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Possible Biological Impacts of Dredging the Existing Channel from Irondequoit Bay to Lake Ontario in Rochester, Monroe County, New York

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POSSIBLE BIOLOGICAL IMPACTS OF DREDGING THE EXISTING CHANNEL FROM IRONDEQUOIT BAY TO LAKE ONTARIO IN ROCHESTER, MONROE COUNTY, NEW YORK

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ABSTRACT

Evaluating the proposed opening of Irondequoit Bay as a harbor of refuge involved identifying the biological parameters to be considered, and describing the geology and chemistry of the bay and its drainage system. Since there is little exchange with Lake Ontario, Irondequoit Bay is more like a lake in a eutrophic condition than an open bay. Environmental problems in the bay are mainly the result of great quantities of sewage effluent. The proposed Corps of Engineers project to deepen and broaden the outlet to Lake Ontario will have little or no effect on increasing the exchange between the two bodies of water. The project will not significantly improve the bay's water quality, but the proposed 8-foot (2.4 m) deep channel will be adequate to make it a harbor of refuge. Dredging will have localized, short-term effects, including destruction of rooted aquatic plants, elimination of benthic organisms, and possible fish kills. But once dredging is completed, reestablishment of these communities will be rapid.

INTRODUCTION

Irondequoit Bay, on the south shore of Lake Ontario in Rochester, New York, has been proposed as a harbor of refuge for pleasure craft using the lake. Under authorization of the 1958 Rivers and Harbors Act, the US Army Corps of Engineers has been empowered to create a permanent boat access to Lake Ontario from the bay. The present entrance to the bay is obstructed by two bridges (a railroad bridge for the Hojack Line of the Penn Central Railroad and a highway bridge for NYS Route 18) and a sandbar at the entrance of the bay. Although the project has been postponed until completion of the Irondequoit-Wayne County Expressway, local public and private groups have expressed concern as to possible biological impacts of the project on the bay area.

In 1973, following resolutions by the Monroe County Legislature and the Monroe County Environmental Management Council, the Irondequoit Bay Policy Committee was formed to set policies and to develop a plan for the bay. The committee felt that more biological information on the possible consequences of opening the bay should be obtained before any decision to dredge the existing channel was made.

It is the intent of this study to identify the biological parameters that should be considered in evaluating the proposed opening of the bay. Available research reports and other biological data on Irondequoit Bay were collected from a variety of sources. These data were analyzed to determine if there were sufficient information on each biological parameter. Recommendations have been made as to what additional information is needed before an informed decision on opening the bay can be made.

Several scientists have undertaken intensive studies of the Irondequoit Bay drainage basin. Leaders in research on these waters are: Robert C. Bubeck and William H. Diment, who have studied the chemical and physical aspects of the bay waters; Herman S. Forest, who has studied the biology of rooted aquatic plants and some aspects of fish life in the bay; Kenneth G. Harbison, who has studied the waters of the bay and Irondequoit Creek basin; and Thomas D. Bannister, who has studied the bay waters and phytoplankton populations.

Current environmental problems in the bay watershed arise from dumping large quantities of domestic sewage effluents into the bay and creek and spreading tons of deicing salts on the highways and streets in the watershed. Acceleration of soil erosion and shore disruptions has occurred from changes in land use in the watershed area.

BAY MORPHOLOGY AND GEOLOGICAL HISTORY

Irondequoit Bay is located between 77°30'W and 77°32'30"W and between 43°10'N and 43°14'N in Rochester, Monroe County, New York. A detailed map of the bay and its immediately adjoining land areas is available (US Geological Survey Map N4307.5 W7730/9 x 7.5, Rochester East, New York). Bubeck (1972) and Tressler *et al* (1953) have described the bay and its watershed in detail. Dimensions of the bay as reported by Bubeck (1972) are:

Length	6.6 km (4.1 mi)
Width	1.2 km (.75 mi)
Area	6.8 km^2 (2.6 sq mi)
Maximum depth .	23.0 m (75.5 sq ft)
Average depth .	6.8 m (22.3 ft)
Volume	0.046 km^3 (3.4×10^6 cu ft)
Area of bay and entire drainage basin	395.0 km^2 (152.5 sq mi)

The bay is almost entirely separated from Lake Ontario by a large sandbar on the north shore of the bay (1.5 km [.93 mi] long, 100+ m [328+ ft] wide). Steep silt bluffs in excess of 50 m (164 ft) line the perimeter of the bay. These areas, bare of vegetation in places, are subject to erosion. The bay's outlet is located on the northwest section of the sandbar. It is shallow (2 m [6.6 ft]) and narrow (20 m [65.6 ft]). The two bridges across the outlet make water travel between the lake and bay impossible for moderate-sized boats. The bay can be roughly divided into quarters in a north-to-south direction. The northern quarter is a shallow basin (less than 3 m [9.8 ft]). Next follows a deep basin, where the bay's maximum depth of 23 m (75.5 ft) is found. The third section is of moderate depth (3 to 9 m [9.8 to 29.5 ft]). The southernmost quarter is another extensive shallow area (less than 3 3 m deep). Figure 1 gives a contour map and vertical cross section of the bay.

Average annual precipitation totals about 32 inches (81.3 cm), with no notable variation over the watershed of Irondequoit Bay. Average annual runoff is about 11 inches (27.9 cm).

The morphology of the bay and its watershed are characteristically related to the geological history of the area. Glacial action diverted the Genesee River west to its present course through the City of Rochester. The old river channel, which once approached and entered Lake Ontario where the bay is now, was blocked at the lake shoreline, thus forming Irondequoit Bay. As a result, fine silts and sand, which would normally have been carried into Lake Ontario, were deposited in the still water zone of the bay by water flowing from inland sources.

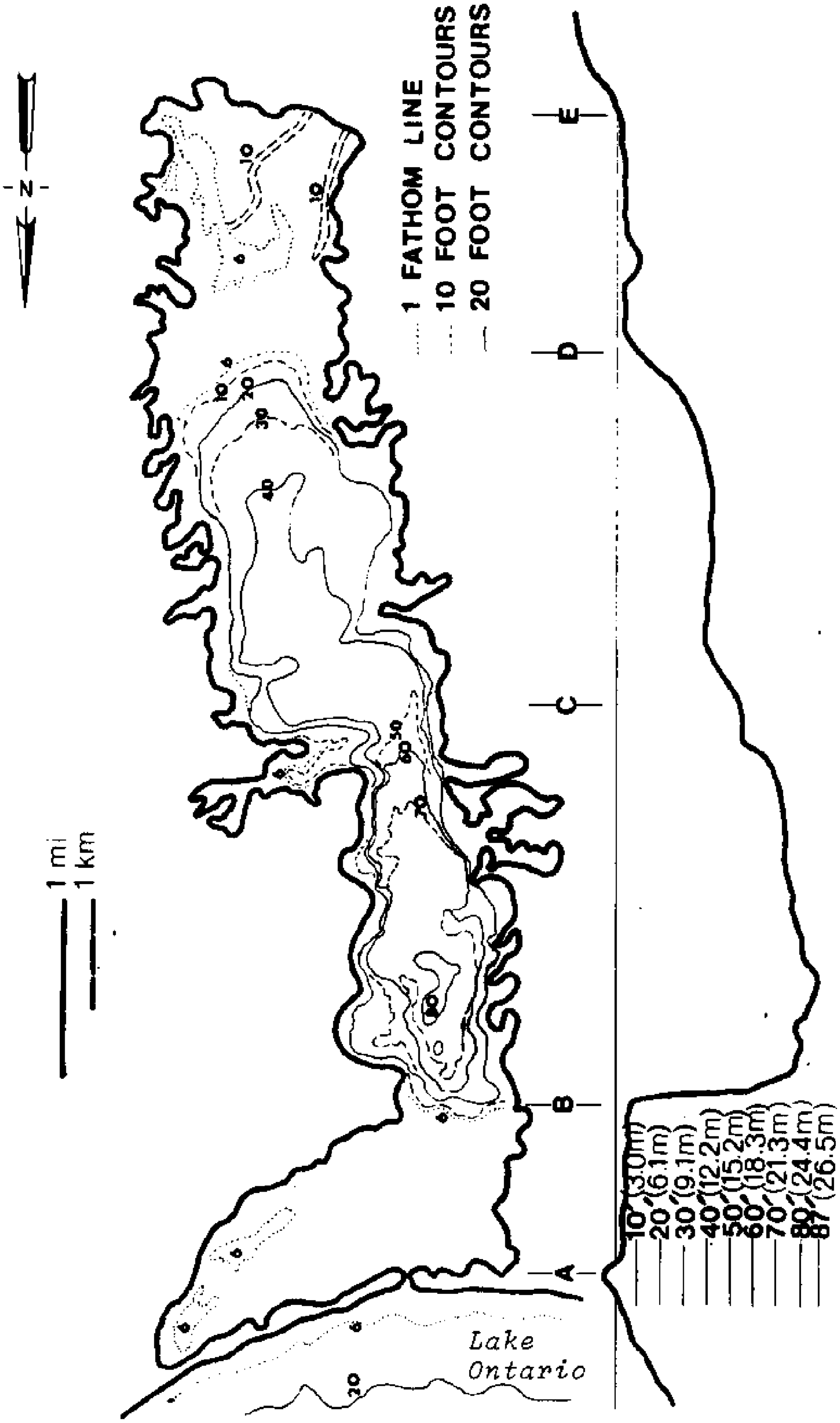
Swamp and marsh areas developed as this natural sedimentation process continued. There are large amounts of organic substance in the more recent deposits. Highway construction and landfill use have displaced soft material from inland areas into Irondequoit Bay. Borings and surface information indicate that from 10 to 25 feet (3 to 7.6 m) of soft materials containing organic substance, shells, and traces of gravel are present beneath the water in the northern quarter. Loose alluvial sands and silts exist beneath this surface layer, and glacial till deposits in excess of 75 feet (22.9 m) deep may be expected in the bay's basin (EBS Management Consultants, 1968).

The maximum surface level of the bay is determined mainly by increase in elevation of the Lake Ontario surface.

Prehistoric inland seas formed by a slowly retreating glacial sheet left the area in a series of terraces, still evident in the watershed. This geological history reveals itself throughout the watershed area in shallow lakes, beaches, deltas, and glacial deposits.

Soil types in the watershed are influenced by the glacial origin of the parent material. The upper reaches are characteristically sandy deposits, subject to severe wind and water erosion.

FIGURE 1 *Contour Map of Irondequoit Bay and Vertical Cross Section of the Bay*



Finer material and organic soils arise from glacial till, outwash, or prehistoric lake deposits. Details of the geological history of the Irondequoit Bay watershed have been reported by Chadwick (1917) and Richard and Fisher (1970).

Recent developments in the watershed region have altered its hydrological characteristics: 1) wells have reduced groundwater supplies; 2) swamps and bogs have been drained and filled; 3) channels of tributaries have been altered; 4) forest lands have been cleared; and 5) an extensive transition from agriculture to urban and industrial land uses has created local problems in the runoff waters and in the groundwater supplies. Maps indicating the geological characteristics and geography of the area (e.g., its demography, vegetation, land uses) may be obtained from the Monroe County Planning Commission.

The water flowing into Irondequoit Bay comes primarily from Irondequoit Creek (Fig. 2). Bubeck (1972) estimated the annual average flow of Irondequoit Creek at about 90.3 million gallons per day (MGD) ($4.0m^3/sec^{-1}$). Seasonal variation is evident, with decreased flow in the summer and increases in early spring. Major tributaries of Irondequoit Creek are: 1) Thompson Creek, carrying the sanitary-storm overflow effluent from the City of Rochester and the runoff from the Town of Brighton dump in addition to residential runoff; 2) Allens Creek, carrying effluent from the Town of Brighton secondary treatment plant (STP) and residential runoff; and 3) Thomas Creek, carrying effluents from STPs in Fairport and residential runoff. The discharges from these creeks were reported by Harbison (1974). Bubeck (1972) summarized the discharges of the Barge Canal into Irondequoit Creek. Other inputs from the bay watershed into the bay have been estimated at 11.3 MGD ($0.5m^3/sec^{-1}$) (Bannister *et al*, 1974).

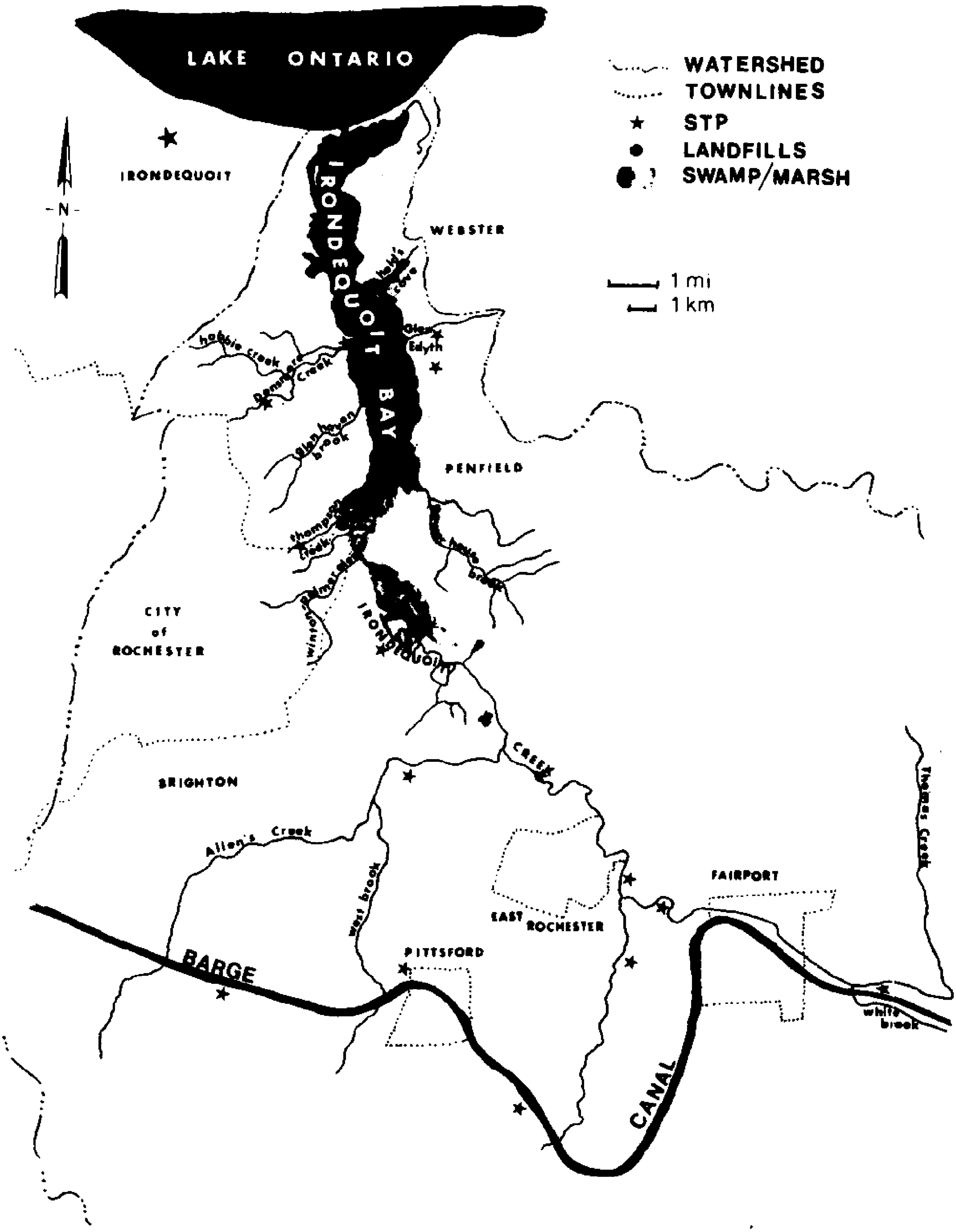
The Monroe County Public Health Department records of sewage treatment plants in 1969 show a discharge of 7.9 MGD ($0.35m^3/sec^{-1}$) into Irondequoit Creek and its tributaries. Three additional plants discharge 1.1 MGD ($0.05m^3/sec^{-1}$) of sewage effluent directly into the bay. Three STPs discharge into the Barge Canal, which in turn enters Irondequoit Bay. Details as to type of treatment, location, daily flow rates, and maximum capacity of STPs in the bay's watershed are available from the Monroe County Pure Waters Agency. Overflows from the City of Rochester sanitary-storm sewage interceptor system also contribute to the bay's input.

Total sewage pouring into Irondequoit Bay exceeds 9.0 MGD ($0.39m^3/sec^{-1}$); thus, at least one part in ten of the bay's input consists of sewage effluents (Bannister *et al*, 1974). Harbison (1974) and Bubeck (1972) detailed the natural water sources of the bay as well as those introduced by man.

Irondequoit Bay is connected to Lake Ontario by the narrow opening at the northern end of the bay, but the mixing of these two bodies of water is minimal. Harbison (1974) estimated a probable maximum value of 5 percent mixing of Lake Ontario water with Irondequoit Bay water. The currents between the two bodies of water have been examined and show no repeating pattern of flow through the channel (Baldwin, 1974). The mixing of lake and bay waters is closely related to the wind-driven water currents observed in the Rochester Embayment area of Lake Ontario. Strong northerly and northwesterly winds appear to maximize the mixing effect (Casey *et al*, 1973). These currents create a situation in which water in Lake Ontario rises in elevation and has a slight damming effect at the mouth of the bay. Only when this occurs with enough force to counteract the outward water flow does Lake Ontario water actually enter the bay.

Harbison (1974) reported that sulfate differences between the two bodies of water, and aerial photographs, are evidence of the minimal mixing. Sulfate levels in Irondequoit Bay are four to five times higher than those in Lake Ontario. Sulfate concentrations at the mouth of the bay were reported within 5 percent of the levels recorded at mid-bay stations. The same effect was recorded by Tressler *et al* (1953), when conductivity measurements were used to compare the two bodies of water. Aerial photographs compared the light absorbed by phytoplankton in the bay and lake waters, using infrared film. These photographs show a plume originating from the mouth of the outlet and extending into the lake. They indicate that the plume's shape is determined by the wind-driven currents. The photographs also show that water entering the bay from the lake is essentially water that previously flowed out

FIGURE 2 *Irondequoit Bay Drainage Basin*



All major tributaries are included, as are the locations of towns, sewage treatment plants, landfill sites, and swamps and marshlands.

of the bay, and is being pushed back into the bay by lake currents. The biological, chemical, and visual observations are all consistent with the hypothesis that the influence of Lake Ontario on the waters of Irondequoit Bay is slight.

Population increases have been rapid in the creek-bay watershed. In the 152 square mile (393.7 km^2) watershed, the total population has risen from about 98,000 in 1920 to about 230,000 in 1970. This increase has resulted in greater residential land use of the bay watershed. Destruction of wooded areas and agricultural fields and meadows has altered the ability of the land to hold water. The transition from agriculture to residential development has caused the low-water flows of major tributaries to become lower, and high-water rates to become higher. Hennigan (1970) detailed the disruption of normal flow rates of runoff waters.

CHEMISTRY OF IRONDEQUOIT BAY

The earliest year-round comprehensive study of the chemical properties of Irondequoit Bay was done by Tressler *et al* (1953) for 1939 to 1940. This work is an excellent reference point for comparing trends in the bay over the following 30 years. The next year-round comprehensive report was Bubeck's (1972), for 1969 to 1970. More recently, Bannister *et al* (1974) studied the phytoplankton populations in the bay, and recorded several chemical parameters during the 1970 to 1971 sample period (Table 1).

Several summer studies on Irondequoit Bay have also been carried out. These brief reports include: Faigenbaum (1939), NYS Department of Environmental Conservation (1939, 1960, 1967, 1971, 1972, 1973), Monroe County Public Health Department (1965-72), Wilson and Levitt (1968), and Shearer (1974). The US Environmental Protection Agency (EPA) surveyed the water quality of both Irondequoit Bay and Lake Ontario, and included 1965 sample stations at the mouth of the channel, thus giving data for comparing the chemistry of the two bodies of water (Table 2).

The chemical properties of an aquatic system dictate the type of biota that can be supported there. Irondequoit Bay has been changed chemically by man's influence on its watershed. Of special interest is the increased chloride concentration, coming from deicing salts in the runoff waters. Other factors, especially domestic sewage, have also affected the bay.

The temperature of the bottom waters of Irondequoit Bay has decreased over the past 30 years. Bubeck (1972) linked this decrease to an influx of cold saline water into the hypolimnion during the more recent winters. Surface waters are influenced almost exclusively by air temperature, and so surface temperatures have remained similar to those recorded in 1939 and 1940.

One of the normal temperature properties of a body of water like Irondequoit Bay is the inverse thermal stratification occurring during winter months. This means that temperature increases with depth. In Irondequoit Bay the development of this inverse stratification is delayed, probably because of the colder saline water now prevalent in the bay's deeper sections (Bubeck, 1972).

The Secchi disk technique has been used to measure the transparency of Irondequoit Bay. The values obtained by Bannister *et al* (1974) and Bubeck (1972) suggest that the average Secchi reading has decreased by about one meter over the past 30 years. A decrease in transparency may indicate an increase in particulate matter or dissolved solids, an increased algae population, or a combination of all of these. Decreased transparency is a characteristic of a eutrophic lake, where increased fertility (normally revealed by plankton blooms) is the major contributing factor. Bubeck (1972) pointed out that high Secchi disk readings of 5.01 m (16.4 ft) on March 1, 1970 and 4.95 m (16.2 ft) on January 29, 1971 occurred during times of low biological productivity (under ice cover), while low Secchi disk readings of 0.4 m (1.3 ft), 0.5 m (1.6 ft), and 0.58 m (1.9 ft) occurred during summer months, at a time of high biological productivity. One hypothesis is that the decreased transparency from 1940 to 1970 was due to the increased plankton numbers.

A reduced nutrient input into the bay may significantly increase transparency by limiting plankton numbers. In other words, there is potential for creating a cleaner, more desirable bay if sewage input is rerouted out of the bay's waters. Due to the natural recycling of nutrients during overturn periods, noticeable clearing takes several years even after sewage pollution is stopped.

TABLE 1 *Physical and Chemical Properties of Irondequoit Bay*

		Tressler 1939-40	*Bannister 1970-71*	*Bubeck 1969-72*
Temperature (C)	[S]	0.8-26	0.5-25	0.041-26.407
	[B]	2.6-13	1.5-7.5	1.437-8.513
Secchi Depth (m)		1.3-5.8	1.0-4.5	0.5-5.0
Conductivity (μmho cm^{-1})	[S]	524-676*	950-1200	930-1515*
	[B]		950-1900	
CO_2 (ppm)	[S]	7.0-32.0		
	[B]	32.0-83.0		
O_2 (ppm)	[S]	3.4-15.9	8.0-12.0	4.56-24.45
	[B]	0.0-15.0	0.0-8.0	0.0-10.77
pH	[S]	6.6-8.4	7.6-9.5	7.32-9.55
	[B]	6.8-7.4	7.4-7.6	7.08-8.05
Alkalinity (as $CaCO_3$ ppm)		110-150*		189-229*
Alkalinity (meq/l)	[S]		3.5-4.1	2.64-4.35
	[B]		4.6-5.2	3.72-6.03
Soluble Phosphorus (ppm)	[S]	0.01-0.4	0.25-1.6	
	[B]	0.05-1.2		
Organic Phosphorus	[S]	0.05-0.6		
	[B]	0.05-1.3		
Cl^- (ppm)	[S]		130-190	103-208
	[B]		130-380	169-537.4
SO_4 (ppm)	[S]		101-115	83-132.9
	[B]		103-120	48.5-147.6
HS^- (ppm)	[S]		0.0-0.0	
	[B]		0.0-5.5	
Br^- (ppm)	[S]		0.4-1.2	0.43-1.56
	[B]		0.1-0.2	0.06-0.62
F^- (ppm)	[S]		0.7	
	[B]		0.7	
PO_4 (ppm)	[S]		1.2-2.9	0.34-5.51
	[B]		2.2-6.0	1.5-13.52
SiO_2 (ppm)	[S]		1.0-7.5	0.01-8.6
	[B]		5.7-10.5	5.76-18.34
NO_3-N (ppm)	[S]		0.1-1.2	0.0-2.56
	[B]		0.0-1.5	0.0-2.41
NO_2-N (ppm)	[S]		0.04-0.28	0.0-0.754
	[B]		0.0-0.28	0.0-0.191
NH_3-N (ppm)	[S]		0.2-1.8	0.0-2.51
	[B]		1.6-4.8	1.6-16.8
Ca^{++} (ppm)	[S]		70-100	85-87.9
	[B]		80-200	81.7-101
Mg^{++} (ppm)	[S]		22-30	24.3-26
	[B]		25-30	25-27
Na^+ (ppm)	[S]		120-135	105-112.6
	[B]		150-245	148.7-253
K^+ (ppm)	[S]		2.3-3.6	
	[B]		5.0	

S = surface sample B = bottom sample * = mean value

Sources: Tressler *et al* (1953), Bannister *et al* (1974), and Bubeck (1972).

TABLE 2 *Comparison of the Chemistry of Lake Ontario and Irondequoit Bay in 1965*

	Spring Average		*Summer Average*		*Fall Average*	
	Lake	*Bay*	*Lake*	*Bay*	*Lake*	*Bay*
NH_3-N	0.14	1.11	0.56	0.96	0.10	1.92
NO_3-N	0.30	1.10	0.01	0.18	0.04	0.10
Organic N	0.45	0.79	0.00	0.43	0.29	0.76
Total N	0.89	3.00	0.57	1.57	0.43	2.78
Total PO_4	0.27	1.66	0.09	1.48	0.04	2.07
Dissolved PO_4	0.07	1.31	0.03	1.13	0.03	1.51
Dissolved Solids	245	611	201	577	212	581
Specific Conductance	314	930	348	810	310	910
Alkalinity	84	164	97	151	92	159
Cl^-	26	115	29	110	27	114
SO_4	33	94	40	131	73	162
Mg	10.0	24	10.0	26	8.6	23
Ca	40	85	42	86	--	79
Na	12.8	71	--	68	--	--
K	1.6	3.8	--	3.9	--	--
Dissolved Oxygen	13.4	11.3	10.0	7.7	10.3	5.5

All values are in parts per million (ppm).

Source: US Environmental Protection Agency (1970).

Electrical conductivity represents the total electrolyte concentrations in an aquatic system. In the case of Irondequoit Bay, there has been a doubling of the conductivity values since the 1939-40 study. Conductivity values for the bay even then were relatively high compared to other New York lakes and bays (Tressler *et al*, 1953). These high values were attributed to sewage effluents, also thought to cause high alkalinity values.

Irondequoit Bay is still comparatively high in conductivity values. Bubeck (1972) reported an average surface water conductivity of 1,016 µmhos. Deicing salt runoff has probably been a major factor in the electrolyte increase indicated by higher conductivity values.

The dissolved oxygen pattern of the bay follows that of a typical eutrophic lake. Oxygen is usually depleted below 10 m (32.8 ft) for most of the summer, while the surface waters may be supersaturated. The abundance of dissolved oxygen in the surface water is due to the photosynthetic activity of the algae blooms, while the oxygen deficiency of bottom waters is due to decomposition processes and the lack of circulation in the thermally isolated hypolimnion. Oxygen depletion of the hypolimnion lasts until the fall overturn, when water from the depths of the bay is mixed with oxygenated surface waters, producing a fairly uniform oxygen concentration from surface to bottom. During the winter, a stagnation effect again occurs and oxygen is again depleted from the deeper waters. In the spring, most temperate lakes have an overturn period, when mixing reoxygenates the bottom waters.

In Irondequoit Bay, however, the sequence is different because of the chloride concentrations (Bubeck, 1972). The first noticeable effect is that the winter stagnation period is delayed due to the density of the colder oxygenated saline water. A second and possibly more serious problem is that no longer is the spring overturn complete in Irondequoit Bay. This means that only in the fall can oxygen be supplied to the bottom waters. Again, Bubeck attributed this to deicing runoff, which creates a chemical gradient of denser saline water along the bottom of the bay. The saline water acts as a barrier to mixing.

Comparisons among Tressler *et al* (1953), Bubeck (1972), and Bannister *et al* (1974) show that 30 years ago the bay was slightly more acidic than it is now. Increased surface alkalinity may be due to increased algae concentrations. However, Bubeck suggested that instrument malfunction may have been the reason for the acidic readings reported by Tressler *et al*, rather than an actual shift in pH values since 1939-40. Generally, pH values are similar for the 1939-40 and 1969-70 studies.

Chloride concentrations have increased dramatically over the last few years. The Monroe County Public Health Department surveys of Irondequoit Bay show that there was a 30 to 50 ppm (parts per million) increase in chloride concentrations between the summer of 1969 and the summer of 1970. Tressler *et al* (1953) did not record any values for chloride in the 1939-40 survey, but Bubeck (1972) reported that 1912 values were about one-tenth the present values for surface waters, and one-thirtieth to one-fiftieth the present concentrations for bottom waters. Records indicate that one percent of all salt used for deicing in the United States in 1969-70 was applied to the Irondequoit Bay drainage basin.

Further problems arising from the chloride concentrations include: 1) eutrophic enhancement through a decrease in the pH, 2) an increase in alkalinity, and 3) an increased sediment release of phosphorus (Bubeck, 1972). Other substances, such as heavy metals, may be affected by the chemical imbalance of excess chloride ions. Each year, more and more chloride is stored in the bay drainage system, in the soil, and in the bay itself, leading to a potential decrease in the quality of the bay water.

Soluble phosphorus concentration has also increased in the bay between 1939-40 and 1969-71. Tressler *et al* (1953) gave an average yearly surface value of 0.19 mg/l, while Bubeck (1972) found that this value was 1.77 mg/l for 1970-71. The concentration in bottom waters also increased more than tenfold, from 0.52 mg/l to 5.37 mg/l. Although at one time the low amount of phosphorus may have limited algal growth, Bubeck's values surpass those needed for algal growth at any time of year.

Soluble nitrogen compounds in Irondequoit Bay showed fluctuation in both the Bubeck and Bannister *et al* (1974) studies. Bubeck found that nitrates, nitrites, and ammonia values reached 0.0 ppm at times during the summer months. Soluble nitrogen is a major plant nutrient in the aquatic system, and these values indicate that low nitrogen may limit algal blooms.

Tressler *et al* (1953) reported high alkalinity values and believed these values were due to pollution inputs and high decomposition rates. In 30 years, there was an increase of approximately 80 ppm alkalinity; again, this can be attributed to an increase in sewage input along with anaerobic decomposition in the bottom sediments.

It is important to remember that the chemical composition shifts in Irondequoit Bay are due to variations in input water composition, particularly of the major tributaries of Irondequoit Creek. The bay acts like a chemical sink for the creek, and any fluctuation of chemical content first becomes obvious in the creek, with a more gradual effect appearing in the bay.

Plants in an aquatic system can provide invaluable information on the condition of their environment. This is especially true for the rooted aquatics and emergent plants, because they lack mobility and are therefore exposed to all environmental changes. Observing these plants may prove worthwhile as a means of determining past and present environmental quality of the bay. Trends in water quality can also be monitored with some degree of accuracy by noting both the presence and abundane of phytoplankton species.

Extensive studies by Clausen (1939) and Forest *et al* (1973) on vascular hydrophytes in Irondequoit Bay suggest a deterioration in water quality, as indicated by a shift in species composition (Table 3).

As pointed out by Forest *et al*, of the emergent plants found in 1939, only *Typha latifolia* (cattail) has survived the present conditions in Irondequoit Bay in great numbers; it has become the dominant littoral plant species. The cattails in the southern marshland are an extremely important component of the Irondequoit Bay ecosystem, acting to reduce the nutrient input of Irondequoit Creek into the bay. Harbison (1974) listed the contributions of this marshland area: 1) sedimentation and passage through submerged portions of the cattails reduces suspended matter by a factor of two, 2) total phosphorus concentrations are reduced by about 10 percent, and 3) total nitrogen is reduced by 16 percent during the summer months. Forest (1973) mapped the distribution of vascular plants in the waters of Irondequoit Bay (Fig. 3).

Other species of emergent aquatic plants reported in the bay by Clausen (1939) are now found infrequently or have disappeared altogether. *Sagittaria heterophylla* and *Scirpus acutus* are extinct, and *Scirpus americanus* and *Nymphea tuberosa* are rare, whereas in 1939 all four were common.

TABLE 3 *Vascular Hydrophytes of Irondequoit Bay*

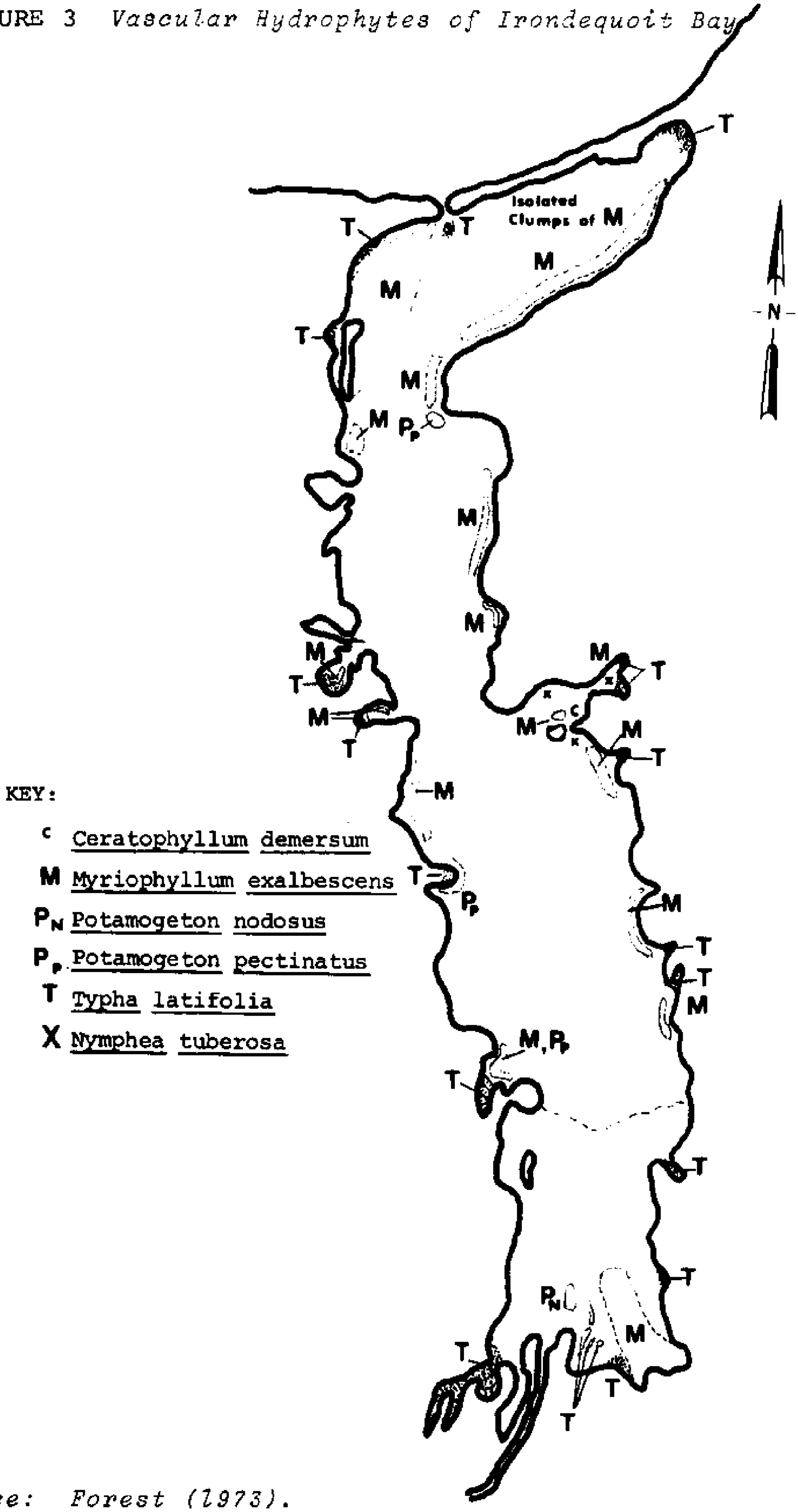
Plant Species	*1939*	*1939-72*
Typha angustifolia	a	x
T. latifolia	c	x
Myriophyllum exalbescens	?	x
Ceratophyllum demersum	c	x
Vallisneria americana	r	
Pontederia cordata		x*
Potamogeton americanus	r	
P. crispus	r	x
P. pectinatus	f	x
Lemna minor	f	x
L. trisulca		x
Spirodela polyrhiza	a	x
Wolfia punctata	f	x
Nymphea tuberosa	c	x
N. odorata		x*
Sparganium eurycarpum	r	x
Sagittaria heterophylla	r	
S. latifolia	f	
Najas flexilis	r	
Scirpus acutus	r	
S. americanus	r	x*
S. validus	f	x
Heterantera dubia	c	x
Polygonum coccineum	f	x
Phragmites communis		x*

a = abundant
c = common
f = frequent
g = rare
x = present
* = Held's Cove only

Source: Forest et al (1973).

The submerged rooted aquatic plants have also undergone extreme species shifting. Clausen's report showed that no *Myriophyllum exalbescens* existed in the bay. However, in 1972 Forest found that north of Snider's Island, *Myriophyllum* was the dominant plant species. The existence of *Myriophyllum* indicates an abundance of nutrients, since it is most often found in polluted or highly enriched (eutrophic) waters. Several other species found in 1939 were not located by Forest's group in 1972. Species now apparently absent from the bay are *Najas flexilis* (naiad) and *Valleneria americana* (eelgrass). However, the apparent shift may be due to sampling procedures, because both

FIGURE 3 *Vascular Hydrophytes of Irondequoit Bay*



KEY:

- c Ceratophyllum demersum
- M Myriophyllum exalbescens
- P_N Potamogeton nodosus
- P_P Potamogeton pectinatus
- T Typha latifolia
- X Nymphea tuberosa

Source: Forest (1973).

of these species occurred only rarely in the Clausen survey.

For the roughly 25 percent of the bay south of Snider's Island, Forest (1973) listed the approximate species composition as: *Potamogeton pectinatus* (sago pondweed)--60 percent; *Myriophyllum exalbescens* (milfoil)--25 percent; *Potamogeton crispus* (curly or crisp-leaved pondweed)--10 percent; and *Ceratophyllum dencreum* (hornwort or coontail)--5 percent.

Held's Cove appears to have the greatest species diversity, with *Nymphea odorata, Scirpus americana,* and *Phragmites communis* observed only in this part of the bay (Forest, 1973).

An important aspect of the distribution of plants in the bay is the vertical range of submerged aquatic plants. The present maximum observed depth of rooted aquatic plants is 5 to 6 feet (1.5 to 1.8 m). This shallow growing depth can be attributed to poor light penetration. In Held's Cove, where diversity is greater, light penetration is as much as one foot deeper. Harbison (1974) found that light penetration of up to 4 feet (1.2 m) deep throughout most of the bay area is sufficient to sustain plant growth during the summer months. But in the northeast section of the bay, two major factors further restrict light penetration: the observed high density of planktonic communities, and the high concentration of suspended and dissolved solids found in the waters (Forest *et al*, 1973).

The plankton blooms that limit light penetration are not a new phenomenon in the bay. Tressler and Austin (1939) reported that "a truly enormous crop of microplankton" was present during the summer months; this limited light penetration to 6.6 feet (2.0 m) on August 15, 1939. The phytoplankton crop consisted primarily of green algae, with some bluegreens also present. The dominant genera were *Scenedesmus, Oocystis, Mougeotia, Sphaerocystis,* and *Crucigenia.* Surface waters contained 2 million algae per liter; *Scenedesmus* (397,000/l), *Oocystis* (380,000/l), and *Crucigenia* (337,000/l) were the most common. At 32.8 feet (10 m) the algal population was 750,000/l. Bluegreen algae were most abundant at the surface and at 5 meters (16.4 ft), and rare at 10 meters. The dominant bluegreen algae were *Aphanizomenon* (147,000/l) and *Merismopedia* (130,000/l) at 5 meters. Diatoms were fairly abundant from 3 to 8 meters (9.8 to 26.2 ft), with *Melosira* dominant (190,000/l) at 3 meters.

Bannister *et al* (1974) studied the phytoplankton of Irondequoit Bay during 1970-71. A summary of this comprehensive study outlines the present conditions of the bay. From May to June, there is a succession of dense algae blooms. First, a bloom of *Cyclotella, Stephanodiscus,* and *Diatoma* species dominate until mid-May. This bloom appears to be limited by silicate concentrations. Around May 20, *Chlamydomonas* appears in mass, which in turn is followed by a mixed green algae bloom. Beginning in mid to late June, an intensive bluegreen population is present. This bloom depletes the nitrogen concentration of the bay from 2.5 ppm to 0.2 ppm. Of the bluegreens, the most common are *Anabaena, Microcystis,* and *Aphanizomenon.* Through July and August, there is a fairly constant algae population. In 1971 bluegreens dominated during this period, but in 1970 the algal composition was a mixture of greens and bluegreens. In September, *Anabaena,* accompanied by *Ceratium,* is reestablished. Finally, in October, diatoms and mixed green algae dominate the phytoplankton until fall overturn of the bay.

Bannister *et al* (1974) reported that nitrogen may be a limiting factor to algal growth in the upper layer (epilimnion) of the bay because the chlorophyll concentration used as a population and productivity estimate reaches a high value of 100 μg/l but does not vary greatly above this value. A reduction in available nitrogen concentration appears during the peak blooms.

A comparison with Tressler and Austin (1939) cannot be quantitative, but some observations are possible. The species composition of phytoplankton appears to have been relatively constant over the last 30 years. Bannister *et al* (1974) reports that the June bluegreen algae bloom has only occurred recently, which may be an indication of further deterioration of the bay water quality.

There are not many data reporting zooplankton community characteristics. Tressler *et al* (1953) lists only limnetic forms collected in 1939-40. Seasonal distributions were plotted for several of the more abundant species found. Table 4 gives the species identified by Tressler *et al*.

Odell (1939) reported that crayfish and shrimp were common in the waters of the bay.

The US Department of the Interior (1969) did some limited studies on the benthic organisms inhabiting both Irondequoit Bay and Irondequoit Creek. At all stations examined, the bottom sediment type was reported as being dark-brown muck in the shallow areas and black muck in the deeper spots. At one station a brownish-gray muck was reported at 5.0 meters (16.4 ft), and 61,334 organisms were collected. Of these, 250 were identified. Table 5 gives the species found.

TABLE 4 *Zooplankton Species of Irondequoit Bay*

Copepoda

Cyclops bicuspidatus
Cyclops leukartic
Diaptomus siciliodes

Cladocera

Alona sp
Bosmina longirostris
Daphnia longispina
Daphnia pulex
Daphnia retrocurva
Leptodora kindtii
Sida crystallina

Rotifera

Asplanchna priodonta
Asplanchna sp
Keratella cochlearis
Keratella quadrata
Monostyla bulla
Notholca longispina
Polyarthra trigla
Rattulus sp
Synchaeta stylata

Source: Tressler et al (1953).

TABLE 5 *Benthic Organisms of Irondequoit Bay*

Isopoda (Asellus)
Trichoptera
Chironomidae
  Polypedilium
  Procladius riparius
  Procladius culiciformis
Pelecyopoda (Sphaerium)
Oligochaeta
Gastropoda
  Helisoma
  Amnicola
  Gyraulus
  Physa
  Goniobasis
  Stagnicola
  Promenetus
  Valvata

Source: US Department of the Interior (1969).

Benthic populations of both the creek and the bay areas are indicative of the high organic loading found in these waters. However, data are insufficient to make any concrete conclusions.

Table 6 represents the observed changes in the populations of fish species in Irondequoit Bay from 1939 to 1970. EnCon did the earlier study (1939). The later data come from studies by Gittelman and Buchanan (1971) and EnCon (1970). Additional information on fish populations prior to 1939 can be obtained from Greeley (1939). Included in the Greeley study are 108 species of fish from 27 different families that were found inhabiting the waters of Lake Ontario before 1940.

EnCon also has lists of resident fish populations for 1946, 1960, and 1972. Forest (1973) gives collection data for a 1967 summer ichthyology course, as well as a detailed account of all fish records and an ecological description of each species identified in the bay.

TABLE 6 *Comparison of Fish Species Reported in Irondequoit Bay, 1939 and 1970*

SPECIES	FAMILY	1939[a]	1970[b]	USES
Stoneroller (*Campostoma anomalum*)	Minnow (Cyprinidae)	+R	-	Forage
Silvery minnow (*Hybognathus nuchalis*)	Minnow (Cyprinidae)	+	-	Forage
Mimic shiner (*Notropis volucellus*)	Minnow (Cyprinidae)	+R	-	Forage, bait
Pugnose shiner (*Notropis anogenus*)	Minnow (Cyprinidae)	+	-	Forage
Black chin shiner (*Notropis heterodon*)	Minnow (Cyprinidae)	+	-	Forage
Steelcolor shiner (*Notropis whipplii*)	Minnow (Cyprinidae)	+	-	Forage
Spotfin shiner (*Notropis spilopterus*)	Minnow (Cyprinidae)	+	-	Forage
Sand shiner (*Notropis stramineus*)	Minnow (Cyprinidae)	+	-	Forage
Common shiner (*Notropis cornutus*)	Minnow (Cyprinidae)	+	-	Forage
Bluntnose minnow (*Pimephales notatus*)	Minnow (Cyprinidae)	+	-	Forage, bait
Golden shiner (*Notemigonus crysoleucas*)	Minnow (Cyprinidae)	+	+	Forage, bait
Carp (*Cyprinus carpio*)	Minnow (Cyprinidae)	+A	+	Forage
Spottail shiner (*Notropis hudsonis*)	Minnow (Cyprinidae)	+	+	Forage, bait
Emerald shiner (*Notropis atherinoides*)	Minnow (Cyprinidae)	+	+A	Forage, bait
Largemouth bass (*Micropterus salmoides*)	Sunfish (Centrarchidae)	+	+	Game
Smallmouth bass (*Micropterus dolomieui*)	Sunfish (Centrarchidae)	+	+	Game
Bluegill (*Lepomis macrochirus*)	Sunfish (Centrarchidae)	+	-	Pan
Pumpkinseed (*Lepomis gibbosus*)	Sunfish (Centrarchidae)	+	+A	Pan

SPECIES	FAMILY	1939	1970	USES
Black crappie (*Pomoxis nigromaculatus*)	Sunfish (Centrarchidae)	+	+	Pan
Rockbass (*Ambloplites ruprestrus*)	Sunfish (Centrarchidae)	+	+	Game
Brook silverside (Labidesthes sicculus)	Silverside (Atherinidae)	+	-	Forage
Eastern banded killifish (*Fundulus diaphanus*)	Killifish (Cyprinidontidae)	+R	+	Bait
White bass (*Roccus chrysops*)	Bass (Percichthyidae)	+	-	Game, commercial
White perch (*Morone americanus*)	Bass (Percichthyidae)	-	+A	Game, commercial
Cisco (*Coregonus artedi*)	Whitefish (Coregonidae)	+	-	Game, commercial
Freshwater drum (*Aplodinotus grunniens*)	Drum (Sciaenidae)	+	-	Commercial
Channel catfish (*Ictalurus punctatus*)	Catfish (Ictaluridae)	-	+	Food
Black bullhead (*Ictalurus melas*)	Catfish (Ictaluridae)	-	+	Food
Brown bullhead (*Ictalurus nebulosus*)	Catfish (Ictaluridae)	+	+	Food
Northern log perch (*Percina caprodes*)	Perch (Percidae)	+	-	Forage, bait
Yellow walleye (*Stizostedion vitrium*)	Perch (Percidae)	+	-	Game
Johnny darter (*Etheostoma nigrum*)	Perch (Percidae)	+	+	Forage
Yellow perch (*Perca flavescens*)	Perch (Percidae)	+	+	Pan
American burbot (*Lota lota*)	Cod (Gadidae)	-	+	Commercial
Alewife (*Alosa pseudoharengus*)	Herring (Clupeidae)	+	+	Forage
Gizzard shad (*Dorosoma cepedianum*)	Herring (Clupeidae)	+	+	Forage

SPECIES	FAMILY	1939	1970	USES
White sucker (*Catostomus commersonii*)	Sucker (Catostomidae)	+	+	Forage, bait
Northern Pike (*Esox lucius*)	Pike (Esocidae)	+	+	Game
Longnose gar (*Lepisosteus oculatus*)	Gar (Lepisosteidae)	+	+	Game
Bowfin (*Amia calva*)	Bowfin (Amiidae)	+	+	Bait
Sea lamprey (*Petromyzon marinus*)	Lamprey (Petromyzontidae)	-	+	Parasite
American eel (*Anguilla rostrata*)	Eel (Anguillidae)	+	-	Game

Other species present but not captured in the 1939 or the 1970 studies:

Northern redhorse sucker (*Moxostoma macrolepidotum*)	Sucker	1967

Additional species not included in the 1939 collection:

Satinfin shiner (*Notropis analostanus*)	Minnow (Cyprinidae)
Iowa darter (*Etheostoma exile*)	Perch (Percidae)

Total number of species collected in 1939 = 36
Total number of families collected in 1939 = 17

Total number of species collected in 1970 = 24
Total number of families collected in 1970 = 13

R = rare
A = abundant

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a Source: EnCon (1939).

b Sources: Gittelman and Buchanan (1971) and EnCon (1970).

Comparing 1939 and 1970 data shows that 18 species of fish present in 1939 were not detected in 1970, and that 7 other species decreased in number. These were fish of the type that thrive in a clear, weedy environment. Five species were found in the 1970 studies that were not identified in the early study; these were types of fish generally found in silty, brackish water having dense vegetation.

Because much of the original data does not cover the entire bay area, it is difficult to make any precise comparisons. However, the general trend of fish populations and diversity is consistent with the more eutrophic conditions of the bay at the present time. An increase of nutrients and salinity of the bay waters has altered fish populations to some degree. The data suggest that the bay is more nutrient-rich, but not so much so that it is uninhabitable to fish.

EnCon has recently embarked on a large-scale salmonid stocking program in the Lake Ontario watershed. The waters of the Irondequoit Bay watershed, especially those of Irondequoit Creek, have been noted for their excellent potential as trout waters (Greene, 1939). Because of the present polluted status of these waters, natural salmonid populations are difficult to maintain, except in the upper reaches of the streams. Details of the fish populations in the bay tributaries are found in Hennigan (1970).

In the spring of 1974, roughly 10,000 steelhead trout smolts (*Salmo gairdneri iridescens*) were stocked in the headwaters of Irondequoit Creek. Steelheads were chosen as the best suited of the salmonids for the recreational needs and demands of this area. In past years, these streams have been stocked with large numbers of brown trout (*Salmo trutta*). It is hoped that the steelheads will survive conditions in the lower bay areas, migrating into Lake Ontario, where they will grow rapidly. If successful, an annual run of steelhead from Lake Ontario to the upper areas of Irondequoit Creek is anticipated.

The success of this operation may well depend on improved creek and bay conditions. Installation of the sewage-interceptor system should divert the major sources of pollution out of the watershed. Proper fish management policies should vastly improve the recreational value of the entire watershed area in future years.

Information on bacteriological studies of the Irondequoit Bay drainage basin and Lake Ontario is available from the Monroe County Public Health Department. Department reports deal with bacteria in the aquatic system, calculated by most probable number (MPN) counts and fecal coliform tests of waters leaving the various sewage treatment plants in the bay's drainage basin and waters near public beaches of the Lake Ontario shoreline. Extremely high MPN counts, recorded throughout the bay's tributaries, generally reflect the large volume of domestic sewage discharged into the bay. Localized high bacteria counts pinpoint the entry of additional STP effluents, inadequate storm and domestic sewage drainage along the bay shore, and runoff from landfill sites.

Public Health Department records have revealed that the tributaries of the bay are a potential disease hazard, making their shores unfit for access. Because of the high fecal pollution input from sewage outflows throughout its drainage basin, Irondequoit Creek is not a self-cleansing body of water.

Aside from localized high bacteria counts, the waters of Irondequoit Bay are safe for recreational use. Of course, the bay cannot be unaffected by the high volume of STP effluent, but this should be substantially reduced upon completion of the sewage-interceptor system at the Durand-Eastman STP. Compared to bacteria counts for the Lake Ontario shore, those for Irondequoit Bay are low. The extremely high lakeshore counts are due to the influence of the Genesee River and the general polluted condition of the Lake Ontario shoreline region.

US ARMY CORPS OF ENGINEERS PROPOSAL FOR OPENING IRONDEQUOIT BAY

A report filed by the chief of engineers, Department of the Army, dated April 15, 1955, presented the preliminary plan resulting from an examination of Irondequoit Bay. This proposal, sent to the 84th Congress, second session, called for the opening of a new channel from Irondequoit Bay to Lake Ontario on the far eastern arm of the bay.

The original plan has since been changed, calling for construction of a wider and deeper channel at the site of the present opening of the bay on its northwestern shore (Fig. 4). The existing project was authorized by the 1958 Rivers and Harbors Act, amended in 1968, and provides for:

a) an entrance channel located at the existing outlet of the bay, 8 feet (2.4 m) deep and 100 feet (30.5 m) wide, extending from the 8-foot depth in Lake Ontario to junction with the inner bay channel;

b) an inner channel, 6 feet (1.8 m) deep and 100 feet (30.5 m) wide, from the entrance channel to deep water in the bay, a distance of about 3,100 feet (945 m);

c) a 6-foot (1.8 m) deep access channel and mooring area leading from the junction of the above channels, 1,600 feet (488 m) in length, for use in connection with the public marina development for small boats to be provided by nonfederal interests;

d) parallel jetties, about 180 feet (54.9 m) apart and 730 feet (222.5 m) long, extending into the lake to protect the entrance channel;

e) replacement of the existing fixed railroad bridge across the existing outlet with a new, movable structure spanning the improved entrance channel; and

f) removal of the existing highway bridge across the existing outlet (US Army Corps of Engineers, 1968).

The estimated federal cost of the existing project was $2,880,000 at June 1971 price levels. In addition, the investment required of local interests for construction of the project was $1,174,000, of which $923,000 was to be a cash contribution. Federal expenditures as of June 30, 1971 were $133,072. The project received Congressional approval, and the necessary funds were appropriated (US Army Corps of Engineers, 1968).

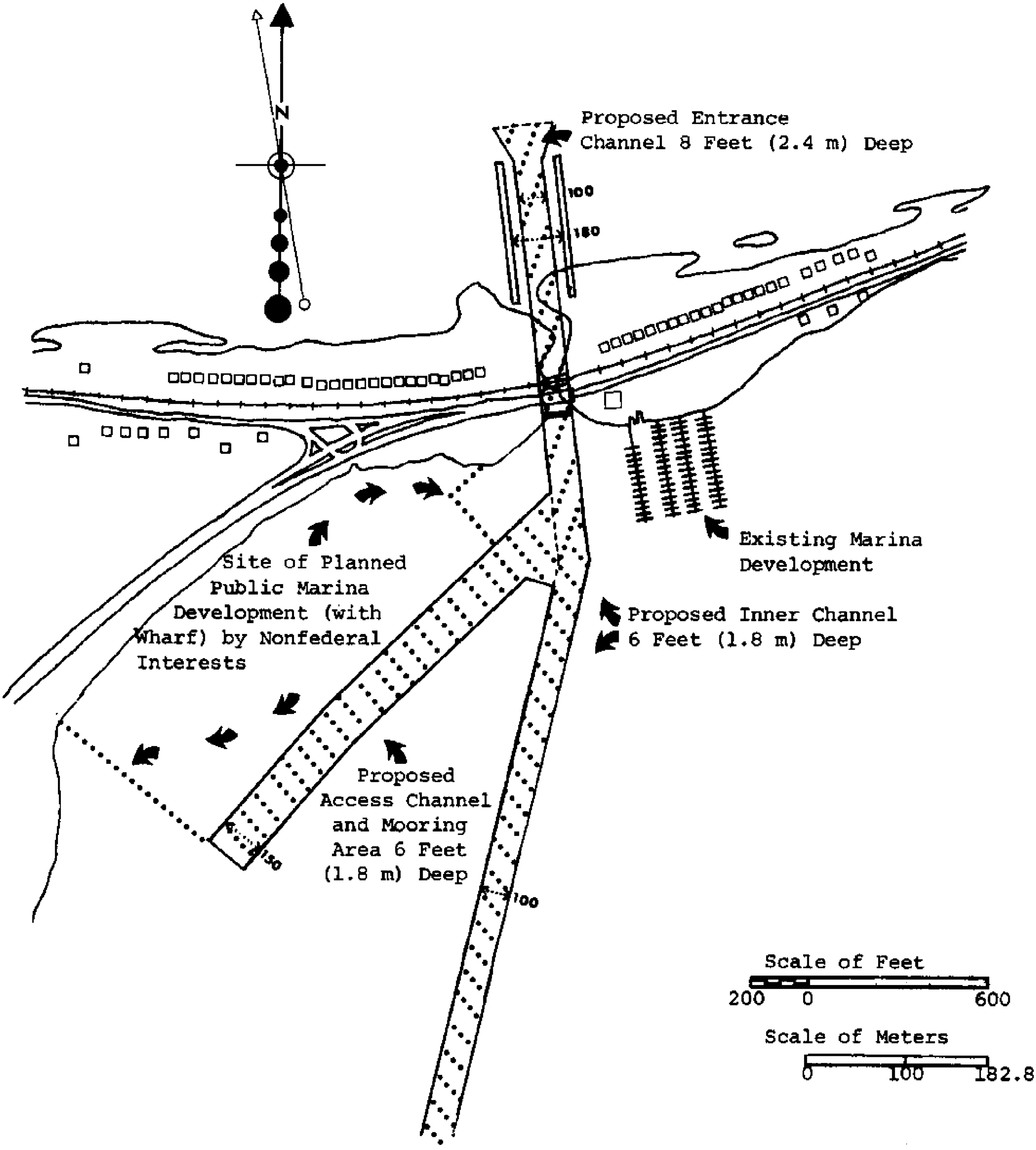
One of the more recent problems confronted by the Corps of Engineers in its dredging project of the Rochester Harbor in the lower Genesee River was sediment disposal. The corps was acting under the Rivers and Harbors Act of 1970, which states that the dumping of polluted material into Lake Ontario must be terminated "at the earliest possible date." Alternate solutions to this problem were outlined by the Monroe County Management Council (1972*a*,*b*,*c*).

The Environmental Protection Agency (EPA) is committed to pollution abatement through administrative action and through the US Attorney General's Office. EPA will provide 75 percent of abatement construction costs, and will also evaluate proposed disposal sites and review environmental impact statements for federally funded projects under the National Environmental Policy Act of 1969. New EPA pollution abatement standards, now being proposed, will determine the fate of dredged spoils from Irondequoit Bay.

In 1971 the New York State Legislature passed a law prohibiting the closing of Route 18 until the Irondequoit-Wayne County Expressway is completed. However, there are no funds available now for completion of this highway.

The presence of the railroad bridge across the bay outlet is another problem to be solved before the project can be initiated. There is insufficient evidence to determine whether or not the Hojack Line of the Penn Central Railroad should be continued. Because of the financial status of the railroad, obtaining the necessary information may take a long time.

FIGURE 4 *Corps of Engineers' Proposed Plan for Opening the Outlet of Irondequoit Bay*



Source: US Army Corps of Engineers (1968).

GENERALIZED EFFECTS OF DREDGING OPERATIONS

With increasing population and industrial development, the United States has become more aware of environmental considerations. This has been particularly true in the Great Lakes region: pollution has contributed to many changes in the biological communities of the Great Lakes (Beeton, 1969). The Great Lakes harbors are generally the most polluted areas of the lakes drainage basin, because of associated industrialization and residential development.

The effects of dredging operations were studied in Chesapeake Bay (Biggs, 1968), in Rhode Island Sound (Saila *et al*, 1968), off the Florida coast (Ingle, 1952), and along the coast of the Gulf of Mexico (Mackin, 1961).

The chemical, physical, and biological effects of the Corps of Engineers dredging operations in the Great Lakes were examined by the corps itself (1969). This study provides a comprehensive bibliographic listing of the biological effects of dredging. For a comparison of dredging operations close to Irondequoit Bay, consult US Environmental Protection Agency (1973); this study details the dredging operations conducted by the Corps of Engineers for Barcelon, Dunkirk, Buffalo, Niagara River, Wilson, Olcott, Rochester, Little Sodus Bay, Great Sodus Bay, Oswego, Cape Vincent, and Ogdensburg Harbors. It was reported that upwards of 97 percent of the dredged sediments from these harbors are polluted. Generally, the study showed a temporary increase in turbidity, nutrient levels, and chemical oxygen demand (COD) in the vicinities of the dredged area and the disposal area. This is accompanied by a high but short-lived killoff of resident invertebrates and fish. Gannon and Beeton (1969,1971) demonstrated that dredged materials are toxic to benthic organisms. They conducted bioassays using the amphipod *Pontoporeia affinis*, a pollution-intolerant species of the Great Lakes region. Eight Great Lakes harbors were tested (Great Sodus Bay was the closest to Irondequoit Bay).

The viability studies showed a different response for each of the harbors tested; Great Sodus Bay waters caused the lowest mortality. Mortalities may be correlated to the biological and chemical oxygen demand of the sediments. They suggest that further experimentation on the effects of dredged materials on aquatic life include analysis of organic compounds, heavy metals, and pesticides.

Rees (1959) studied the effects of stream dredging on young coho salmon (*Oncoryhnchus kisutch*) and bottom fauna in Little Bear Creek, a tributary of the Sammamish River northeast of Seattle, Washington. Dredging eliminated 97 percent of the bottom organisms in the test area. Reduced fauna populations persisted for five months but within ten months had recovered completely. Salmon and trout fingerlings showed 69 percent and 81 percent mortality, respectively, immediately after dredging. Fish kills were attributed to the dredging apparatus, destruction of food supply, and elimination of suitable living areas. Population estimates made one year after the beginning of the dredging compared favorably with pre-dredging numbers. Bottom rehabitation by organisms reflected the changed water flow and bottom characteristics of the new channel.

Dredging of Boca Ciega Bay, Florida is reported to have caused a $1.4 million annual loss in fishery products. Minimum annual losses of biological resources are estimated at 25,841 metric tons (MT) of sea grass, 73 MT of fishery products, and 1,091 MT of bottom-dwelling animals. "Inestimable" losses were reported--the result of sedimentation, turbidity, and domestic sewage (Taylor and Saloman, 1969).

POSSIBLE BIOLOGICAL IMPACTS OF ENLARGING THE CHANNEL OUTLET OF IRONDEQUOIT BAY

Dredging Irondequoit Bay as proposed by the Corps of Engineers would result in immediate chemical changes through disruption of the sediments in the dredge site: 1) there would be a sharp rise in the COD from the increased organic material released into the water (this tends to deplete oxygen in the immediate dredge area); 2) phosphates would increase; 3) soluble nitrogen, if present in the sediments, could increase; 4) heavy metals and pesticides, which could also be contained in the sediments, would be released into the water; and 5) turbidity would also increase and would persist, depending on the particle size of the sediment materials. Some of the chemical effects would be short-lived. However, introducing heavy metals, pesticides, and major plant nutrients into bay waters, which could have more prolonged effects, represent potentially hazardous impacts to the bay environment. Until sediment analysis is completed, evaluating changes in the bay's chemistry can be made only by speculation and comparison to other dredging operations.

In the immediate area of the dredging site, rooted aquatic plant populations would be greatly disrupted. Increased nutrients in the waters of the dredge site could increase phytoplankton populations, and would contribute to the turbidity of these waters. An increase in turbidity would reduce light penetration and would be expected to limit vascular plant recolonization and the depth at which phytoplankton populations could exist.

A large number of benthic organisms would probably be eliminated from the dredged areas. Predominant surviving forms would most likely be the more pollution-tolerant species. Recolonization should be fairly rapid unless toxic materials are released from the sediments. Recolonization would be most closely related to the substrate type of the new channel and the mobility of each species.

In the immediate dredging site, fish populations may become severely reduced from the mechanical operation of the dredging operation. Additional fish population reductions could result from: 1) depleted oxygen in the surrounding area, 2) release of toxic materials, 3) reduction of food supplies caused by disrupted food webs, and 4) clogging of the gills by increased particulate matter in the water. Longer-term effects on fish populations would include: 1) elimination of suitable living areas, 2) disruption of spawning and migration patterns, 3) elimination of food organisms, and 4) destruction of spawning sites. Therefore, dredging plans should take into consideration the spawning activities of the more important sport and forage species, making the time of year one of the more crucial aspects.

Other considerations include the need for drafting of regulations and recommendations for the use of Irondequoit Bay. The success of the bay opening may well depend on proper use and environmental considerations *after* the channel has been dredged.

RECOMMENDATIONS

A number of recommendations are offered for further research before the Corps of Engineers initiates its dredging project:

1) A comprehensive study of the sediments in the dredging area is of utmost importance to determine that no potentially harmful materials are released into the bay.

2) No extensive information on benthic and zooplankton communities is now available. Because these organisms are important in the aquatic food web, such information is necessary to evaluate the consequences of opening the bay.

3) Information is lacking on fish movement into and out of the bay. Such knowledge may prove useful in establishing a sportfishery in Irondequoit Bay.

4) There is sufficient information detailing the chemical and physical aspects of the bay waters. However, diversion of sewage effluents out of the bay may substantially alter the chemical composition of the water. If effluents are diverted, studies should then be made to determine the effects.

5) Studies should be conducted during the actual dredging to evaluate the short-term and immediate effects of the operation, and follow-up studies should be conducted to determine the long-term effects on the bay's chemical, physical, and biological characteristics.

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