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ICE FREEZE UP AND BREAKUP IN THE LOWER THAMES RIVER: 1982-83 OBSERVATIONS

by

S. Beltaos

Environmental Hydraulics Section
Hydraulics Division
National Water Research Institute
Canada Centre for Inland Waters
P.O. Box 5050
Burlington, Ontario, Canada L7R 4A6

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ABSTRACT

The 1982-83 ice season was uneventful due to the unusually mild winter conditions. An ice cover formed in the study reach in mid-January and partly broke up in early February. This breakup produced one ice jam near the Golf Course and was followed by alternating cold and mild weather periods. The remaining thin ice cover deteriorated and disappeared by February 23. Observations concerning breakup initiation and ice jam stage were found to be consistent with previous results which extends the applicability of earlier developed methods to unusually thin ice and low discharge conditions.

RÉSUMÉ

Compte tenu de l'hiver particulièrement peu rigoureux que nous avons connu en 1982-1983, la saison des glaces n'a donné lieu à aucun incident particulier. Dans le cadre de l'étude, la couche de glace s'est formée à la mi-janvier et il y a eu une débâcle partielle au début de février. Cette débâcle a créé un embâcle à proximité du terrain de golf. Des périodes de température plus clémente ont fait suite à d'autres plus rigoureuses. La mince couche de glace qui restait s'est détériorée peu à peu pour disparaître tout à fait le 23 février. Les observations sur la débâcle et la formation de l'embâcle correspondaient aux résultats antérieurs, ce qui justifie l'application des méthodes élaborées plus tôt à des conditions où prévalent une couche de glace inhabituellement mince et un faible débit.

1.0 INTRODUCTION

A major component of the Hydraulics Division's ice jam research program is the annual documentation of ice regime and jamming in two Southern Ontario river reaches, i.e., the lower Thames and the upper Grand Rivers. This is a long-term effort, initiated in late 1979, aimed at both quantification of ice-related phenomena in the observation reaches and improvement of qualitative understanding as a guide to laboratory and theoretical research.

This report pertains to the Thames River and describes the results of the fourth year's observations. Earlier reports (Beltaos 1981, 1983, 1985) contain more detailed information on the rationale and objectives of the field observation program. The Thames River study reach extends from about Bothwell to the river mouth in Lake St. Clair (Fig. 1). An approximate water surface profile of the river, from the mouth to Middlemiss, is shown in Fig. 2. Water surface elevations have been obtained from a series of 1:25,000 topographic maps at the intersections of elevation contours with the stream boundaries. Straight lines have been drawn between points representing successive contour intersections. Relevant information, such as river crossings, towns, tributaries and the like are also shown in Fig. 2. Additional hydrologic and hydraulic data are included in an earlier report (Beltaos, 1981).

2.0 ICE REGIME

The 1982-83 ice season was very brief, owing to unusually mild winter weather. Figure 3 shows that persistent cold began on January 7. Site inspection on January 18 and 19 indicated that an ice cover had formed through most of the study reach but only moving slush pans were noticed further upstream (see photos in Appendix A). At 1440 on January 18, there was ice cover at Kent Bridge with open water starting about 30 m upstream. Open water sections had also been observed earlier on

January 18, between Kent Bridge and Highway 21 at Thamesville. At the latter location, stationary ice cover formed by juxtaposition of incoming slush pans between 1415 and 1630 on January 18. Water Survey of Canada estimated that ice effects on stage at Thamesville commenced on January 17. The corresponding degree-days of frost and river discharge are 30.8°C days and 46.0 m^3/s.

The formation of the ice cover was followed by alternating cold and mild periods with significant rainfalls on January 22, 29 and 30 and February 1 and 2 (Fig. 3). The ice cover was still in place on February 2, but breakup had already commenced on February 4. A description of breakup observations is presented next.

February 4. In early afternoon, the river was open at the Middlemiss, Dutton, Wardsville and Bothwell W. crossings (see Fig. 1). Open water was also observed by Fairfield Museum and Tecumseh Monument. At the latter location, measurements on ice blocks left on the right bank indicated that the ice cover thickness varied between 5 and 15 cm, averaging 11 cm. At 1345, open water was noted at the Thamesville gauge site and the water level was 13.38 m (gauge height). This measurement was obtained manually as the recording gauge was malfunctioning during this time. Consequently, a continuous water level record is not available for 1982-83. From ice blocks left on the river banks at this site, the high water mark was estimated to have been at about 13.7 m. Subsequent observations indicated that breakup was already in progress between Thamesville and Kent Bridge. At Kent Bridge, breakup was initiated during 1445 and 1620, at a stage of about 177.05 m (geodetic).At 1800, the stage was down to 176.93 m while by 2030, all ice had been cleared from the vicinity of Kent Bridge. Flow estimates by Water Survey of Canada indicate that the river discharge would have been increasing during this time [Q = discharge ≈ 32.2, 35.0, 76.2, 153, 159, 113, 91.8 m^3/s for February 1, 2, 3, 4, 5, 6, 7, respectively]. Downstream of Kent Bridge and as far as Sherman Brown Bridge, there was relatively competent ice cover with occasional open water patches and leads.

Through Chatham and downstream to Prairie Siding, there were frequent open leads, occasionally attaining lengths of several kilometres.

February 5. Open water conditions prevailed in the upper part of the study reach to at least 3 km below Kent Bridge. At Thamesville, the water level was 13.69 and 13.67 m at 0923 and 1325 respectively. At Kent Bridge, the water level remained constant at 177.96 m during 0945 to 1240 which represents a rise of about 1 m since the previous evening, despite the local open-water conditions and the slight, if any, increase in discharge. This was the result of an ice jam that formed near the Golf Course, about 6 km below Kent Bridge. This jam was first noticed at 1000 and its stage was photographically documented during the next 30 minutes (see Fig. 4 and photos in Appendix A). At 1300, the jam was still in place but exposed surface water was already freezing up. Downstream of the jam, ice conditions had changed little since the previous day. Near Louisville, narrow strips of open water were noticed at the sides with longitudinal (hinge) cracks located 1.8 - 2.1 m off the ice edges. At 1105, the stage at Sherman Brown Bridge was approximately 176.00 m and this is likely to have been the peak stage during this event, judging by the gauge record at Chatham (Water Survey of Canada, Surface Water Data for 1983-Ontario).

February 9 and 10. Figure 3 shows that, starting on February 5, the weather remained cold until February 14 while the flow dropped considerably. This suggests that the February 4-5 breakup could not progress appreciably and this was verified by a site inspection on February 9 and 10. The only noteworthy change since February 5 was that the Golf Course jam had moved about 2.3 km downstream to Louisville and had compressed to a length of 500 m. At Kent Bridge, the water level was 176.14 m at 1320 on February 9; at Sherman Brown Bridge, it was 175.35 m at 1416 on February 9 and 175.26 m at 0950 on February 10. These readings indicate considerable drop from those prevailing on February 5.

February 17. Mild weather began again on February 15 and the river stage began to rise slowly (Fig. 3). Inspection on February 17 indicated that the river had remained open to a few kilometres above Kent Bridge. At Kent Bridge and downstream to Louisville, a new ice cover had formed since February 10. This cover appeared to be very thin and weak (see photo in Appendix A). At Kent Bridge, the water level was 175.83 m at 1400. Near the toe of the February 5 jam at Golf Course, shear walls about 1 m thick were now exposed by the lower stage; a similar configuration was observed near the February 9 jam site at Louisville. Below Louisville, the original ice cover had remained in place.

February 23. Following a small amount of rain on February 22 and continued rise in stage (Fig. 3), another inspection was carried out on February 23. The river was open throughout the study reach.

Summary: Unusually mild weather conditions resulted in a brief and uneventful ice season. Freeze up started in mid-January, leading to formation of an ice cover that attained a thickness of about 11 cm. Through Chatham and downstream, the ice cover never attained complete integrity but contained numerous and large open leads. Mild weather and rainfall in late January and early February caused a partial breakup that advanced as far downstream as Louisville. Renewed mild weather, starting on February 15 led to complete clearance of the ice by February 23. Only one ice jam was observed during the 1983 breakup. This jam formed near the Golf Course but the attendant stage remained sufficiently low to be of no concern.

3.0 ANALYSIS OF DATA

3.1 Initiation of Breakup

The available data on breakup initiation are summarized in Table 1. Here H_F = stable freeze up stage; H_B = stage when breakup is initiated, i.e., when the ice cover starts to move; h_i = thickness of the ice cover. It may be noted in Table 1 that H_B is only known for Kent Bridge whereas only upper and lower bounds are known for Sherman Brown Bridge and Thamesville.

For Thamesville, a simple empirical relationship that has been developed using past data reads (Beltaos 1985):

$$H_B - H_F \simeq 8\ h_i \tag{1}$$

For h_i = 11 cm and H_F = 11.86 m (Table 1), Eq. 1 gives H_B = 12.74 m which is consistent with the fact that, at a stage of 13.38 m, breakup had already started.

A dimensionless relationship that has also been developed from past observations reads (Beltaos 1985):

$$\frac{W_B}{W_i} = f\left(\frac{h_i}{W_i}\right) \tag{2}$$

in which W_B = channel width at the stage H_B; and W_i = width of ice cover $\simeq W_F - 2\ \ell_s$ with W_F = channel width at the stage H_F and ℓ_s = distance of side cracks from the respective ice cover edges (Beltaos 1984). Pertinent data for the three sites of Table 1 are summarized in Table 2 and plotted along with previous data in Fig. 5. It is seen that the 1983 data are consistent with previous years' results and help extend the range of observations at the lower end of the graph.

3.2 Ice Jams

Only one jam was observed in 1983, as shown in Fig. 4. Using photos of the jam level against identifiable objects on the river banks, the profile of the jam was surveyed and is shown in Fig. 6. The "average" line plotted through the data points indicates a slope of 0.55 m/km well upstream of the transition region near the toe. The discharge at the time of observation is estimated as 150 m^3/s*. Using also cross-sectional data at 44.59 km, it is found that H_j = total water depth ≈ 4.4 m and W = width at the bottom elevation of the jam ≈ 50.5m. The corresponding dimensionless parameters η and ξ ($\eta = H_j/WS_w$; $\xi = (q^2/gS_w)^{1/3}/WS_w$; S_W = water surface slope; q = Q/W; g = acceleration due to gravity) work out to be 159 and 424 respectively. Figure 7 shows that the 1983 jam is consistent with data from previous years in the Thames and other rivers (see Beltaos, 1985, for a full description of data sources pertaining to Fig. 7). Figure 6 indicates that there is considerable uncertainty in determining S_W because of the limited number of available data points. However, it has been calculated that even if S_W were as low as 0.3 m/km or as high as 0.8 m/km, the resulting values of ξ and η would still be consistent with previous findings in Fig. 7.

4.0 SUMMARY

The 1982-83 ice season was uneventful owing to exceptionally mild winter conditions. Observations regarding breakup initiation and ice jamming were shown to be consistent with findings from previous

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* This figure was obtained from stage readings at Thamesville and assuming no ice effect at this site. This seems reasonable given the relatively low jam stage and the large distance between the jam and Thamesville (≈ 20 km).

years. The main interest of the 1982-83 data lies in the unusually low values of ice thickness (≈ 11 cm) and river discharge (≈ 150 m^3/s) which extend the documented range of applicability of theoretical and empirical models that have been developed to date.

5.0 ACKNOWLEDGEMENTS

Hydrometric information has been kindly provided by Water Survey of Canada (Guelph) and Lower Thames Valley Conservation Authority. Mr. W. Moody assisted with the field observations and performed hydrometric surveys and data processing. Review comments by Dr. T.M. Dick and Dr. Y.L. Lau are appreciated.

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TABLE 1. Summary of Breakup Initiation Data, 1983-83 Ice Season.

Location	H_F(m) / date	H_B (m) / time and date	h_i (cm)	Accuracy of h_i	Remarks
Thamesville (WSC gauge)	11.86 / Jan. 18	< 13.38 / 1345, Feb. 4	11	Average of measurements on ice blocks by Tecumseh Monument	H's are gauge heights; add 167.56 mm to find geod. elev. Peak stage during event ≈13.7 m. Prior to p.m. Feb. 4.
Kent Bridge	176.32 / Jan. 18	177.05 / ≈1600, Feb. 4	11	Est'd [1]	H's are geod. elevations Peak stage during event ≈178.0 m, a.m. Feb. 5.
Sherman Brown Bridge	≈175.35 / Jan. 18	>176.00 / 1105, Feb. 5	12	Est'd [2]	H's are geod. elevations Peak stage during event ≈176.0 m, a.m. Feb. 5.

[1] h_i assumed equal to that at Thamesville.

[2] h_i increased slightly in accordance with previous experience showing ice thickness to increase in downstream direction.

TABLE 2. Dimensionless Breakup Initiation Parameters, 1982-83 Ice Season.

Location	W_F (m)	h_i (cm)	W_B (m)	W_i (m)	$\frac{100hi}{W_i}$	$\frac{W_B}{W_i}$
Thamesville	37.2	11	<44.2	32.8	0.34	<1.35
Kent Bridge	50.5	11*	54.6*	46.1*	0.24*	1.19*
Sherman Brown Bridge	69.4	12*	>72.5	64.7*	0.19*	>1.12*

* Estimated or uncertain data.

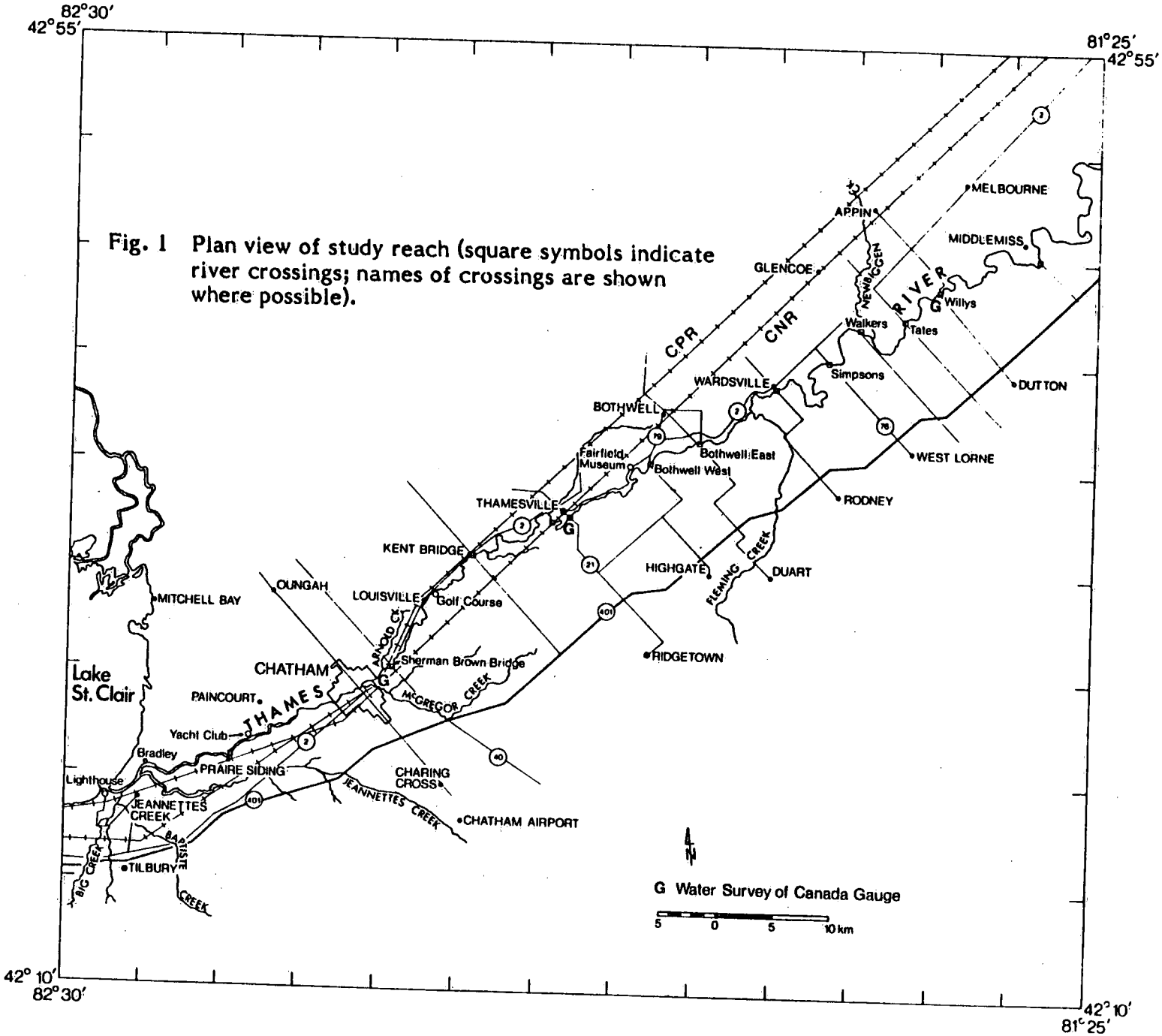


Fig. 1 Plan view of study reach (square symbols indicate river crossings; names of crossings are shown where possible).

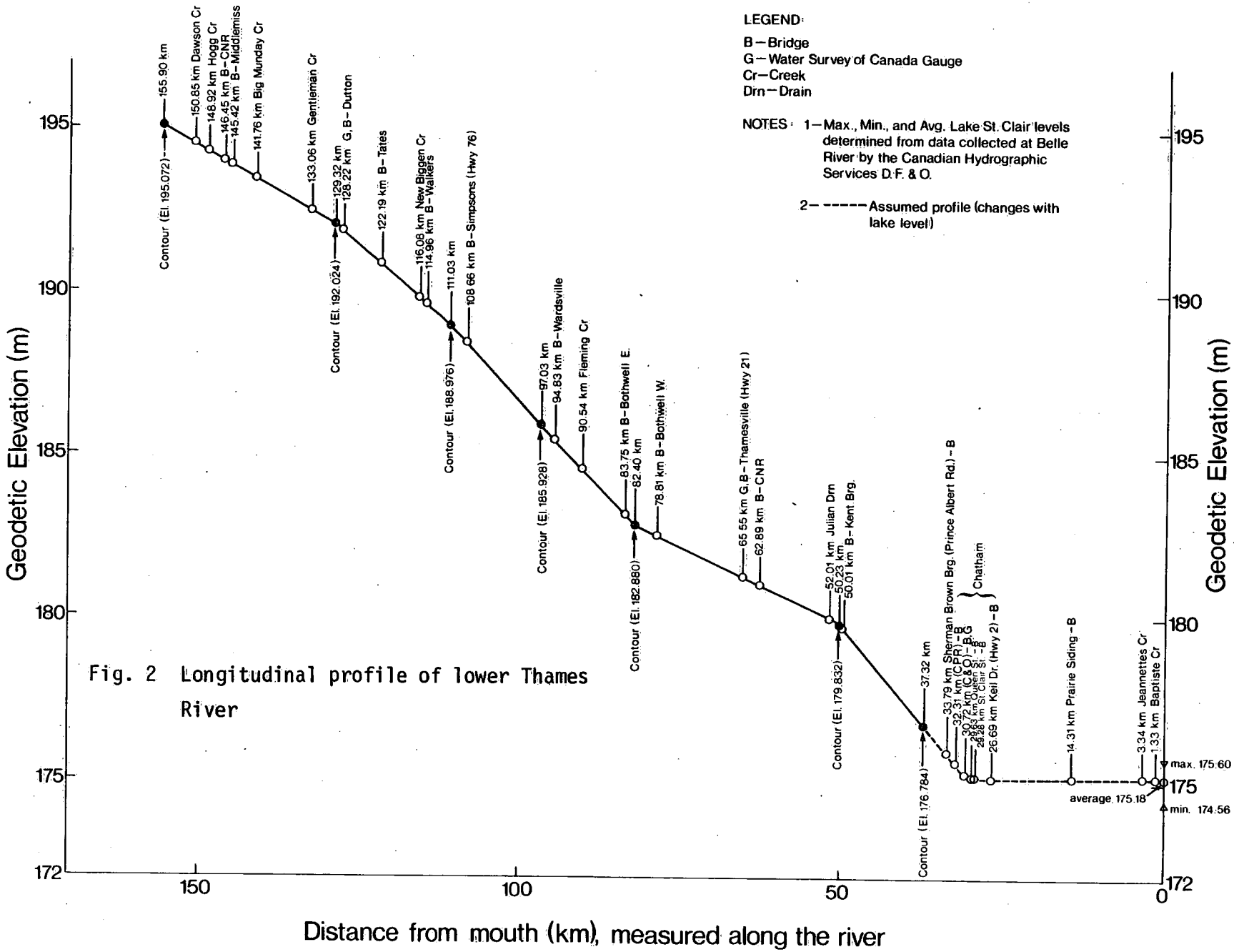


Fig. 2 Longitudinal profile of lower Thames River

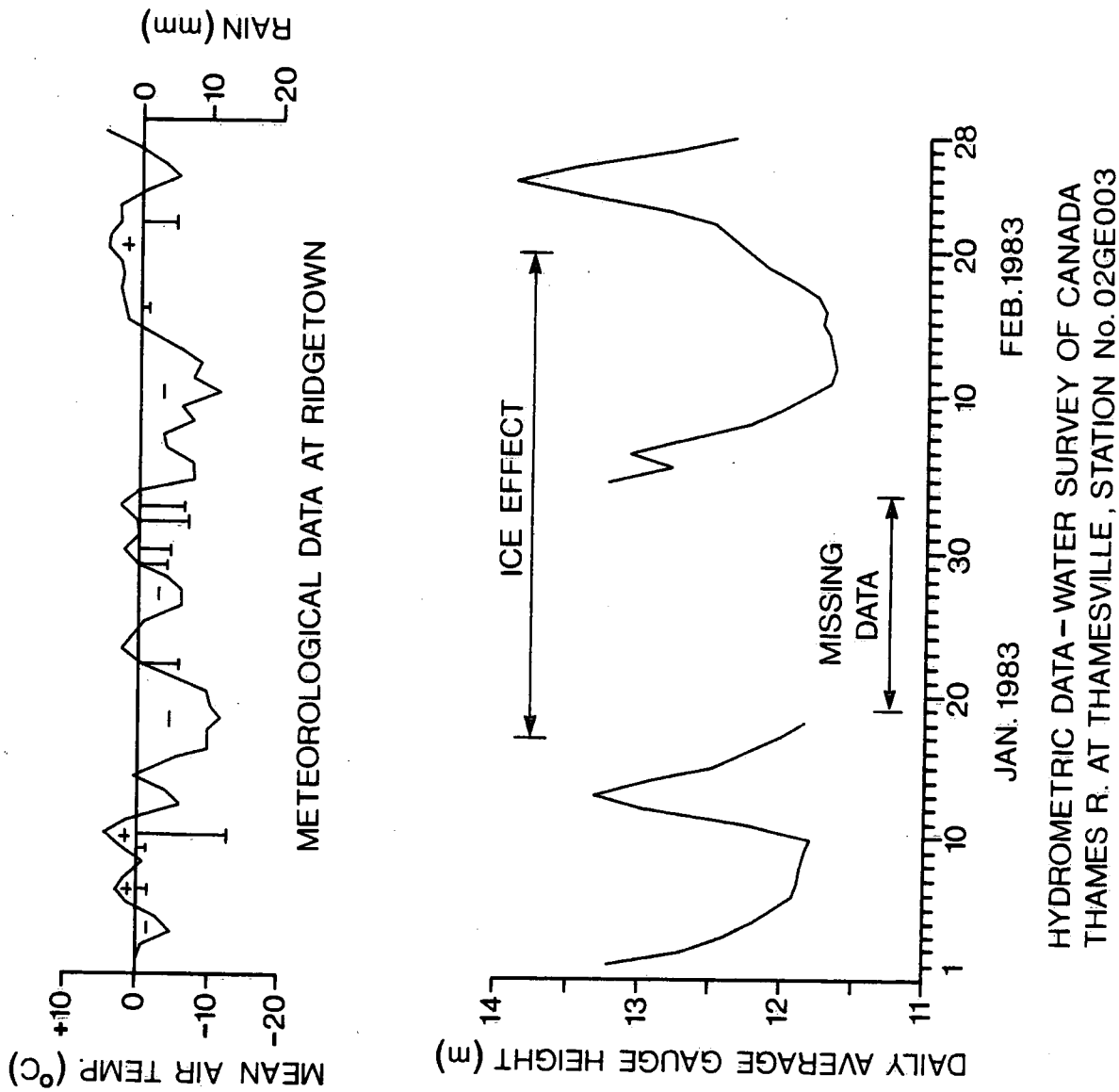


Fig. 3. Meteorological data and water levels near Thamesville.

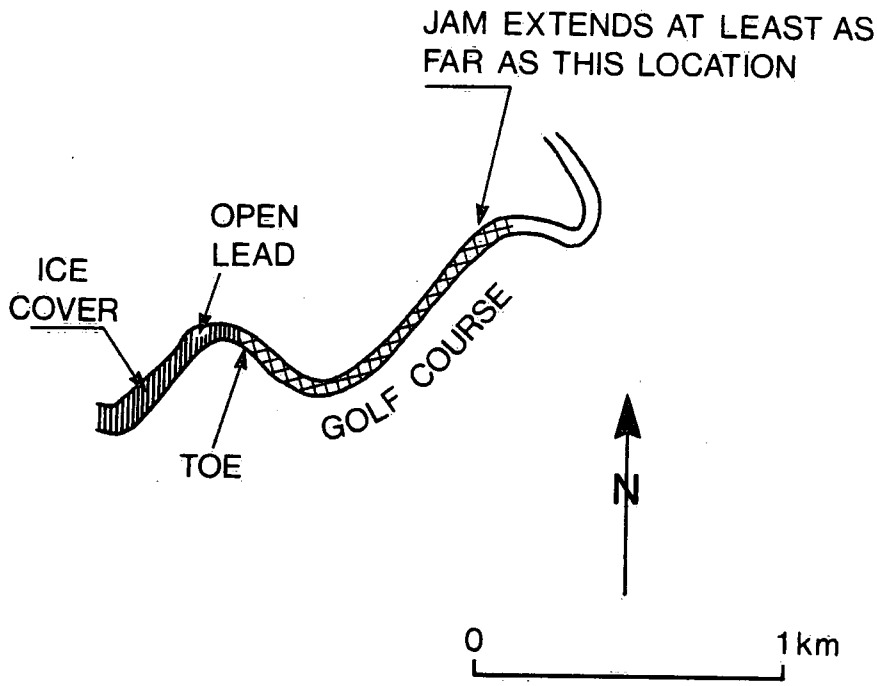


Fig. 4. Plan view of ice jam, 1000 - 1030, February 5, 1983.

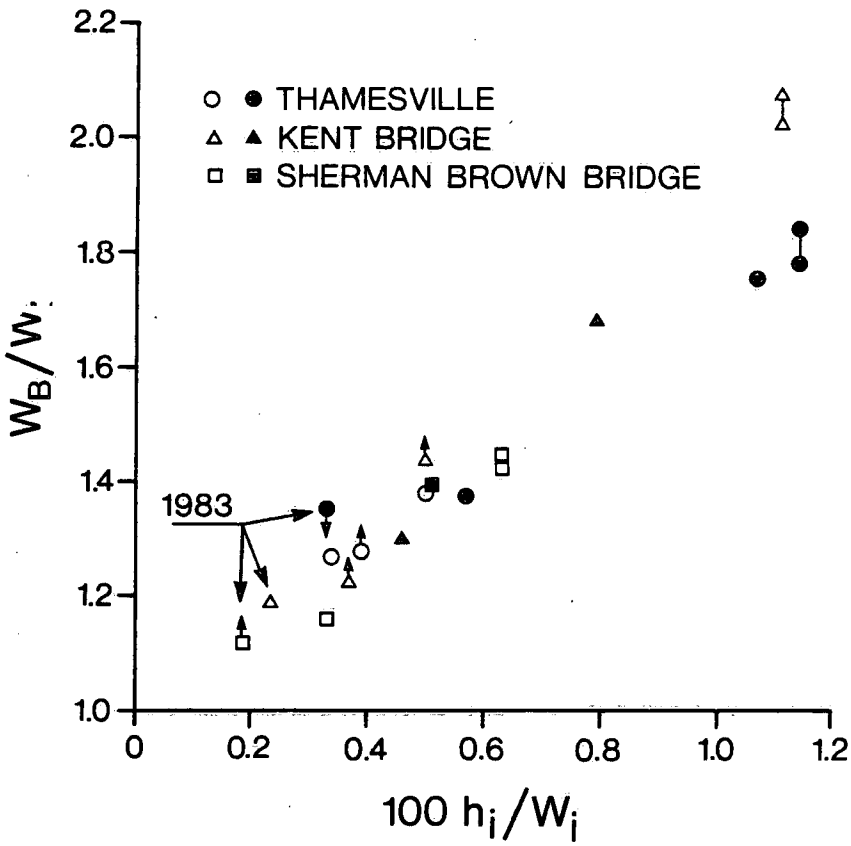


Fig. 5. Dimensionless breakup initiation relationships at three sites; open symbols denote uncertain data.

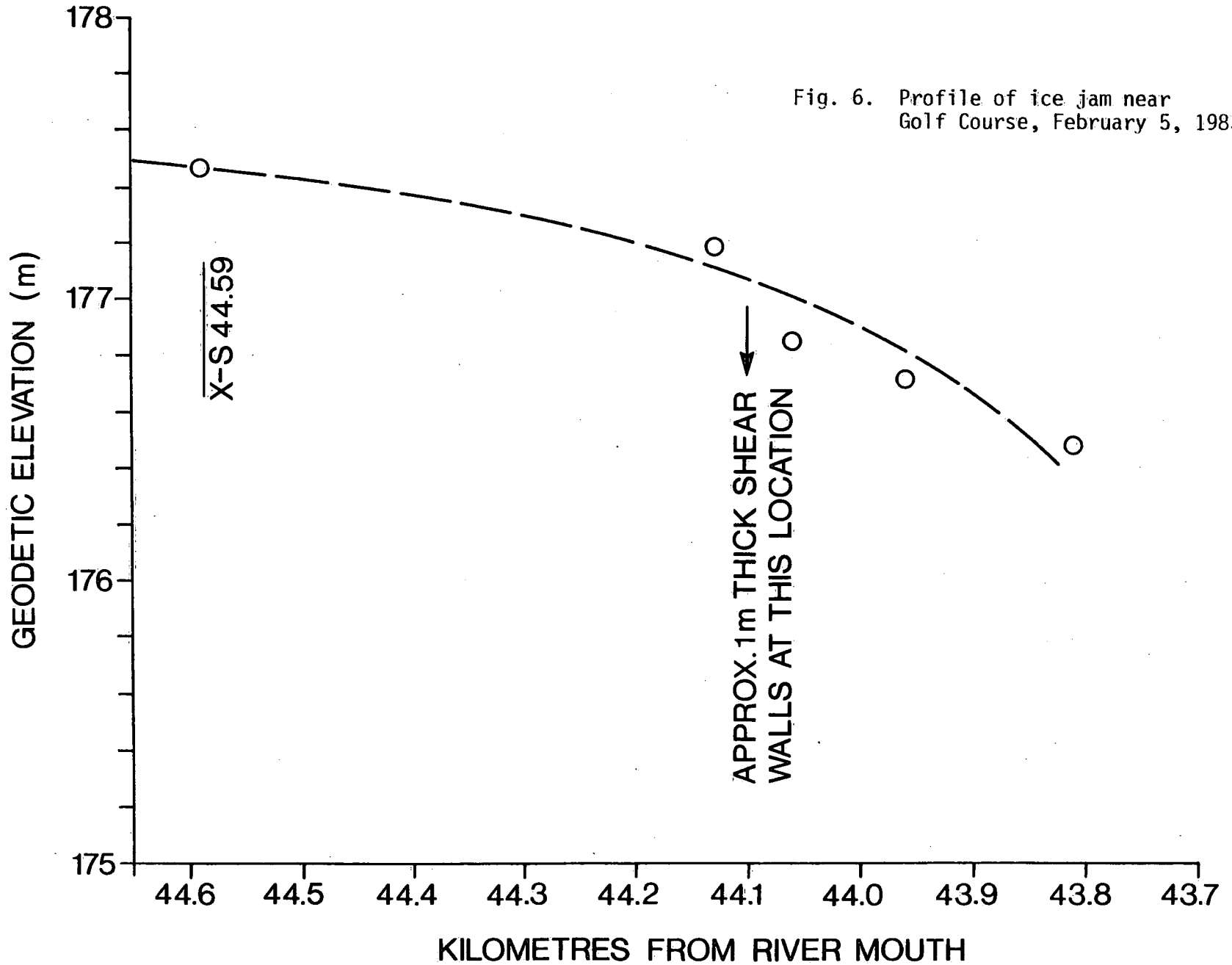


Fig. 6. Profile of ice jam near Golf Course, February 5, 1983.

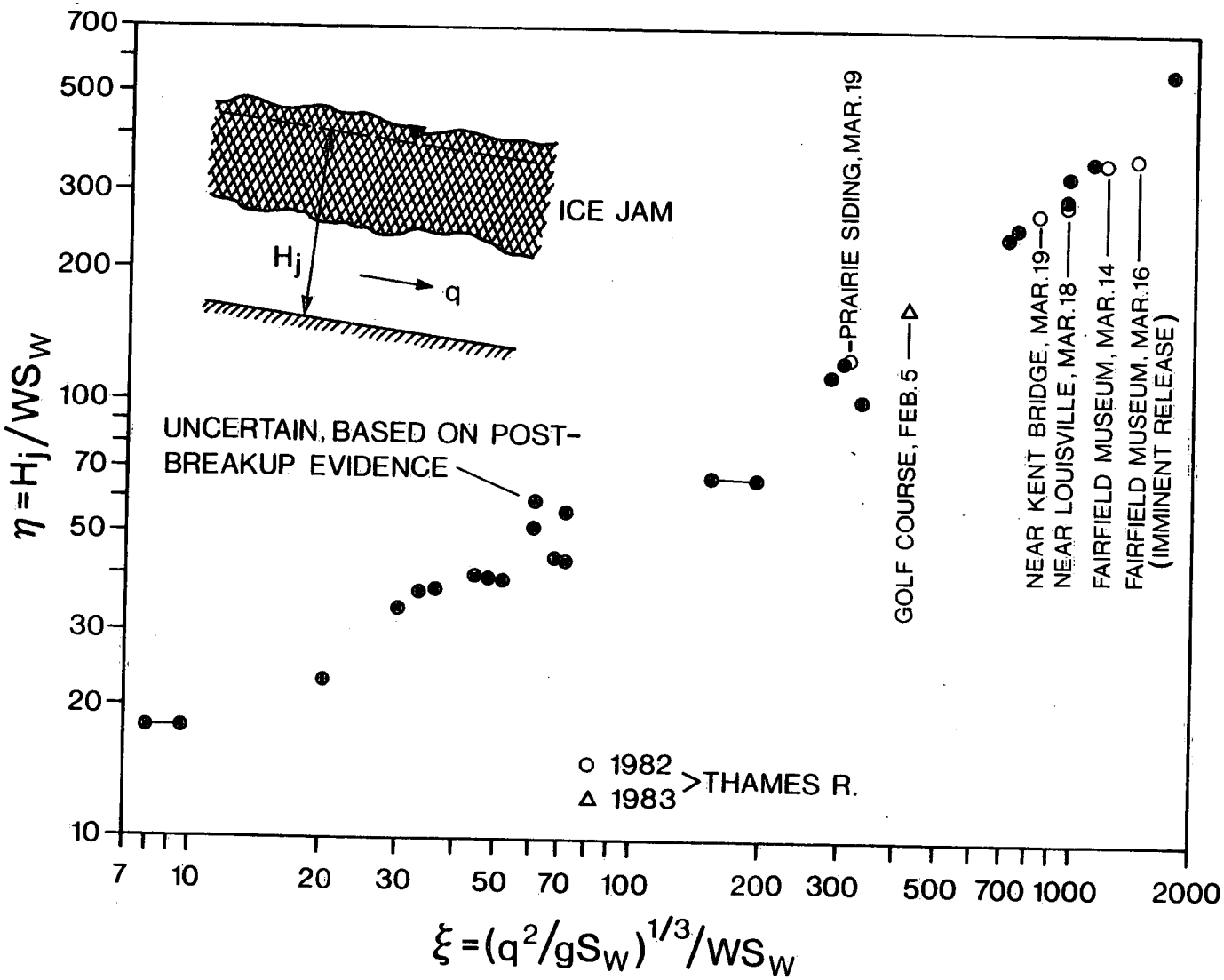


Fig. 7. Dimensionless depth versus dimensionless discharge for ice jams.

NOTE

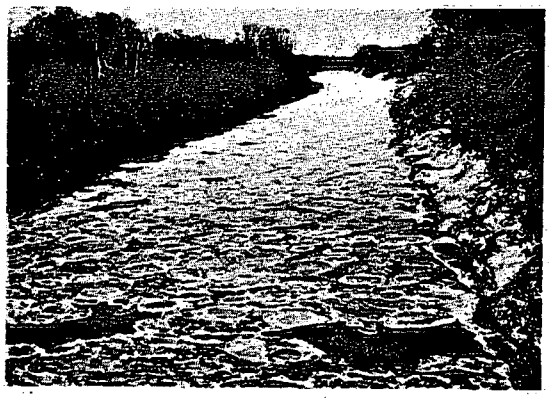
For Appendix A the following abbreviations have been used.

→	view toward
U/S	upstream
D/S	downstream
BDG	bridge
HWY	highway

APPENDIX A PHOTOGRAPHS

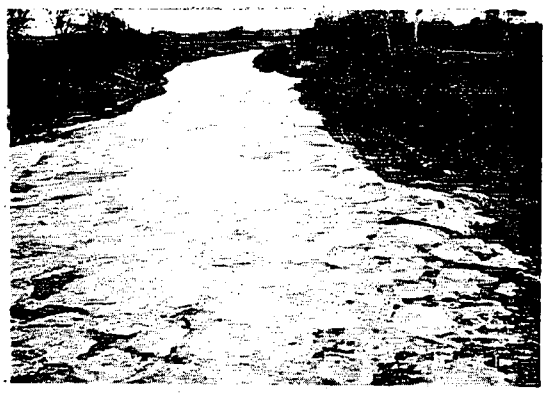
1. → D/S FROM DUTTON ROAD BDG, JAN. 19.

2. → D/S FROM DUTTON ROAD BDG, JAN. 25. COMPARE WITH PHOTO 1.



3. → U/S FROM HWY 21 BDG, 1630, JAN. 18. NOTE NEWLY FORMED ICE COVER AND OPEN WATER FAR U/S.

4. → D/S FROM HWY 21 BDG, 1630, JAN. 18.



5. → D/S FROM HWY 21 BDG, JAN 25. COMPARE WITH PHOTO 4.

6. → D/S FROM HWY 21 BDG, 1430, FEB. 4. COMPARE WITH PHOTOS 4 AND 5.

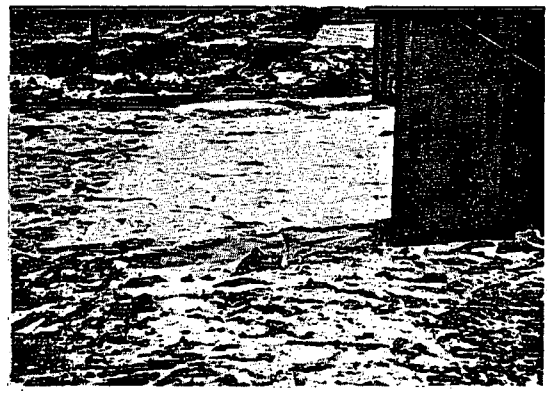
7. ICE BLOCKS ON LB, JUST U/S HWY 21 BDG, 1350, FEB 4.

8. ICE BLOCKS ON RB, JUST U/S HWY 21 BDG, 1300 FEB 17.

9. → U/S. ICE RUN BETWEEN THAMESVILLE AND KENT BDG, 1700 FEB 4.

10. → U/S FROM KENT BDG, 1440 JAN. 18. NOTE NEWLY FORMED ICE COVER.

11. → D/S FROM KENT BDG, 1440, JAN. 18.

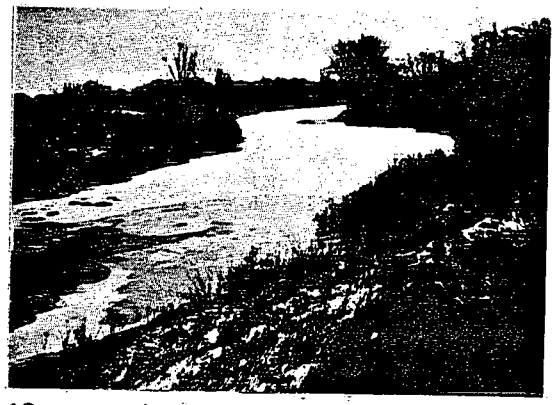


12. → LB AT KENT BDG, 1440, JAN. 18.

13. → U/S FROM KENT BDG, JAN. 19. COMPARE WITH PHOTO 10.

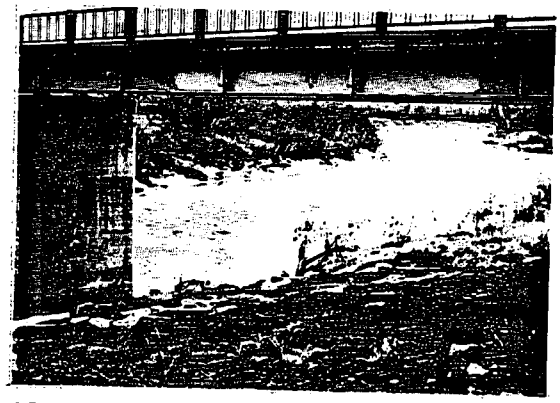
14. → U/S FROM KENT BDG, JAN. 25. COMPARE WITH PHOTOS 10 AND 13.

15. → U/S FROM KENT BDG, 1420, FEB. 4. NOTE INTACT ICE COVER AND OPEN WATER SECTIONS.



16. → D/S FROM KENT BDG, 1420, FEB. 4.

17. → U/S FROM KENT BDG, 1615, FEB. 4. COMPARE WITH PHOTO 15.



18. → D/S FROM KENT BDG, 1400 FEB. 17. NOTE THIN ICE COVER, FORMED AFTER FEB. 4 BREAKUP.

19. → D/S. ICE JAM AT GOLF COURSE, 1000, FEB. 5.

20. → RB. SURFACE TEXTURE OF JAM AT GOLF COURSE. 1020, FEB. 5.

21. → RB. SURFACE TEXTURE OF JAM U/S OF PHOTO 20. 1020, FEB. 5.

22. → RB AT TOE OF JAM. 1020, FEB. 5.

23. → RB. REMNANTS OF ICE JAM AT GOLF COURSE, 1600, FEB. 17.

24. → D/S FROM SHERMAN BROWN BDG, 1500 JAN. 18. NOTE SMOOTH ICE COVER.