DETROIT RIVER

PHYSICAL AND HYDRAULIC CHARACTERISTICS[1]

Jan A. Derecki

GLERL Open File Report

June 1984

[1]GLERL Contribution No. 417.

National Oceanic and Atmospheric Administration
Great Lakes Environmental Research Laboratory
Ann Arbor, Michigan 48104

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1. INTRODUCTION

The Detroit River connects Lake St. Clair with Lake Erie and forms the lower part of the St. Clair-Detroit River outflow system from Lake Huron. It flows through a heavily industrialized area. Levels and flow in the Detroit River are important because of the river's role in the hydrologic mass balance, navigation, sediment transport, and the movement of pollutants.

2. PHYSICAL CHARACTERISTICS

The Detroit River is approximately 51 km (32 mi) long and its total fall is about 0.9 m (3 ft). The river slope is relatively uniform and mild for most of its length, except for the steep upper Amherstburg Channel in the lower river segment above its mouth. The Detroit River has two distinct reaches with different hydraulic characteristics.

2.1 The Upper Reach

The upper reach extends downstream from Lake St. Clair to the head of Fighting Island. This reach of the river forms a broad arc spanning about 21 km (13 mi) and falls about 0.3 m (1 ft). Channel orientation in this reach changes from westerly to southerly. Except for an area near the head of the river where the channel is divided by Peach Island and Belle Isle, the river in this reach forms a single and well-defined channel approximately 600-m to 900-m (2,000-ft to 3,000-ft) wide. In the island section, at the head of the river, the combined channel width approximately doubles to about 1,200-1,500 m (4,000-5,000 ft), but the hydraulically effective width is reduced by approximately 300 m (1,000 ft) due to shallow stretches running primarily along the islands. The upper river channel is generally deep, with midchannel depths varying from about 9 m to 15 m (30 ft to 50 ft), and has steep banks. Bottom material in the channel consists of sand and clay.

2.2 The Lower Reach

The lower reach of the Detroit River is characterized by a broad river channel, with many islands and wide shallow expanses of water. The total river width extends from 1.5 km to 3 km (1 mi to 2 mi), but large segments of this are shallow expanses that are hydraulically ineffective. The significant width is generally much smaller, averaging about 1,200 m (4,000 ft) and varying from 900 m to 1,800 m (3,000 ft to 6,000 ft). The larger islands (Fighting Island, Grosse Ile, and Bois Blanc Island) divide the river into distinct channels. The main channel, west of Fighting Island and east of Grosse Ile, runs along four major navigation channels. The two-directional main navigation route in the upper portion of the lower Detroit River follows the Fighting Island Channel, running along the island, and the Ballards Reef Channel downstream to Stony Island, for a combined distance of about 14 km (9 mi). At the head of Stony Island the navigation channel divides into two one-directional navigation routes--the downbound Livingstone Channel (west of Bois Blanc Island) and the upbound Amherstburg Channel (along the Canadian mainland)--that cover the remaining 16 km (10 mi) to Lake Erie. Project depths in the navigation channels are maintained at 8.2-8.5 km (27-28 ft), but natural depths in excess of 9 m (30 ft) occur only in the Fighting Island Channel. In this upper part of the lower river reach the banks rise with a gentle slope and the bottom consists of sand, clay, boulders, and rock. Downstream of Fighting Island, the natural depths in the main channel are generally under 6 m (20 ft), and the bottom material over the 10-km (6-mi) stretch to Bois Blanc Island is composed mainly of bedrock and boulders. The natural bed formation of the lower river required extensive rock excavation and dredging, along with compensating dikes, to provide present navigation channels. The Detroit River slope is steepest in this area. In a relatively short stretch of about 10 km (6 mi), including the Stony Island-Bois Blanc Island reach, the river falls approximately 0.5 m (1.5 ft), leaving less than 0.2 m (0.5 ft) for the rest of the lower Detroit River.

A secondary major channel along the entire length of the lower river reach is the Trenton Channel, which branches west of the main channel at the head of Fighting Island and separates Grassy Island and Grosse Ile from the United States mainland. The Trenton Channel generally approaches 300 m (1,000 ft) in width. An 8.2-m (27-ft) navigation channel and turning basin extends past the Upper Bridge, followed by a 6.4-m (21-ft) navigation channel and turning basin, which terminate just below the Lower Bridge. Natural river depths at the south end of the Trenton Channel are less than 3 m (10 ft) and do not permit through navigation of deep-draft vessels.

3. HYDRAULIC CHARACTERISTICS

3.1 River Discharge

Flow in the Detroit River produces an average discharge of about 5,200 $m^3 s^{-1}$ (185,000 $ft^3 s^{-1}$) which varies seasonally from a winter low of about 4,400 $m^3 s^{-1}$ (155,000 $ft^3 s^{-1}$) to a summer high of about 5,700 $m^3 s^{-1}$ (200,000 $ft^3 s^{-1}$) per month, with somewhat larger extremes (lower and higher) for shorter periods. Periodic long-term low and high mean annual flows produced by below-normal and above-normal water supplies vary from about 4,200 $m^3 s^{-1}$ to 6,400 $m^3 s^{-1}$ (150,000 $ft^3 s^{-1}$ to 225,00 $ft^3 s^{-1}$), respectively. The range of seasonal variation in monthly flows is within 800 to 1,300 $m^3 s^{-1}$ (30,000 to 45,000 $ft^3 s^{-1}$).

Water depths and flows in the Detroit River depend on the levels of Lakes St. Clair and Erie, which vary seasonally. Short period fluctuations due to wind are superimposed on the seasonal variation. Fluctuations of a couple meters (several feet) may be experienced during storms for short periods (several hours). Such fluctuations at the mouth of the Detroit River are produced by high easterly or westerly winds, which cause high surges and seiches on Lake Erie. Because western Lake Erie is relatively shallow and lake orientation coincides with predominant storm tracks, these water level changes have been observed to reach 2-2.5 m (7-8 ft) and produce 4-4.5 m (14-15 ft) lake surface slope between Buffalo and Toledo. [During a 5-hour period on April 6, 1979, the water level of western Lake Erie changed by 2.4 m (8 ft), with a total lake surface slope of 4.4 m (14.5 ft).] Because the Detroit River fall is only 0.9 m (3 ft), the water level at the mouth of the river may become higher during such times than the level at its head and produce a short period flow reversal, at least of surface water mass in the lower river. This is a unique phenomenon peculiar to the Detroit River in the Great Lakes connecting channels.

3.2 Flow Distribution

The main channel of the upper Detroit River, north of Peach Island and south of Belle Isle (Fleming Channel), carries 77 percent and 66 percent of the total river flow, respectively. Flow distribution in the lower Detroit River is rather complex, with several channels separating or combining the river flow. In the upper end of the lower reach, at the head of Fighting Island, the river flow is divided among the upper Trenton Channel, Fighting Island Channel, and a secondary channel east of Fighting Island with 26 percent, 51 percent, and 23 percent of the flow, respectively. At the head of Grosse Ile, the flow distribution for the Trenton and Fighting Island Channels changes to 21 percent and 56 percent, respectively. The flow east of Fighting Island divides at its southern end, north and south of Turkey Island, with 12 percent and 11 percent of the flow, respectively. The Ballards Reef Channel flow of 79 percent is distributed at the head of Stony Island among a minor channel west of Stony Island, the upper Livingstone Channel, and the Amherstburg Channel with 6 percent, 26 percent, and 47 percent, respectively. At the head of Bois Blanc Island, this flow is redistributed, with 11 percent of the total flow from the two navigation channels going west of these channels and 4 percent going between the Livingstone Channel and Bois Blanc Island. Flow distribution past that point among the minor channels west and east of Livingstone Channel, and the Livingstone and Amherstburg Channels is 17 percent, 4 percent, 22 percent, and 36 percent, respectively. At the lower end of the river, the Trenton Channel flow is divided west and east of Celeron Island, with 15 percent and 6 percent, respectively, while the flow west of Livingstone Channel is divided west and east of Sugar Island, with 12 percent and 5 percent of flow, respectively.

3.3 River Velocities

Flow velocities in the river are variable, depending on location and controlling flow conditions. Average velocities in the Detroit River, shown in figure 1 (Coordinating Committee, 1982), vary from about 0.3 m s^{-1} (1 ft s^{-1}) to over 0.6 m s^{-1} (2 ft s^{-1}). Maximum midchannel surface currents in the upper river reach, in the vicinity of the Ambassador Bridge, attain 0.9 m s^{-1} to 1.2 m s^{-1} (3 ft s^{-1} to 4 ft s^{-1}). The surface currents in the lower river are generally lower, but this section of the river also has the highest river velocities. Maximum surface currents in the upper Amherstburg Channel can exceed 1.5-1.8 m s^{-1} (5-6 ft s^{-1}). In the Trenton Channel the maximum surface

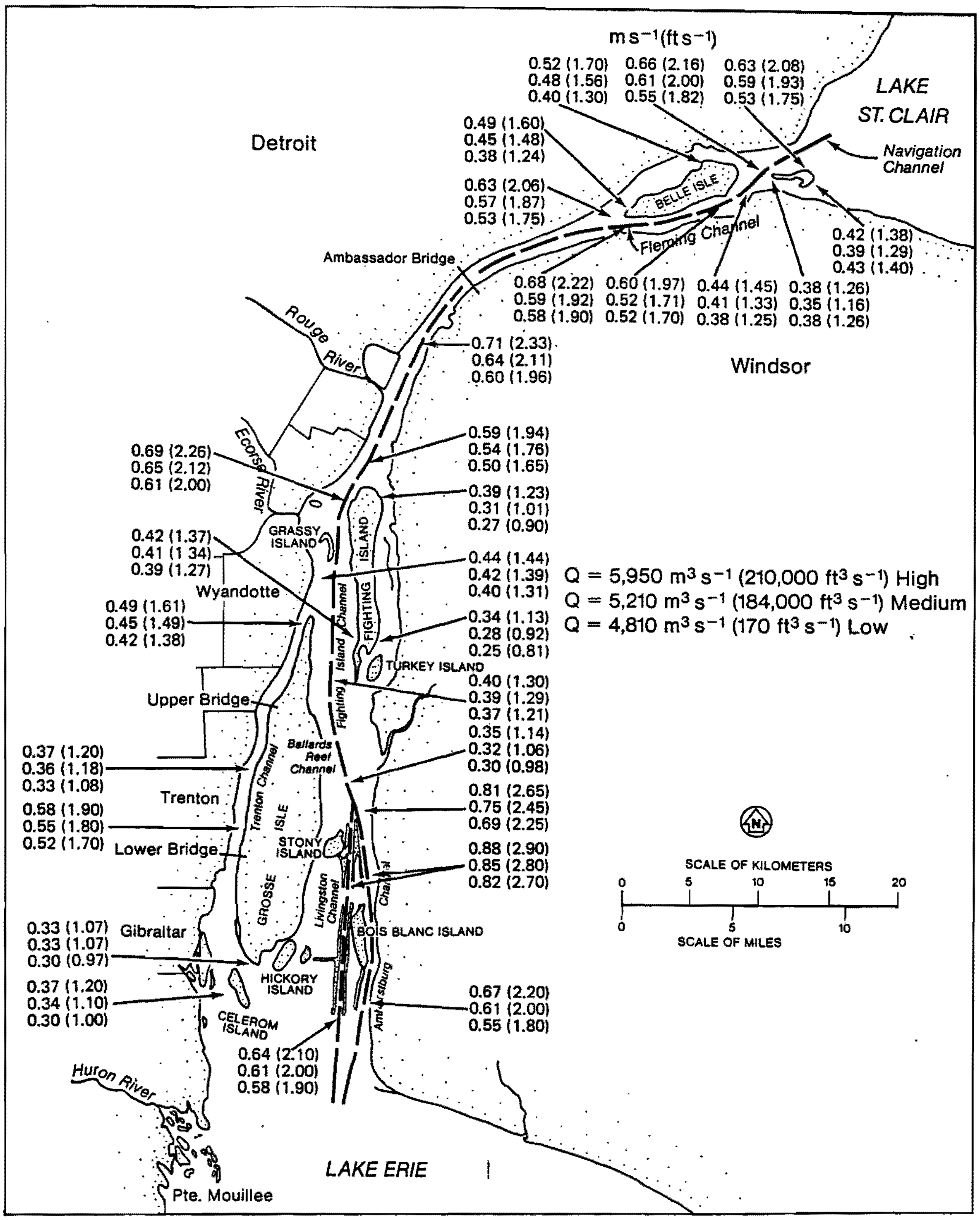

FIGURE 1.--*Detroit River average velocities.*

TABLE 1.—*Detroit River flow time in hours—mean flow*

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Head, Belle Isle	1.1													
2. Foot, Belle Isle														
A. Main Ch.	3.5	2.4												
B. West Ch.	4.3*	3.2*												
3. Auto Tunnel	4.9	3.8	1.4											
4. Ambassador Bridge	6.3	5.2	2.8	1.4										
5. Ft. Wayne	7.3	6.2	3.8	2.4	1.0									
6. Rouge River	8.4	7.3	4.9	3.5	2.1	1.1								
7. Foot, Anchorage Area	9.6	8.5	6.1	4.7	3.3	2.3	1.2							
8. Head, Trenton Ch.	10.4	9.3	6.9	5.5	4.1	3.1	2.0	0.8						
9. Foot, Grassy Is.														
A. Main Ch.	11.6	10.5	8.1	6.7	5.3	4.3	3.2	2.0	1.2					
B. Trenton Ch.	12.1	11.0	8.6	7.2	5.8	4.8	3.7	2.5	1.7					
10. Pt. Hennepin														
A. Main Ch.	12.5	11.4	9.0	7.6	6.2	5.2	4.1	2.9	2.1	0.9				
B. Trenton Ch.	13.1	12.0	9.6	8.2	6.8	5.8	4.7	3.5	2.7	1.0				
11. Fighting Is. Shoal Lt.														
A. Main Ch.	14.3	13.2	10.8	9.4	8.0	7.0	5.9	4.7	3.9	2.7	1.8			
B. Trenton Ch. (Upper Bridge)	14.8	13.7	11.3	9.9	8.5	7.5	6.4	5.2	4.4	2.7	1.7			
12. Head, Livingstone Ch.														
A. Main Ch.	16.5	15.4	13.0	11.6	10.2	9.2	8.1	6.9	6.1	4.9	4.0	2.2		
B. Trenton Ch. (Lower Bridge)	17.6	16.5	14.1	12.7	11.3	10.3	9.2	8.0	7.2	5.5	4.5	2.8		
13. Head, Bois Blanc Is.														
A. Amherstburg Ch.	17.6	16.5	14.1	12.7	11.3	10.3	9.2	8.0	7.2	6.0	5.1	3.3	1.1	
B. Livingstone Ch.	17.5	16.4	14.0	12.6	11.2	10.2	9.1	7.9	7.1	5.9	5.0	3.2	1.0	
C. Trenton Ch. (Head, Calf Is.)	18.8	17.7	15.3	13.9	12.5	11.5	10.4	9.2	8.4	6.7	5.7	4.0	1.2	
14. Lake Erie														
A. Amherstburg Ch.	19.3	18.2	15.8	14.4	13.0	12.0	10.9	9.7	8.9	7.7	6.8	5.0	2.8	1.7
B. Livingstone Ch.	19.1	18.0	15.6	14.2	12.8	11.8	10.7	9.5	8.7	7.5	6.6	4.8	2.6	1.6
C. Trenton Ch. (Foot, Celeron Is.)	20.9	19.8	17.4	16.0	14.6	13.6	12.5	11.3	10.5	8.8	7.8	6.1	3.3	2.1

*Note: For spills occurring in the channel west of Belle Isle, add 0.8 h to downstream travel times.

Key: 0) Windmill Pt., 1) Head, Belle Isle, 2) Foot, Belle Isle, 3) Auto Tunnel, 4) Ambassador Bridge, 5) Ft. Wayne, 6) Rouge River, 7) Foot, Anchorage Area, 8) Head, Trenton Ch., 9) Foot, Grassy Is., 10) Pt. Hennepin, 11) Fighting Is. Shoal Lt., 12) Head, Livingstone Ch., 13) Head, Bois Blanc Is.

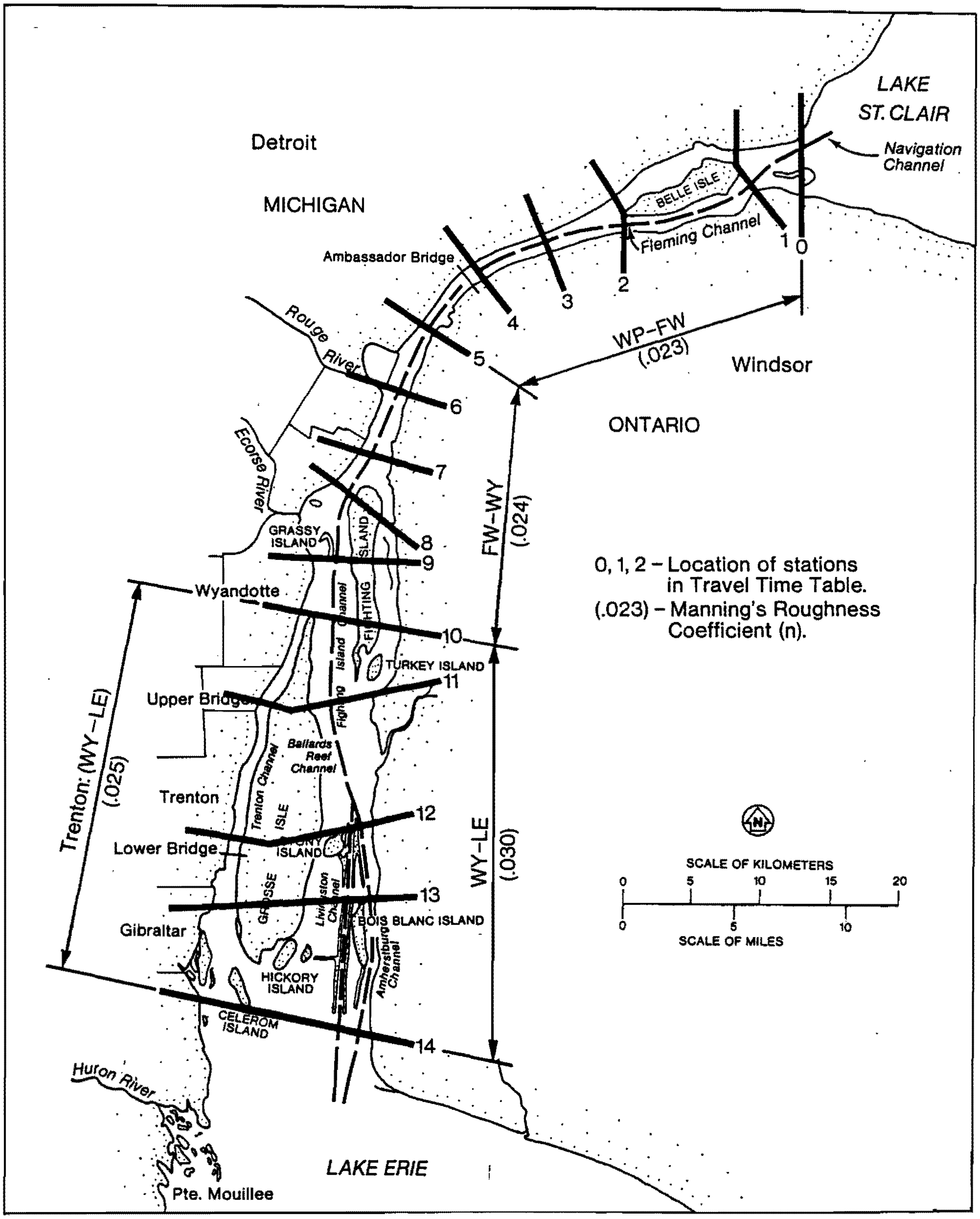

FIGURE 2.—*Detroit River travel time sections.*

currents midway between the Grosse Isle bridges can exceed 1.2 m s^{-1} (4 ft s^{-1}). The average velocities represent the average velocity in the river cross section at specified locations for the high, mean, and low flows indicated in the figure. Because of nonlinear velocity distribution in the channel (logarithmic vertically and parabolic transversely across the channel), the maximum midchannel surface currents are approximately 1.3 times higher for normal flow conditions. During storm surges on Lake St. Clair, the normal flow velocities can be considerably higher (about 1.5 times normal), but storm surges on Lake Erie may reduce the normal velocities and at times even reverse the flow in the lower river. Thus, weather conditions may have a very important effect on the distribution and transport of spills.

The transit time along the river computed for the normal mean flow conditions is summarized in table 1 (Derecki, 1983). This table shows that the total travel time in the main channel is about 19 h, but about 21 h in the Trenton Channel. For spills occurring in the secondary channel north of Belle Isle add approximately 1 h to downstream travel times shown in the table. These travel times may be affected by the hydraulic and weather conditions and by important physical/chemical differences between water and pollutant particles involved. Locations of numbered points along the river used in the table are shown in figure 2. The figure also indicates average hydraulic roughnesses for river reaches between gages, with Manning's roughness coefficients (n) in parentheses.

3.4 Dynamic Flow Models

A one-dimensional mathematical transient model was used to compute the average cross-sectional velocities shown in figure 1. One-dimensional numerical models are used to compute river flow by solving the complete nonlinear equations of motion (continuity and momentum) governing the movement of water in a longitudinal direction. These models can be used to determine the average longitudinal velocities along the river, provided sufficient cross sections are included to represent the actual river configuration. The one-dimensional models for the Detroit River have been developed by the Great Lakes Environmental Research Laboratory (GLERL) in Ann Arbor, Mich., (Quinn and Hagman, 1977) and the Corps of Engineers (COE) in Detroit, Mich., (no published documentation). Calibration of these models is based on periodic flow measurements conducted during the open water season; thus, the models may poorly simulate winter flows with substantial ice cover. Winter flow experiments are currently being conducted by GLERL on the St. Clair and Detroit Rivers to correct this model weakness. Two GLERL Detroit River models are available for computing flows on hourly or daily time scales. The upper river model computes single channel flows in the upper reach between Windmill Point, Mich., and Wyandotte, Mich., water level gages. The total river model computes the river flows between Lakes St. Clair and Erie, using the gages at the Windmill Point and Fermi Powerplant at Stony Point, Mich., and determines the division of flow around Grosse Ile in the lower river. However, both models use idealized river cross sections that do not indicate actual channel configuration needed for determining average velocities along the river. Revision of computational procedure and recalibration of the models based on actual channel configuration is in process. The GLERL Detroit River models

TABLE 2.--*Detroit River transient model, 1982 (24-hour time increments)*
(basic computations performed in the English units: ft and $ft^3\ s^{-1}$)

Day	Month	Year	Erie	WY	WP	QWE	QWW	QTE	QTW	QWY	QWP	QE	WYM	DEV	WV	WD
1	11	1982	570.99	572.55	573.84	156552.	156552.	46429.	46429.	202981.	202981.	202981.	572.56	-.01	0.00	0.00
2	11	1982	571.09	572.64	573.93	157076.	157428.	46644.	46774.	204203.	204651.	203720.	572.66	-.02	0.00	0.00
3	11	1982	570.92	572.58	573.93	160665.	160125.	47897.	47697.	207821.	207536.	208562.	572.59	-.01	0.00	0.00
4	11	1982	570.70	572.44	573.83	162909.	162393.	47911.	47719.	210112.	209575.	210820.	572.41	.03	0.00	0.00
5	11	1982	569.49	571.80	573.41	174268.	170935.	50108.	48871.	219806.	217281.	224377.	571.82	-.02	0.00	0.00
6	11	1982	570.36	572.03	573.51	164679.	167874.	44589.	45774.	213648.	215328.	209268.	572.12	-.09	0.00	0.00
7	11	1982	570.79	572.39	573.68	156217.	156646.	45780.	45939.	202585.	203372.	201997.	572.40	-.01	0.00	0.00
8	11	1982	570.76	572.41	573.75	159301.	159148.	46731.	46674.	205822.	205800.	206032.	572.39	.02	0.00	0.00
9	11	1982	571.31	572.70	573.93	152473.	154128.	44912.	45526.	199654.	200876.	197384.	572.71	-.01	0.00	0.00
10	11	1982	571.60	572.91	574.03	146966.	147351.	44804.	44946.	192297.	192666.	191770.	572.91	-.00	0.00	0.00
11	11	1982	571.01	572.57	573.80	153796.	151905.	46853.	46151.	198057.	196481.	200649.	572.54	.03	0.00	0.00
12	11	1982	569.97	571.97	573.43	165929.	163444.	48304.	47382.	210826.	208867.	214233.	572.02	-.05	0.00	0.00
13	11	1982	570.54	572.23	573.68	164222.	166625.	45794.	46685.	213311.	215267.	210016.	572.26	-.03	0.00	0.00
14	11	1982	570.76	572.43	573.78	160092.	160093.	47003.	47003.	207096.	207217.	207095.	572.46	-.03	0.00	0.00
15	11	1982	570.52	572.32	573.74	164158.	163492.	47939.	47692.	211184.	210758.	212097.	572.29	.03	0.00	0.00
16	11	1982	570.75	572.40	573.77	160891.	161698.	46501.	46801.	208498.	208917.	207392.	572.43*	-.03	0.00	0.00
17	11	1982	571.03	572.58	573.87	156864.	157464.	46262.	46485.	203949.	204521.	203125.	572.54	.04	0.00	0.00
18	11	1982	571.09	572.62	573.89	155656.	155656.	46409.	46409.	202065.	202042.	202065.	572.61	.01	0.00	0.00
19	11	1982	571.18	572.65	573.89	153561.	153793.	45830.	45917.	199709.	199800.	199391.	572.64	.01	0.00	0.00
20	11	1982	571.19	572.66	573.88	152743.	152693.	45813.	45794.	198487.	198443.	198555.	572.67	-.01	0.00	0.00
21	11	1982	571.06	572.64	573.93	157369.	157100.	47100.	47000.	204099.	204189.	204469.	572.61	.03	0.00	0.00
22	11	1982	571.45	572.86	574.09*	153737.	154986.	45901.	46364.	201351.	202295.	199638.	572.85	.01	0.00	0.00
23	11	1982	571.04	572.74	574.08	161772.	160344.	49236.	48706.	209050.	208395.	211009.	572.69	.05	0.00	0.00
24	11	1982	570.62	572.50	573.99	169326.	168561.	49836.	49552.	218113.	217503.	219162.	572.47	.03	0.00	0.00
25	11	1982	570.39	572.35	573.89	171616.	171144.	49651.	49476.	220620.	220177.	221267.	572.36	-.01	0.00	0.00
26	11	1982	570.62	572.47	573.99	170514.	171334.	49039.	49343.	220677.	221386.	219553.	572.49	-.02	0.00	0.00
27	11	1982	571.26	572.79	574.13	160416.	161972.	47200.	47777.	209749.	210699.	207615.	572.81	-.02	0.00	0.00
28	11	1982	571.46	572.93	574.17	155217.	155339.	47177.	47222.	202561.	202698.	202394.	572.94	-.01	0.00	0.00
29	11	1982	570.64	572.51	573.94*	166400.	164013.	50196.	49310.	213322.	211623.	216596.	572.48	.03	0.00	0.00
30	11	1982	571.19	572.64	573.49E	156679.	158766.	45358.	46132.	204898.	205798.	202037.	572.77	-.13	0.00	0.00
Average			570.86	572.51	573.86	160069.	160100.	47107.	47118.	207218.	207238.	207176.	572.52	-.01		

Starting Elevations: Windmill Point = 573.84
Wyandotte = 572.56
Lake Erie = 570.99

* = Missing data in the records.
E = Estimated data.

WY = Wyandotte.
WP = Windmill Point.
QWE = Computed flows in Main Channel below Grosse Ile.
QWW = Computed flows in Main Channel above Grosse Ile.
QTE = Computed flows in Trenton Channel below Grosse Ile.
QTW = Computed flows in Trenton Channel above Grosse Ile.
QWY = Computed flows in Main Channel and Trenton Channel at Wyandotte.
QWP = Computed flow in Main Channel and Trenton Channel at Windmill point.
QE = Computed flow in Main Channel and Trenton Channel at Lake Erie.
WYM = Measured levels at Wyandotte.
DEV = Deviation between computed and measured levels at Wyandotte.
WV = Wind velocity used.
WD = Wind direction used.

also differ from the COE model in that the GLERL models provide an option for the inclusion of the surface wind stress effects (Quinn, 1980), which may be important during the more intensive short period flow fluctuations associated with storms.

An example of flow computation with the GLERL total Detroit River model is shown in table 2. Computation with the upper river model is simplified because of the elimination of flow division around Grosse Ile in the lower river. The table is largely self-explanatory and provides information on the river profile and flows at three points corresponding to gage locations. It also provides an indication of computation accuracy by providing a "mid-gage" check of deviations between computed and measured water levels. The results are presented in either English (ft and $ft^3\ s^{-1}$) or metric (m and $m^3\ s^{-1}$) units, along with an indication of the model upper and lower reaches enclosed by three gages, and the computational time increments employed. Computations for the hourly time scales are grouped and averaged for daily periods, while those for the daily time scales are arranged by months. The computations proceed upstream between two gages enclosing the model reaches, separated by a "mid-gage." The measured elevations at the lower and upper model boundaries and in between computed elevation for the "mid-gage," designated as "Erie" (Fermi gage), "WY" (Wyandotte), and "WP" (Windmill Pt.) determine the river profile and related flows. The computed flows are shown in the next seven columns. The first two of these columns indicate flows in the main channel below and above Grosse Ile (Lake Erie and Wyandotte) and are designated "QWE" and "QWW," respectively. The next two flow columns show comparable flows in Trenton Channel and are designated "QTE" and "QTW." Summation of flows in the main channel and Trenton Channel at Wyandotte is shown next under "QWY," and is followed by flows at the head of the river (Windmill Point) marked as "QWP," and finally the summation of flows at the mouth of the river "QE." The next column shows the measured levels for the "mid-gage" (Wyandotte) under "WYM" and is followed by "DEV," indicating deviations between computed and measured levels at this location. Except for periods of missing gage data, these deviations are normally small, indicating good gage agreement and flow accuracy during the open water season. During winter, the deviations normally increase significantly, indicating loss of accuracy due to ice problems. Because lateral inflow to the Detroit River is relatively small, there is normally very little difference between total flows along the river as indicated in the table. The last two columns show the use of any wind velocity and direction data, designated as "WV" and "WD," respectively. Occasional periods of partially or fully missing gage data may affect the accuracy of computed flows or gage deviation checks; these periods are flagged with an asterisk (*) for partial records and a letter "E" for estimates during periods without any records.

4. ICE EFFECTS

Ice conditions in the Detroit River are considerably different from those in the St. Clair River because of the difference in the upstream lakes, which are the primary ice supply source for both rivers. Lake St. Clair is relatively small and shallow, and responds quickly to wind and temperature changes, while Lake Huron possesses large heat storage capacity, which delays both the formation and deterioration of ice cover. An ice bridge or arch usually develops in Lake St. Clair upstream of Peach Island, across the head of the Detroit River. The upper river normally does not freeze over, except for the broad and shallow area between Belle Isle and the United States mainland. Its narrow main channel has a relatively swift current and is generally capable of transporting Lake St. Clair ice downstream without major problems; minor ice jams may occur when ice comes down from Lake St. Clair in large quantities, especially if the lower river is blocking downstream ice passage. Because of steep river banks, ice-induced flooding in the upper river does not present serious problems. In the lower river, ice cover develops in the broad and shallow expanses adjacent to its many islands; however, the main navigation channels are generally open, permitting free passage of ice to Lake Erie. Ice in western Lake Erie is usually fast, but can shift in large sheets under the influence of prevailing winds. Westerly winds can create large areas of open water downstream of the river mouth, which can absorb the ice movement from the river. Easterly winds move Lake Erie ice into the lower river, which can cause ice jams that raise the upstream water levels, reducing river slope and flows, and hampering winter navigation (such as coal shipments between Lake Erie and Detroit). Occasionally, with heavy ice movement from Lake St. Clair (prolonged warm spells or early spring breakup of lake ice) and the blockage of the river mouth by ice from Lake Erie, the entire river may fill with ice. Flooding hazard in the lower river is more serious because of shallow river banks, especially when there are large storm-induced surge and seiche effects on Lake Erie.

5. SUMMARY

The Detroit RIver connects Lakes St. Clair and Erie, with a total length of about 51 km (32 mi) and a total fall of about 0.9 m (3 ft). The river drains the upper Great Lakes (Superior, Michigan, and Huron) and Lake St. Clair, producing an average discharge of about 5,200 $m^3\ s^{-1}$ (185,000 $ft^3\ s^{-1}$). Average flow velocities in the Detroit River vary from about 0.3 $m\ s^{-1}$ to 0.9 $m\ s^{-1}$ (1 $ft\ s^{-1}$ to 3 $ft\ s^{-1}$), depending on location and controlling flow conditions. The river flows are determined with dynamic flow models, which are based on periodic flow measurements. Winter flows are generally affected by ice.

6. REFERENCES

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