Rochester Committee
for Scientific Information
Rochester, NY

RCSI Bulletin 198
Improvement in Irondequoit Bay Following a Decrease of Road Salting in the Watershed

By: Richard Burton
June 1976

THE ROCHESTER COMMITTEE FOR SCIENTIFIC INFORMATION
P. O. Box 5236, River Campus Station
Rochester, New York 14627

Bulletin #198

June 1976

Improvement in Irondequoit Bay Following a Decrease of Road Salting in the Watershed

by

Richard Burton*

Summary

Irondequoit Bay can now be added to the list of lakes that have started to recover from degradation due to pollution control measures.

Studies of Bay waters in the years 1969-1976 showed that the use of deicing salt in the watershed was so heavy that it interfered with the spring and fall overturns and was gradually turning the Bay into a body of dilute salt water. A voluntary reduction by towns from 76,000 tons in 1969-1970 to 43,000 tons by 1974-1975 reversed this trend. For the first time in at least 6 years the Bay overturned completely in the spring of 1975, and overturn occurred somewhat earlier in the fall of 1975. Complete spring mixing was also recorded in 1976.

Background

In the winter of 1971-1972 the Monroe County Environmental Management Council convened a salt task force to study effects of deicing salt in the County. That group was the first to involve County and Town representatives with environmentalists in a discussion of salting. It produced the first guidelines in the County. They were not widely disseminated, but salt use started to decline in 1972-1973. The use of deicing salt was curbed further in 1973-1974, still more in 1974-1975 and probably even more in 1975-1976.

In 1974 after RCSI Bulletins #166, #167 and #171 were published (1,2,3) the Sierra Club issued a list of suggested guidelines for salting of streets, and distributed them to all concerned officials. This was followed by a symposium on deicing salt co-sponsored by the Monroe County Department of Public Works, the Sierra Club and the Center for Environmental Information.

* The author is Associate Chemist, Monroe County Health Department.

After the symposium, the Director of the Department of Public Works organized a committee to study the use of deicing salt. The Committee was not appointed by any county agency, but its members included representatives from 4 Towns (2 urban, 2 rural), the City, County Health, Public Works and Police Departments, State Department of Transportation, the Environmental Management Council and the Sierra Club. The Committee met throughout the summer of 1975 and drafted guidelines for salting in the winter of 1975-1976. They also organized a wide scale public relations program to publicize salt cut-back and encourage safe snow driving habits. Safety (number of accidents) correlates with the amount of snow, not the amount of salt used (4) in Monroe County.

Overturn of a Lake

The opening of Irondequoit Bay into Lake Ontario is so small that the Bay behaves like a separate lake. Lakes of the shape and depth of Irondequoit Bay in this climate circulate vertically (thermally) twice a year. The bottom water mixes with the water on top. At other times of the year the lake is stratified. In the winter cold water is on top and warmer water is on the bottom. During the summer warmer water is above and cooler water below.

A number of factors influence overturn mixing. Among them are:

1. Temperature at the surface and at the bottom;
2. Density of the water (Water is most dense at $4^{o}C$);
3. Wind conditions (Wind enhances mixing);
4. The difference between the salinity on top and on the bottom may determine the depth of mixing, as salt increases the density of water at all temperatures.

A twice mixing ("dimictic") lake overturns both in the spring and in the fall when the surface water approaches a temperature of maximum density ($4^{o}C$). The surface water is then denser than the water of the bottom, and it sinks, mixing with deeper water. During some years the temperature fluctuates so that the water remains at approximately $4^{o}C$ for a prolonged period and the mixing period is extended. In other years winds and temperatures are such that the lake warms or cools rapidly and the mix is completed quickly. The longer mixing period improves the likelihood of complete mix and increases the distribution of oxygen in the lower water.

Overturn in Irondequoit Bay

The Bay is nutrient-rich. The bottom deposits are a sludge of organic matter that uses up oxygen so fast that water in the deeper zones is anaerobic much of the time.

Salt input into Irondequoit Bay increased rapidly from the mid-1950's through the 1960's. This resulted in a sharp increase in the chloride level that went unnoticed until it prevented complete

mixing in the spring of 1970 (5). The incomplete mixing can, therefore, be described as a measurable marker of a continually deteriorating condition. It is also the point at which the Bay can no longer function normally because of increased salinity. The rate of deterioration can be followed by the increase in the thickness of unmixed salt laden water remaining at the bottom after the spring mix. In Irondequoit Bay this layer increased in thickness from 5 feet in 1969-1970 to 11 feet in 1971-1972 (6).

The County began to decrease its use of salt in the fall of 1972 with the largest percent decrease coming in 1974-1975. The decrease in salt level is reflected in the trend back to a normal mixing pattern in the Bay. The Bay still contains a great deal of salt; however, there is hope that with continued careful and minimal use of deicing salt and with sewage diversion, the load of salt in the Bay will continue to decrease. The salt level in the Bay is now such that it may or may not mix completely each year depending on how we treat it. Future good practice should stabilize the system in the proper direction, and insure normal annual mixing patterns.

Salt in the Irondequoit Bay Drainage Basin

In 1969 geologists at the University of Rochester started to study the effects of salt in the Irondequoit Bay Drainage Basin on the Bay. The work was initially supported by RCSI, and subsequently received federal support and national recognition. Bubeck (6) determined the number of tons of salt spread in the basin from salt company records of the number of tons purchased by each Town. To compute the amount each Town contributed to the Bay Drainage Basin, he estimated the percent of each Town within the Basin and calculated the salt spread there proportionately.

RCSI has figures from Monroe County records recording how much salt was spread in each Town. Records are scanty before the winter of 1972-1973. For 1972-1973 the figures supplied by the County came within 1,500 tons of the figure supplied by the salt companies to Dr. Bubeck. This computation includes the Towns of Brighton, Irondequoit, Mendon, Penfield, Perinton, Pittsford and Webster and omits the City of Rochester because the City is largely in another drainage basin. The contribution from Ontario County to the drainage basin is relatively small, and was not included in Bubeck's calculations.

In Table 1 the salt usage for 1969-1970 to 1972-1973 is taken from Diment et al (6). The next column records the salt usage for 1972-1973 to 1974-1975 from the County records for the seven Towns listed above. There was a 44% reduction in the amount of salt spread in the Irondequoit Bay Drainage Basin in 1974-1975 as compared to 1969-1970 (the year of the heaviest salt usage) and a 33% reduction as compared to 1972-1973. 1972-1973 was down 10% from 1971-1972 and 20% from 1969-1970.

Deicing Salt in the Bay

All of the salt that is spread on the roads does not go directly into the Bay the same winter. How much does depends on such factors as time and length of thaws, how much salt is held in the ground and how fast the water percolates through the soils.

Deicing salt entering the Bay during the winter from the streams is dissolved in cold, oxygen rich water that tends to sink toward the bottom. This process was noted by Bubeck in the deepest portion of the Bay (23 meters) (7). Normally organic muds would use up all of the oxygen in the bottom waters very soon, but due to the direct injection of salt run-off, the bottom water was colder, saltier and oxygenated for a slightly longer period than would be expected. As the salt water came in, it stratified so that a concentration gradient developed with the salt level increasing with depth.

Salt delayed the overturn in the fall, but once it started the water mixed completely from top to bottom. After fall, therefore, the salt concentration in the Bay is uniform throughout, and knowing the volume of water, the total salt load can be calculated. The base amount of salt in the Bay in the fall was 8,500 tons in 1969; it was up to 12,500 tons by 1971. In 1972 it was roughly the same as 1971 - 12,000 tons (Table 1, column 1)(6). Obviously the base amount of salt in the Bay was gradually rising. Since there had been no significant rise in sewage or other non-deicing salt sources in those years, the added salt must have come from deicing. Thus, so much salt was being put into the watershed that the Bay was showing a net accumulation which was gradually modifying its circulation pattern.

Between the fall of 1972 and 1974 use of deicing salt was cut at least 30% and salt levels in the Bay during the fall of 1974 and 1975 dropped to 9,300 tons and 8,800 tons respectively.* The Bay responded in the spring of 1975 by starting to recover its ability to mix completely.

Effects of Salt on the Bay

As a result of the use of deicing salt, Irondequoit Bay was developing two major problems: all of the water was becoming increasingly salty, and the difference between the amount of salt on the top and on the bottom at spring mix was increasing. Water at the bottom of the Bay was not mixing with top water in the spring and therefore remained without oxygen until fall.

---

* Calculated from Monroe County Health Department data.

Bottom water that does not overturn in the spring is not replaced by the water from the top and remains cold. Since fall mixing depends on surface water cooling to a density somewhat greater than the bottom water, the closer the bottom water temperature is to the temperature of maximum water density, the greater the likelihood of late fall mixing. Accordingly, in 1939 before deicing salt was added, the fall mixing occurred in early October at 12°C. In 1971-1972, a year of excessive salting, the fall overturn did not finish until December at surface temperatures of 4-5°C, nearly the temperature of maximum density. The cold deep water remnant which failed to mix in the spring was a primary factor in this delay. The delay in fall mixing increased still further the length of time that the deeper waters were without oxygen.

In 1974-1975, when the salt was decreased substantially, several favorable changes occurred. In the spring, the mixing was complete, allowing some of the bottom organic material to come to the top where aerobic bacteria could degrade it, and oxygen-rich warmer water to reach the bottom. By mid- to late spring, the organic deposits of decaying algae had once again depleted the oxygen on the bottom, but the anaerobic period was shorter, because by mid-November oxygen was brought to the bottom by the fall overturn, as shown in Table 2.

Status of the Programs to Reclaim the Bay

The Bay is a very complicated body of water which has been producing large crops of algae for centuries. We do not know if it ever had a clean sandy bottom, but prior to the rapid increase in waste discharges and salt, it was a more usable body of water. Programs are under way to return it to a boatable and more swimmable condition. These include:

1. The Pure Waters Program - which will stop sewage from entering the creeks and the Bay by 1977.
2. The Freshwater Wetlands Act - which supplies the legal authority to control the filling of wetlands where they serve to filter nutrient-rich material coming into the Bay. The State DEC has not assigned these wetlands for purchase under the Environmental Quality Bond Act.
3. The County program to decrease the use of deicing salt. This program, in effect for 4 years, is beginning to show results. The Bay once again has a complete spring overturn and a timely fall overturn, and the total chloride level has decreased. Future good salt management should stabilize this system and keep the Bay a body of fresh water.

All these programs are essential if we wish to restore the Bay to an ecologically healthy condition, in which the water remains clean and pleasant for recreational use. The Bay, like all lakes, has capacity for coping with pollution. It can absorb some deicing salt and some pollution from shores, but must be protected from the kind of abuse that it suffered in the past several years.

References

(1) Holmes, Lindsay, *"Environmental Effects of Deicing Salts: Introductory Bulletin"*; RCSI Bulletin #166, December 1973

(2) Holmes, Lindsay, *"Salt Storage in Monroe County"*; RCSI Bulletin #167, December 1973

(3) Holmes, Lindsay, *"The Use of Deicing Salt in Monroe County"*; RCSI Bulletin #171, June 1974

(4) Holmes, Lindsay, *"Accidents and Salting in Monroe County"*; RCSI Bulletin #196, February 1976

(5) Bubeck, Robert C., William H. Diment, Bruce L. Deck, Alton L. Baldwin and Stewart D. Lipton, *"Runoff of Deicing Salt: Effect on Irondequoit Bay, Rochester New York"*; Science 172: 1128-1132, 1971

(6) Diment, W.H., R.C. Bubeck and B.L. Deck, *"Effects of Deicing Salts on the Waters of the Irondequoit Bay Drainage Basin, Monroe County, New York"*; In the Fourth Symposium on Salt, Alan H. Coogan, ed., 1974

(7) Bubeck, R.C., *"Some Factors Influencing the Physical and Chemical Limnology of Irondequoit Bay, Rochester, New York"*; Ph.D. Dissertation, The University of Rochester, 1972

Table 1. Comparison of Salt in Watershed and Salt in Bay

Year	Estimated Salt Content of the Bay (Tons)		Winter Saltfall in the Watershed (Tons)	
	November	March	Diment et al	County Data
1969-1970	8,500	18,300	76,600	
1970-1971	9,300	18,000	73,500	
1971-1972	12,500	19,800	68,900	
1972-1973	12,000	14,800	64,000	65,400
1973-1974				61,000
1974-1975	9,300	12,600		43,000
1975-1976	8,800	12,200		

Table 2. Overturn in Irondequoit Bay

Year	Depth in Meters of Water Unmixed After Spring Overturn	Bottom Temp. End of September, °C	End of Spring Mix	Salt in Water Spring Overturn (Chloride mgm/L) 3meters/21meters		Salt in Water Fall Overturn	Month of Fall Mix	Temp at End of Fall Mix(°C)
1939-40	0	8	4/11-4/28				early Oct	12
1969-70	5	6.9	4/7-4/28	200	300	110	11/13	8 -9
1970-71	8	5.6	4/13-4/15	200	380	220	11/25	7-8
1971-72	11	5.0		220	400	170	12/10	4-5
1972-73	3			180	270	160	12/1	4-5
1973-74	--	8.5		--	--	--	--	
1974-75	0	8.6	3/27[a]	--	--	123	11/25	6.9
1975-76	0		3/22[a]	158	318[b]	116	11/28	7.0

a mixing complete on or before this date

b at 22 meters