

# INFORMATION ON THE VELOCITY AND FLOW PATTERN OF DETROIT RIVER WATER IN WESTERN LAKE ERIE REVEALED BY AN ACCIDENTIAL SALT SPILL<sup>1</sup>

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## ABSTRACT

On 2 December 1970, a dock of the Detroit Bulk Dock Inc., in Detroit, Michigan, gave way, spilling 20,000 tons of rock salt into the Rouge River, a tributary of the Detroit River. The rate and pattern of flow of the salt into the southern end of the western basin of Lake Erie were measured by monitoring the chloride content of Lake Erie water received at the Toledo Water Treatment Plant.

On 10 December 1970, a salt-rich (35 ppm NaCl) water mass, having chloride concentrations twice the normal background, was detected at the Toledo Water Intake. This demonstrated clearly that Detroit River water does indeed move far into the southwestern basin of Lake Erie, a fact for which previous scientific support has been limited, and permitted a determination of the rate at which the water moves across the lake, at least at this time of year. After correcting for the time during which the salt mass was in the Rouge River and Detroit River, and the time required for the water to travel from the Intake to the Toledo treatment plant, the velocity of this salt-rich water mass across western Lake Erie, i.e. from the mouth of the Detroit River to the Toledo Water Intake, was calculated to be approximately 0.3 feet/second.

## INTRODUCTION

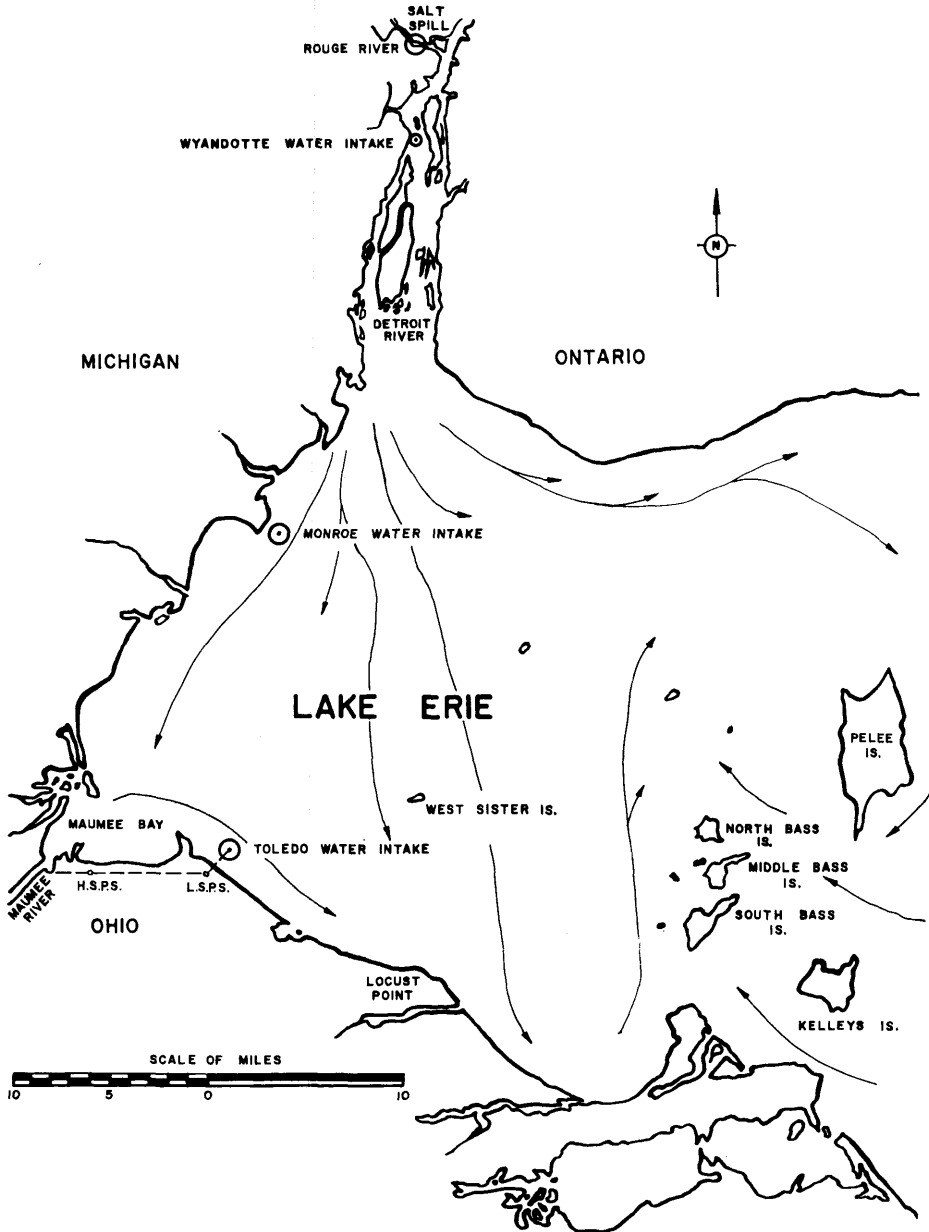
The report of an accidental spilling of 20,000 tons of rock salt (NaCl) into the Rouge River at Detroit, Michigan, at 6 P.M. on 2 December, 1970, provided the opportunity for determining, at the Toledo Water Treatment Plant, whether Detroit River water moves south across western Lake Erie as far as the Toledo intake, whether it generally maintains its original character, and how fast it moves. These determinations were done by monitoring the water received at the intake, located in the southwestern part of the Lake Erie basin (fig. 1), and watching for the sudden increase in salt content that could identify the Rouge River spillage.

The original announcement of this spillage appeared in *The Detroit Free Press*, on 3 December, 1970, which reported that "the pile of salt that fell into the water was about 200 by 75 feet. It was situated on a concrete pad that cracked and spilled in the water." The Rouge River drains directly into the Detroit River, and the spill took place about 1.5 miles above their confluence.

In order to reach a sound conclusion, it was necessary to demonstrate that the water received at the intake could be definitely identified as having come from the Detroit River and was not that brought in by the Maumee River, which itself contains some persistent salt (NaCl) contamination. Depending on such factors as wind direction and water level at the Maumee River mouth, either lake water, or Maumee River water can dominate in the flow into the intake. Maumee River water is usually found at the intake following periods of persistent north to northeast winds, perhaps due to the release of Maumee River water that was delayed, and piled up at or near the river's mouth, due to the force of the wind. Toledo Water Treatment Plant personnel have regularly recognized Maumee River water by its high alkalinities (95 to 150 ppm). This characteristic was tested by a separate analysis of water collected directly out of the Maumee River, the analyses of which (140 to 150 ppm) support the generalization that Maumee River water is higher in alkalinity than is normal Detroit River-Lake Erie water, a characteristic which can be used to identify it. Conversely, Detroit River-Lake

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Erie water can be recognized by its lower alkalinities (80 to 85 ppm). These characteristics are used here (fig. 2) to identify the source of the water samples being tested for evidence of the possible salt contamination.



### WESTERN LAKE ERIE BASIN

(After Hartley, et al, 1966)

FIGURE 1. Western basin of Lake Erie showing currents mapped by Hartley *et al.* (1966).

Normal chloride concentrations also differ in the two types of water. Chlorides are lower in Detroit River-Lake Erie water (approximately 15 ppm), and higher in Maumee River water (approximately 25 ppm), though both of these concentrations are considerably lower than the anticipated level of the salt-contaminated water from the spill in the Rouge River, should it reach the Toledo Water Intake.

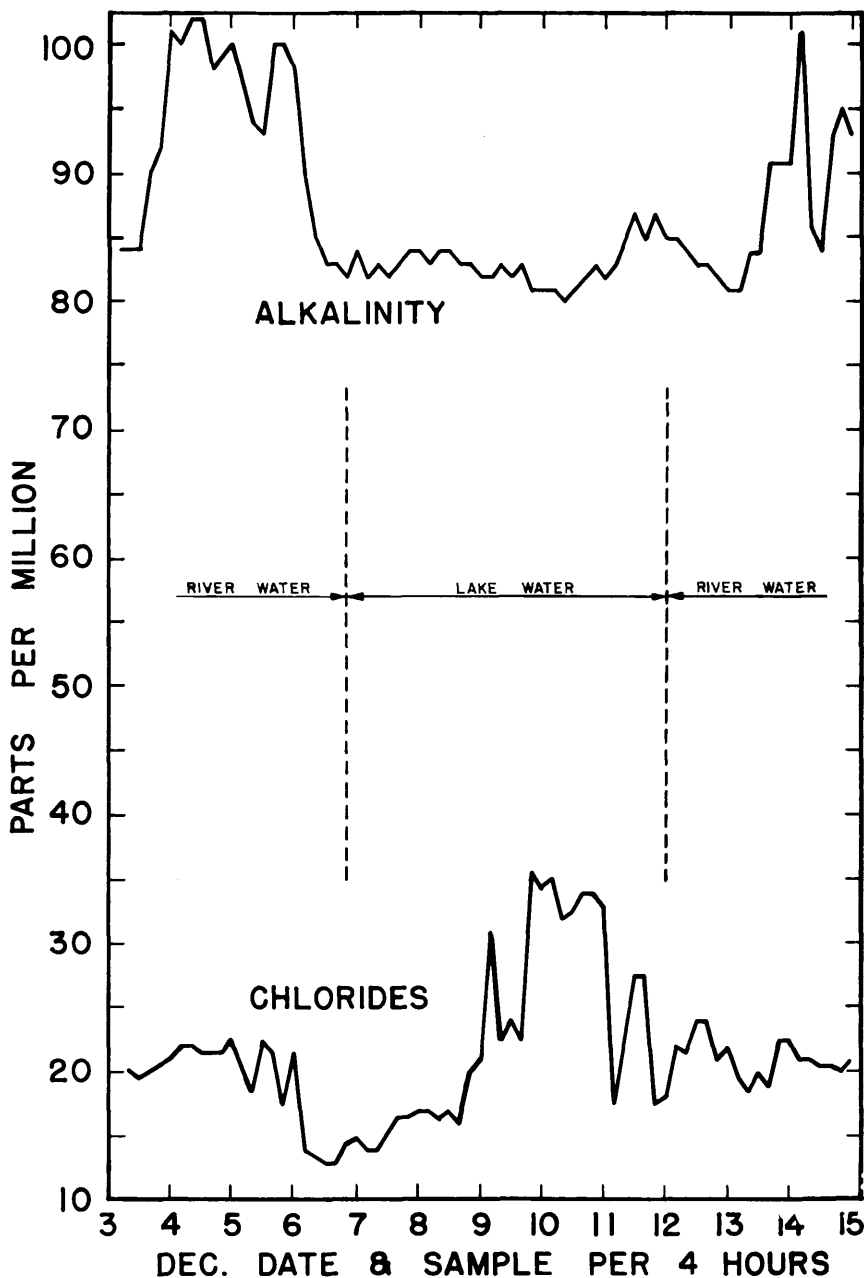


FIGURE 2. Chloride and alkalinity determinations on Lake Erie water samples from the Toledo Water Intake, 3 to 15 December, 1970.

Studies of water movements in the western basin of Lake Erie show the dominant flow of Detroit River water current in the lake to be toward the south; however, no adequate information is available that demonstrates how far south this water really flows. Harrington (1895), using bottles to measure currents, determined that the flow of water from the Detroit River split just south of its mouth, the major part going eastward to Pelee Passage and another part going southward toward Maumee Bay, but he gave no indication of what happened to the flow in the Maumee Bay area. Olson (1950), on the basis of data derived from drift cards, concluded that the Detroit River water became divided into three parts, all three of which, after flowing southward approximately halfway across the basin, flowed back to the north shore and continued eastward along that shore. Hartley, Herdendorf, and Keller (1966), employing turbidity, pH, conductivity, and water temperature, mapped currents in the western basin as shown by the arrows in Figure 1. Hartley *et al.* believed that part of the Detroit River flow reached the Ohio shore.

None of these studies identified the detailed pattern of the flow of Detroit River water in the southwestern part of the Lake Erie basin. The fact that a salt-contaminated water mass was in this flow, a feature of the water which could readily be detected at the Toledo Water Intake, provided an opportunity to test whether that flow came as far south as the intake. The purpose of this study, therefore, was to take advantage of this unfortunate salt spill into the Rouge River to determine:

- 1) whether this salt contamination could be identified in water from The Toledo Water Intake, to prove that Detroit River water does, at least at times, move as far south in the western Lake Erie basin as the position of this intake (fig. 1);
- 2) whether the salt concentration was strong enough to imply that very little mixing had taken place during the movement of this water southward through Lake Erie basin; and
- 3) the rate of flow of this Detroit River water across the western end of Lake Erie.

#### PROCEDURE

The water flowing into the Toledo intake was sampled every four hours throughout each day from 4 December to 16 December, 1970. Each water sample was analyzed for chlorides (NaCl) and for alkalinity. Alkalinity was tested in order to distinguish Detroit River-Lake Erie water from Maumee River water.

Chloride was determined by adding approximately 0.3 to 0.5 grams (one scoopful) of Hach's diphenylcarbazone indicator buffer powder to 100 ml of the sample in a 250-ml Erlenmeyer flask. The sample was then titrated with 0.0141 N mercuric nitrate.

Alkalinity was determined by adding 3 to 4 drops of mixed bromocresol-green-methyl-red indicator to 100 ml of the water sample in a 250 ml Erlenmeyer flask. The sample was then titrated with 0.02 N sulfuric acid to the equivalence point. The detailed procedures for both the chloride and alkalinity analyses are explained in detail in the Thirteenth Edition of *Standard Methods for the Examination of Water and Wastewater* (1971).

#### RESULTS

The salt as chloride ions did eventually arrive at the Toledo Water Intake, in concentrations of 35 ppm, twice the normal background content of lake water, suggesting incomplete mixing of this salt-rich water mass as it moved southward across the basin (fig. 2). The approximate time of arrival at the treatment plant was midnight on 10 December, 1970, a total of eight days after the spill in the Rouge River.

The chloride content of the raw water for the month of November, 1970, the month preceding the arrival of the salt-rich water, had averaged approximately 18 ppm, with only slight deviation. The alkalinity during the same period had remained fairly stable at about 90 ppm, identifying the water as Detroit River-Lake Erie water. Immediately prior to and after the salt began to arrive, Maumee River water, characterized by its higher alkalinities (which were somewhat erratic, due to varying amounts of dilution with Lake Erie water) flowed into the intake. Had the Maumee River water persisted for another two to three days, it would have obscured or prevented the identification of the salt-rich water mass. However, Detroit River-Lake Erie water, identified by its characteristically low (80 to 85 ppm) constant alkalinities, began to be received shortly before the arrival of the salt-rich water and persisted throughout the time of high salinities.

#### WATER VELOCITIES

Knowing the time the salt spill occurred, the time the salt-rich water was detected at the treatment plant, and the distance between the spill and the intake (approximately 45 miles), the velocity of this water mass as it moved south across the basin could be computed, once several corrections had been made.

The actual time of the salt spill was not given in the newspaper article, which stated that the spill occurred late on Wednesday, 2 December, 1970. Therefore it was necessary to contact the reporter of the article, Tom Delisle, who reported the time of the spill to be approximately 6 P.M. (personal communication, 10 September, 1971). The salt-rich water was first detected at the treatment plant at midnight on 10 December, 1970. This meant that the total elapsed time between when the spill took place and when the salt-rich water arrived at the treatment plant was  $8\frac{1}{4}$  days, or 198 hours.

The Toledo treatment plant is located approximately 13 miles from the intake. The lake water enters the intake and flows approximately three miles to the Reno Low Service Pumping Station (LSPS), and is then pumped another ten miles to the Collins Park Water Treatment Plant and High Service Pumping Station (HSPS) (fig. 1). Time for this total transit, based on pipe diameter and rate of flow, calculated using the hydraulic tables of Hazen and Williams (1963), was approximately eight hours.

Travel time of the water mass in the Rouge and Detroit Rivers was calculated using information on December velocities in these rivers supplied by the U.S. Army Corps of Engineers, Detroit District (P. McCallister, personal communication, 28 July, 1971). The information received from the Corps of Engineers was as follows:

- 1) velocities in the Rouge River below Jefferson Avenue are normally in the range of 0.05–0.1 ft/sec;
- 2) velocities in the upper Detroit River between the Rouge River and the head of Fighting Island are about 2.0 ft/sec; and
- 3) velocities in the lower Detroit River between Fighting Island and the rivers' mouth are about 1.0 ft/sec at this time of year.

The time that it took the salt-rich water to flow from the site of the spill to the mouth of the Detroit River, a distance of about 18 miles, was therefore approximately 40 hours.

Of the total 198 hours, then, 40 represented travel time in the Rouge and Detroit Rivers, and eight represented the time during which the water was moving through the Toledo water pipe system, so the travel time from the mouth of the Detroit River to the Toledo Water Intake was 150 hours. This distance is approximately 27 miles, so the calculated water velocity across the western Lake Erie basin was slightly less than 0.3 ft/sec. Herdendorf (1969), using temperature and conductivity values, determined the average velocity of Detroit River water

in western Lake Erie to be approximately 0.5 ft./sec. Although the calculation based on the salt spill shows a velocity almost twice as slow as that of Herdendorf, it must be realized that this spill took place in December, a period of low flow, whereas the study made by Herdendorf was conducted in June, a time of higher flow.

Two other waterworks between Toledo and the spill (Wyandotte and Monroe) were contacted in an effort to establish the time when the salt-rich water passed their intakes. The Wyandotte waterworks was informed of the spill on 3 December and began hourly analyses for chlorides. However, no increase in chlorides above their normal level of 7 to 8 ppm was ever detected (Dale O. Simmons, personal communication, 21 June, 1971). This may have been due to the offshore location of the Wyandotte intake, for Rouge River water appears to remain close to the west shore of the Detroit River in this area (fig. 1). The Monroe waterworks also made daily chloride determinations and they too noted no great departure from the daily norm (Wilfred L. LePage, personal communication, 1 July, 1971). The location of the Monroe intake is apparently too close to the shore to receive water directly from the main flow of the Detroit River (fig. 1).

#### CONCLUSIONS

This incident provides evidence that, in December of 1970, some of the Detroit River water did flow south to a position close to the Ohio shore, as postulated by Hartley *et al.* (1966), that it generally maintained its original (high-salt) character, and that the velocity of this water mass was slightly less than 0.3 ft/sec.

#### ACKNOWLEDGMENTS

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