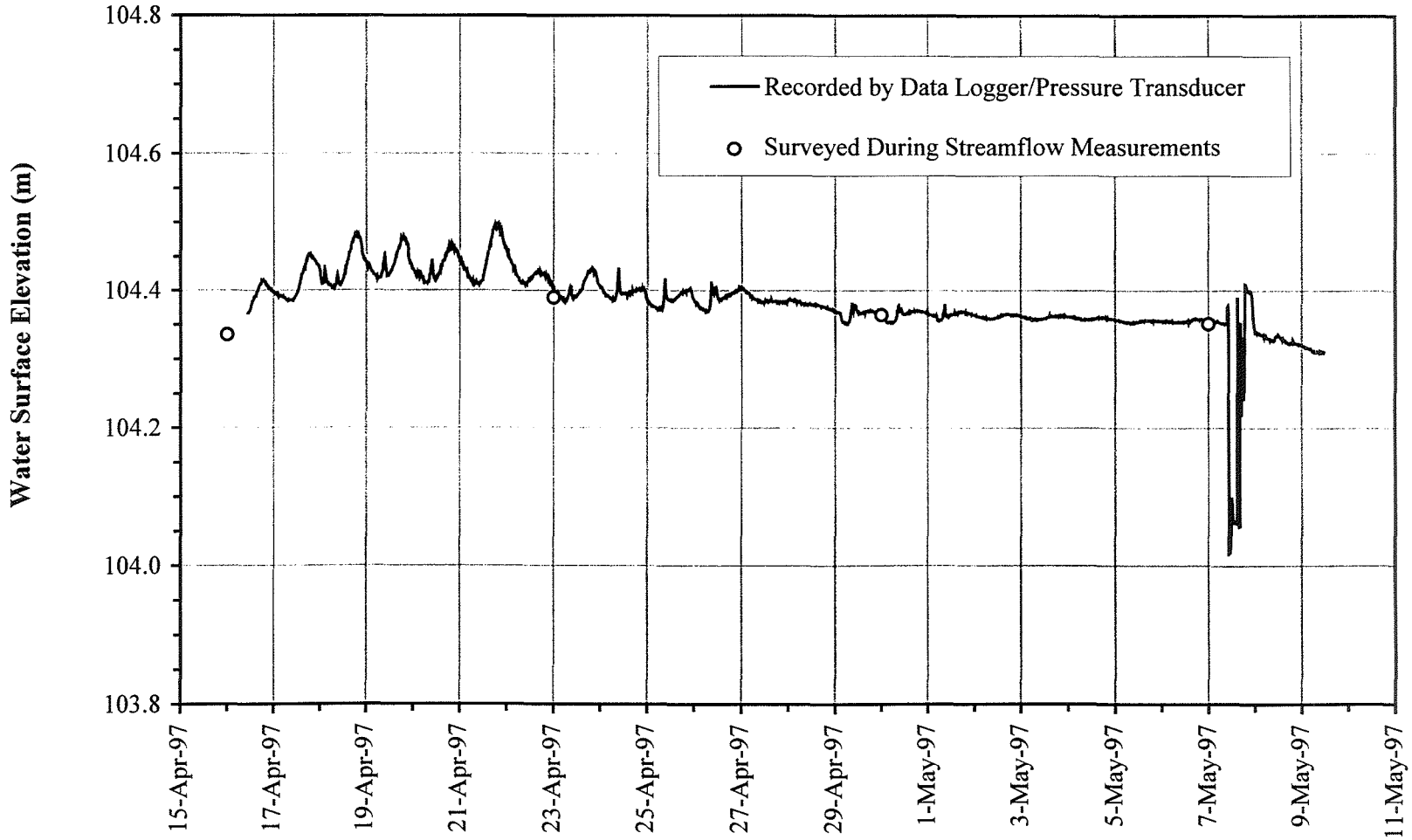


Figure 9. Snowmelt - Stage Hydrograph at Mills Creek Station (S6)



8. CONCLUSIONS AND RECOMMENDATIONS

The Shell 1997 surface water winter program has resulted in a collection of essential hydrologic and hydrometric data for the winter and spring period of 1997. The program has filled some of the data gaps and expanded the available baseline hydrologic database developed for the Syncrude Aurora Mine Project. The specific contributions of this winter program towards development of an improved hydrologic database for the Shell EIA are summarized below.

- The topographic survey of river cross sections along the study reaches of the Muskeg River and Jackpine Creek provides the geometric information and data required to compute before and after river flood levels and to assess the potential impact of mine encroachment on river flood levels and flow velocities.

- The 1997 winter low flow measurements contribute to a continuing development of a winter low flow database required for the analysis of winter flow characteristics, winter water quality and fish habitat conditions at tributary streams of the Muskeg River.

- The 1997 snow course survey and snowmelt flow measurements provide a valuable set of precipitation and streamflow data during the 1997 snowmelt period. This is a first, successful step towards continuing collection of snowmelt flow data required for a reliable calibration of a hydrologic model to characterize the snowmelt runoff of the local river basins.

- The winter program has resulted in establishment of a new streamflow monitoring station on the Mills Creek. Continuing operation of this station will provide essential streamflow data for analyzing the basin runoff characteristics of the Mills Creek basin which would be affected by the proposed mine development on the west side of the Shell Lease.

The improved hydrologic database, complete with supplemental data from the 1997 winter program and the recent climatic and streamflow data collected since 1995 by Syncrude for the

Aurora Mine Project, provides a sound basis for conducting the hydrology component of the EIA for the proposed Shell Mine development on Lease 13.

It is essential and, therefore, recommended that collection of streamflow and climatic data at the existing monitoring sites established by Syncrude and Shell be continued and that monitoring should cover the entire hydrologic cycle including winter low flows, snowmelt, and summer flows in the open-water season. Continuation of the monitoring program is needed for development of an improved hydrologic database, which will allow updating of previous hydrologic analyses and modeling based on site specific data. The continuation will also provide the baseline data necessary for monitoring potential environmental impacts of the proposed mine development activities.

10. REFERENCES

AGRA Earth & Environmental Limited (1995). Hydrologic Study of the Syncrude Mine Site near Fort McMurray, Alberta. Prepared for Syncrude Canada Limited. Calgary, Alberta. July, 1995.

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APPENDIX I

CROSS-SECTIONAL SURVEY DATA - MUSKEG RIVER AND JACKPINE CREEK

Table A1
Surveyed Cross-Sectional Coordinates (x,y,z) - Muskeg River and Jackpine Creek

X Coordinate (m)	Y Coordinate (m)	Z Coordinate (m)	X Coordinate (m)	Y Coordinate (m)	Z Coordinate (m)	X Coordinate (m)	Y Coordinate (m)	Z Coordinate (m)	X Coordinate (m)	Y Coordinate (m)	Z Coordinate (m)
CROSS SECTION # 1			**CROSS SECTION # 3**			**CROSS SECTION # 4**			**CROSS SECTION # 6**		
-9935.94	-18173.1	280.60	-7430.80	-14698.5	284.41	-5988.44	-13780.7	281.00	-3947.52	-11367.8	282.72
-9819.67	-18260.9	279.38	-7346.19	-14740.1	285.75	-5934.89	-13866.1	281.00	-3854.40	-11612.4	280.21
-9733.65	-18325.9	278.56	-7265.09	-14780.0	278.75	-5906.15	-13911.9	283.03	-3816.43	-11688.4	279.21
-9664.34	-18378.3	276.42	-7210.42	-14806.8	278.02	-5883.12	-13948.6	284.99	-3812.77	-11733.1	280.61
-9631.73	-18402.9	275.01	-7141.14	-14840.9	278.64	-5852.16	-13997.9	282.64	-3786.83	-11807.5	279.91
-9619.96	-18411.8	273.06	-7078.07	-14871.9	279.19	-5845.09	-14009.2	280.01	-3785.29	-11811.6	279.11
-9611.12	-18418.5	271.95	-7074.26	-14873.8	276.86	-5839.50	-14018.1	277.01	-3783.83	-11814.3	278.56
-9607.21	-18421.4	273.06	-7068.93	-14876.4	275.19	-5836.47	-14022.9	276.66	-3782.12	-11822.7	279.31
-9591.21	-18433.5	276.34	-7065.52	-14878.1	276.42	-5833.83	-14027.1	277.45	-3780.84	-11825.7	279.71
-9544.64	-18468.7	275.71	-7065.20	-14878.2	276.39	-5828.15	-14036.2	280.46	-3762.63	-11878.9	279.01
-9453.87	-18537.3	279.46	-7056.83	-14882.3	278.96	-5811.48	-14062.7	280.15	-3745.47	-11935.1	280.51
-9393.46	-18582.9	280.69	-7030.45	-14895.3	278.80	-5791.77	-14094.1	282.90	-3725.72	-11970.8	280.81
			-6993.30	-14913.5	278.92	-5769.74	-14129.3	286.78	-3703.44	-12008.7	280.71
CROSS SECTION # 2			-6903.83	-14957.5	279.06	-5741.02	-14175.0	287.22	-3647.41	-12104.1	280.71
-8384.68	-15893.7	280.52	-6808.06	-15004.6	278.20	-5726.12	-14198.8	286.71			
-8324.14	-15966.0	278.36	-6712.82	-15051.4	278.20				**CROSS SECTION # 7A**		
-8287.15	-16010.2	278.04				**CROSS SECTION # 5**			-2947.02	-11126.5	281.33
-8211.01	-16101.2	277.64				-5133.80	-12156.3	281.32	-2773.41	-11128.3	281.54
-8184.13	-16133.3	276.32				-4966.91	-12332.5	281.32	-2773.41	-11128.3	281.54
-8181.82	-16136.1	275.44				-4938.26	-12362.7	281.03	-2646.59	-11124.6	280.44
-8179.59	-16138.8	274.67				-4865.58	-12439.4	279.32	-2577.25	-11130.1	280.44
-8178.81	-16139.7	275.28				-4860.86	-12444.4	278.24	-2480.86	-11123.4	280.74
-8178.10	-16140.5	275.45				-4858.70	-12446.7	276.96	-2366.44	-11125.7	280.54
-8175.24	-16144.0	276.88				-4856.80	-12448.7	278.43	-2363.43	-11125.3	279.74
-8148.38	-16176.1	277.73				-4854.16	-12451.5	279.01	-2359.96	-11125.8	279.34
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-7995.86	-16358.3	277.55				-4743.65	-12568.1	280.50	-2352.76	-11125.7	280.34
-7922.89	-16445.5	277.76				-4690.92	-12623.8	280.68	-2205.16	-11124.2	281.64
						-4668.40	-12647.6	280.87	-2105.34	-11123.5	281.75
						-4583.48	-12737.2	281.20	-1911.29	-11123.8	282.45
									-1781.14	-11124.6	282.45

NOTE:
Horizontal coordinates (x,y) are referred to NE33 TWP.96RGE.9W4M. Vertical elevations (z) are referred to the geodetic datum based on ASCM No. 157735 (282.058 m).

Surveyed Cross-Sectional Coordinates (x,y,z) - Muskeg River and Jackpine Creek

X Coordinate (m)	Y Coordinate (m)	Z Coordinate (m)	X Coordinate (m)	Y Coordinate (m)	Z Coordinate (m)	X Coordinate (m)	Y Coordinate (m)	Z Coordinate (m)	X Coordinate (m)	Y Coordinate (m)	Z Coordinate (m)
CROSS SECTION # 7B			**CROSS SECTION # 9**			**CROSS SECTION # 10**			**CROSS SECTION # 12**		
-2629.99	-10514.5	282.25	-4771.92	-13163.4	279.96	-3364.45	-14064.6	291.38	-1249.27	-16706.0	314.17
-2235.20	-10789.1	280.95	-4753.83	-13252.9	280.41	-3314.61	-14051.1	291.29	-1231.77	-16694.3	312.77
-2231.87	-10790.0	280.05	-4730.08	-13370.5	281.00	-3257.28	-14035.6	289.49	-1158.08	-16645.3	305.87
-2227.55	-10788.3	279.35	-4701.39	-13457.1	281.20	-3209.10	-14022.6	288.49	-1117.54	-16618.4	305.27
-2223.93	-10791.8	279.95	-4692.65	-13519.5	281.10	-3165.04	-14010.7	284.99	-1078.40	-16592.4	304.07
-2220.45	-10794.3	280.55	-4688.96	-13544.8	279.30	-3163.53	-14010.3	283.99	-1073.54	-16589.1	301.67
-1766.00	-11102.3	282.45	-4686.12	-13548.2	278.70	-3159.21	-14009.1	283.59	-1069.96	-16586.7	301.78
			-4683.10	-13551.4	278.20	-3157.99	-14008.8	282.79	-1068.45	-16585.7	302.57
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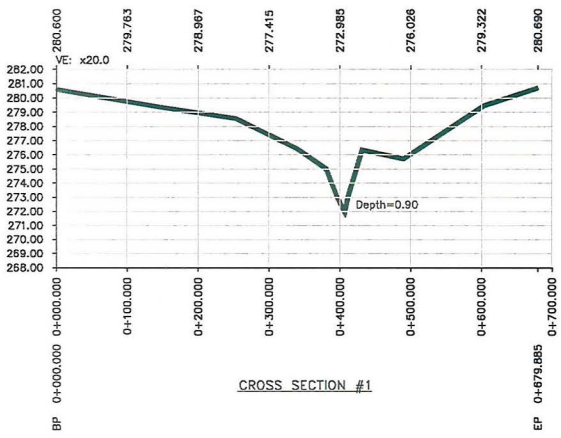
-2023.82	-9600.4	282.47	-4674.95	-13709.2	280.90	-2959.13	-13955.0	289.19	-880.40	-16460.7	317.48
-1778.37	-9691.2	281.67	-4674.78	-13854.9	281.10						
-1775.43	-9691.2	280.77	-4674.79	-13976.2	281.40	**CROSS SECTION # 11**			**CROSS SECTION # 13**		
-1772.46	-9691.3	280.37				-2296.53	-15279.1	302.08	-605.70	-18410.7	316.35
-1770.23	-9691.4	280.77				-2254.81	-15243.2	302.88	-521.38	-18408.2	315.66
-1767.04	-9691.4	281.37				-2191.33	-15188.5	301.98	-419.77	-18405.3	315.56
-1529.41	-9779.7	281.77				-2181.43	-15179.9	297.58	-385.27	-18404.3	309.26
-1396.86	-9828.9	281.77				-2152.21	-15154.8	294.98	-313.37	-18402.2	308.86
						-2147.03	-15150.3	293.38	-312.73	-18402.2	308.46
						-2143.60	-15147.3	293.08	-311.48	-18402.1	308.46
						-2142.18	-15146.1	293.18	-309.25	-18402.1	308.16
						-2138.09	-15142.6	294.78	-305.68	-18402.0	307.76
						-2099.51	-15109.3	297.48	-252.84	-18400.4	314.26
						-2087.80	-15099.3	302.18	-86.23	-18395.6	316.46
						-2041.64	-15059.5	302.18			
						-1998.17	-15022.0	301.69			

NOTE:
Horizontal coordinates (x,y) are referred to NE33 TWP.96RGE.9W4M. Vertical elevations (z) are referred to the geodetic datum based on ASCM No. 157735 (282.058 m).



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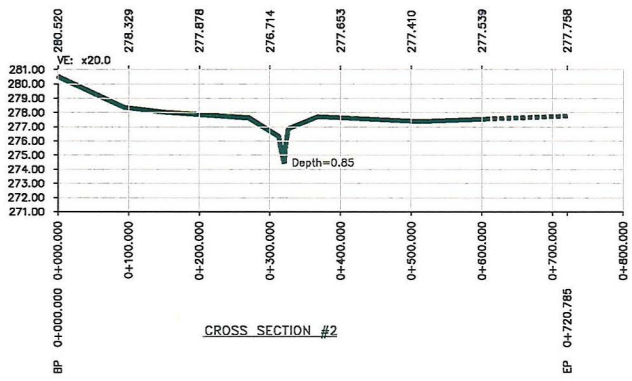

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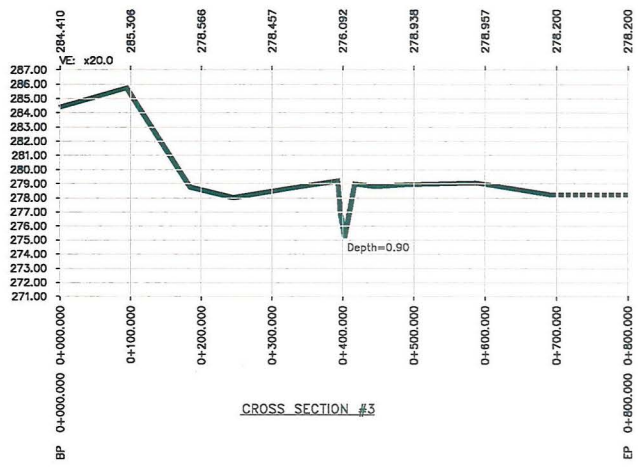

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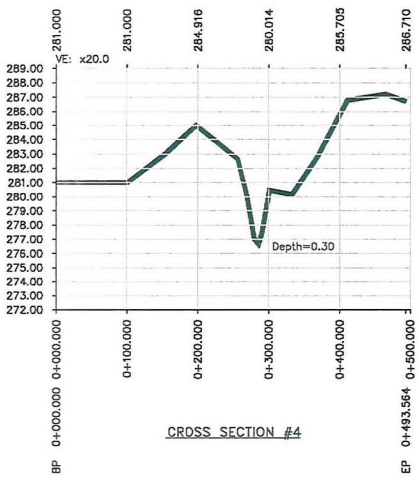

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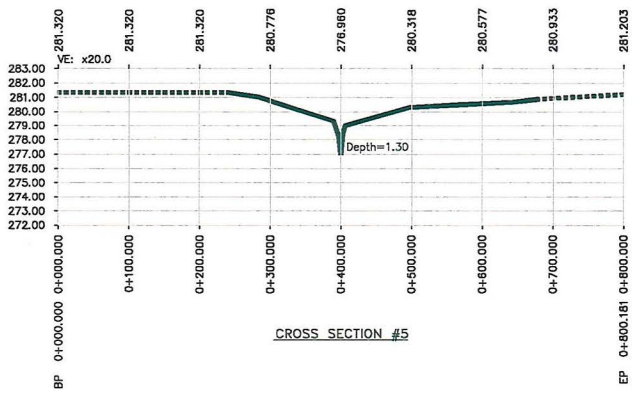

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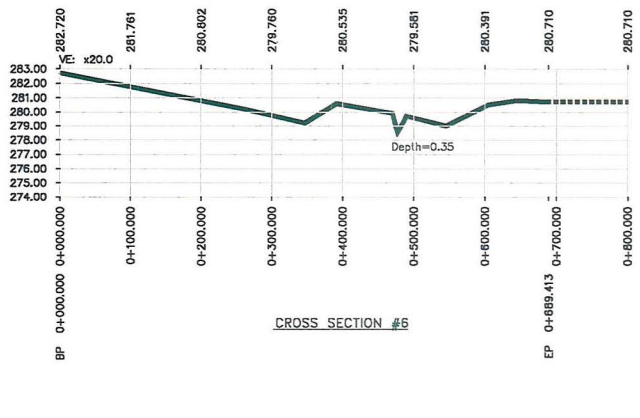

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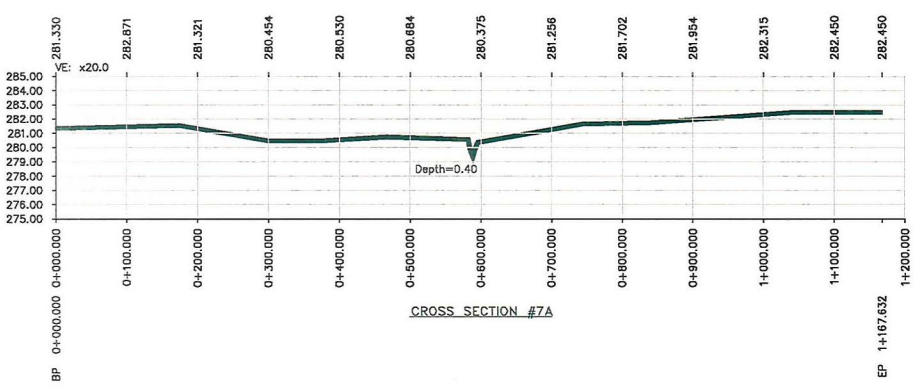

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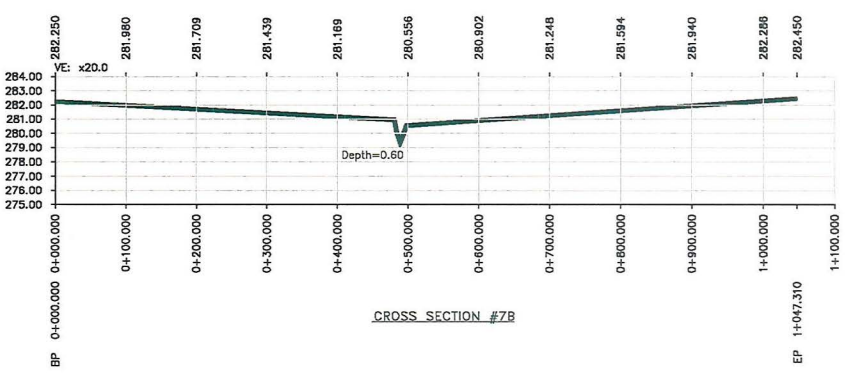

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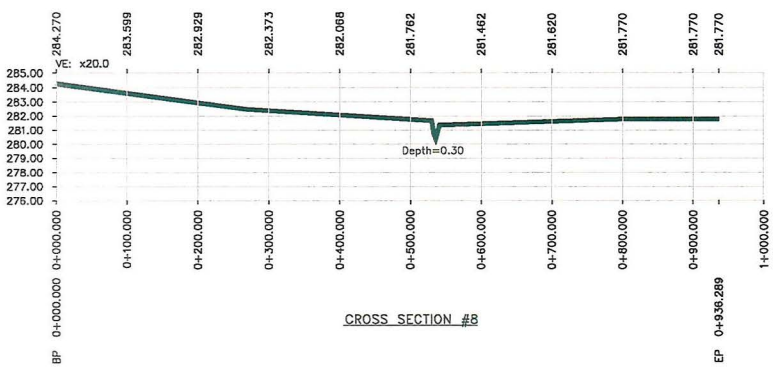

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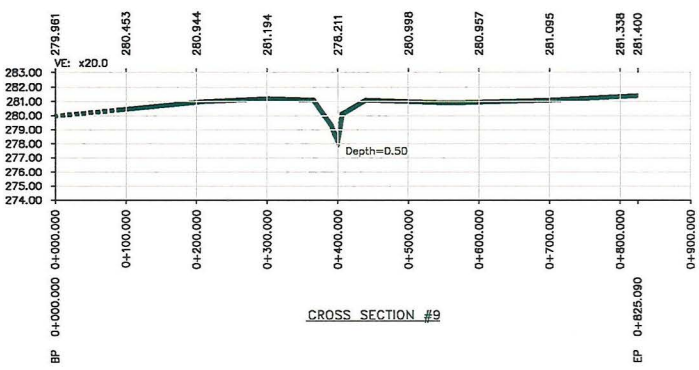

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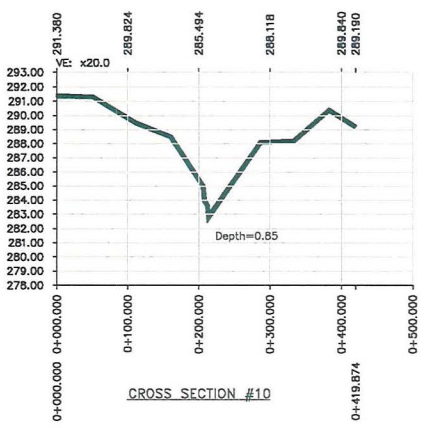

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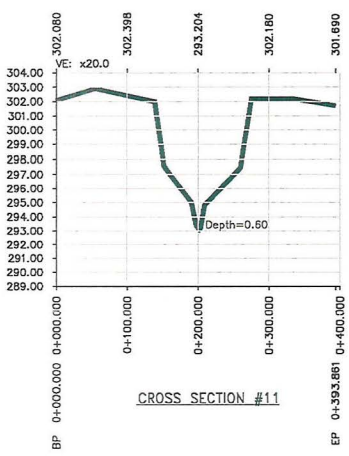

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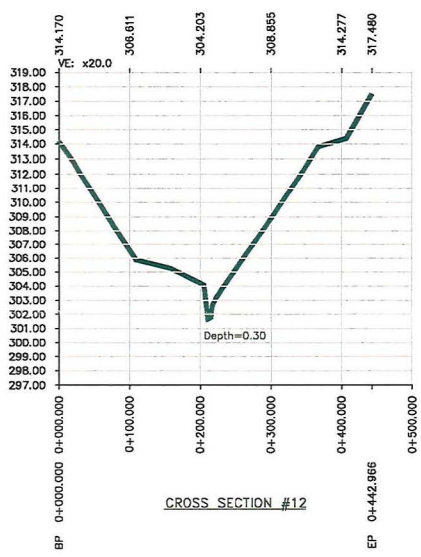

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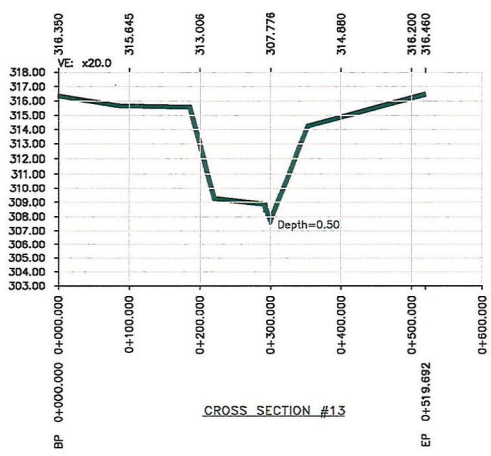

CROSS SECTION #13

SHELL CANADA LIMITED

NOTES:

1. ALL UNITS ARE IN METERS.
2. BP = BEGINNING OF PROFILE
   EP = END OF PROFILE
   VE = VERTICAL EXAGGERATION
3. DEPTH = WATER DEPTH AT TIME OF SURVEY.
4. DOTTED LINES SHOW EXTENDED CROSS-SECTIONAL PROFILE BASED ON SITE OBSERVATIONS.

CAN-AM SURVEYS LTD.
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FILE: M16897X2
DISK No.: M092

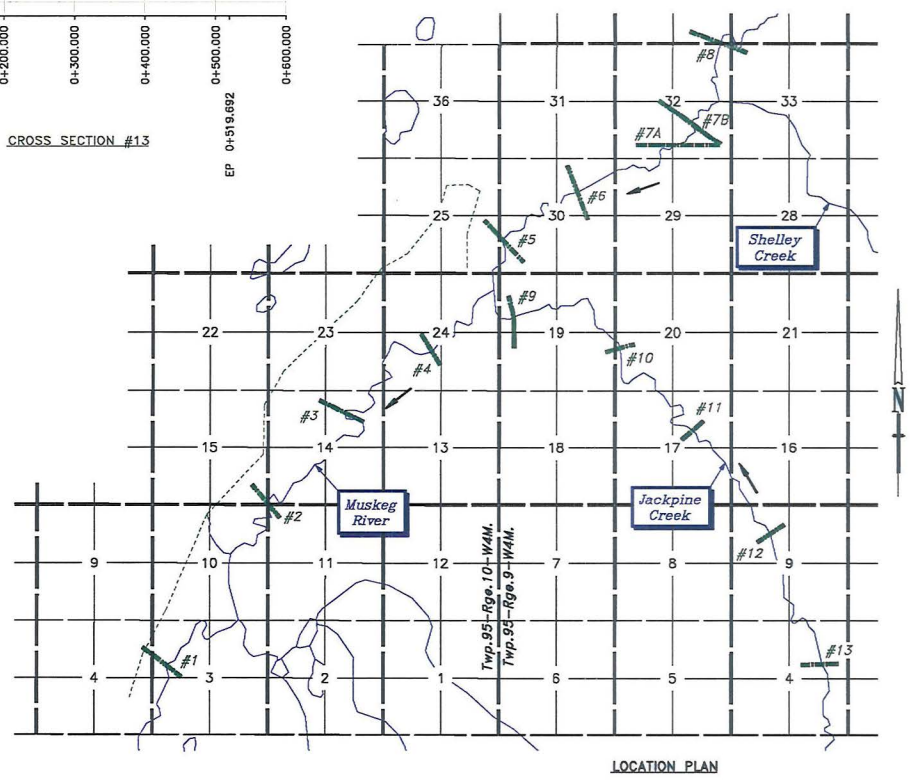
HORIZONTAL SCALE = 1 : 5000
VERTICAL SCALE = 1 : 250
APRIL 8, 1997

Golder Associates

DRAWING No. A1

CROSS SECTIONAL SURVEYS OF MUSKEG RIVER AND JACKPINE CREEK

All elevations are based on a geodetic datum and are referred to ASCM 157735, Elevation = 282.058m



LOCATION PLAN

NOT TO SCALE

APPENDIX II

SNOW COURSE SURVEY DATA AND PHOTOGRAPHS

Table B1
Summary of Snow Course Survey Data

Terrain Type	Survey Plot No	Date of Survey	GPS Location	Snow Density (g/cm^3)	Snow Depth (cm)	Snow Water Equivalent (mm)	Description of Vegetation	Snow Cover Appearance
Flat Low Lying Area	FL #1	17 Mar.'97	468114.7E 6343422.6N	0.188	54.2	101.9	Understory of dead willow - 30%	White loose to compacted coarse granular
	FL #2	17 Mar.'97	468767.5E 6340621.5N	0.170	50.4	85.6	Understory of willow - 50% av. ht. - 3m	White, clean loose, coarse granular
	FL #3	17 Mar.'97	464993.0E 6339612.9N	0.189	76.5	144.6	Understory willow - 40%, av. ht.-2m, Black spruce - < 2%, av. ht. - 2m	White, clean, loose coarse granular
	FL #4	19 Mar.'97	473432.3E 6343441.8N	0.179	65.6	117.2	Understory willow - 60% to 65%, av. ht. - 3m to 3.5m Bog birch - 5%, av. ht.- <1m	Deep, white, loose, coarse granular
Open Land Area	OP #2	17 Mar.'07	464053.8E 6347510.7N	0.184	44.3	81.6	Cut block/gravel pit. Site cleared with some forbes vegetation	White, clean, hard crust 3" below wind swept surface
	OP #3	17 Mar.'97	463884.5E 6332502.4N	0.185	47.6	88.2	Gravel pit/pipeline crossing. Topography - slightly rolling towards Athabasca river. Area surrounded by mixed deciduous (Aspen & Spruce)	Slightly dirty with dust particle from road, hard crust at 6 cm below wind swept surface, coarse granular
Open Lake Area	OP #1	17 Mar.'97	469084.5E 6340889.0N	0.176	14.6	25.6	Surrounded by willow at shoreline, trembling aspen 90% and white spruce 10%.	Compacted, hard, wind swept, clean, white, coarse granular
	OP #4	18 Mar.'97	463378.2E 6342927.1N	0.201	18.2	36.7	Surrounded by black spruce, white birch, trembling aspen and white spruce	Compacted, clean, hard, wind fetch from north, white, coarse granular
Mixed Deciduous Area	MD #1	17 Mar. '97	470450.4E 6341953.2N	0.204	54.7	111.8	White spruce - 30%, av. ht.- 17m, dia.- 20cm. Trembling aspen - 60%, av. ht.- 18m, dia.-15cm. Understory - green alder - 60%, wild rose <1%, white spruce 5%.	White, loose to compacted, coarse granular
	MD #2	19 Mar. '97	475141.1E 6344001.4N	0.206	37.4	77.0	White spruce - 30%, av. ht.-18m, dia.- 18cm. Trembling aspen - 55%, av. ht. - 24m, dia.-20cm. Understory - green alder-20%, ht. 2m - trembling aspen-15%, ht. 0.5m - white spruce 10%, ht. 2m to 2.5m	Loose to slightly compacted hard crust at 6cm below new loose snow, fairly clean with some leaves and snow fleas
	MD #3	19 Mar.'97	476660.4E 6344618.0N	0.182	44.0	80.1	White spruce - 20%, av. ht.-20m, dia.- 19cm. Trembling aspen - 70%, av. ht. - 23m, dia.-20cm. Understory - green alder 40%, ht. 2.5m - trembling aspen -5%, ht.- 1.0m	Loose to slightly compacted coarse granular and lots of snow fleas
	MD #4	19 Mar.'97	480690.9E 6348323.5N	0.241	48.6	117.1	White spruce - 25%, av. ht.-18m, dia.- 15cm. Trembling aspen - 50%,av. ht.-20m, dia.- 18cm. White birch <2%, ht. 14m. Understory - green alder 20%, ht.-2m -white birch 15%, ht. 3.5m -willow 5%, ht.1.5m - white spruce 13%, ht. 3m	Slightly compacted and 'sticky' due to warmer temperature, coarse granular, some snow fleas
Jack Pine Area	JP #1	17 Mar.'97	468016.4E 6343202.0N	0.171	44.9	76.5	Jack Pine - 80%, av. ht.-18m, dia. 18cm. Trembling aspen - 5%, av. ht.-16m, dia.- 10cm. Understory - buffaloberry 10%, trembling aspen 2%	White, loose, granular with pine needles
	JP #2	17 Mar.'97	472067.6E 6343054.4N	0.165	48.5	80.2	Jack Pine - 60%, av. ht. 20m, dia.17cm. Understory - white spruce 5%	White, clean, loose, coarse granular
	JP #3	19 Mar.'97	469621.3E 3641137.3N	0.168	51.1	85.8	Jack Pine -70%, av. ht. 20m, dia. 16cm. Trembling aspen - 2%, av. ht.20m, dia. 11cm. Understory - buffaloberry 10%, white spruce 1%	White, loose to compacted, coarse granular with lot of fine needles
	JP #4	19 Mar.'97	473911.2E 6343295.0N	0.179	43.2	77.1	Jack Pine - 75%, av. ht. 21m, dia. 19cm. Understory - green alder 35%, ht. 1m to 1.5m. - labrador tea <2%	White, loose to slightly compacted, clean, coarse granular with pine needles interspersed among snow

Photographs

Photograph 1 Survey Plot FL #1: Flat low lying area (site of the snow depth/snow density, Mar. 17, 1997)

Photograph 2 Survey Plot FL #2: Flat low lying area (site of the snow depth/snow density, Mar. 17, 1997)

Photographs

Photograph 3 Survey Plot FL #3: Flat low lying area (looking north, Mar. 17, 1997)

Photograph 4 Survey Plot FL #4: Flat low lying area (facing south - south west, Mar. 19, 1997)

Photographs

Photograph 5 Survey Plot OP #1: Open lake area (facing north, Mar. 17, 1997)

Photograph 6 Survey Plot OP #4: Open lake area (Isadore's Lake, Mar. 18, 1997)

Photograph 7 Survey Plot OP #2: Open land area (facing south, Mar. 17, 1997)

Photograph 8 Survey Plot OP #3: Open land area (facing south, Mar. 17, 1997)

Photographs

Photograph 9 Survey Plot MD #1: Mixed deciduous area (facing east, Mar. 17, 1997)

Photograph 10 Survey Plot MD #2: Mixed deciduous area (facing west, Mar. 19, 1997)

Photograph 11 Survey Plot MD #3: Mixed deciduous area (facing west, Mar. 19, 1997)

Photograph 12 Survey Plot MD #4: Mixed deciduous area (facing west, Mar. 19, 1997)

Photographs

Photograph 13 Survey Plot JP #1: Jack pine area (Jack pine stand, Mar. 17, 1997)

Photograph 14 Survey Plot JP #2: Jack pine area (facing south, Mar. 17, 1997)

Photographs

Photograph 15 Survey Plot JD #3: Jack pine area (facing north, Mar. 19, 1997)

Photograph 16 Survey Plot JD #4: Jack pine area (facing west, Mar. 19, 1997)

APPENDIX III

PHOTOGRAPHS OF STREAMFLOW MONITORING STATIONS (S1 TO S6)

Photographs

Photograph 1 Station S1 – Alsands Drain, looking downstream towards weir (17 March 1997).

Photograph 2 Station S2 – Jackpine Creek, facing downstream of transect (16 March 1997).

Photographs

Photograph 3 Station S3 – Iyinimin Creek, looking RDB to LDB (18 March 1997).

Photograph 4 Station S4 – Blackfly Creek, facing downstream across transect (18 March 1997).

Photographs

Photograph 5 Station S5 – Muskeg River, looking RDB to LDB at transect (18 March 1997).

Photograph 6 Station S6 – Mills Creek, view of creek upstream; thin ice formed on surface (28 March 1997).

Photograph 7 Station S1 – Weir at Alsands Drain (16 April 1997).

Photograph 8 Station S2 – View of Jackpine Creek gauging station (17 April 1997).

Photographs

Photograph 9 Station S3 – Iyinimin Creek, view from the air (17 April 1997).

Photograph 10 Station S4 – Blackfly Creek (17 April 1997).

Photograph 11 Station S5 – Water ponding on top of ice at Muskeg River (17 April, 1997).

Photograph 12 Station S6 – Mills Creek, looking upstream (16 April 1997).

Photograph 13 Station S1 – Alsands Drain, looking upstream from 30 m downstream of weir (30 April 1997).

Photograph 14 Station S2 – Jackpine Creek, panoramic view LDB (01 May 1997).

Photograph 15 Station S3 – Iyinimin Creek, looking upstream - panoramic (01 May 1997).

Photograph 16 Station S4 – Blackfly Creek, looking upstream - from LDB (01 May 1997).

Photograph 17 Station S5 – Muskeg River, panoramic view LDB (01 May 1997).

Photograph 18 Station S6 – Mills Creek, looking downstream (30 April 1997).

APPENDIX IV

LICENSE FOR INSTALLING THE MILLS CREEK STREAMFLOW GAUGING STATION

Alberta
ENVIRONMENTAL PROTECTION

Natural Resources Service
Northeast Boreal Region
Water Management

7th floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta
Canada T5K 2J6

Telephone 403/427-5296
Fax 403/422-0528

April 23, 1997

File: 60131

Mr. Senarath Ekanayake/Mr. Lawrence Low
Golder Associates
1011 - 6th Avenue, S.W.
Calgary, Alberta
T2P 0W1

Dear Mr. Ekanayake/Low:

RE: INSTALLATION OF TEMPORARY STREAMFLOW MEASURING WEIR AND GAUGING STATION
SHELL CANADA LIMITED
MILLS CREEK - SW-17-95-10-W4

Enclosed is Permit No. 97-086-NEB which authorizes the above under the Water Resources Act.

Please note that:

1. This authorization does not supersede approvals required pursuant to other applicable acts.

2. Approval under the Public Lands Act may be required. Please contact Land Administration Division (427-3570) for further details.

If you have any questions in regard to the Permit please call me at 427-5296.

Sincerely,

Ann Carlson

Ann Carlson
Regional Technologist

Enclosure

Alberta

PERMIT

ENVIRONMENTAL PROTECTION
Water Resources Administration Division

PURSUANT TO PROVISIONS OF THE

WATER RESOURCES ACT

Shell Canada Limited
400 - 4th Ave., S.W.
Calgary, Alberta
T2P 2H5

FILE NO. 60131

DATE ISSUED: April 23, 1997

PERMIT NO. 97-086-NEB

is authorized under THE WATER RESOURCES ACT , as soon as right of way is obtained, to install a streamflow monitoring station and temporary weir in Mills Creek located in SW-17-95-10-W4 according to plans filed and identified in departmental records as:

W.R. PLAN NO.	TITLE
60131-1	Proposed Streamflow Monitoring Station
60131-2	Location Plan
60131-3	View of Weir Looking N/S
60131-4	Details of River Gauging Station

This permit is subject to the following conditions:

1. This authority to install and operate this monitoring station and temporary weir expires on April 23, 1998, at which time the weir and related equipment are to be removed and the site to be reclaimed.

2. The permittee is responsible for the construction, operation and maintenance of the works and for any damages that may result.

3. The deposition of deleterious material on the ice or in the water of Mills Creek is prohibited.

4. Disturbance of the bed and/or banks of Mills Creek during the construction of the proposed works is to be kept to a minimum and confined to the immediate site.

5. A copy of the permit is to be available at the job site during installation.

6. The stream directly below the weir is to be monitored to ensure that there is no build up of fish. If there is a build up of fish, please contact Larry Rhude at Fisheries Management in Fort McMurray at 743-7200.

Department of Environmental Protection

Head, Water Administration Branch
Northeast Boreal Region

cc: Department File Copy
D. Huberdeau - Land and Forest - Ft. McMurray
L. Rhude -Fisheries Management - Ft. McMurray

Alberta

ENVIRONMENT

APPLICATION for LICENCE

Pursuant to Sec. 11 (1) (a) (b) (c)
THE WATER RESOURCES ACT

APPLICANT'S NAME: GOLDER ASSOCIATES FOR SHELL CANADA LTD.
Please type or print full name clearly

ADDRESS: 1011, 6TH AVE. S.W.
Street, P.O. Box or R.R. No.

299-5853 | CALGARY | ALBERTA | T2P 0W1
Phone No. | City, Town or Village | Province | Postal Code

hereby applies for authority to construct the works shown on plans filed in connection with this application and for the right to divert N/A acre-feet of water annually from —

MILLS CREEK
Name of stream, lake, reservoir, aquifer or other source of supply

at a point in

	or	SW	17	95	10	W 4 M
LSD	or	Quarter	Section	Township	Range	Meridian

for STREAM - FLOW MONITORING purposes.

The lands on which the works are to be built are held as follows:

as registered owner ☐; purchaser under agreement for sale ☐; lessee ☑; renter ☐;

to be negotiated ☐. (Check applicable boxes)

(If several parcels are affected by proposed works show ownership of each on an accompanying map)

Plans, supporting data and reports showing details of water requirements, construction and operating procedures accompany this application, or are to be filed on my behalf by.

GOLDER ASSOCIATES LTD. (403) 299-5853
Name and address of consultant, agent or other engineering services | Phone No.

I/We agree to construct works in accordance with plans filed and approved in connection with this application and to recognize the rights of other water users.

Signature(s) of applicant or signing authority

Date 02 APR. 19 97

SENARATH EKANAYAKE
Type or print name and title of signing authority

OTHER APPLICATION FORMS	FORWARD COMPLETED APPLICATIONS TO:
Under The Water Resources Act available on request WR 1A – Drainage – Sec. 11 (1)(d) WR 1B – Permits – Sec. 11 (1)(e) WR 1C – Exploration Permit – Sec. 15	Controller of Water Resources Alberta Environment Oxbridge Place 9820 – 106 Street Edmonton, Alberta. T5K 2J6

FOR WATER RIGHTS OFFICE USE ONLY:

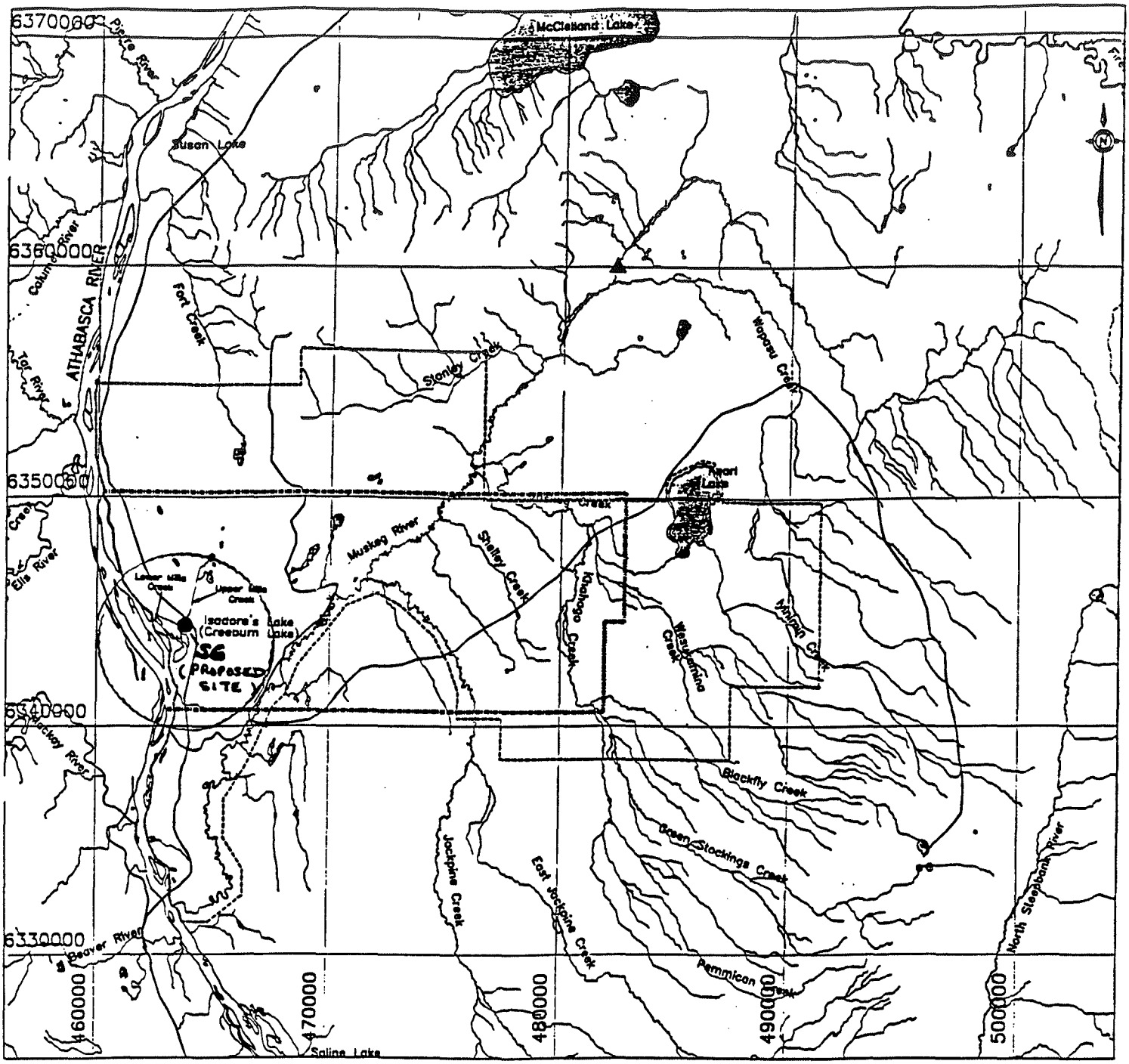
Advertizing required ☐; waived ☐ ☐ File No. _____

Priority No.				
	Year	Month	Day	Number

Recorded by: _____

Approved: Date _____ 19 ____ By _____
Controller of Water Resources

WR 1 (NOV/82) SEE OVER FOR INFORMATION FOR APPLICANTS



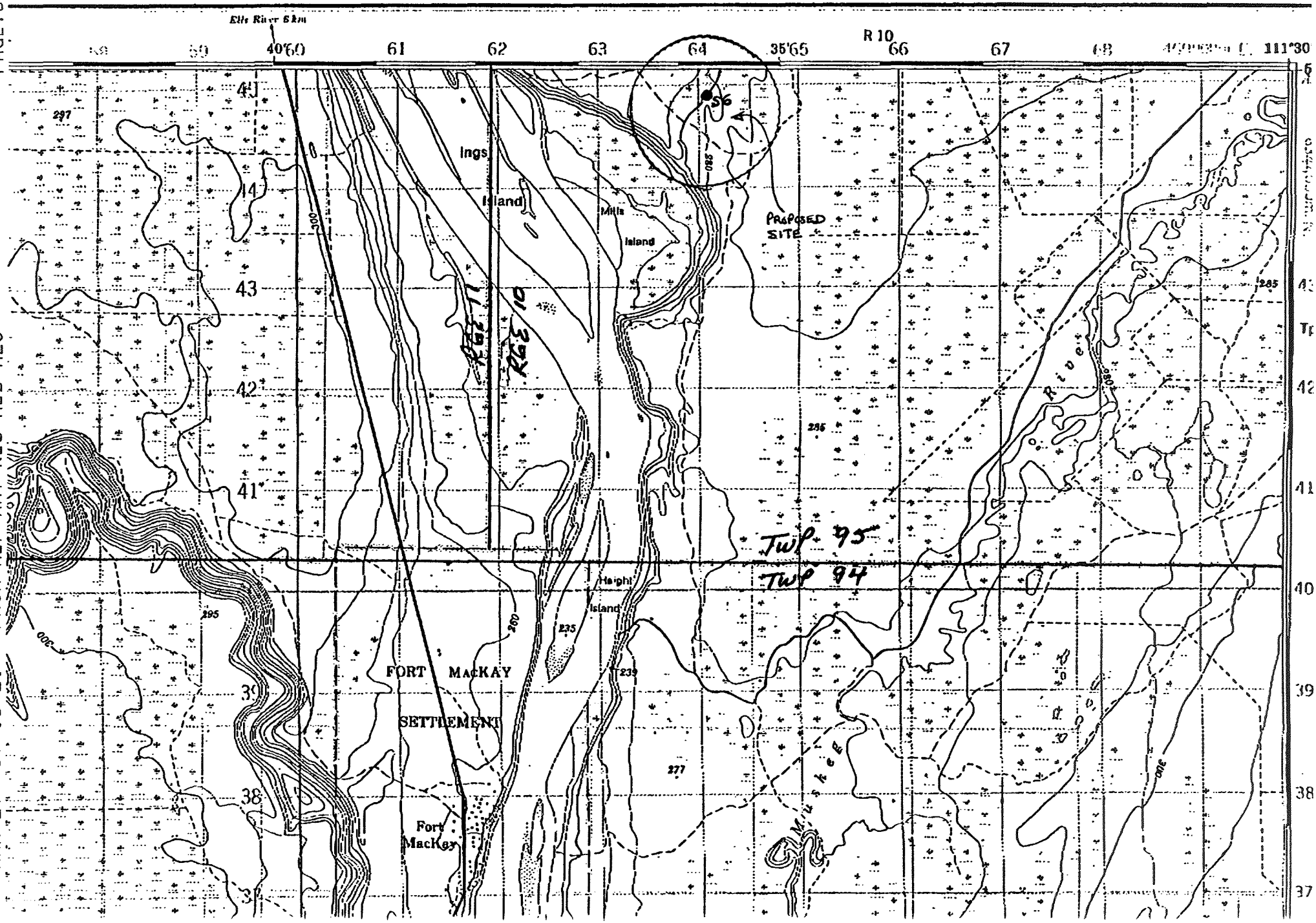
LEGEND

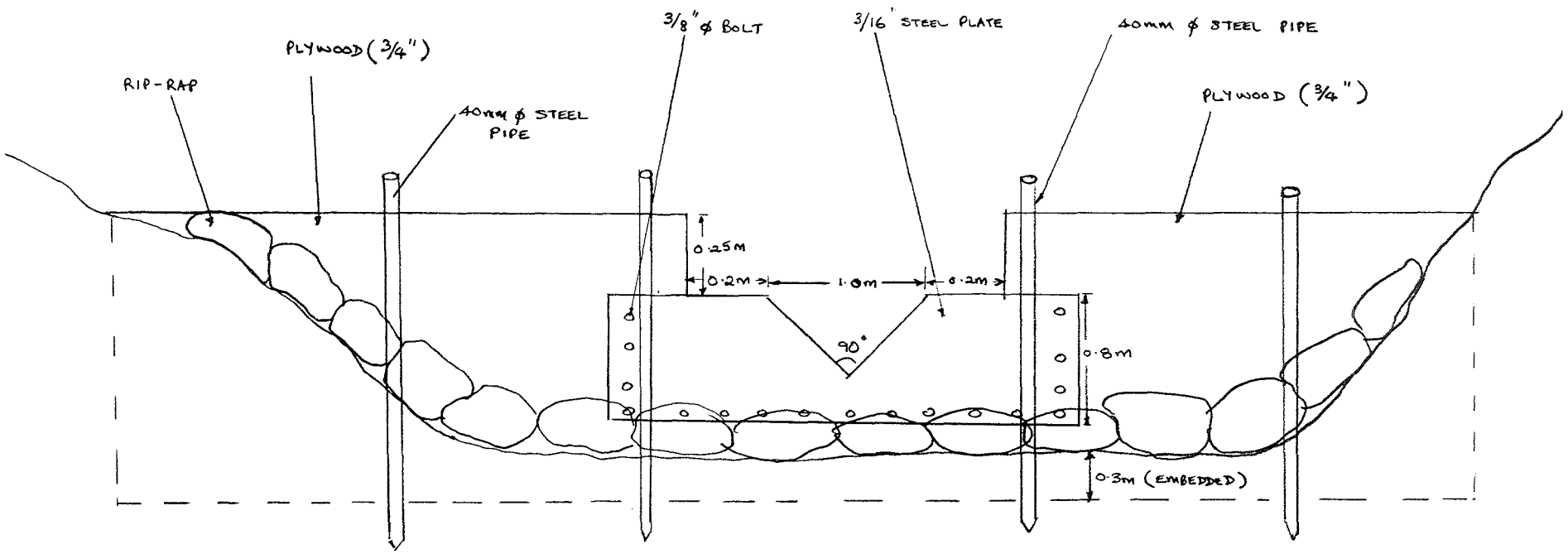
● PROPOSED STREAMFLOW MONITORING STATION

REFERENCE

DRAWING FROM AGRA EARTH AND ENVIRONMENTAL LIMITED
FIG.1435-A3 CATCHMENT BOUNDARIES OF LOCAL STUDY AREA
JAN, 1996.

EDITION 3

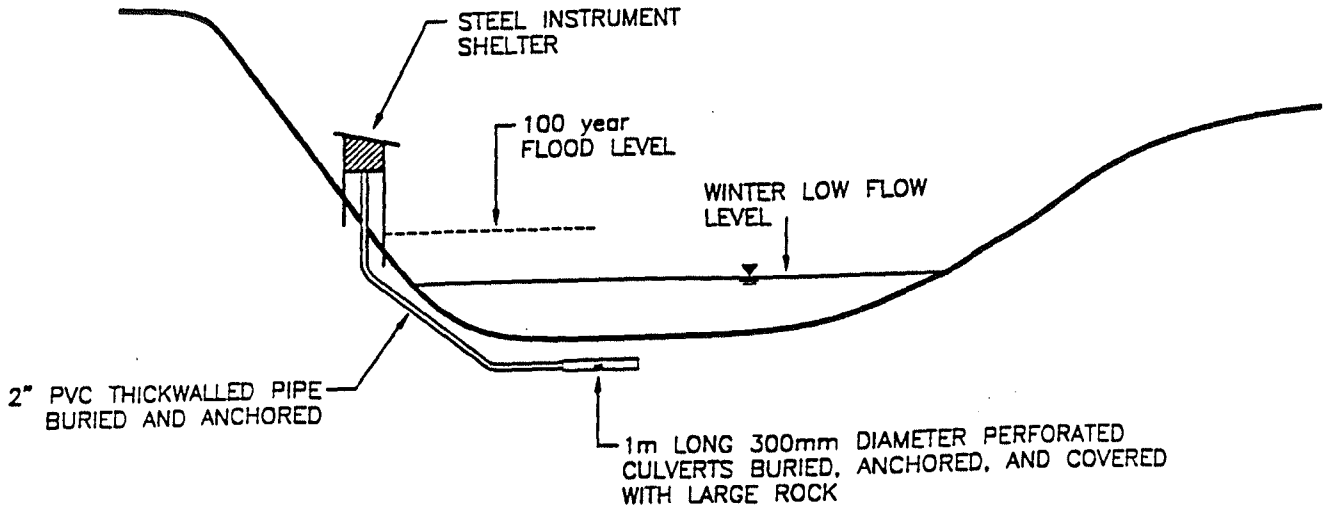




VIEW OF AS-BUILT WEIR - LOOKING U/S

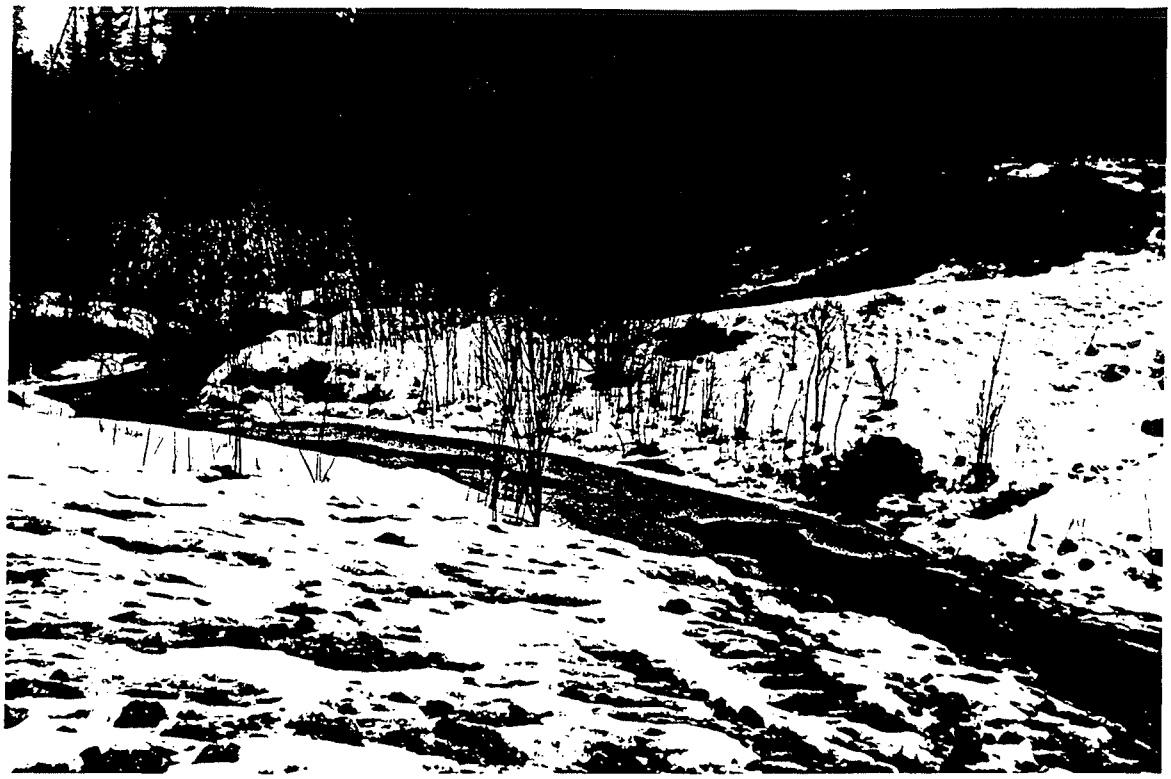
N.T.S

DETAILS OF RIVER GAUSING STATION



NOT TO SCALE
SCHEMATIC ONLY

PROJECT _____ DRAWN _____ REVIEWED _____ DATE _____ RVRFLOW.dwg



VIEW OF MILLS CREEK – LOOKING U/S

APPENDIX V

WINTER LOWFLOW AND SNOWMELT FLOW MEASUREMENTS

Winter Lowflow Measurements (March 16 to 28, 1997)

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 17 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0830 hr.
MEASUREMENT END TIME: 0930 hr.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.1	0.000
1	0.20	0.00	0.04			-0.010	0.2	0.000
2	0.40	0.00	0.09			0.000	0.2	0.000
3	0.60	0.00	0.13			0.570	0.2	0.015
4	0.80	0.00	0.14			0.710	0.2	0.020
5	1.00	0.00	0.13			1.030	0.2	0.027
6	1.20	0.00	0.10			0.800	0.2	0.016
7	1.40	0.00	0.09			-0.020	0.2	0.000
8	1.60	0.00	0.08			0.370	0.2	0.006
9	1.80	0.00	0.05			0.130	0.2	0.001
10	2.00	0.00	0.01			0.000	0.15	0.000
Right Bank	2.10	0.00	0.00			0.000	-1	0.000
							Total Discharge	0.084

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Ice thickness was not measured(!)

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 28 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0945 hrs.
MEASUREMENT END TIME: 1020 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.10	0.000
1	0.20	0.00	0.09			0.090	0.20	0.002
2	0.40	0.00	0.17			0.140	0.20	0.005
3	0.60	0.00	0.17			0.220	0.20	0.007
4	0.80	0.00	0.19			0.470	0.20	0.018
5	1.00	0.00	0.20			0.810	0.20	0.032
6	1.20	0.00	0.15			0.330	0.20	0.010
7	1.40	0.00	0.11			0.020	0.20	0.000
8	1.60	0.00	0.09			-0.010	0.25	0.000
Right Bank	1.90	0.00	0.00			0.000	-0.80	0.000
							Total Discharge	**0.074**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Ice thickness was very thin - average thickness at the edge was 45mm and at the middle was 15mm.
3. Ice covered was broken up and flow was measured as open water

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471657.4E/6346353.7N
Substrate: Sand and silt

MEASUREMENT DATE: 16 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: KA/TC
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1228 hrs.
MEASUREMENT END TIME: 1330 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00	0.00	0.00	0.000	0.425	0.000
1	0.85	0.65	0.72	0.00	0.03	0.015	0.825	0.009
2	1.65	0.57	0.76	0.01	0.02	0.015	0.59	0.007
3	2.03	0.58	0.75	0.01	0.01	0.010	0.4	0.003
4	2.45	0.59	0.66	0.01	0.00	0.005	0.46	0.002
5	2.95	0.58	0.52	0.01	0.01	0.010	0.5	0.003
6	3.45	0.62	0.32	0.00	0.00	0.000	0.525	0.000
Right Bank	4.00	0.00	0.00	0.00	0.00	0.000	-1.725	0.000
							Total Discharge	**0.023**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Snow depth on stream channel average 0.52m

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 28 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1230 hrs.
MEASUREMENT END TIME: 1300 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.50	0.00			0.000	0.15	0.000
1	0.30	0.37	0.72			0.110	0.3	0.024
2	0.60	0.30	0.76			0.140	0.35	0.037
3	1.00	0.30	0.75			-0.030	0.35	-0.008
4	1.30	0.35	0.66			0.150	0.45	0.045
Right Bank	1.90	0.35	0.00			0.000	-0.65	0.000
							Total Discharge	**0.098**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Water surface was below the bottom of ice
3. Flow was measured as open water

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 18 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0830 hr.
MEASUREMENT END TIME: 0920 hr.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank								
1								
2								
3								
4								
5								
Right Bank								
						Total Discharge		0.000

Note: 1. Drilled 4 holes of 50 cm apart - no water.
2. Snow covered measurements at channel are 47cm, 57cm and 51cm.
3. Ice thickness 30cm to 35cm.

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 27 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/Tom Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1115 hrs.
MEASUREMENT END TIME: 1130 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank								
1								
2								
3								
4								
5								
Right Bank								
						Total Discharge		0.000

Note: 1. Redrilled 4 holes of 50 cm apart - no water.
2. Average snow covered measurements at channel was 35cm.
3. Average ice thickness 40cm.

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 18 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0925 hr.
MEASUREMENT END TIME: 1030 hr.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank								
1								
2								
3								
4								
5								
Right Bank								
						Total Discharge		0.000

Note: 1. Drilled 5 holes of 60 cm apart - no water.
2. Snow covered measurements at channel are 0.16m, 0.20m and 0.24m.
3. Ice thickness 50cm

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 27 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1043 hrs.
MEASUREMENT END TIME: 1105 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank								
1								
2								
3								
4								
5								
Right Bank								
						Total Discharge		0.000

Note: 1. Redrilled 5 holes of 60 cm apart - no water.
2. Average snow covered measurements at channel was 0.20m.
3. Average ice thickness 0.6m.

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Muskeg
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 18 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1040 hr.
MEASUREMENT END TIME: 1230 hr.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00	0.00	0.00	0.000	0.25	0.000
1	0.50	0.45	1.17	0.00	0.01	0.005	0.625	0.004
2	1.25	0.46	1.25	0.01	0.01	0.010	0.775	0.010
3	2.05	0.40	1.24	0.02	0.02	0.020	0.755	0.019
4	2.76	0.41	1.26	0.01	0.02	0.015	0.74	0.014
5	3.53	0.44	1.26	0.03	0.02	0.025	0.79	0.025
6	4.34	0.44	1.20	0.03	0.03	0.030	0.74	0.027
7	5.01	0.45	1.15	0.02	0.02	0.020	0.755	0.017
8	5.85	0.43	1.07	0.01	0.02	0.015	0.875	0.014
9	6.76	0.42	1.01	0.01	0.02	0.015	0.825	0.012
10	7.50	0.46	1.02	0.01	0.02	0.015	0.745	0.011
11	8.25	0.49	0.89	0.01	0.01	0.010	0.68	0.006
12	8.86	0.52	0.82	0.00	0.00	0.000	0.575	0.000
Right Bank	9.40	0.00	0.00	0.00	0.00	0.000	-4.43	0.000
							Total Discharge	**0.159**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Muskeg
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 27 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1150 hrs.
MEASUREMENT END TIME: 1310 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00	0.00	0.00	0.000	0.35	0.000
1	0.70	0.41	1.21	0.00	0.01	0.005	0.75	0.005
2	1.50	0.42	1.31	0.02	0.01	0.015	0.8	0.016
3	2.30	0.38	1.20	0.01	0.02	0.015	0.75	0.014
4	3.00	0.31	1.32	0.03	0.04	0.035	0.8	0.037
5	3.90	0.45	1.24	0.03	0.03	0.030	0.8	0.030
6	4.60	0.46	1.17	0.04	0.03	0.035	0.7	0.029
7	5.30	0.46	1.13	0.03	0.04	0.035	0.75	0.030
8	6.10	0.45	1.00	0.03	0.02	0.025	0.85	0.021
9	7.00	0.43	0.98	0.01	0.02	0.015	0.85	0.012
10	7.80	0.47	1.02	0.02	0.02	0.020	0.8	0.016
11	8.60	0.50	0.88	0.01	0.01	0.010	0.65	0.006
12	9.10	0.52	0.80	0.01	0.01	0.010	0.45	0.004
Right Bank	9.50	0.00	0.00	0.00	0.00	0.000	-4.55	0.000
							Total Discharge	**0.218**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES: 463828.7E/6344743.3N
Substrate: Silt and Gravel

MEASUREMENT DATE: 15 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: KA/TC
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1430 hrs.
MEASUREMENT END TIME: 1515 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.25	0.000
1	0.50	0.00	0.22			0.050	0.5	0.006
2	1.00	0.00	0.24			0.090	0.5	0.011
3	1.50	0.00	0.20			0.100	0.5	0.010
4	2.00	0.00	0.16			0.090	0.5	0.007
5	2.50	0.00	0.08			0.020	0.28	0.000
Right Bank	2.56	0.00	0.00			0.000	-1.25	0.000
							Total Discharge	**0.034**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Ice thickness was not measured(!)

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: 28 March 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0820 hrs.
MEASUREMENT END TIME: 0920 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00	0.000	0.000	0.000	0.15	0.000
1	0.30	0.00	0.12	0.020	0.020	0.020	0.3	0.001
2	0.60	0.00	0.22	0.070	0.050	0.060	0.3	0.004
3	0.90	0.00	0.25	0.070	0.070	0.070	0.3	0.005
4	1.20	0.00	0.26	0.090	0.077	0.084	0.3	0.007
5	1.50	0.00	0.26	0.100	0.080	0.090	0.3	0.007
6	1.80	0.00	0.26	0.100	0.090	0.095	0.3	0.007
7	2.10	0.00	0.29	0.100	0.090	0.095	0.3	0.008
8	2.40	0.00	0.25	0.060	0.050	0.055	0.3	0.004
9	2.70	0.00	0.22	0.020	0.010	0.015	0.3	0.001
10	3.00	0.00	0.13	0.000	0.000	0.000	0.3	0.000
Right Bank	3.30	0.00	0.00	0.000	0.000	0.000	-1.5	0.000
							Total Discharge	**0.044**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Ice thickness was easily broken up - thickness at the edge of stream was 20mm and at the middle was 3mm
3. Ice was broken up and flow was measured as open water

Snowmelt flow Measurements (April 16 to May 8, 1997)

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 16 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1204 hrs.
MEASUREMENT END TIME: 1250 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.04			0.190	0.30	0.002
2	0.60	0.00	0.08			0.130	0.30	0.003
3	0.90	0.00	0.08			0.080	0.30	0.002
4	1.20	0.00	0.14			0.540	0.30	0.023
5	1.50	0.00	0.20			1.240	0.30	0.074
6	1.80	0.00	0.08			0.690	0.30	0.017
7	2.10	0.00	0.05			0.290	0.25	0.004
Right Bank	2.30	0.00	0.00			0.000	-1.05	0.000
							Total Discharge	**0.125**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Pressure transducer was installed

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 23 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1230 hrs.
MEASUREMENT END TIME: 1355 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.19	0.000
1	0.38	0.00	0.07			0.320	0.29	0.006
2	0.58	0.00	0.07			0.380	0.20	0.005
3	0.78	0.00	0.04			0.020	0.19	0.000
4	0.95	0.00	0.04			0.160	0.18	0.001
5	1.13	0.00	0.06			0.190	0.18	0.002
6	1.30	0.00	0.12			0.090	0.19	0.002
7	1.50	0.00	0.15			0.850	0.20	0.026
8	1.70	0.00	0.17			1.660	0.20	0.056
9	1.90	0.00	0.14			1.220	0.20	0.034
10	2.10	0.00	0.11			1.060	0.20	0.023
11	2.30	0.00	0.09			0.170	0.18	0.003
12	2.45	0.00	0.09			0.010	0.16	0.000
Right Bank	2.61	0.00	0.00			0.000	-1.23	0.000
							Total Discharge	**0.159**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 30 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1340 hrs.
MEASUREMENT END TIME: 1435 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.02			0.000	0.30	0.000
2	0.60	0.00	0.04			0.020	0.30	0.000
3	0.90	0.00	0.06			0.170	0.30	0.003
4	1.20	0.00	0.04			0.270	0.30	0.003
5	1.50	0.00	0.05			0.250	0.30	0.004
6	1.80	0.00	0.04			0.230	0.30	0.003
7	2.10	0.00	0.04			0.180	0.30	0.002
8	2.40	0.00	0.06			0.340	0.30	0.006
9	2.70	0.00	0.07			0.430	0.30	0.009
10	3.00	0.00	0.09			0.390	0.30	0.011
11	3.30	0.00	0.13			0.460	0.30	0.018
12	3.60	0.00	0.11			0.540	0.23	0.013
13	3.75	0.00	0.08			0.290	0.15	0.003
Right Bank	3.89	0.00	0.00			0.000	-1.88	0.000
							Total Discharge	**0.076**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Alsands Drain
LOCATION: S1
COORDINATES: 470006.2E/6345533.7N
Substrate: Cobble and Gravel

MEASUREMENT DATE: 09 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1335 hrs.
MEASUREMENT END TIME: 1421 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.04			0.170	0.30	0.002
2	0.60	0.00	0.04			0.140	0.30	0.002
3	0.90	0.00	0.03			0.010	0.30	0.000
4	1.20	0.00	0.04			0.250	0.30	0.003
5	1.50	0.00	0.04			0.230	0.30	0.003
6	1.80	0.00	0.06			0.410	0.30	0.007
7	2.10	0.00	0.06			0.540	0.30	0.010
8	2.40	0.00	0.07			0.670	0.30	0.014
9	2.70	0.00	0.06			0.290	0.30	0.005
10	3.00	0.00	0.05			0.350	0.30	0.005
11	3.30	0.00	0.06			0.230	0.30	0.004
12	3.60	0.00	0.06			0.150	0.28	0.002
Right Bank	3.85	0.00	0.00			0.000	-1.80	0.000
							Total Discharge	**0.059**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Temporary transducer was removed and replaced with permanent transducer inside the perforated horizontal pipe
3. Water sample taken for TSS

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 17 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1400 hrs.
MEASUREMENT END TIME: 1438 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.02	0.00			0.000	0.4	0.000
1	0.80	0.02	0.16			0.040	0.85	0.005
2	1.70	0.15	0.19			0.030	0.65	0.004
3	2.10	0.08	0.36			0.130	0.45	0.021
4	2.60	0.10	0.53			0.180	0.45	0.043
5	3.00	0.10	0.38			0.130	0.45	0.022
6	3.50	0.05	0.17			0.190	0.75	0.024
Right Bank	4.50	0.00	0.00			0.000	-1.75	0.000
							Total Discharge	**0.120**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Water was flowing on top of the ice - approxiameately 25cm deep
3. Flow was measured as open water
4. Backflow was noticed at the augered hole distance 3.0m i.e. water from underneath the ice was flow to the surface
5. Pressure transducer was installed.

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 25 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T. Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1315 hrs.
MEASUREMENT END TIME: 1635 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00	0.00	0.00	0.000	0.1	0.000
1	0.20	0.00	1.09	0.18	**0.01**	0.095	0.35	0.036
2	0.70	0.00	1.37	0.21	0.05	0.130	0.5	0.089
3	1.20	0.00	1.46	**0.10**	**-0.12**	-0.010	0.5	-0.007
4	1.70	0.00	1.75	**0.48**	**0.07**	0.275	0.5	0.241
5	2.20	0.00	1.83	0.70	0.08	0.390	0.5	0.357
6	2.70	0.00	1.75	0.92	0.58	0.750	0.5	0.656
7	3.20	0.00	1.35	0.86	0.65	0.755	0.75	0.764
8	4.20	0.00	1.10	0.68	0.26	0.470	1	0.517
9	5.20	0.00	0.93	0.69	0.45	0.570	1	0.530
10	6.20	0.00	0.81	0.61	0.35	0.480	1	0.389
11	7.20	0.00	0.55	0.40	0.36	0.380	1	0.209
12	8.20	0.00	0.57	0.20	0.01	0.105	0.67	0.040
Right Bank	8.54	0.00	0.00	0.00	0.00	0.000	-4.1	0.000
						Total Discharge		**3.821**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Measurement taken usung the cablecart
3. Ice sheet and slush flowing downstream - difficult to measure
4. Possible ice at bottom of creek
5. Water sample taken
6. No problem with pressure transducer
7. Readings in bold need to recheck

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 01 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T. Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1135 hrs.
MEASUREMENT END TIME: 1350 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.68			-0.020	0.4	-0.005
2	0.80	0.00	0.93	0.21	0.30	0.255	0.5	0.119
3	1.30	0.00	1.11	0.58	0.45	0.515	0.75	0.429
5	2.30	0.00	1.30	0.69	0.44	0.565	1	0.735
7	3.30	0.00	1.25	0.78	0.52	0.650	1	0.813
9	4.30	0.00	1.02	0.84	0.72	0.780	0.75	0.597
10	4.80	0.00	1.24	0.90	0.75	0.825	0.5	0.512
11	5.30	0.00	1.31	0.93	0.86	0.895	0.5	0.586
12	5.80	0.00	1.94	0.94	0.60	0.770	0.5	0.747
13	6.30	0.00	1.73	0.90	0.46	0.680	0.5	0.588
14	6.80	0.00	1.62	0.39	0.53	0.460	0.5	0.373
15	7.30	0.00	1.39	0.32	0.37	0.345	0.75	0.360
17	8.30	0.00	1.09	0.22	0.22	0.220	0.7	0.168
Right Bank	8.70	0.00	0.00	0.00	0.00	0.000	-4.15	0.000
							Total Discharge	**6.019**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Measurement taken usung the inflated boat
3. Water temperature was 4°C
4. Water sample taken for TSS
5. No problem with pressure transducer

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Jackpine Creek
LOCATION: S2
COORDINATES: 471952.0E/6346165.0N
Substrate: Sand and silt

MEASUREMENT DATE: 08 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: T. Staples/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1250 hrs.
MEASUREMENT END TIME: 1655 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00	0.00	0.00	0.000	0.15	0.000
1	0.30	0.00	0.56	-0.05	-0.04	-0.045	0.4	-0.010
2	0.80	0.00	0.78	0.23	0.28	0.255	0.75	0.149
3	1.80	0.00	1.16	0.65	0.40	0.525	1	0.609
4	2.80	0.00	1.04	0.65	0.46	0.555	1	0.577
5	3.80	0.00	1.19	0.71	0.45	0.580	1	0.690
6	4.80	0.00	1.14	0.69	0.60	0.645	1	0.735
7	5.80	0.00	1.57	0.89	0.42	0.655	1	1.028
8	6.80	0.00	1.24	0.37	0.46	0.415	1	0.515
9	7.80	0.00	0.95	0.38	0.11	0.245	0.9	0.209
Right Bank	8.60	0.00	0.00	0.00	0.00	0.000	-3.9	0.000
							Total Discharge	4.503

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Measurement taken from the cablecart as the boat was punctured
3. Water temperature was 9°C
4. Water sample taken for TSS
5. No problem with pressure transducer - unable to retrieve the temporary transducer as water was too high
6. The temporary transducer was left as it was before - hope to replace it next trip

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 17 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/Tom Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1025 hrs.
MEASUREMENT END TIME: 1040 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank								
1								
2								
3								
4								
5								
Right Bank								
						Total Discharge		0.000

Note: 1. Ice covered to stream bed
2. Average snow covered measurements at channel was 35cm.
3. Average ice thickness 40cm.
4. No pressure transducer was installed

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 25 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B.Kulcum/Tom Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0920 hrs.
MEASUREMENT END TIME: 1130 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00		0.00			0.000	0.30	0.000
1	0.30		0.08			-0.600	0.60	-0.029
2	0.60		0.10			-0.100	0.50	-0.005
3	0.80		0.22			-0.040	0.40	-0.004
4	1.00		0.24			0.020	0.40	0.002
5	1.20		0.28			0.290	0.50	0.041
6	1.50		0.33			0.630	0.50	0.104
7	1.70		0.32			1.010	0.40	0.129
8	1.90		0.35			0.630	0.40	0.088
9	2.10		0.38			0.750	0.40	0.114
10	2.30		0.34			0.280	0.50	0.048
11	2.60		0.32			0.020	0.50	0.003
12	2.80		0.26			0.070	0.50	0.009
13	3.10		0.23			-0.010	0.60	-0.001
14	3.40		0.22			0.000	0.50	0.000
15	3.60		0.24			0.010	0.40	0.001
Right Bank	3.80		0.00			0.000	-3.60	0.000
							Total Discharge	**0.500**

Note: 1. Water flowing on top of ice
2. Water was silty
3. Water sample taken
4. No problem with pressure transducer

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 01 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B.Kulcum/Tom Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0915 hrs.
MEASUREMENT END TIME: 1010 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00		0.00			0.000	0.15	0.000
1	0.15		0.13			0.010	0.50	0.001
2	0.50		0.13			0.040	0.65	0.003
3	0.80		0.19			0.230	-0.40	-0.017
4	0.10		0.25			0.610	0.60	0.092
5	1.40		0.30			0.800	1.60	0.384
6	1.70		0.35			0.720	0.60	0.151
7	2.00		0.35			0.800	0.60	0.168
8	2.30		0.31			0.060	0.60	0.011
9	2.60		0.28			-0.010	0.60	-0.002
10	2.90		0.16			-0.040	0.60	-0.004
11	3.20		0.12			-0.010	0.60	-0.001
12	3.50		0.15			0.000	0.60	0.000
Right Bank	3.80		0.00			0.000	-3.50	0.000
							Total Discharge	0.786

Note: 1. Ice on stream bottom
2. Water was silty and temperature was 0°C
3. Water sample taken for TSS

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Iyinimin Creek
LOCATION: S3
COORDINATES: 489490.6E/6345028.7N
Substrate: Silt and Sand

MEASUREMENT DATE: 08 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: T. Staples/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1120 hrs.
MEASUREMENT END TIME: 1230 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.40	0.000
1	0.40	0.00	0.16			0.270	0.70	0.030
2	0.70	0.00	0.23			0.180	0.60	0.025
3	1.00	0.00	0.26			0.160	0.60	0.025
4	1.30	0.00	0.26			0.240	0.60	0.037
5	1.60	0.00	0.43			0.300	0.60	0.077
6	1.90	0.00	0.50			0.460	0.60	0.138
7	2.20	0.00	0.58			0.600	0.60	0.209
8	2.50	0.00	0.60			0.140	0.60	0.050
9	2.80	0.00	0.50			0.090	0.60	0.027
10	3.10	0.00	0.48			0.240	0.60	0.069
11	3.40	0.00	0.52			0.430	0.60	0.134
12	3.70	0.00	0.35			0.400	0.60	0.084
13	4.00	0.00	0.43			0.260	0.45	0.050
Right Bank	4.15	0.00	0.00			0.000	-4.00	0.000
							Total Discharge	**0.957**

Note: 1. No Ice on stream bottom - trace of snow/ice at LDB
2. Water was silty and temperature was 2.5°C
3. Water sample taken for TSS
4. Installed permanent transducer

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 17 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0911 hrs.
MEASUREMENT END TIME: 1010 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank								
1								
2								
3								
4								
5								
Right Bank								
						Total Discharge		0.000

Note: 1. Drilled through the ice to substrate - no flow
2. No snow in the creek
3. Approximately 25cm of water was flowing on top of the ice surface
4. Pressure transducer was installed

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 25 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1135 hrs.
MEASUREMENT END TIME: 1300 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00		0.00			-0.020	0.20	0.000
1	0.20		0.12			-0.020	0.40	-0.001
2	0.40		0.16			-0.030	0.40	-0.002
3	0.60		0.20			0.050	0.50	0.005
4	0.90		0.21			0.160	0.50	0.017
5	1.10		0.22			0.310	0.40	0.027
6	1.30		0.23			0.510	0.40	0.047
7	1.50		0.24			0.700	0.40	0.067
8	1.70		0.30			0.910	0.40	0.109
9	1.90		0.32			1.000	0.40	0.128
10	2.10		0.32			1.010	0.40	0.129
11	2.30		0.35			1.120	0.40	0.157
12	2.50		0.35			1.120	0.40	0.157
13	2.70		0.34			1.120	0.40	0.152
14	2.90		0.33			1.000	0.40	0.132
15	3.10		0.32			0.900	0.40	0.115
16	3.30		0.33			0.850	0.40	0.112
17	3.50		0.29			0.860	0.40	0.100
18	3.70		0.21			0.530	0.47	0.052
Right Bank	3.97		0.00			0.000	-3.70	0.000
							Total Discharge	1.504

Note: 1. Drilled through the ice to substrate - no flow
2. Water was flowing on top of the ice
3. No problem with pressure transducer

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 01 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1020 hrs.
MEASUREMENT END TIME: 1125 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00		0.00			0.000	0.35	0.000
1	0.35		0.03			0.190	0.65	0.004
2	0.65		0.04			0.250	0.60	0.006
3	0.95		0.11			0.540	0.60	0.036
4	1.25		0.11			0.610	0.60	0.040
5	1.55		0.27			0.710	0.60	0.115
6	1.85		0.40			0.780	0.60	0.187
7	2.15		0.46			0.730	0.60	0.201
8	2.45		0.46			0.730	0.60	0.201
9	2.75		0.42			0.680	0.60	0.171
10	3.05		0.39			0.540	0.60	0.126
11	3.35		0.30			0.320	0.60	0.058
12	3.65		0.26			0.270	0.60	0.042
13	3.95		0.22			0.260	0.60	0.034
14	4.25		0.20			0.270	0.60	0.032
15	4.55		0.06			0.080	0.65	0.003
Right Bank	4.90		0.00			0.000	-4.55	0.000
							Total Discharge	1.258

Note: 1. Water was flowing on top of the ice
2. No problem with pressure transducer
3. Water temperature 0^0C
4. Water sample was collected for TSS

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Blackfly Creek
LOCATION: S4
COORDINATES: 484469.3E/6340171.5N
Substrate: Silt and Sand

MEASUREMENT DATE: 08 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: T. Staples/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0930 hrs.
MEASUREMENT END TIME: 1115 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00		0.00			0.000	0.15	0.000
1	0.15		0.19			0.010	0.45	0.001
2	0.45		0.26			0.090	0.60	0.014
3	0.75		0.29			0.240	0.55	0.038
4	1.00		0.33			0.380	0.55	0.069
5	1.30		0.40			0.440	0.60	0.106
6	1.60		0.44			0.550	0.60	0.145
7	1.90		0.45			0.600	0.60	0.162
8	2.20		0.44			0.620	0.60	0.164
9	2.50		0.45			0.520	0.60	0.140
10	2.80		0.41			0.430	0.60	0.106
11	3.10		0.36			0.300	0.60	0.065
12	3.40		0.30			0.230	0.60	0.041
13	3.70		0.32			0.150	0.60	0.029
14	4.00		0.27			0.150	0.60	0.024
15	4.30		0.20			0.020	0.68	0.003
Right Bank	4.68		0.00			0.000	-4.30	0.000
							Total Discharge	**1.107**

Note: 1. No ice at bottom of the creek
2. No problem with temporary pressure transducer - replaced with permanent transducer
3. Water temperature 5^{0}C
4. Water sample was collected for TSS
5. The stilling well was still iced up

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 17 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1115 hrs.
MEASUREMENT END TIME: 1257 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00	0.00	0.00	0.000	0.65	0.000
1	1.30	0.39	1.28	0.08	0.08	0.080	1	0.102
2	2.00	0.34	1.36	0.09	0.08	0.085	0.8	0.092
3	2.90	0.48	1.30	0.10	0.10	0.100	0.8	0.104
4	3.60	0.43	1.30	0.09	0.10	0.095	1.55	0.191
5	6.00	0.44	1.03	0.08	0.04	0.060	2.55	0.158
Right Bank	8.70	0.35	0.00	0.00	0.00	0.000	-3	0.000
							Total Discharge	**0.648**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Approximately 10 cm of water ponded in the mid-stream
3. Pressure transducer was installed

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 25 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1645 hrs.
MEASUREMENT END TIME: 1945 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00		0.00			0.000	0.25	0.000
1	0.50		0.15			0.000	0.5	0.000
2	1.00		0.24			0.000	0.5	0.000
3	1.50		0.37			0.010	0.5	0.002
4	2.00		0.50			0.000	0.5	0.000
5	2.50		1.72	0.01	0.06	0.035	0.75	0.045
7	3.50		2.23	0.12	0.14	0.130	1	0.290
9	4.50		2.35	0.25	0.24	0.245	1	0.576
11	5.50		2.35	0.24	0.29	0.265	1	0.623
13	6.50		2.30	0.31	0.29	0.300	1	0.690
15	7.50		2.22	0.29	0.26	0.275	1	0.611
17	8.50		2.25	0.24	0.23	0.235	1	0.529
19	9.50		2.17	0.15	0.15	0.150	1	0.326
21	10.50		1.98	0.10	0.17	0.135	1	0.267
23	11.50		0.95	0.05	0.02	0.035	1.2	0.040
Right Bank	12.90		0.00	0.00	0.00	0.000	-5.75	0.000
						Total Discharge		**3.997**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Water was too silty
3. Possible layer of ice at bottom of river
4. No problem with the pressure transducer
5. Water sample was taken

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 01 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1405 hrs.
MEASUREMENT END TIME: 1645 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00		0.00			0.000	0.25	0.000
1	0.50		0.11			0.000	0.5	0.000
2	1.00		0.23			0.000	0.5	0.000
3	1.50		0.25			0.030	0.5	0.004
4	2.00		0.33			0.010	0.5	0.002
5	2.50		0.45			0.010	0.5	0.002
6	3.00		0.54			0.010	0.5	0.003
7	3.50		0.78			0.010	0.5	0.004
8	4.00		1.84	0.11	0.13	0.120	0.5	0.110
9	4.50		2.07	0.17	0.14	0.155	0.5	0.160
10	5.00		2.25	0.23	0.24	0.235	0.5	0.264
11	5.50		2.15	0.23	0.26	0.245	0.5	0.263
12	6.00		2.50	0.32	0.21	0.265	0.75	0.497
14	7.00		2.50	0.25	0.26	0.255	1	0.638
16	8.00		2.44	0.35	0.26	0.305	1	0.744
18	9.00		2.38	0.16	0.25	0.205	1	0.488
20	10.00		2.33	0.15	0.22	0.185	1	0.431
22	11.00		2.27	0.14	0.10	0.120	1	0.272
24	12.00		2.10	0.09	0.18	0.135	1	0.284
26	13.00		1.02	0.04	0.04	0.040	1	0.041
28	14.00		0.75	0.00	0.00	0.000	0.7	0.000
Right Bank	14.40		0.00	0.00	0.00	0.000	-7	0.000
						Total Discharge		**4.207**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Water was temperature was 4°C
3. No problem with the pressure transducer
4. Water sample was taken for TSS

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Muskeg River
LOCATION: S5
COORDINATES: 479802.8E/6356565.4N
Substrate: Soft Silt and Sand

MEASUREMENT DATE: 08 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: T. Staples/L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1705 hrs.
MEASUREMENT END TIME: 1935 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.25	0.000
1	0.50	0.00	0.18			0.000	0.5	0.000
2	1.00	0.00	0.55			0.000	0.5	0.000
3	1.50	0.00	0.75			0.000	0.5	0.000
4	2.00	0.00	1.11	0.01	0.00	0.005	0.5	0.003
5	2.50	0.00	1.30	0.04	0.04	0.040	0.5	0.026
6	3.00	0.00	1.79	0.08	0.17	0.125	0.75	0.168
7	4.00	0.00	2.20	0.19	0.21	0.200	1	0.440
8	5.00	0.00	2.36	0.13	0.23	0.180	1	0.425
9	6.00	0.00	2.32	0.36	0.27	0.315	1	0.731
10	7.00	0.00	2.28	0.32	0.30	0.310	1	0.707
11	8.00	0.00	2.12	0.32	0.29	0.305	1	0.647
12	9.00	0.00	2.23	0.22	0.22	0.220	1	0.491
13	10.00	0.00	2.01	0.16	0.22	0.190	1	0.382
14	11.00	0.00	1.38	0.15	0.17	0.160	1	0.221
Right Bank	12.00	0.00	0.00	0.00	0.00	0.000	-5.5	0.000
						Total Discharge		**4.239**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Water was temperature was 9°C
3. No problem with the temporary pressure transducer - was removed and replaced with the permanent transducer
4. Downloaded the data into the computer
5. Water sample was taken for TSS

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: 16 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0920 hrs.
MEASUREMENT END TIME: 1015 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.14			0.100	0.3	0.004
2	0.60	0.00	0.16			0.210	0.3	0.010
3	0.90	0.00	0.26			0.180	0.3	0.014
4	1.20	0.00	0.24			0.200	0.3	0.014
5	1.50	0.00	0.27			0.220	0.3	0.018
6	1.80	0.00	0.30			0.240	0.3	0.022
7	2.10	0.00	0.30			0.200	0.3	0.018
8	2.40	0.00	0.22			0.120	0.3	0.008
9	2.70	0.00	0.18			0.050	0.3	0.003
10	3.00	0.00	0.10			0.000	0.25	0.000
Right Bank	3.20	0.00	0.00			0.000	-1.5	0.000
							Total Discharge	0.111

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Pressure transducer was installed

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES: 6388.7E/ 6254763.3N
Substrate: Silt and Gravel

MEASUREMENT DATE: 23 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1435 hrs.
MEASUREMENT END TIME: 1535 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.1	0.000
1	0.20	0.00	0.11			0.150	0.2	0.003
2	0.40	0.00	0.18			0.230	0.2	0.008
3	0.60	0.00	0.24			0.270	0.2	0.013
4	0.80	0.00	0.22			0.380	0.15	0.013
5	0.90	0.00	0.28			0.310	0.1	0.009
6	1.00	0.00	0.26			0.300	0.15	0.012
7	1.20	0.00	0.21			0.360	0.2	0.015
8	1.40	0.00	0.18			0.340	0.2	0.012
9	1.60	0.00	0.20			0.350	0.2	0.014
10	1.80	0.00	0.17			0.390	0.2	0.013
11	2.00	0.00	0.18			0.350	0.2	0.013
12	2.20	0.00	0.18			0.400	0.2	0.014
13	2.40	0.00	0.18			0.270	0.2	0.010
14	2.60	0.00	0.20			0.270	0.2	0.011
15	2.80	0.00	0.20			0.170	0.2	0.007
16	3.00	0.00	0.16			0.070	0.2	0.002
17	3.20	0.00	0.12			0.010	0.2	0.000
18	3.40	0.00	0.04			0.000	0.205	0.000
Right Bank	3.61	0.00	0.00			0.000	-1.7	0.000
							Total Discharge	0.169

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: 30 April 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: B. Kulcum/T.Staples
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 1450 hrs.
MEASUREMENT END TIME: 1535 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.12			0.100	0.25	0.003
2	0.50	0.00	0.15			0.270	0.2	0.008
3	0.70	0.00	0.16			0.310	0.2	0.010
4	0.90	0.00	0.25			0.210	0.2	0.011
5	1.10	0.00	0.19			0.250	0.25	0.012
6	1.40	0.00	0.16			0.210	0.3	0.010
7	1.70	0.00	0.14			0.260	0.3	0.011
8	2.00	0.00	0.13			0.280	0.3	0.011
9	2.30	0.00	0.14			0.210	0.3	0.009
10	2.60	0.00	0.16			0.200	0.3	0.010
11	2.90	0.00	0.15			0.030	0.25	0.001
12	3.10	0.00	0.1			0.000	0.2	0.000
Right Bank	3.30	0.00	0.00			0.000	-1.55	0.000
							Total Discharge	**0.095**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$

PROJECT NAME: Shell/Lease 13/Ft. McMurray
PROJECT NO.: 972-2221-6600
DISCHARGE DATA

STREAM NAME: Mills Creek
LOCATION: S6
COORDINATES:
Substrate: Silt and Gravel

MEASUREMENT DATE: 07 May 1997
METER NUMBER: Flo-Mate 2000

MEASUREMENT BY: L.Low
COMPUTATIONS BY: LL

MEASUREMENT START TIME: 0845 hrs.
MEASUREMENT END TIME: 0905 hrs.

STATION	DISTANCE FROM LEFT BANK (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m3/sec)
Left Bank	0.00	0.00	0.00			0.000	0.15	0.000
1	0.30	0.00	0.13			0.080	0.3	0.003
2	0.60	0.00	0.16			0.180	0.3	0.009
3	0.90	0.00	0.12			0.230	0.3	0.008
4	1.20	0.00	0.13			0.180	0.3	0.007
5	1.50	0.00	0.13			0.230	0.3	0.009
6	1.80	0.00	0.14			0.240	0.3	0.010
7	2.10	0.00	0.18			0.220	0.3	0.012
8	2.40	0.00	0.19			0.290	0.3	0.017
9	2.70	0.00	0.15			0.220	0.3	0.010
Right Bank	3.00	0.00	0.00			0.000	-1.35	0.000
							Total Discharge	**0.084**

Note: 1. Velocity at 0.6 Depth was computed as $(V_{0.2}+V_{0.8})/2$
2. Water sample was taken for TSS
3. Installation of a new gauging station - 75% completionby 07 May '97. The transducer was not installed inside the horizontal perforated pipe.
4. Installation of the weir was carried out - managed to complete the construction. Installation took approx. 10 hours due to high discharge
5. The pressure transducer was moved and installed temporary at a different elevation by 1200 hours on 07 May
6. The permanent transducer was installed inside the perforated horizontal pipe by 09 May '97