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NOTE

LAKE MICHIGAN RECORD LEVELS OF 1838, A PRESENT PERSPECTIVE

Frank H. Quinn and Cynthia E. Sellinger
NOAA/Great Lakes Environmental Research Laboratory
2205 Commonwealth Blvd.
Ann Arbor, Michigan 48105-1593

ABSTRACT. Record high lake levels for this century, set for all lakes but Ontario in 1985 and 1986, caused extensive economic losses and were a major concern of riparian interests. An analysis of early Lake Michigan-Huron water levels recorded at Milwaukee, Wisconsin, beginning in 1819 revealed an extremely high lake level regime peaking in 1838. To provide a valid comparison with recent data, the 19th century data were first adjusted to the International Great Lakes Datum of 1955 and corrected for differential isostatic rebound between Milwaukee and the outlet water level gage for Lake Michigan-Huron at Harbor Beach, Michigan. A comparison of the 1838 lake levels with the recent records indicates the former to be approximately 50 cm higher than the record set in 1986. A future recurrence of the climatic conditions causing the 1838 high lake levels would have a severe outcome for riparian interests throughout the Great Lakes region.
INDEX WORDS: Water level fluctuations, water levels, history, Lake Michigan.

INTRODUCTION

The record high water levels of 1986 have increased interest in assessing the potential range of Great Lakes water level fluctuations. Record high lake levels for this century, set for all lakes but Ontario in 1985 and 1986, caused extensive economic losses and were a major concern of riparian interests. It is widely recognized that the historical range in water levels derived from the prime instrumental records may not adequately represent the range of future fluctuations. Recent research has lead to conflicting conclusions. Larsen (1985), using data from the Kenosha-Waukegan shoreline of Lake Michigan, concluded that over the past several thousand years Lake Michigan has been at times about a meter higher than the recorded high levels. Bishop (1987) however, looking at archaeological evidence from several sites, concluded that lake levels over the past 350 years were within the range of recorded levels. The latter view is supported by earlier research of Houghton (1839), the first state geologist of Michigan, which indicated that the water levels of 1838 may have been the highest lake levels in the prior 100–200 years. The purpose of this study is to provide additional perspective on high Lake Michigan-Huron water levels by extending the prime published data, 1860–present, with discontinuous measurements taken at Milwaukee, Wisconsin, during 1819–1959. This period includes the extremely high levels of 1838.

DATA ANALYSIS

Published monthly and annual water level data from 1860–present are available from the National Ocean Service (1986). These include data for the outlet Lake Michigan-Huron water level gage at Harbor Beach, Michigan, and the Lake Michigan gage at Milwaukee (Fig. 1). Early Lake Michigan-Huron water levels, 1815–1859, were recorded at Milwaukee, Wisconsin, far from the St. Clair River outlet of Lake Michigan-Huron at Port Huron-Sarnia. Because of the differential isostatic rebound between the outlet and the Wisconsin coastline, the older Milwaukee data must be transferred to the reference water level gage at Harbor Beach to provide valid comparisons with the late 19th and 20th century extreme high water levels.

Water level data prior to 1860 for each of the Great Lakes was summarized by the United States Deep Waterways Commission (1897). The early

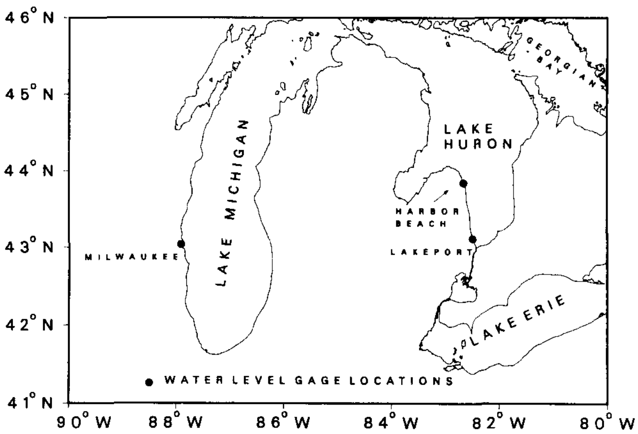

FIG. 1. Great Lakes water level gage locations.

data were obtained from staff gages as compared to the modern recording water level gages in use at the present time. For the monthly mean data used in this analysis, the difference in the data collection procedures is not deemed significant.

The Lake Michigan-Huron plane of reference for the water level elevations in the Commission's report was the high water of 1838 which has an elevation of 584.34 ft (178.11 m) on the Lake Survey Datum of 1877. The corresponding elevation on the 1903 datum is 584.69 ft (178.21 m) (Moore 1939). For comparison with the prime instrumental record it is first necessary to adjust the Commission's data to the present datum, the International Great Lakes Datum of 1955, IGLD (1955). Water level elevations at the Milwaukee gage for the period 1836–1876 depend upon Benchmark No. 1 which has an elevation of 593.025 ft. (180.74 m) on 1903 datum and 591.07 feet (180.158 m) on IGLD (1955), (Coordinating Committee 1978). Subsequently, the adjustment necessary to convert water levels from the 1877 datum to the IGLD (1955) datum requires taking the difference between the 1903 and 1838 bench mark elevations (591.07 - 593.025), and adding this to the difference of the 1903 and the 1838 planes of reference (584.69 - 583.34). This adjustment of -1.60 feet (-0.49 m), when applied to the high water datum of 1838 at Milwaukee, yields an elevation of 582.74 feet (177.62 m) IGLD (1955).

Table 1 gives the pre-1860 water levels at Milwaukee adjusted to IGLD (1955). For valid comparisons under present conditions the recorded data from Milwaukee must be transferred to the Harbor Beach water level gage which represents the water levels at the controlling outlet for Lake Michigan-Huron. This transfer is dependent upon the differential isostatic rebound between Milwaukee, Wisconsin, and Harbor Beach, Michigan.

The analysis of isostatic rebound is based upon the concept of isostasy which states that land masses must maintain an equilibrium within the earth's crust. A tremendous weight such as a regional glacier can theoretically force localized land masses downward into the crust until a compensatory equilibrium is achieved. Once that weight is removed, as in a glacial retreat, the landmass will rebound upward to once again achieve equilibrium. The Laurentide glacier of the Pleistocene Epoch depressed the crust in the Great Lakes area differentially because the thickest ice was to the northeast. Geophysical measurements and comparison to modern ice caps indicate the ice was 3,000 meters thick beneath the center of this glacier with varying thicknesses throughout (Clark and Stern 1968). Due to these varying thicknesses of ice cover over the Great Lakes region, differential isostatic rebound rates are location specific. Although the ice melted fairly quickly, with respect to the geologic time scale, the crustal rebound response was much slower and continues today.

Several methods of determining isostatic uplift were examined. Clark and Persoage (1970) calculated relative vertical movement using isobases at their points of intersection with the eastern shore of Lake Michigan. MacLean (1961) suggested that post glacial uplift would best be estimated by measuring the warping of depositional and erosional landforms. Lake level differences between water levels at Milwaukee and Harbor Beach were calculated and a linear regression was computed to fit these differences (Coordinating Committee 1977). The slope of this linear regression line represents the isostatic rebound. An analysis of linear and nonlinear methods was also conducted. Comparing the Coordinating Committee's linear method to a logarithmic non linear calculation, a negligible difference of .001 feet/100 years (.0003 m/100 yr) was obtained. Kite and Adamowski (1973) also concluded that differences in elevation could be represented by first order linear trends. Therefore, the method used by the Coordinating Committee (1977) is used in this study. The linear regression equation consisted of the slope-intercept form:

$$y = mx + b$$

TABLE 1. Lake Michigan water levels in meters at Milwaukee (IGLD 1955).

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1819		175.59				176.20						
1820												
1821												
1822												
1823												
1824												
1825												
1826												
1827												
1828						177.06	177.08	177.06				
1829												
1830						177.06						
1831												
1832												
1833												
1834												
1835												
1836			176.40			177.32						
1837					176.65	177.44						
1838						177.62	177.62					
1839							177.22					176.50
1840	176.25			176.69	176.72	176.74	176.82	176.74	176.64	176.59	176.54	176.47
1841	176.49											176.27
1842												
1843												
1844												
1845						176.55						
1846	176.28	176.27	176.32	176.47	176.58	176.57	176.59	176.51	176.36	176.29	176.20	176.09
1847	175.98	175.94	176.01	176.04	176.10	176.23	176.25	176.23	176.26	176.17	176.13	176.07
1848	176.01	175.99	175.99	176.10	176.01	176.08	176.26	176.26	176.21	176.18	176.15	176.17
1849	176.16	176.19	176.13	176.19	176.22	176.39	176.48	176.48				
1850												
1851							176.84	176.92			176.88	
1852								177.16	177.01	176.98	177.02	
1853												
1854				176.49	176.69	176.77	176.87	176.86	176.83	176.65	176.57	176.55
1855	176.47	176.46	176.48	176.50	176.68	176.78	176.80	176.84	176.86	176.83	176.76	176.80
1856	176.81	176.66	176.67	176.71	176.84	176.82	176.84	176.78	176.75	176.69	176.67	176.60
1857	176.54	176.62	176.66	176.80	176.91	177.00	177.13	177.19	177.15	177.17	176.92	176.93
1858	176.91	176.82	176.80	176.96	177.10	177.23	177.35	177.34	177.22	177.17	177.07	177.07
1859	176.93	176.97	176.98	177.18	177.22	177.22	177.42	177.33	177.26	177.16	177.01	177.03

where: y is the isostatically corrected lake level
m is the slope
x is the year
b is the intercept

Differential isostatic rebound is described by the negative slope between gages at Milwaukee and Harbor Beach (Fig. 2) indicating a rise in lake level of western Lake Michigan. In contrast, Figure 3 shows minor lake level differences between gages at Lakeport and Harbor Beach. While the period of record is too short for significant extrapolation, there appears to be relatively little differential vertical movement along the southern shore of Lake Huron between Harbor Beach and the outlet. The regression equation was then applied to the pre-1860 Milwaukee gage data (Table 1) to obtain corresponding Harbor Beach lake levels (Table 2).

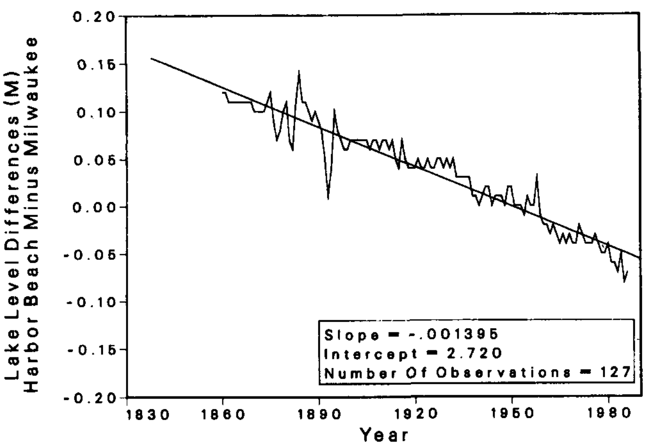

FIG. 2. Differential isostatic rebound between Milwaukee, Wisconsin, and Harbor Beach, Michigan (1838–1990).

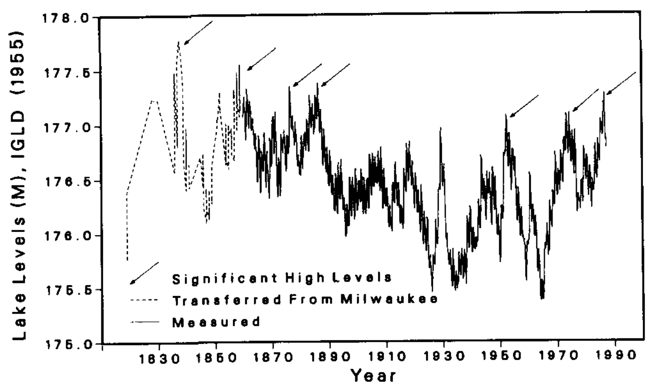

FIG. 4. Lake Michigan-Huron annual maximum monthly mean water levels at Harbor Beach, Michigan.

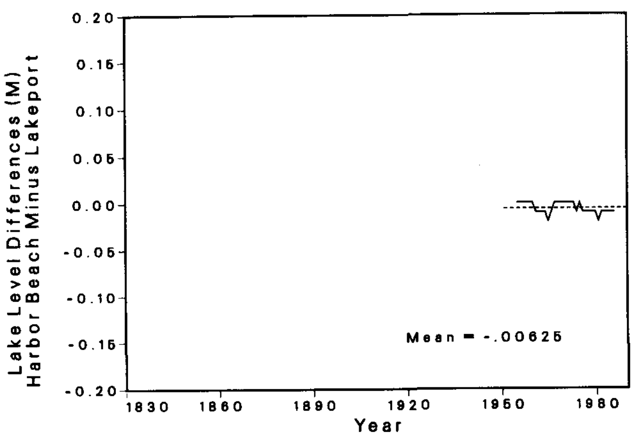

FIG. 3. Differential isostatic rebound between Harbor Beach, Michigan, and Lakeport, Michigan (1950–1990).

DISCUSSION

Figure 4 shows the integrated time series of the annual maximum monthly mean water levels for Lake Michigan-Huron at Harbor Beach. The top six events are compared in Table 3. They clearly show the large excursions of very high water levels in the 19th century, with 1838 being the record. These events are useful in putting the recent high levels in perspective. It is significant to note the differences in the lake regime between the early to mid-20th century consisting of the regulation of Lake Superior, interbasin diversions of water, a higher capacity outlet due to dredging, and extensive land use changes in the basin.

The net impact of the diversions on Lake Michigan-Huron water levels is -1 cm (International Joint Commission 1985) which is negligible in comparison with St. Clair River dredging projects between 1900 and 1988 which lowered the water levels by 27 cm (Derecki 1985). Other St. Clair River dredging was undertaken between 1860 and 1900 with estimated effects ranging from a lowering of 10 cm to 35 cm (Brunk 1961, 1968; Quinn and Croley 1981; Lawhead 1961). Combined effects of dredging between 1860 and 1988 have lowered the water levels of Lake Michigan-Huron by 37 cm to 62 cm. The regulation of Lake Superior produces relatively little bias on the levels of Lake Michigan-Huron (Quinn 1978). Perhaps the most significant change between the early 1800s and the present is changes in land use, primarily deforestation and artificial drainage, with resulting increases in runoff, which is an area of ongoing research. The increases runoff due to land use changes increases the Great Lakes water supplies, leading to increased lake levels, which may partially offset the lake level lowering due to the St. Clair River dredging. The offset increases the validity of comparisons between the 1838 water levels and today's conditions. Thus the 50-cm difference in levels between 1838 and 1986 could be significant for water resource planning.

TABLE 2. Lake Michigan-Huron water levels in meters at Harbor Beach, deduced table (transferred from Milwaukee).

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1819		175.8				176.4						
1820												
1821												
1822												
1823												
1824												
1825												
1826												
1827												
1828						177.2	177.2	177.2				
1829												
1830						177.2						
1831												
1832												
1833												
1834												
1835												
1836			176.6			177.5						
1837					176.8	177.6						
1838						177.8	177.8					
1839							177.4					176.7
1840	176.4			176.9	176.9	176.9	177.0	176.9	176.7	176.7	176.7	176.6
1841	176.6											176.4
1842												
1843												
1844												
1845						176.7						
1846	176.4	176.4	176.5	176.6	176.7	176.7	176.7	176.6	176.5	176.4	176.3	176.2
1847	176.1	176.1	176.1	176.2	176.2	176.4	176.4	176.4	176.4	176.3	176.3	176.2
1848	176.1	176.1	176.1	176.2	176.1	176.2	176.4	176.4	176.3	176.3	176.3	176.3
1849	176.3	176.3	176.3	176.3	176.4	176.5	176.6	176.6				
1850												
1851							177.0	177.1			177.0	
1852								177.3	177.1	177.1	177.2	
1853												
1854				176.6	176.8	176.9	177.0	177.0	177.0	176.8	176.7	176.7
1855	176.6	176.6	176.6	176.6	176.8	176.9	176.9	177.0	177.0	177.0	176.9	176.9
1856	176.9	176.8	176.8	176.8	177.0	176.9	177.0	176.9	176.9	176.8	176.8	176.7
1857	176.7	176.7	176.8	176.9	177.0	177.1	177.3	177.3	177.3	177.3	177.0	177.1
1858	177.0	176.9	176.9	177.1	177.2	177.4	177.5	177.5	177.3	177.3	177.2	177.2
1859	177.0	177.1	177.1	177.3	177.3	177.3	177.5	177.5	177.4	177.3	177.1	177.1

TABLE 3. Comparison of 1838 and 1859 transferred Lake Michigan-Huron extreme water levels with recorded extremes.

Year	Month	Elevation (meters)
1838	June-July	177.8
1859	July	177.5
1876	July	177.35
1886	June	177.38
1952	August	177.08
1973	August	177.09
1986	October	177.28

CONCLUSIONS

The water levels of 1838 are the highest recorded levels for Lake Michigan-Huron and may have been the highest levels over the past 250–300 years. While the lake regime and basin conditions have changed considerably since then, the water levels document the occurrence of a very high precipitation regime, or climate shift, which could recur in the future. If such an episode were to occur, with water levels 50 cm over the 1986 highs, it would have extremely severe economic consequences for riparian interests throughout the Great Lakes region.

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