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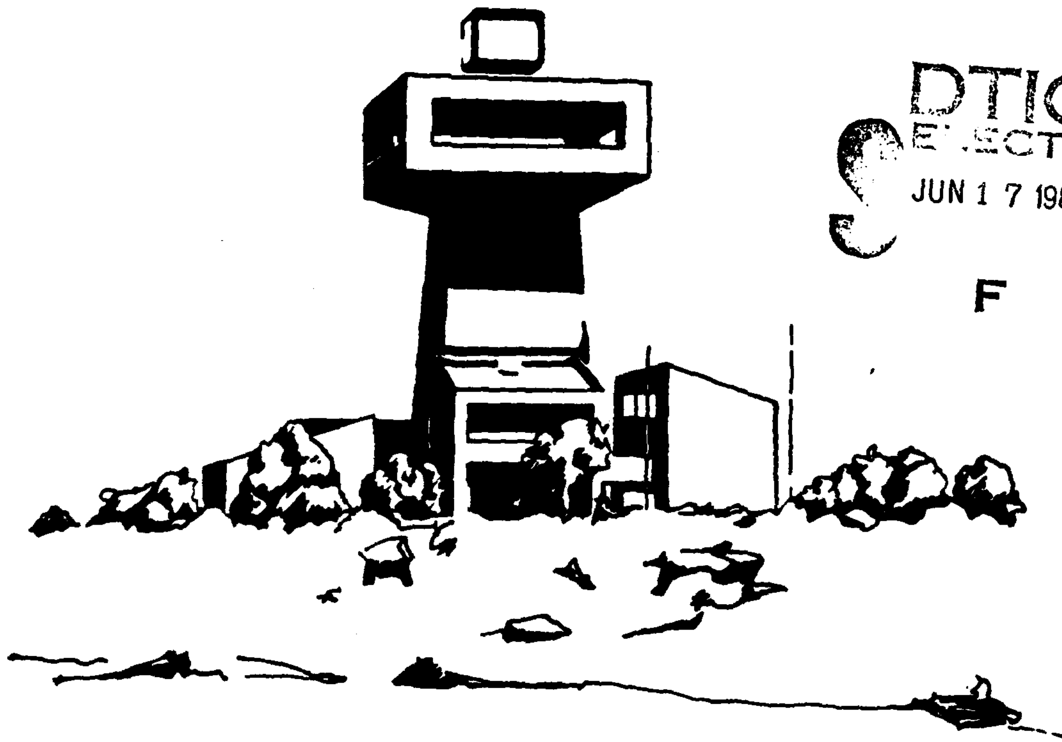
Buffalo River and Outer Harbor of Buffalo, N.Y.

Final Report

U. S. Army Corps of Engineers

June 1982

Volume I



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The U.S. Army Corps of Engineers is considering the feasibility of dredging the Outer Harbor and Buffalo River channels deeper to accomodate deeper draft vessels and/or to construct alternative means of trans-shipment of raw materials. An intensive study of the Buffalo River, Ship Canal and Outer Harbor of Buffalo, New York, was undertaken between April 1981 and May 1982 with the following general objectives:

To evaluate existing conditions in the river and harbor and to evaluate

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) the biological impact of dredging the existing channel deeper in the Buffalo River and Outer Harbor;

2. To evaluate the biological impact of alternative proposals to dredging such as transshipment of raw materials by conveyor;

3. To evaluate the biological impact of removal of debris, old pilings, etc. along the Buffalo shoreline;

4. To evaluate existing conditions in potential disposal areas (Fig.2) and to evaluate the biological impact of spoil disposal in these areas; and

5. To provide a functional assessment of the ecological components studied and evaluate their significance with and without project implementation to the area ecosystem.

In Volume 1, the Final Report, our analysis and interpretation of existing conditions and our assessment of impacts are presented. In Volume 2, the Data Report, the raw field data is presented in tabular form.

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The U.S. Coast Guard Station at Buffalo allowed us to berth our boats, store equipment and utilize their premises for analyzing field samples and drying nets. We thank the Coast Guard personnel for their help and especially Mr. Murak, the Commanding Officer.

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INTRODUCTION

The shoreline of the Buffalo River is developed with heavy industry such as Republic Steel, Allied Chemical, Mobil Oil and numerous grain elevators. Similarly, on the southeast shore of the Outer Harbor, heavy industry such as Bethlehem Steel, Huron Cement and Lackawanna Steel is evident. On the eastern shore of the Outer Harbor, freighters unload salt, taconite, coal, etc. into large storage piles for later use by the area industries. Large lake-going freighters and oilers routinely use the previously dredged channel existing along the entire length of the study area (Fig. 1) while servicing the industries located along the water front.

The U.S. Army Corps of Engineers is considering the feasibility of dredging the Outer Harbor and Buffalo River channels deeper to accommodate deeper draft vessels and/or to construct alternative means of transshipment of raw materials. An intensive study of the Buffalo River, Ship Canal and Outer Harbor of Buffalo, New York, was undertaken between April 1981 and May 1982 with the following general objectives:

(1) To evaluate existing conditions in the river and harbor and to evaluate the biological impact of dredging the existing channel deeper in the Buffalo River and Outer Harbor;

(2) To evaluate the biological impact of alternative proposals to dredging such as transshipment of raw materials by conveyor;

(3) To evaluate the biological impact of removal of debris, old pilings, etc. along the Buffalo shoreline;

(4) To evaluate existing conditions in potential disposal areas (Fig. 2) and to evaluate the biological impact of spoil disposal in these areas; and

(5) To provide a functional assessment of the ecological components studied and evaluate their significance with and without project implementation to the area ecosystem.

In Volume 1, the Final Report, our analysis and interpretation of existing conditions and our assessment of impacts are presented. In Volume 2, the Data Report, the raw field data is presented in tabular form.

METHODS AND MATERIALS

Fish

Electroshocking

A 7-m pontoon boat fitted with an 18 HP outboard motor, 240 V (20A) DC generator and electroshocking booms was used to electrofish in shallow water at Stations 2, 3, 5 and 9-14 (Fig. 1) and at Disposal Areas 1 and 4 (Fig. 2) in April, May, June, July, August, September, October, November and December. While one crewman drove the boat slowly along shore, two crewmen used 3-m dip nets to lift stunned fish out of the water into a plastic garbage can filled with water. A 60-m (200 ft) section of shoreline was shocked (~4-min run) at each shallow water station and ~30-min runs were made at each proposed aquatic disposal area. Upon completion of a run, surface and bottom temperatures were taken with a Whitney Thermometer. Approximate number and species of fish observed but not captured during shocking runs were also recorded.

Captured fish were measured (cm), examined for reproductive condition and sex (by squeezing) and returned alive, if possible, to the river or harbor. Species, length, sex and reproductive condition (NG=not gravid, F=female, M=male, G=gravid, S=spent) were recorded. Taxonomic keys used for identification of fish are listed in Table J1 in Volume 2. Particular attention was given to noting any rare or endangered species which occur or might occur.

Gill Netting

Gill nets were 53 m long, 2 m wide, and consisted of seven 7.6-m panels in 1.25-cm increments ranging from 2.5 to 10.2-cm bar measure. Nets were set in April, May, June, July, August, September, October, November, December and January.

Trap nets were 1.2 m in diameter with one 15.2-m lead and two 7.6-m wings. Two trap nets were set in Disposal Area 1 in May 1981; all other sampling dates and stations (Figs. 1 and 2) were sampled with one experimental gill net, except Disposal Areas 1 and 4 which received two. Gill nets were set at the bottom 3 to 12 m deep, depending on the maximum depth of a station (Table 1). In January, Station 14's gill net was set using a "Prairie Ice Jigger" (Sprules 1957) (Table K1 in Volume 2).

Nets were set in one morning and retrieved in the same order approximately 24 hr later. A crew of 5 to 10 people removed fish from nets, then washed, dried and repacked nets for further use. Fish were identified, measured (cm) and sex condition was determined by squeezing. On occasions when the sex of game fish or rough fish exhibiting some signs of reproductive condition could not be determined by squeezing, a ventral incision was made to determine sex condition. The sex condition code was the same as described previously. For fish opened ventrally additional codes were used: I=immature, R=ripe. After recording species, length and sex condition information, live fish were returned to the water and dead fish disposed of far from shore. Obvious external lesions or tumors were noted.

For electroshocking and gill netting samples, catch per unit effort (c/f) and diversity indices (H') were calculated. Electroshocking c/f is defined as total fish captured per 30 m of shore shocked, and netting c/f is defined as total fish caught per 53 m of net. The Shannon-Weaver Index was used to calculate diversity indices (Poole 1974).

Ichthyoplankton

A Miller High-Speed Sampler equipped with a flow meter was used to collect ichthyoplankton. Samples were collected in May, June and July, day and night, surface and bottom, using 3-min tows at Stations 1-14 and two 6-min tows at Disposal Areas 1 and 4. At night, samples were examined using a high intensity light. Samples were preserved in 10% formalin and returned to the laboratory for identification to the lowest practicable taxonomic level. Keys utilized for taxonomic identification of ichthyoplankton are listed in Table J1, Volume 2.

Benthos - Disposal Areas 1 and 4

One Ponar grab was taken at each of the seven sampling stations in Disposal Areas 1 and 4 (Fig. 2) in July and September. In some instances, a benthic sample was not initially retrieved with the Ponar sampler. A repeat sample was attempted, but if no substrate was dredged up, the bottom was assumed to be rock or large cobble. In the field, each dredge sample was washed through a 0.471-mm mesh screened bucket to remove fine sediments. Debris and organisms retained on screens were placed in bottles and preserved in a 10% formalin solution.

In the laboratory, organisms were hand-picked from the debris. Invertebrates were keyed to the species level, where possible, and preserved in 95% ethyl alcohol. Counts per grab were converted to individuals per square meter (Ponar grab bite = 0.0529 m^2). Keys used for taxonomic identification of benthic invertebrates are presented in Table J1, Volume 2.

Aquatic Macrophytes - Disposal Areas 1 and 4

Disposal Area 1 was sampled along a grid (Fig. 3) for aquatic macrophytes on 4 September 1981, using either a Ponar or Ekman Bottom Sampler. Disposal Area 4 was also "gridded," using the main north-south breakwater adjacent to the site as a baseline. Westerly transects, each 200 m apart, were laid out from the jetty and sampled at 100-m intervals for a total of 28 samples. The azimuth of each transect from the jetty was 240°.

An Ekman Bottom Sampler (8"x8") was used at both disposal areas, except where heavy vegetation necessitated use of the Ponar Sampler. Representative plant material was separated from each sample and pressed at the time of sampling. Identification was done in the laboratory from the pressed materials following the taxonomic keys in Table J1, Volume 2.

Terrestrial Vegetation - Disposal Areas

Disposal Areas 1, 2 and 3 (Fig. 2) were surveyed for terrestrial vegetation on 8-9 May 1981 and on 11-17 July 1981. Terrestrial vegetation on Disposal Area 1 is limited to a narrow strip between the old railroad track adjacent to Fuhrmann Boulevard and the shoreline of the harbor. The survey method was to map the trees by measuring their distance from the Cargill pier (southerly) edge of the site. Herbaceous vegetation was collected, pressed and subsequently identified in the laboratory.

Disposal Area 2 (Fig. 2) was gridded by laying out north/south transects 50 m apart parallel with the north-south railroad track. Origin of the grid was taken as the intersection at the southern edge of Disposal Area 2. East/west transects were laid out at 100-m intervals at right angles to the north/south transects, starting at the most easterly rail of the north-south railroad. Intersections of the grid were "flagged" and marked as to distance from the origin.

Field observers walked Disposal Area 2 and plotted landmark vegetation, vegetational changes and predominant vegetation on a gridded map, using the flagged and labelled intersection of the field grid for reference. The gridded map was derived from an aerial photograph of Disposal Area 2 provided by U.S. Army Corps personnel. Voucher specimens were collected. Unknowns were subsequently identified in the laboratory, by keying and by comparison with herbarium specimens in the SUNY College at Brockport reference herbarium.

Disposal Area 3 had discrete patches of vegetation in an otherwise highly disturbed area. A few trees, Popular deltoides and Salix sp., were present among predominant rank weeds. These discrete vegetational areas were identified on an aerial photograph, walked and characterized by predominant species. Less abundant species were noted and voucher collections were made for subsequent laboratory and herbarium identification.

Birds - Disposal Areas

The censuses in Disposal Areas 1 and 3 (Fig. 2) were conducted by moving slowly about the edge of the water area and stopping at 50-pace intervals for 5-10 min in April, May, June, July, October, November, December, and March. Since the entire study area can be seem from almost any shoreline point, only new arrivals were noted. Any bird which may have left the study area and returned was counted as a new arrival unless definitely known otherwise. Tabulation was by disposal area proper and by discrete adjacent area (i.e., open harbor beyond the proposed fill site, old fill area adjacent to the proposed fill site). The April and May observations represent "full-time counts" (i.e., all birds seen during the observation periods were recorded). On other dates, one-hour counts were made at Disposal Areas 1, 3 and 4, unless otherwise noted, and the remainder of the observation period at each site was used to watch for "new species" for that day. The reason for reducing the count to one hour was because of the obvious redundancy of foraging birds. In reality, quantification represents an interplay of factors other than absolute numbers of birds present, including such factors as foraging behavior, weather conditions, lake conditions, "people pressure" and visibility.

Disposal Area 2 (Fig. 2) was surveyed by slowly walking transects 100 paces apart, in zig-zags, and as described below, parallel to the north-south railroad which runs through the disposal area. Each transect spanned the disposal area and required approximately one-half hour to traverse. The zig-zags were approximately 30 paces wide. Only birds within about 50 paces of the center line of the transect were counted in order to limit redundance. Transect #1 was northerly, along the east edge of the railroad tracks. Transect #2 was southerly, 100 paces east of the north-south railroad. Transect #3 was northerly, 100 paces east of Transect #2. Transect #4 was southerly, along the river. Transect #5 was northerly, parallel to the north-south railroad and 100 paces west of it. Transect #6 was southerly, 100 paces west of Transect #5 and adjacent to the storage silos.

Birds on Disposal Area 4 (Fig. 2) were observed from a boat and/or from the outer harbor jetty. Sears (8x50) binoculars and a Bausch & Lomb spotting scope with 10x, 20x and 60x eyepieces aided in identifying and observing birds. References were carried afield and used as needed for field identification (Table J1, Volume 2).

Mammals, Amphibians and Reptiles - Disposal Areas

In order to ascertain the diversity of mammals, amphibians and reptiles at Disposal Areas 1, 2 and 3 (Fig. 2), the following procedures were utilized in April, May, June, September, October and January. The site was initially scanned with 8x50 Sears binoculars. Subsequently, a systematic examination of the area was conducted; the ground was examined, rocks and debris turned over. Signs and estimates of the number of animals involved were noted. Specifically, the following was of concern: live animals, tracks, burrows, runs, nests, scats, food remains, carcasses and suitable habitats or refugia. Particular attention was given to noting any rare or endangered species which occur or might occur at the site.

Disposal Areas 1 and 3 have little vegetation or suitable habitat for species of concern. Therefore, species are probably limited and signs can provide (along with watching for live animals) information necessary to provide a checklist and sound estimate of species numbers. Disposal Area 2, however, has a good quality habitat, vegetation obscures the substrate, and the potential for species diversity is high. Therefore, in addition to the above observation, 50 Sherman live traps (4" x 4" x 10") baited with rolled oats were set for about a 24-hr period. The traps were set in a systematic fashion (Fig. 4) at 25-m intervals. The trap setting covered the optimal areas of species occurrence and was determined by an initial reconnaissance study. Sex, species and trap number of each animal caught were noted. Keys for taxonomic identification are listed in Table J1, Volume 2.

HABITAT DESCRIPTION - AQUATIC SITES

Aquatic Sites 1-14 (Fig. 1) and Disposal Areas 1 and 4 (Fig. 2)

Defining habitat as "good" or "bad" is subjective because a given set of environmental conditions are good or bad depending on what fish and wildlife are being considered. High summer temperatures, low oxygen levels, muddy substrate and poor water quality make the Buffalo River "poor" habitat for salmonids, "moderate" habitat for contrarchids and "good" habitat for carp, suckers and bullheads. Even this evaluation is relative because centrarchids, carp, suckers and bullheads would do even better in less disturbed habitat

In the following habitat appraisals, several characteristis important to fish have been used to determine whether a habitat is good or bad. "Good" habitat is considered stable over time (i.e., not affected by a perturbation such as prop wash) with a diversity of substrates and cover (e.g., macrophytes) plus good water quality. "Poor" habitat lacks cover and substrate, diversity, stability of environment or water quality in several of these categories. "Moderate" habitats fall between extremes, being deficient in one or a few categories listed above. Fish species, diversity and abundance are also measures of habitat quality. A diverse, abundant fish assemblage generally indicates "good" habitat while low abundance and diversity generally indicate "poor" habitat.

Disposal Areas

Disposal Area 1

Disposal Area 1 is a small embayment bordered by rubble rip-rap on the north, a trash strewn gravel-cobble-beach on the east and concrete walls on the south. Bank vegetation is non-existent to the north and south and consists of sparse weeds and shrubs to the east. Further description of this vegetation is presented in Disposal Area 1, Terrestrial Vegetation. Shallow areas near shore drop off slowly to approximately 5 m deep throughout most of the bay. The bottom is covered with a luxurious growth of aquatic macrophytes by July. By September, the embayment is best described as choked with weeds. The section on Disposal Area 1, Aquatic Vegetation discusses this further. Substrate is sand-gravel-cobble near shore depending on area examined. In deeper water a dark brown gelantinous type sediment (gyttja) was observed. There was evidence of fish reproduction, as yearling rock bass were observed while electro-shocking and ichthyoplankton were found. The area (weedy and shallow) provides good habitat for centrarchids, carp, bullheads and other species as evidenced by our sampling.

Disposal Areas 2 and 3 (see sections titled Disposal Areas 2 and 3, Vegetation)

Disposal Area 4

The breakwall of Disposal Area 4 is formed of cubical blocks of rock (~1m x .5m x .5m) with ~15-cm cracks between them. The breakwall drops rapidly to ~8 m and can not be seen from the surface 3 m from its emergence. Luxurious growths of Cladophora are evident on the breakwall by August. No macrophytes were evident at this site after a systematic survey of the area (see Disposal Area 4, Aquatic Vegetation). Rock bass, smallmouth bass and yellow perch were shocked from cracks between blocks. This would seem to be an excellent habitat for sheltering young fish although few were observed. Nesting by bass appeared extensive but few ichthyoplankton were found (see Disposal Area 4, Ichthyoplankton). The major problem for fish inhabiting the west side of the breakwater is surf. During storms, wave action is intensive in this area with waves breaking over the jetty. During one storm, part of the breakwater was damaged. Small fish would have a difficult time surviving in this area.

<u>River</u> (Stations 10-14, Fig. 1)

Station 14

This station is located on the west shore of the river, just below the bridge below the fork of the river. The water depth drops to 8+ m within 3 m of shore. Banks are steep and formed of gravel and trash. Shoreline vegetation consists of three trees, sparse grasses, weeds and bushes. No macrophytes were observed. Deep water sediment is gray-black gyttja. Prop wash from ships often disturbs bottom dramatically increasing turbidity. Based on the small numbers of fish electroshocked and the rapid drop-off along the muddy shore, the fish habitat is extremely poor.

Station 13

This station is located on the east shore of the river at a bend in the river. Water depth is shallow with a slower drop-off to 8 m. Banks are steep and sandy with staghorn sumac. Aquatic macrophytes are not abundant. Deep water sediment is characterized by dark gray clay. However, the shallow area is sandy and was observed as a spawning and nesting site for centrarchids, especially pumpkinseeds.

Station 12

This site is located on the west shore of the river between concrete walls. The shore embankment is steep with crushed cement and boulders. Bottom is crushed cement, sand and posts. Shoreline vegetation consists of several trees hanging over the river. No macrophytes were observed. Deep water sediment is gray-black gyttja. The diversity of substrate provides moderately good fish habitat but is the only such area in the vicinity, as concrete docks line both sides of the channel up and downstream.

Station 11

This site is located at the junction of the river and the Ship Canal. Banks are rip-rap with scattered trees. Shallow substrate is boulders with sunken pier posts. Macrophytes were present in summer. Deep water sediment is gray-black gyttja. The area provides good fish habitat as evidenced by electroshocking and because boulders provide protection and shelter.

Station 10

This site is characterized by old pier posts (many sunken) and a very steep drop-off to ~8 m. The bank is steep with cement chunks, logs and trash rising to a parking lot. No aquatic or terrestrial vegetation was observed. Bottom sediments are gray-black gyttja. The moderately good fish habitat near shore due to sunken posts is compromised by the great depth increase directly offshore.

Evaluation of River Stations

The Buffalo River is generally poor fish habitat in comparison to undisturbed rivers. Bank vegetation is sparse or replaced by concrete and rubble. The river bank has been extensively modified for industrial development. The river basin has been previously dredged.

Water quality is low as evidenced by the many oil slicks on the surface, presence of chemical dyes in the water, and by the number of industrial sewers entering the river. Yet carp, white suckers, bullheads and pumpkinseeds apparently are year-round river residents while golden, emerald and spottail shiners, drum and other species utilize the river for spawning. In fact, ichthyoplankton were found (in very small numbers) at each of the river stations, indicating that water quality and habitat conditions permit at least limited reproduction. However, the overall abundance and diversity of fish in the Buffalo River are much lower than in an equivalent undisturbed river. For example, Oak Orchard Creek, a much smaller stream on Lake Ontario, is literally teaming with fishlife compared to the Buffalo River (Makarewicz et al. 1979). Because so much of the bank is artificial and drops off quickly to 8 m, the amount of shallow, protected habitat necessary for the young of most fish species is small. This limit on suitable habitat plus overall poor water quality keeps fish populations relatively impoverished.

Harbor (Stations 1-9, Fig. 1)

Station 9

Station 9 is located by a concrete wall bordered by rip-rap on the river side of the Coast Guard Station. No shoreline vegetation is present, but aquatic macrophytes were present in summer. Substrate consists of large boulders. Deep water sediment is gray-black gyttja. The area is an excellent fish habitat as evidenced by the variety and quality of fish electroshocked and ichthyoplankton netted.

Station 8

This station is a relatively shallow water area near the north breakwall. Bottom sediment consists of sand with large beds of macrophytes evident by July. Schools of ichthyoplankton were observed in July.

Station 7

This station is a deep water site between North End Light and Old Breakwater. Bottom sediment consists of cobble. Aquatic macrophytes were not evident in dredge hauls in July.

Station 6

Station 6 is a deep water site in mid-harbor channel between the Coast Guard Station and Disposal Area 3. Bottom sediment consists of cobble and gravel. Aquatic macrophytes were not evident in dredge hauls in July.

Station 5

Station 5 is a shore area that consists of high banks of concrete slab located off Disposal Area 3. Sparse weed and shrub vegetation with few macrophytes is evident along shore. Bottom sediments are sand and cobble. Station 5 is an unlikely spawning habitat due to exposed location of unstable substrate. Few fish were electroshocked here, especially before July.

Station 4

This is a deep water area in the channel between Old and South Breakwaters. Bottom sediment consists of cobble and gravel. No macrophytes were observed in this area.

Station 3

This station is in the small boat harbor. Shoreline consists of rocks and boulders from the artificial jetty. Abundant aquatic macrophytes were observed in summer. Station 3 is an excellent centrarchid habitat as evidenced by electroshocking success in summer.

Station 2

Electroshocking was along the rubble-strewn outer wall of the small boat harbor breakwater. Macrophytes were present by August. Bottom sediment consists of large boulders which provide moderately good habitat for small fish as evidenced by electroshocking results.

Station 1

This is a deep area (~9 m) located at the end of south jetty. Bottom sediment consists of mixed cobble and gravel. No aquatic macrophytes were evident in July dredge hauls.

The lower turbidity and greater clarity of the water suggest that water quality in the harbor is much better than in the river. Substrate diversity is also greater. Accordingly, fish species diversity is greater with many annual residents (e.g., yellow perch, rock bass) and diverse, often seasonal, game fishes (e.g., salmonids, pike). Cracks between breakwall stones (e.g., Station 4) plus boulders and cobble (e.g., Stations 2 and 6) provide shelter for fish in deep waters. Shoreline habitats in the harbor are sparsely vegetated (except for summer aquatic macrophytes) and lined with cobble, boulders or debris. Wave action makes many of these areas unstable, and fish abundance is low (e.g., Station 5).

Abundant yellow perch and shiner ichthyoplankton demonstrate the suitability of the harbor for open water spawners. Certain areas (e.g., Station 6) are particularly attractive to ichthyoplankton of these species. Other species (e.g., centrarchids, drum) appear to utilize shallow, weedy areas like the Small Boat Marina. Carp and suckers are found throughout the harbor.

DISPOSAL AREA 1 (Fig. 2): EXISTING CONDITIONS

Fish and Ichthyoplankton (Tables B1-B4, C1-C3, E1-E4 in Volume 2)

Disposal Area 1 (Fig. 2) provides the most diverse and the second most productive ichthyoplankton area in the entire study area. Fry larvae of emerald shiners, yellow perch, golden shiners and pumpkinseeds were observed with each having a density of $\sim$10 larvae/10 m^3 of water (Fig. 5).

The major adult fishes sampled in Disposal Area 1 were pumpkinseeds, yellow perch and bullheads plus some largemouth bass, rock bass, muskellunge, carp and drum. By summer the area is ideal for centrarchids and bullheads as macrophytes fill the embayment. As mentioned, ichthyoplankton sampling revealed centrarchid reproduction, while young of the year fish were observed while electroshocking. Carp and drum may also enter the area to spawn. Two muskellunge, shocked in May, indicated that either spawning or foraging was taking place. Disposal Area 1, much like the Small Boat Marina, is rich in macrophytes which shelter and support centrarchids and other species. It is the largest, most obvious nursery area (shallow water, stable substrate, macrophytes) in the harbor.

Macrobenthic Invertebrates

Disposal Area 1 is actually a bay off the Outer Harbor possessing a gyttja type sediment. The macrobenthic community is dominated by Gastropoda (snails) and Pelecyopoda (clams), together, accounting for 94.5% of the organisms sampled (Table 3). The snails Amnicola limosa, A. integra, Bithynia tentaculata, Valvata sincera, V. tricarinata and the clam Pisidium spp. are the most abundant invertebrates having densities in excess of 3,000 individuals/m^2 in June (Table H1-H2, Volume 2). Diversity and standing crop of the benthic community were high with mean densities of 10,050/m^2 and 20,680/m^2 in June and September, respectively (Table 2). These invertebrate densities are similar to other bays and harbors in the Great Lakes; for example, about 2,000 to 50,000/m^2 in Hamilton Bay (Johnson and Matheson 1967), 50,000 commonly and up to 200,000/m^2 in Toronto Bay (Brinkhurst 1970), and 21,000/m^2 in Oswego Harbor and River (Kinney 1972). Little change in overall composition was evident between June and September except for the increase in Oligochaeta from 0.06 to 4.6% of the benthic community.

Aquatic Vegetation (Table I1, Volume 2)

Certain vegetation appeared to grow in discrete beds across the entire site, particularly masses of Myriophyllum. Aside from that, nothing that suggests patterns of vegetation on Disposal Area 1 appeared from this survey.

Myriophyllum is of limited value directly as a waterfowl food. However, portions may be eaten and may support insects of significance. Vallisneria, a prime food for certain waterfowl, was observed at every offshore sampling station. Also various Potamogetons were ubiquitous and serve as prime waterfowl food. A highly developed and productive aquatic plant community exists that provides excellent habitat for ichthyoplankton and adult fish.

Terrestrial Vegetation (Tables I3 and I4, Volume 2; Fig. 3)

Eight species of woody plants and 26+ species of herbaceous vegetation were observed on Disposal Area 1. A sparse, opportunistic transitional vegetation was distributed along a narrow strip between the pebble beach and the railroad bed (Fig. 3).

The area involved is small, although it does represent a critical erosion-prone zone. In fact, the old railroad bed between the beach and Fuhrmann Boulevard has been eroded away. No plants of significance to wildlife value were observed in the area. No reliable cover for birds and wildlife exists through the winter.

Birds (Tables F1-F29, Volume 2)

Disposal Area 1 is shallow, open water, bordered on three sides by jetty, rubble beach and an abandoned grain elevator. The fourth side (westerly) is open to the Outer Harbor.

Submerged, rooted macrophytes and their associated invertebrates and fish provide food resources for diving waterfowl, gulls and terns. The rubble beach has a scattering of small (~5 m) willows. Sparse opportunistic vegetation grows along the abandoned railroad bed which separates the beach from Fuhrmann Boulevard.

Since it is somewhat protected from open lake winds and does have waterfowl food resources, it attracts diving ducks and geese during migration. It freezes in winter. More than 38 species of birds were observed on or over the site, more than at any other site under consideration.

The most abundant birds observed were ring-billed gulls and herring gulls. During migration large numbers of lesser scaup and canvasbacks fed and rested on the site. Game birds included mallard, greater scaup, lesser scaup, blue-winged teal, redhead, black scoter (November), common goldeneye, canvasback, ring-necked pheasant, Canada goose, white-winged scoter (November) and common eider (November). Migrating birds were dominated by lesser scaup and canvasbacks in autumn and red-breasted mergansers and common mergansers in spring. Other common species observed included red-winged blackbirds, spotted sandpipers and common terns. Some of the less common birds observed at Disposal Area 1 included laughing gull, black scoter, white-winged scoter and common eider. No endangered or rare species were encountered, except that laughing gull is apparently uncommon to that locale. There are interactions of birds with the adjacent Tifft Farms Preserve.

Common waterbirds, shorebirds and the smaller common terrestrial birds use this aquatic site on an incidental basis. They forage and rest in this area but do not nest on this small embayment adjacent to the Outer Harbor.

Mammals (Table 4)

Except for a small number of meadow voles along the border of this area, the mammalian species are sparse and transient. The few larger mammals noted, such as the raccoon and dog, utilize the area as a route to other areas and to forage and are thus transients throughout the year.

Amphibians and Reptiles (Table 4)

Although considerable effort was made in searching for these species, none were observed.

DISPOSAL AREA 2 (Fig. 2): EXISTING CONDITIONS

Vegetation - Spring (Table I3, Volume 2; Fig. 8)

In May, meadow vegetation is dominated by grasses with scattered herbs. Areas of secondary succession contain elderberry stands and clumps of red panicled dogwood. The western portion contains a moist depression where two species of Umbelliferae dominate. Ditches along the east side of the railroad contain willow stands, areas of standing water with cattails and *Iris* sp. The east meadow becomes wetter as one proceeds south. Hummocky grass stands dominate. The northern portion of the east side contains a stand of elderberries, a stand of Jerusalem artichoke and dogbane. Scattered willows and poplars occur along the shoreline of the Buffalo River. Starry false Solomon's seal [*Smilacina stellata* (L.) Desf.] occurs sparingly and was a surprising find in the area. Staghorn sumac occurs along the railroad banks.

Vegetation - Summer (Table I5, Volume 2; Fig. 9)
East side of the north-south railroad

The eastern portion is wet meadow with interspersed clumps of shrubs and masses of tall composites. The north bank is bordered by willow and an occasional boxelder. Staghorn sumac occurs on the active railroad bank. A ditch runs along the easterly railroad bank and contains emergent species such as common cattail, iris, willow herb, jewel weed, and willow trees and shrubs.

As indicated on the map, a stand of Jerusalem artichoke, wild parsnip, elderberry and staghorn sumac occurs in the northern portion.

Coarse meadow vegetation consisting of Canada thistle, bindweeds, spreading dogbane, common milkweed and grapevines characterize this section. Grasses occur throughout with red fescue most common.

The coarse meadow vegetation gradually grades into a wet red fescue meadow to the south. Shrub thickets of red panicle dogwood, silky dogwood, northern arrow-wood occur as indicated on the vegetation map (Fig. 8). Sedges, Canada thistle, vetch, lance-leaf goldenrod, Canada goldenrod and other herbs are interspersed throughout.

A stand of staghorn sumac borders a portion of the eastern shoreline. Willows and quaking aspen occur along the active east-west railroad. A depression containing cattail, iris and water parsnip is located along the east-west railroad.

Disposal Area 2 is essentially wet meadow in its easterly portion. Wetland shrub, sedge and grasses form small tussocks surrounded by water. The portions of the site adjacent to the railroad are deeper drainage channels in which some *Typha* grows. In fact, muskrat houses were observed. Mature willows grow adjacent to the north-south railroad and along the river. Ditches traverse the site and drain into the north-flowing channel adjacent to the tracks.

Vegetation - Summer (Table 16, Volume 2; Fig. 9)
west side of the north-south railroad track

The western portion is generally higher, drier and grassy although the central depression between is low. In general, composites fill the depression and a *Rhus* thicket borders it. The river bank near the railroad bridge is bordered by willow, cottonwood, boxelder, hawthorn and ash. Staghorn sumac, grapevines, grasses and a mixture of herbs are interspersed.

Abandoned railways loop through the west side of the study area. This disturbed area is now predominantly dry meadow vegetation. A depression within this railroad loop contains stands of angelica elderberry and Jerusalem artichoke. Staghorn sumac, quaking aspen and willow occur on the border as indicated on the vegetation map. Staghorn sumac borders much of the north-south railroad, with honeysuckle occasionally encountered. Dry meadow vegetation is encountered throughout the area exclusive of the depression. Coarse grasses are most common with herbs interspersed.

The south-western shoreline is bordered with willow, Mexican bamboo, staghorn sumac and ash. An active road runs parallel to the north-south railroad for approximately 400 m.

In total, 15 species of woody plants and 75+ species of herbaceous vegetation were observed. Plant cover did exist through the winter above and below the snow cover. This richness of vegetation covered the entire site, although not homogeneously, and provided requisites for a richness of fauna, including reproductive populations of game birds and animals.

Birds (Tables F1-F29, Volume 2)

Disposal Area 2 is bisected by a north-south railroad. The easterly portion is mostly wet meadow, with interspersed clumps of shrubs and masses of tall herbaceous plants like composites. The westerly portion is drier, with abandoned railroad beds leading to an abandoned grain elevator. Grasses, composites and shrubs; like staghorn sumac, predominate. The site occupies a loop in Buffalo River and is surrounded on three sides by the river. To the south are railroad yards with large abandoned areas of similar vegetation. Tifft Farms Preserve adjoins to the south and west. Birds move among the whole complex of the Preserve, railroad yards and Disposal Area 2. Pheasants commonly fly northeasterly across the river when flushed.

More than 37 species of birds were observed on or over Disposal Area 2, almost the same number as were found on Disposal Area 1. The most abundant birds observed were red-winged blackbirds, song sparrows, ring-necked pheasants, American robins, starlings, house sparrows and common grackles. There may be transient accumulations of swallows, gold-finches and "patrolling gulls." Mallards may congregate in the adjacent river in winter. Other common species observed included willow fly-catchers, rock doves, brown-headed cowbirds, common flickers, and yellow and other warblers during migration. Some of the less common birds observed, but of interest, were red-tailed hawk, kestrel, peregrine falcon and Coopers hawk. The peregrine was the only endangered species observed near the site; it was observed trying to feed very near the site on two occasions.

Although it was not a requisite of this study, an attempt was made to identify pheasant nesting success. Two nests were found, both on the westerly portion of the site. However, the fledged and unfledged young were usually found in the wet meadow east of the north-south railroad.

By the May 28 site visit, two broods were seen, one fledged. During the June 15 visit, four different broods were observed with 2, 6, 7 and 5 fledglings. One female apparently without young was observed. Our best estimate is that at least 5 pheasant broods were raised on Disposal Area 2, varying in size from 2 to 11 young. The varying ages of the pheasant broods observed during the spring of 1981 suggests that re-nesting was common and successful.

In March 1982, 45 pheasants were observed on the adjacent southerly railroad. The one carcass observed during the study contained wheat and grain mash in the crop, apparently from spillage along the railroad.

No waterfowl nests were observed on the site, although young mallards were observed on the adjacent Buffalo River. One woodcock nest was observed. Nesting success was not determined.

Mammals (Table 4)

This area has a large population of meadow voles whose number fluctuates only slightly throughout the year. It is relatively productive in game species, harboring a number of rabbits, muskrats and woodchucks. In lesser numbers are found small shrews, raccoons and skunks. Rats were observed throughout the area. All of these are believed permanent residents of the area.

Amphibians and Reptiles (Table 4)

Only a few species were found at this area. Due to the cover and moistness, with temporary standing water, leopard frogs occur in high numbers and are most prevalent during the spring and summer. Garter snakes predominate the reptiles noted and should occur on the area year-round but hibernate during the colder seasons. Turtles are few and seem transient, going from one part of the river to another as well as scavenging on the nearby shore.

DISPOSAL AREA 3 (Fig. 2): EXISTING CONDITIONS

Vegetation (Tables I3 and I7, Volume 2; Figs. 10 and 11)

Three species of woody plants and 44 species of herbaceous vegetation were observed on Disposal Area 3. The site is highly disturbed because of its use as a bulk storage area for salt, limestone sand and taconite. The vegetation is sparse and opportunistic with much of the site devoid of vegetation.

The vegetation occurs in four subareas between the roads and storage piles. Some patches have the appearance of pioneer vegetation invading a dunes area. Another larger area is dry old-field, dominated by ragweed, goldenrod, various grasses and the like. The trees are few, of seedling, sapling and pole-size. What is present now may not be present a few months later because of shifting use patterns. Little reliable cover existed during the winter.

Birds (Tables F1-F29, Volume 2)

Pheasants use this terrestrial area year-round and may nest there occasionally, although no actual nesting sites were found in this area. A female mallard was observed in nesting behavior although no nest was found. Red-winged blackbirds, killdeer and spotted sandpipers do nest on the site. A total of 26 species of birds were observed. The most abundant birds were ring-billed gulls, herring gulls and rock doves, with killdeer and spotted sandpipers in season. Migrating birds were dominated by various sparrows and snow buntings.

Disposal Area 3 is seriously and constantly disturbed because of the bulk storage and transshipment activities going on there. Despite those activities, it is a courtship and nesting area for migratory birds such as killdeer and spotted sandpipers. Most other birds observed there appeared to be transients who merely rested or foraged there briefly.

As pointed out elsewhere, the vegetation is mostly opportunistic herbaceous vegetation. The very heavy usage and almost constant physical disruption caused by present storage activity keeps this site almost bare and of limited wildlife value. However, it does provide some year-round habitat for pheasants.

Mammals (Table 4)

Most populous are meadow voles, and they occur in small numbers only. Norway rats and two rabbits are the only other residents believed to inhabit this sparsely covered area. Large mammals, of which there are very few, are only transient, moving across the area to other places or to scavenge.

Amphibians and Reptiles (Table 4)

None were noted or expected to inhabit the rather barren, dry area.

DISPOSAL AREA 4 (Fig. 2): EXISTING CONDITIONS

Fish and Ichthyoplankton (Tables B1-B4, C1-C3, E1-E4 in Volume 2)

In Disposal Area 4 only a few smelt larvae were observed (Fig. 5) even though twice the sampling effort of Stations 1-14 occurred. A similar low abundance and low diversity occurred at all of the lake stations near the breakwall (Stations 1, 4, 7 and Disposal Area 4). In fact, only smelt larvae were caught at the lake stations. Low ichthyoplankton abundance in Disposal Area 4 probably arises from two causes: (1) extremely rapid drop-off from the breakwater to deep water makes the area unsuitable for shallow water spawners; and (2) wind, wave and current action outside the breakwalls are not conducive to survival of larvae of pelagic spawners. Exceptions to these limitations might be nesting species, such as smallmouth and rock bass, that were observed between breakwall blocks. However, no ichthyoplankton of rock and smallmouth bass were caught in Disposal Area 4.

Disposal Area 4 had a higher adult fish catch per unit effort and species diversity than Disposal Area 1 (Table 5), but these differences were not significant ($P > 0.05$, Mann-Whitney U-test). Severe clogging of the gill nets in Disposal Area 1 by macrophytes in July and September (which greatly reduced fishing effectiveness) probably accounts for the lower catch per unit effort. Averaged over seasons, one would expect the nearshore lake to have a more diverse adult fish assemblage than small, shallow, warm embayments.

The outer breakwall fish assemblage is dominated by rock bass, yellow perch, stonecats and smallmouth bass plus walleyes and logperch.

These species shelter among breakwall blocks, and several (rock bass, smallmouth bass) may spawn between blocks forming the breakwall. We observed fishes in these cracks while electroshocking. Walleyes and smallmouth bass undoubtedly forage on the percids and rock bass. The area outside the breakwall is productive for walleye and popular with fishermen.

Macrobenthic Invertebrates

The macrobenthic invertebrate community is characterized by a very low diversity of organisms and extremely low abundance (Table 2). Gastropoda (snails) and Pelecyopoda (clams) were dominant comprising 75.1% of the benthic macroinvertebrates. However, the Chironomidae and the Oligochaeta were also important accounting for 23.9% of the organisms sampled (Table 3). *Amnicola integra* was the most abundant snail and *Pisidium* spp. was the most abundant clam (Tables H1-H2, Volume 2).

The low abundance of macroinvertebrates appears to be a function of substrate type and location. Disposal Area 4 has a mixed cobble and sand substrate unlike the highly organic gyttja type sediment of Disposal Area 1. Generally, a gyttja sediment will provide a more productive and diverse assemblage of macroinvertebrates. At Disposal Area 4 the bottom appears to be scoured by the currents into the Niagara River and by considerable wave and surf generated by storms on the nearby breakwater.

Aquatic Vegetation (Table I2, Volume 2)

No aquatic macrophytes were observed on Disposal Area 4. The area was sampled in 100-m intervals along seven east/west transects. Apparently, the depth of the water (3-11 m) and its low transparency rendered the bottom below the compensation depth of aquatic plants.

<u>Birds</u> (Tables F1-F29, Volume 2)

Disposal Area 4 may be an early seasonal resting area for waterfowl and a minor feeding area for gulls and terns. Since no aquatic macrophytes were found on the site, birds requiring such habitat will not be attracted. Its current openness to lake weather limits its value as a refuge. It freezes in winter and remains ice-choked until the ice boom is removed.

Almost all the birds observed on or near Disposal Area 4 were merely flying over it. Probably even the "gull patrol" was present only because of favorable air currents dependent upon the jetty. A total of only 12 species of birds were observed; the most abundant being the ring-billed gull and herring gull. Other species observed included common terns, mallards, various swallows, lesser scaup, old squaw, black ducks, buffleheads and Sabine's gulls. Of these, none except common teals, mallards and <u>Larus</u> gulls actually alighted on the area. All others only incidentally flew over the site. Sabine's gull is relatively rare to the Buffalo area.

THE BUFFALO RIVER, SHIP CANAL AND OUTER HARBOR (Fig. 1): EXISTING CONDITIONS

Physical Aspects

The dredged portion of the river (up to Station 14, Fig. 1) has a low gradient (17 cm/km) and low current velocities and is occasionally subject to reversals in flow direction as a function of changes in Lake Erie water levels (EPA Report 1975). The bulk of the flow from the river enters the Black Rock Canal near the beginning of the Niagara River (Black *et al*. 1980). Currents in the Outer Harbor, an artificial harbor created by construction of breakwaters in Lake Erie, generally flow in a northwest direction towards the Niagara River and the Black Rock Canal.

Sediment types within the project area are variable in type (Table 6). Moving northward from the southern extreme of the project area (Station 1), a mixed cobble-sand-gravel bottom is evident at Stations 1-5 (Fig. 1). Further northward, the influence of the discharge of the Buffalo River becomes evident (Stations 6, 7 and 8) as a coprogenous sediment mixture consisting of particulate remains, inorganic precipitation and minerogenic matter (gyttja) is observed. The channel of the Buffalo River and Ship Canal also possessed gyttja type sediments. However, some gravelly type sediments were observed toward shore on the inward bend near Station 13.

Chemical Aspects

Within the project area, the waters of the Buffalo River, the Ship Canal and the Outer Harbor are not anaerobic, that is they do contain dissolved oxygen. Hydrogen sulfide was evident in the sediments of the Ship Canal, the Buffalo River and Stations 6 and 8 near the mouth of the river.

Toxic Chemicals

The Buffalo River has a history of chemical and domestic sewage pollution and is considered among the most heavily polluted waters in the United States (Black et al. 1980). Contamination of Buffalo River sediments with industrial organic compounds, including polycyclic aromatic hydrocarbons (PAH) (Black et al. 1980) and aromatic amines (Nelson and Hites 1980), is evident along the entire length of the project area (Nelson and Hites 1980). In addition, several aromatic amines, formerly produced by a dye manufacturing plant, have been detected in fish from the Buffalo River. Pathologic examination of fish in 1980 revealed a high incidence of proliferative tissue lesions present among goldfish x carp hybrids, sheepshead, white suckers and bullheads (Black et al. 1980). Our sampling effort in 1981-1982 also revealed a high incidence of lesions in bottom-feeding fish. The neoplasia in bottom-feeding fish is attributed to chronic exposure to a complex of PAH pollutants. Results of Ames bacterial mutagenesis assays revealed a strong correlation between the level of mutagenic activity of sediment extracts and the proximity of a local dye manufacturing plant. These pollutants are mutagenic and there is a strong correlation between mutagenicity and carcinogenicity (Commoner et al. 1976). The sediments of the Buffalo River contain potential carcinogens (Black et al. 1980).

Ichthyoplankton (Tables C1-C3, Volume 2)

Larval fish tows are selective in that they sample species inhabiting the more open mid-water areas. They do not accurately represent species which inhabit very shallow or very deep zones. Species which hide between rocks or other structures are not sampled successfully. Larvae lying on the bottom are also difficult to sample due to irregularities in the bottom which snag or foul the sampler.

Ichthyoplankton were sampled in late May, mid-June and mid-July. In May two yellow perch (quite immature) were found. In June yellow perch larvae were more numerous and widespread in the project area and advanced in development; smelt appeared in Outer Harbor samples. In July emerald shiners dominated samples, but yellow perch, smelt, gizzard shad, pumpkinseeds, rock bass, carp and golden shiner larvae were observed (Tables C1-C3, Volume 2). Figure 5 displays total seasonal ichthyoplankton abundance by stations or disposal area.

Ichthyoplankton densities ranged from 0 to 35 larvae/10 m^3 for a given site, values consistent with studies elsewhere in North America (Table 7). Within the project area, differences do occur in ichthyoplankton abundance which can be arranged into three groups: (1) Buffalo River Stations 10-14 ($\bar{x}$ = 4.86 larvae/10 m^3, SE = 1.56; (2) Outer Harbor Stations 2, 3, 5, 6, 8, 9 and Disposal Area 1 ($\bar{x}$ = 22.99, SE = 6.24); and (3) Lake Stations 1, 4, 7 and Disposal Area 4 ($\bar{x}$ = 2.95, SE = 1.50). Station 9, at the river mouth, is included with Outer Harbor samples because of its predominately harbor-like conditions (water quality and physical character) and because of observed ichthyoplankton density similarities. Similarly, Disposal Areas 1 and 4 were included with Outer Harbor and Lake samples, respectively. Mann-Whitney U-tests indicate that ichthyoplankton are significantly more abundant in the Outer Harbor than in the lake or the river ($P < 0.05$).

Low ichthyoplankton density in the Buffalo River probably stems from two factors: (1) low water quality created by ship traffic (e.g., turbidity created by prop wash & discharge of fuel oils from vessels) and industrial pollutants; and (2) lack of shallow, shoreline areas necessary for spawning by typical river species (carp, white suckers, bullheads and sunfish) by past dredging and channelization. Low ichthyoplankton density in the lake beyond the harbor breakwalls also probably arises from two causes: (1) extremely rapid drop-offs to deep water make the area unsuitable for shallow water spawners; and (2) wind, wave and current action outside the breakwalls are not conducive to survival of larvae of pelagic spawners such as smelt and yellow perch. Exceptions to these limitations might be nesting species such as smallmouth and rock bass. Adults of these species were observed between breakwall blocks, but no ichthyoplankton of either species were sampled outside the breakwall.

The Outer Harbor lacks the disadvantages of the river and the lake relative to ichthyoplankton. Water quality is good, sufficient shallow areas exist, and wave action is largely diminished by the breakwalls. The higher abundance of ichthyoplankton reflects these favorable conditions.

However, shoreline fish populations of the Outer Harbor are relatively impoverished (e.g., Station 5), except in the Small Boat Marina and Disposal Area 1. Although few ichthyoplankton were found in the Small Boat Marina, we observed numerous juvenile centrarchids and percids. The shallow, weedy, protected nature of the marina is ideal for ichthyoplankton production. Either boat traffic significantly inhibits reproduction in the marina or (more likely) we failed to sample larger numbers of ichthyoplankton because the sampler was repeatedly clogged by weeds. Disposal Area 1 also has ideal ichthyoplankton production conditions, and there we found the second highest larval density. This is the most diverse and most productive ichthyoplankton area of the harbor. Station 6 had a high density due to the sampling of a school of emerald shiners, but the station lacked the diversity of Disposal Area 1.

Fish - Overview (Tables A1-A11, D1-D12, Volume 2)

Two assemblages of fish (with some overlap among assemblages) utilize the study area: lake residents that seasonally enter the river or harbor, and harbor and river residents (Figs. 6 and 7). Mean abundance of fish in gill net samples (average number of fish per station per sampling period) was compared statistically using Mann-Whitney U-tests. No significant differences in fish abundance ($P < 0.05$) were observed among river (Stations 10-14; 11.0 ± 3.6 fish/sample), Outer Harbor (Stations 2, 3, 5, 6, 8, 9, DA1; 10.1 ± 3.5 fish/sample) and lake (Stations 1, 4, 7, DA4; 9.2 ± 3.6 fish/sample) sampling sites.[1] This result contrasts sharply with ichthyoplankton results where larval abundance was significantly lower in the river and Outer Harbor stations. Thus it appears that while ichthyoplankton are adversely affected by environmental conditions in the river and lake, adult fish are not.

Shannon-Weaver diversity indices for gill netting data were averaged over samples within stations and disposal areas. Although river diversity was somewhat lower, Mann-Whitney U-tests revealed no significant differences ($P > 0.05$) in diversity among river (0.37 ± 0.12), harbor (0.44 ± 0.08) and lake (0.44 ± 0.11) stations. Thus, while species composition of adult fish varied considerably among river, harbor and lake stations, overall catch per unit effort and diversity indices did not vary (Table 5). Composition of fish does differ between Outer Harbor, river and lake and is discussed in the following sections.

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[1] The mean for the lake stations does not include the 200+ yellow perch caught in early May at Station 4. These fish were obviously in spawning condition and represented a lake population moving into the Outer Harbor to spawn.

<u>Fish - Buffalo River and Ship Canal</u> (Stations 10-14) (Fig. 1)

Carp, white suckers and shiners dominated samples in the river throughout spring and into summer, but bullheads, gizzard shad and pumpkinseeds became more important as summer progressed. In April and early May, shiners (emerald, spottail and golden) and white suckers dominated the river station fish assemblage. Scattered carp, goldfish, carp x goldfish hybrids, yellow perch, drum and bullheads were also found. In late May and June, white suckers dominated with shiners, carp, pumpkinseeds, yellow perch and gizzard shad scattered throughout the samples. From July through September, carp, pumpkinseeds and gizzard shad dominated samples, with goldfish, bullheads, white suckers and yellow perch also present. After September, numbers of fish sampled declined sharply as water temperatures fell and fish movement activity declined. In the cooler water temperatures of spring and fall, occassional salmonids, muskellunge, pike and yellow perch were observed at river stations. Yellow perch were also observed during the summer in the river.

Carp, goldfish, goldfish x carp hybrids, bullheads, pumpkinseeds and some white suckers appear to be year-round river residents. Emerald, spottail and golden shiners and gizzard shad are pelagic lake species that utilize the river for spawning in spring and early summer. White suckers, redhorse suckers and freshwater drum are primarily benthic lake species that make spring spawning runs (especially pronounced for white suckers) into the Buffalo River and Harbor. Salmonids, muskellunge and walleyes found in the river were probably foraging on spawning shiners and gizzard shad in the spring.

References to the spawning habits of the species discussed below come from Scott and Crossman (1973). Carp and goldfish spawn in large groups from May to July wherever shallows exist; white suckers often spawn in rivers from early May to early June; shiners and gizzard shad frequently spawn in the lower reaches of rivers in May and June; and pumpkinseeds spawn by nesting in shallows in June and July. Drum spawn in the lower portions of rivers throughout the summer, but most were captured by us in May. Salmonids forage near shore in spring, move to deeper, cooler Lake Erie in summer, then return near shore or to tributaries in autumn. Lack of suitable substrate(gravel), water quality (flowing, highly oxygenated, pollution-free) and temperature makes successful salmonid spawning highly improbable throughout the study area. Muskellunge and walleyes also appear to forage in the lower river in spring and fall, but successful reproduction is unlikely due to the absence of suitable spawning habitat (shallow gravels for walleye, flooded weeds for muskies) and poor water quality.

Despite the occurrence of many species in reproductive condition (i.e., gravid) at times the literature suggests they should spawn, little evidence (i.e., few ichthyoplankton) of successful spawning was observed in the Buffalo River or Ship Canal (see Ichthyoplankton).

Water quality probably plays a major role limiting fish distribution and abundance in the river. The scarcity of river ichthyoplankton, despite obvious spawning utilization of the river by adults, indicates that the river is generally not suitable as a reproduction/nursery area. While lack of suitable reproductive/nursery habitat is a problem, the suitable habitat areas that do exist (see Habitat Description) should produce abundant river ichthyoplankton if water quality were not so poor (existence of high turbity, polycyclic aromatic hydrocarbons, aromatic amines, etc.) (Black et al. 1980, Nelson and Hites 1980).

<u>Fish - Outer Harbor</u> (Station 1-9) (Fig. 1)

Yellow perch, rock bass, white suckers and carp were the most abundant species sampled in the harbor. Important game fish sampled were walleyes, smallmouth bass, northern pike, muskellunge and an occasional salmonid. Also sampled were gizzard shad, emerald and spottail shiners. largemouth bass, pumpkinseeds, shorthead redhorse suckers, bullheads and stonecats. In April and early May, the harbor fish assemblage was dominated by cold water fishes primarily moving in from Lake Erie: shiners, yellow perch and white suckers dominated with northern pike, salmon and trout scattered among the samples. For example, in early May a large school (> 200 fish) of yellow perch in spawning condition were caught at Station 4. In late May and June the transition to a warmwater assemblage began: yellow perch, pumpkinseeds, rock bass, muskellunge, walleyes and white suckers dominated with carp, drum and stonecats mixed in. During the summer, carp, pumpkinseeds, gizzard shad and yellow perch dominated samples with smallmouth bass, rock bass and bullheads scattered through the samples. After September, as in the river, abundance of fish diminished in the Outer Harbor.

In many cases (smallmouth bass, yellow perch, white suckers, rock bass, stonecats and shorthead redhorse suckers) considerable interaction among lake and harbor populations appears to occur. In particular, three species (rock bass, smallmouth bass, yellow perch) frequently exhibited abundance peaks in the harbor during their expected spawning seasons (e.g., Fig. 7). It appears that while resident harbor populations of these species exist, they are greatly supplemented during the spawning season by lake populations that spawn in shallow nearshore waters.

The presence and abundance of yellow perch, rock bass, shiners, gizzard shad and smelt (mostly found dead after spawning and as ichthyoplankton) undoubtedly attract game fishes into the harbor from Lake Erie and the Niagara River. Especially in the Small Boat Marina (Station 3) we found northern pike gorged with yellow perch in April and early May. The habitat in the marina is an unlikely spawning site for pike, but fishermen indicated that pike extensively utilize (via drainage pipes) the Tifft Creek area, which is flooded in early spring, for spawning. Later in summer the marina becomes a weed-filled centrarchid nursery.

Walleyes were found in the harbor from late May through July and again in autumn, especially at deeper stations outside the breakwall (Stations 1, 4 and 7). The dietary preference of walleyes for yellow perch is well known (Forney 1965), and walleyes prefer to spawn over gravel-cobble substrates which exist throughout the harbor.

The Niagara River supports a major muskellunge population (Harrison and Hadley 1979), and individuals appear to enter the harbor and lower Buffalo River reaches to forage in spring and autumn and perhaps to spawn in spring. Muskellunge generally spawn in late April and early May, a time we observed them in the harbor.

Smallmouth bass probably spawn throughout the harbor area in May and June, preferring to nest over gravel-cobble substrates in deeper waters than other centrarchids. Largemouth bass and pumpkinseeds utilize weedy shallows to build nests and spawn.nearshore (particularly in the Small Boat Marina) from late May through July.

Yellow perch spawn in open waters from mid-April through May and are a major forage species for walleyes, pike, muskellunge and bass. We observed gravid yellow perch through May, and ichthyoplankton samples were dominated by yellow perch plus emerald shiners. Rock bass nest among rocks and weeds along shore and the breakwalls in May and June and also may serve as an important forage species.

In spring and early summer, the debris-strewn harbor shore has generally poor fish habitat due to unstable substrate, wave action and lack of terrestrial/aquatic vegetation. However, fish numbers along the shore had increased by August as had aquatic macrophytes. The harbor appears to have a well-balanced assemblage of predator and prey species that occupy an area of good water quality and diverse habitats. Muskies, pike, salmonids, shiners and gizzard shad appear to be temporarily present in spring and/or fall, but yellow perch, rock bass, smallmouth bass, largemouth bass, pumpkinseeds, suckers, carp and perhaps walleyes are permanent residents. This assemblage provides diverse, high quality opportunities for anglers.

ASSESSMENT OF IMPACT - PROPOSED DISPOSAL AREAS

Disposal Area 1 (Fig. 2)

Fish and Ichthyoplankton

Disposal Area 1 is used as a nursery area by numerous harbor and lake species, especially by centrarchids and perhaps by muskellunge. Spoil disposal here will completely destroy that nursery potential. It is well known that a significant reduction in the reproductive capacity of a species due to spawning bed damage could endanger species survival more than the effect of the loss of part of the existing adult fish population (Ricker 1945). Disposal Area 1 is the largest defined nursery area remaining in the Outer Harbor. Its destruction via spoil disposal could deplete harbor populations utilizing it for reproduction.

Macrobenthic Invertebrates

Benthic organisms are important in aquatic environments in that they function as the crucial link in a detritus-based food chain. They utilize organic matter and recycle nutrients that otherwise would collect and remain trapped in the sediments. Benthic organisms supply food to many species of fish and to other predatory aquatic organisms. Containment of dredge spoils above the water level of Lake Erie in Disposal Area 1 will completely eliminate the macrobenthic invertebrate community.

Aquatic and Terrestrial Vegetation

Of all the sites evaluated, using Disposal Area 1 as a landfill would have greatest impact on submergent aquatic vegetation. Furthermore, the vegetation is likely to be important to waterfowl and game fish of the area. To simply denude the terrestrial vegetation along the shoreline would likely produce significant environmental impacts because of the erosion-prone nature of the shoreline. However, a landfill on Disposal Area 1 would protect and extend the present shoreline. Any landfill operation would have little significant lasting impact on terrestrial vegetation because the present amount of terrestrial vegetation is small and is of an opportunistic nature.

Depending on how the site is finished in regards to cover plants and habitat types (i.e., wetlands, pond, etc.) after landfill operations have ceased, an improvement in quality of plants and terrestrial habitat is possible. Disposal of dredged materials could create new habitat for terrestrial wildlife by new construction methods. For example, the Army Corps of Engineers at Vicksburg has recently concluded a program describing methodology of creating habitat and describing the benefits of these "finishing" operations on quality of habitat and wildlife (see section on Habitat Development on Dredged Materials in this study). If the site were left unfinished, it is likely that larger quantities of vegetation similar to the current terrestrial plant community would initially invade the completed fill site. A brief survey by us of the previous disposal area north of proposed Disposal Area 1 (Fig. 2) supports this contention.

Birds

The site is an important migratory stop for certain diving waterfowl. The adjacent Outer Harbor and lake apparently do not provide the vegetation and associated invertebrates upon which scaup, canvasbacks, redheads and scoters feed. Dabblers, such as mallards and blue-winged teals, apparently can reach food in the shallows, although primary use for them seems to be as an open water refuge.

Most of the bird activity consists of overflights. However, spotted sandpipers, killdeer, red-winged blackbirds and even ring-necked pheasants feed along the narrow eastern shore.

Dredge spoil disposal at this site would eliminate the only shallow, productive, protected aquatic habitat in the entire study area available to waterfowl. Of the sites considered, disposing of dredged materials on Disposal Area 1 would have the greatest negative impact on birds. Depending upon how the habitat on this site were developed (if used as a landfill), there would likely be a shift in kinds of birds on the site. If it were finished like the adjacent, northerly fill site, rather undisturbed and with a pond, then one would expect nesting birds like mallards, black ducks, blue-winged teals, red-winged blackbirds, ring-necked pheasants, spotted sandpipers, green herons and song sparrows (see section on Habitat Development on Dredged Materials). If it were developed or constantly disturbed such as Disposal Area 3, the variety and numbers of birds would likely decrease and shift away from nesting birds to transitory visitors.

There is little aquatic habitat of this type (shallow, productive, protected) in the study area.

Mammals

Little and only temporary effects would be apparent to the sparse mammal life if the site were disturbed. Since the habitat for mammalian species is presently very poor with a lack of adequate vegetative cover and food plants, disturbance by filling could allow for improved mammalian habitat to develop.

Amphibians and Reptiles

Since none of these species occur on Disposal Area 1, disturbance by filling could only provide habitat more appropriate to these species. Some leopard frogs, but especially garter and brown snakes and turtles, may be found to subsequently inhabit this area once filled and early old-field succession begins.

Disposal Area 2 (Fig. 2)

Vegetation

Because of the indicator vegetation present, portions of Disposal Area 2 are likely to be considered wetlands under N.Y.S. Conservation Law. Certainly any fill operation is likely to destroy this vegetation, but it could return if the site were finished appropriately (see section on Habitat Development on Dredged Materials). In the interim, those fauna of interest (see Birds and Mammals, Disposal Area 2), which now thrive on the site, would be displaced and if sufficient alternate habitat of suitable quality is not present, they may be permanently lost.

Birds

The area is likely to be the most hospitable of any of the sites studied for certain terrestrial birds. Even though it is surrounded by industrial development and private homes across the river, it is relatively free of human predation and provides food and nesting sites. Together with the adjacent railroad yard and Tifft Farms, it forms a large, relatively undisturbed, interrelated habitat complex. In short, it is a refugium for birds that would not be expected in such a highly developed area. In particular, the apparent reproductive success of the local pheasant population is of some interest.

Pheasant populations are generally in decline throughout Western New York State (Dixon 1981). Disposal Area 2 appears to be an exception to this trend. Disposal of dredge spoils in this area will probably destroy valuable pheasant nesting habitat. Using this area for disposal will have the greatest immediate negative impact on nesting avians of any potential disposal area studied. Also, a peregrine falcon was observed near this site (see section on Endangered Species).

Whether the impact of a fill operation on Disposal Area 2 would extend permanently to adjacent areas, including the Tifft Farms Preserve, was not determined by the scope of this study. There is interchange of birds with surrounding areas in all directions. As discussed in Habitat Development of Disposal Areas, long-term impact would depend upon how the disposal area, if utilized, were "finished off."

Mammals

Disturbance to this site would immediately and drastically reduce the small mammal populations. Larger mammals would move from the area, probably to the nearby Tifft Nature Preserve. However, once the area were filled and if old-field succession were allowed, the mammal population would eventually restore itself by colonizing individuals from perhaps the Tifft Nature Preserve.

Amphibians and Reptiles

These species would be reduced drastically if this area were utilized for spoil disposal. Some emigration would occur, and recolonization is likely after dumping of dredge spoils ceases.

Disposal Area 3 (Fig. 2)

Vegetation

It is not likely that a short-term landfill operation would have significant impact on an already seriously and continually disturbed plant community. As in Disposal Area 1, considerable improvement in the quality and quantity of vegetation could be accomplished by selectively finishing the site (see section on Habitat Development on Dredged Materials) and by curtailing storage operations in this area. If this area were used as a site for disposal dredge spoils, attention should be given to the secondary impacts on any displaced commercial activity.

Birds

In view of the current disturbed condition of Disposal Area 3, there is no compelling reason, by virtue of the bird life observed there, against using it as a fill site. Short-term displacement of pheasants, killdeer and spotted sandpipers would likely result with spoil disposal.

Whether permanent displacement would occur would depend upon how the site were finished and used, and whether or not surrounding habitat for these birds persists. If dredging spoils were dumped in this area and left untouched, it would likely be quickly "reclaimed" by old-field succession and associated avifauna. Adjacent areas currently give indication of potential successional patterns. If the current use pattern were to continue after disposal of dredged materials, the impact on birds would be negligible. No long-term impact on avifauna is probable, although a positive impact (larger numbers of individuals and greater species diversity) is possible, with appropriate management technique (see section on Habitat Development on Dredged Materials).

There is evidence from the low level of illegal recreational use (e.g. fishing and pheasant hunting) presently occurring on the site that it could become an important recreational resource.

Mammals

If disturbed, only temporary reductions in the few species present would likely occur. Those species now present would emigrate to nearby habitat adjacent to this area, perhaps to return at a later date upon project completion. The poor habitat present, due to the reoccurring disturbance by storage of salt, coal, etc., could be made more productive if allowed to develop by old-field succession or managed.

Amphibians and Reptiles

Since no species of these groups were noted, no detrimental effects could occur. Disturbance may even make the site more appropriate for these species by subsequently increasing cover and suitable habitat.

Disposal Area (Fig. 2)

Fish and Ichthyoplankton

Spoil disposal in Disposal Area 4 will temporarily disrupt the fishery, but if it were finished like the existing breakwall, a greater amount of similar habitat than now exists would be available. Spoil disposal in Area 4 would have little permanent effect on fishes due to the large amount of equivalent habitat available throughout the harbor area and to the ability of adult fish to move away from temporarily disturbed areas.

Macrobenthic Invertebrates

Benthic organisms are important in aquatic environments in that they function as the crucial link in a detritus-based food chain. They utilize organic matter and recycle nutrients that otherwise would collect and remain trapped in the sediments. Benthic organisms supply food to many species of fish and to other predatory aquatic organisms. Containment of dredge spoils above the water level of Lake Erie in Disposal Area 4 will completely eliminate the macrobenthic inveretebrate community. However, the impact of filling this area to fish feeding on macroinvertebrates would be minimal because of the low biomass and species diversity of macroinvertebrates in this area.

Aquatic Vegetation

There are no compelling environmental reasons, by virtue of the almost complete lack of aquatic vegetation present, against using Disposal Area 4 as a landfill.

Birds

There are not compelling reasons, by virtue of the birds found there, against using Disposal Area 4 as a fill site. Of all the sites considered, impact on birds would likely be least if Disposal Area 4 were filled. In fact, if the final configuration and use of the site were properly planned, the "island" created by a fill operation could increase the numbers and variety of birds in the area (see "Habitat Development in Disposal Areas"). This disposal area is in close proximity to a Tern site, but should have no impact on it.

Endangered Species

The Endangered Species Act of 1973 (16 USC 1531-1543, 87 Stat. 884) provides Federal Protection of certain species whose existence is considered to be threatened or endangered. New York State, under jurisdiction of Section 11-0535 of the Environmental Conservation Law, also protects species considered to be endangered within the State and is currently updating its Endangered and Threatened Species List. The Federal Register of 20 May 1980, Vol. 45, No. 99, pages 33768-33781, presents a current list of species protected under the Endangered Species Act.

The Act essentially makes it a violation of Federal Law to take any species that are listed as endangered except by permit for scientific purposes or for enhancing the propagation of survival of the species. Threatened species are considered to be in less peril of survival but could possibly become endangered in all or part of their range in the foreseeable future. Regulations concerning them are less rigorous.

While setting gill nets near Disposal Area 2 on the Buffalo River on 8 November 1981, the crew of the R.V. Madtom reported observing a peregrine falcone (Falco peregrinus) stoop on a hooded merganser. The peregrine was observed later in the same day in the same location by R.C. Dilcher, our ornithologist, and again by the crew of the R.V. Madtom. A peregrine falcon has also been observed at the Tifft Farm/railroad yard border and immediately downriver from Disposal Area 2 on 9 October 1981. There was no evidence of the peregrine roosting in the proposed Disposal Area 2. However, the population of house sparrows and starlings apparently living about the grain elevator all summer at Disposal Area 2 had disappeared. This could suggest that the peregrine was hunting in the area.

No other animals or plants observed in the project area are currently protected by the Endangered Species Act.

Disposal of dredge spoils in Disposal Area 2 will destroy habitat for prey species of the peregrine falcon. The peregrine falcon does have a wide hunting range and it is possible that the birds will simply hunt elsewhere. Nevertheless, Section 7 of the Endangered Species Act states that any action that involves a federal agency must not "jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species...."

Habitat Development on Dredged Materials

The low initial shear strength of the high-water-content organic materials derived from dredging operations, along with the slow rate of strength increase with time and their associated large volume changes, seriously limits the usefulness of landfills composed of dredged materials. Unless special steps are taken to improve the quality of dredged materials, their use is restricted largely to wildlife refuges, parks, recreation areas, parking lots and the construction of light buildings with flexible joints and flexible floors which would allow for settlement. Most maintenance dredgings are not ideal materials for building and landfills (Krizek and Giger 1978). Because it seems unlikely that the proposed disposal areas could be used for construction of buildings, an opportunity exists to develop much needed wildlife habitat in the Buffalo area. The feasibility, methodology and technology to develop habitat has been carefully developed by the Dredged Material Research Program of the U.S. Army Corps of Engineers (e.g., Smith 1978).

Habitat development refers to the establishment of relatively permanent and biologically productive plant and animal habitats. Habitat development using dredged materials offers an alternative dredged disposal method that is often feasible from biological, engineering and economic standpoints (Smith 1978). Careful use of this alternative could significantly increase the extent of wildlife resources in the Buffalo area. Except for the development of the Tifft Farm area, it is evident that a loss of natural habitats has occurred in the Buffalo area.

Four general habitats are suitable for establishment on dredged materials: marsh, upland, island and aquatic (Smith 1978). Several distinct benefits should arise from developing wildlife habitat (Smith 1978) in the Buffalo area: (1) improved public acceptance of dredge disposal; (2) possible elimination of a problem area; and (3) creation of biologically desirable habitat.

Immediately north but adjacent to Disposal Area 1 is an area of the Outer Harbor that was filled and provides an interesting example. It contains a wetland with some standing water. Willow, cattails, *Phragmites*, loosestrife and other marsh/wet shrub vegetation dominate.

Our observations here provide an indication of potential long-term impacts of fill operation on bird life. Unlike the present open water area of Disposal Area 1, the old fill site provides nesting habitats and other territorial requisites for a striking array and number of bird species including game birds. In fact, the fill area compliments the Tifft Farms Nature Preserve. Furthermore, it is obvious that how the fill site was "finished" strongly influenced the bird life now present. For example, blue-winged teals, mallards, black ducks and American wigeons all use the fill area while at least mallards and black ducks successfully nest there. It is unlikely that such breeding success would have occurred had the area been finished without the "pond area" in this fill site.

It is apparent that if Disposal Area 1 is used as a dredge spoil disposal area, the manner in which it is finished will strongly influence subsequent quality and quantity of bird life. Leaving a low, open pond area will generally encourage a diversity of species with shore birds, herons and "dabbling ducks" replacing terns, mergansers and "diving ducks."

If filled and properly managed, the productivity in flora and fauna of any one of the disposal areas could be greatly enhanced. We would recommend that part of the area be developed as a marsh and refer you to Giles (1969) and Benson (1967) for more details and suggest a discussion with the Environmental Conservation Department.

In essence, the land would be built up with an existing concavity that could be flooded. For example, Disposal Area 4 would become an island, with protective breakwaters surrounding it and a concavity for a marsh/pond ecosystem. An ideal marsh is flooded shallowly (75% less than 0.6 m). The healthy marsh has emergent and submergent aquatic plants. The emergents survive best in very shallow water (<0.3 m) while submergents grow luxuriantly in deeper water (but less than 8 m). Therefore, the ideal marsh, which is one of the most productive wildlife environments, should be shallow. Management must plan for drawdown every several years; however, complete drawdown is not desirable. A diversity of cover both in the water and on shore should be the goal. Half the shoreline could be kept as wet meadow; further back it could be drier with grasses, shrubs and small trees. Desirable plants to promote in the marsh are duckweed, bulrush, smartweed, wild rice, arrowhead, sedge, pondweed and cattail (see Giles 1969, Waterfowl Techniques Handbook 1963). On the shore and away from the water, promote bluegrass, rye, brome and millet (see Giles 1969). These plants can be used for food and shelter by a variety of animals (including ducks and muskrats) (Johnson 1925, Waterfowl Techniques Handbook 1963).

Disposal Areas - Ecosystem Considerations and Recommendations

1. The *shallow*, productive, protected aquatic habitat that characterizes proposed Disposal Area 1 is unique within the project area. The productive aquatic vegetation provides cover for fish life and food for some waterfowl. A large macroinvertebrate population also exists that is undoubtedly used by both fish and birds as a food source. In addition, this area is the last major nursery area for fish within the project area and is a migratory stop for some diving waterfowl. Adult fish, such as muskellunge and largemouth bass, do forage in this area. Of the proposed disposal areas considered, disposal of dredged materials at Disposal Area 1 (Fig. 2) would have the greatest negative impact on fisheries and waterfowl of area ecosystems. We would not recommend using *this site* for disposal of dredged materials.

2. Disposal Area 2 possesses 15 species of woody plants and 75+ species of herbaceous vegetation. This heterogeneous and diverse vegetation covers the entire site and provides requisites for a richness of fauna, including reproductive populations of game birds and animals. Portions of this area may be considered marginal wetlands under New York State Conservation Law. An endangered species, the peregrine falcon, was observed foraging on two occasions near and on this area. In addition, prey species of the peregrine falcon are found in this area. Section 7 of the Endangered Species Act states that any action that involves a federal agency must not jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of such species. The existence of the peregrine falcon seems to rule out the use of this area for disposal of dredged

materials by a federal agency. Disposal Area 2 also possesses a relatively large reproductively successful population of pheasants, a game population in general decline in Western New York.

There are wildlife interactions between Disposal Area 2 and the adjacent Tifft Farm which were not fully explored under the current scope of work. That is, we do not know the extent to which Disposal Area 2, Tifft Farm and other little used railroad property are interdependent.

Disposal Area 2 is one of the most environmentally sensitive sites considered. Functionally, it seems to be a refugium for species not generally expected in an urban ecosystem. To what extent it supports the urban ecosystem, including Tifft Farm and adjacent railyards, with juveniles is not known. Even without the endangered species, by virtue of its wildlife productivity, richness in vegetation and quality habitat, we would not recommend using Disposal Area 2 as a fill site.

3. Disposal Area 3 is seriously and constantly disturbed because of the bulk storage and transshipment activities going on there. The vegetation is sparse and opportunistic with much of the site devoid of vegetation. The poor habitat results in unimpressive populations of birds and mammals with apparently little nesting in the area. No significant long-term impact is envisioned on vegetation, reptiles, amphibians, birds, mammals or area ecosystems in this site were utilized as a fill area. There is no compelling biological argument against using Disposal Area 3 as a disposal site. However, the displaced storage and transshipment activities resulting from use of this site as a disposal area need to be identified and evaluated.

4. Proposed Disposal Area 4 has some walleye present during the summer along the present breakwater, which suggests that they are foraging for food. However, creation of a "dredge disposal island" will create similar habitat to the present breakwater. This area is not a nursery area for fish or birds; no mammals, amphibians, reptiles or vegetation were observed. Dredge spoil disposal will have no significant impact on the disposal area or area ecosystem and may actually improve conditions for wildlife. There seems to be no compelling reasons for not using Disposal Area 4 as a disposal site. Depending on if and how habitat were developed on the dredged material, much needed wildlife habitat, particularly bird habitat, could be developed. We would recommend Disposal Area 4 as the site for disposal of dredged materials.

5. Pollutant mobilization from dredged spoils by plants and leaching of pollutants from the filled disposal area may occur and enter the food chain. With the Buffalo River being heavily polluted, this seems to be apparent. In addition, at Disposal Area 4 any pollutants released could, but probably would not, enter the water intakes of the public water supply located diagonally across at the mouth of the Niagara River but downstream of Disposal Area 4. Information on current patterns is required to assess this further. We would recommend a dye study utilizing the "operational" Army Corps Disposal Area 4. Such a study could provide insight on leaching from a disposal area and current patterns near "proposed" Disposal Area 4 (Fig. 2). A study of toxic chemicals present in sediments is being conducted by another group and will not be discussed here.

6. It is generally accepted and self-evident that a large loss of natural and recreational habitat has occurred in the Buffalo area.

Because landfills of dredged materials do not make a good base for construction of buildings, a unique opportunity exists to create parks, recreational areas or even a wildlife refuge, eventually, on Disposal Area 3. A cursory survey of the Toronto Harbor and Boston's Back Bay would provide a model for long-term development of the Buffalo Harbor area that would satisfy many of the economic, recreational and aesthetic interests of the area. We would recommend that a study be initiated to determine the needs of the public and the feasibility of such development if this site were chosen as a disposal area.

7. In regards to Disposal Area 4, the isolation of this area from the mainland makes it an ideal site for a bird refuge. The feasibility, methodology and technology to develop bird habitat has been carefully developed by the Dredged Material Research Program of the U.S. Army Corps of Engineers. Because marsh, upland, island and aquatic habitats are suitable for establishment on dredged material, we recommend that a study be initiated to determine which type of habitat be developed if the site is chosen for disposal of dredged material.

ASSESSMENT OF IMPACT - DRIFT AND DEBRIS REMOVAL

Despite the occurrence of many adults in reproductive condition, little evidence of successful spawning was observed in the Buffalo River or Ship Canal. The scarcity of river ichthyoplankton, despite obvious spawning utilization by adults, indicates that the river is generally not suitable as a reproductive/nursery area. Because so much of the embankment is artificial and drops off quickly to 8 m, the amount of shallow, protected habitat necessary for the survival of the young of most fish species is small. In fact, the only area where any nests (centrarchids) were observed was in the inward bend of the river near Station 13. Also, the only fish caught with any degree of regularity in the nearshore of the Buffalo River or Ship Canal were carp, white suckers, goldfish and carp/goldfish hybrids. None of these fish are highly desirable or prized (i.e., trash fish) by fishermen. Removal of debris and drift in the Buffalo River and Ship Canal indicated in Plates 5 and 6 (Drift and Debris Locations, Buffalo-Lackawanna) provided by the Army Corps of Engineers would not have a major short-term or long-term impact on fisheries. The larger adult fish would simply move out of the area until the disturbance ended.

In spring and early summer, the debris-strewn Outer Harbor shoreline has generally poor fish habitat due to unstable substrate, wave action and lack of aquatic vegetation. However, fish numbers along the shore of the Outer Harbor increased by August as the macrophyte community developed. Rock bass nest among rocks and weeds along the shore and also serve as an important forage species. Largemouth bass and pumpkinseeds utilize weedy shallows to build nests and spawn along the Outer Harbor (particularly in the Small Boat Marina). Removal of drift in the Outer Harbor should not have a significant impact if completed by June of the year. This would also apply to structures 37 and 38 on Plates 5 and 6 (Drift and Debris Locations, Buffalo-Lackawanna).

Removal of the deteriorated planked retaining wall on the north side of the abandoned Cargill Post Elevator (structure 39) will not affect fisheries if care is taken not to create a turbidity plume. Structure 39 forms the border of a highly productive nursery area for fish.

The dilapidated mooring cluster (structure 40) is also near productive fish nursery areas (i.e., proposed Disposal Area 1). Removal of this structure will not have any adverse effects on spawning or young of the year if removal takes place in early May or preferably late September.

NAVIGATION IMPROVEMENT PROJECT

ALTERNATIVE IIa - OPTION 2[1]: ASSESSMENT OF IMPACT

The following work items are planned with this option:

(1) Deepen a portion of the Outer Harbor to 28 ft below low water datum;

(2) Deepen a portion of the Outer Harbor to 30 ft below low water datum;

(3) Deepen the Buffalo River and the Buffalo Ship Canal to 28 ft below low water datum;

(4) Deepen the south entrance channel to 32 ft below low water datum;

(5) Remove 850 ft of breakwater at the south entrance;

(6) Construct 450 ft of breakwater at the south entrance; and

(7) Move the north side light at south entrance channel.

Dredging: Physical Aspects

Dredging is basically a process of artificially induced sediment erosion, transport and deposition. It differs from the natural process in that its occurrence is much more concentrated in time and space. A turbidity plume is created when bottom sediments are mechanically disturbed and resuspended during dredging operations. This most visually obvious physical impact causes water discoloration and reduction in light penetration. The reduction in light penetration caused by turbidity plumes is temporary in nature and disappears within a few hours after dredging (Morton 1976).

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[1] Option 2 is discussed before Option 1 for the sake of convenience of presenting impact assessments.

Changes are likely to occur in medium grain size, porosity and degree of sorting of dredged sediments as they are dredged, transported and redeposited. The larger, heavier particles (sands, clumps of mud, etc.) will settle rapidly out of suspension; the fine silts and clays will remain suspended for longer periods. Fine silts and clays will be transported from the dredge site by currents into the Niagara River and Black Rock Canal. These changes in mechanical properties of sediments could affect the processes controlling the exchange of contaminants from polluted sediments to the water, the distribution of benthic organisms, fish reproduction, etc. The effects on biota are discussed in the appropriate sections.

Newly dredged channels have been observed to cause significant hydrographic alterations such as rerouting river current, changing flushing rates, inducing sediment deposition (shoaling) or erosion and creating deadwater and stagnant pockets. Relative significance of these impacts on a given ecosystem will be a function of the ratio of the dredged area to the total bottom area and contained water volume. We are not professionally capable of predicting hydrodynamic effects of dredging in the Buffalo area.

Dredging: Chemical Aspects

Dredging operations are likely to produce changes in the chemistry of the water overlying the dredging site. First, undisturbed sediments typically exhibit a gradient from oxidized surface deposits to increasingly reduced sediments in the deeper layers. The deeper, reduced sediments will create an oxygen demand (B.O.D. and C.O.D.) when they are exposed to the aerobic environment of the overlying body of water, thereby causing a decrease in dissolved oxygen (Mackin 1961, Army Corps of Engineers 1969, Slotta et al. 1973). Numerous authors (Marshall 1968, Chesapeake Bay Laboratory 1970, Saila et al. 1972) attribute the high organic content of the sediment as being the major cause of reduced oxygen concentrations in benthic systems. In the project area, the sediments of high organic content exist between Stations 8-14 (Fig. 1). The sediments in this area can be expected to have a high biochemical oxygen demand causing a decrease in dissolved oxygen concentration in the project area and downstream from the project area.

It is generally assumed that the chemical constituents associated with the surface sediment are in dynamic equilibrium with the overlying water while those associated with the deeper sediments are not (Keeley and Engler 1974). As the deeper sediments are mixed with water during dredging, the potential for remobilization of their chemical constituents will increase. Dissolved concentrations in the vicinity of the dredging have an important effect on the chemical forms and on the solubility and mobility of chemicals. For example, as reduced sediments are oxidized during dredging, a decrease in interstitial hydrogen sulfide and an increase in sulfates might be expected. Oxidation of sulfides increases the mobility of heavy metals, such as silver, lead and zinc, that were found as sulfides (Gordon et al. 1972). If toxic chemicals are present in the sediments, thay also may be released into the water column. Discussion on this potential impact is presented in the section on Toxic Chemicals. Nutrients, especially ammonia, that stimulate plant growth may be released (Morton 1976).

Dredging: Toxic Chemicals

Dredging of contaminated sediments can cause the redistribution and remobilization of toxicants sorbed to the sediments. Contaminants seldom occur in the surface sediments and in water columns at concentrations high enough to have lethal effects on aquatic organisms. However, chronic exposure to a complex of PAH pollutants will cause neoplasia in bottom-feeding fish (Black et al. 1980). Another danger with toxic contaminants is that persistant toxicants are concentrated, cycled and magnified in the food web. This accumulation of toxic chemicals in the tissues of organisms is referred to as bioconcentration. Important pathways by which contaminants can enter the food web are from sediment via marsh grass, from water via phytoplankton, from ingestion of contaminated particulate matter by filter feeders and deposit-feeding organisms, from ingestion of food organisms that have already concentrated contaminants, and by direct uptake from the water. In the Buffalo River, Black et al. (1980) observed a 6 and 20 fold increase in PAH in tubifex worms and carp compared to Buffalo River sediments.

Dredging of the Buffalo River should physically remove toxicants from the dredged area. However, dredging will also cause redistribution (i.e., redeposition) and remobilization of toxicants sorbed to the sediments. Along with the fine silts and clay transported in the turbidity plume will be toxicants carried by currents downriver into the Black Rock Canal and the Niagara River. Thus it is likely that high concentrations of toxicants between Stations 13 and 14 (Black et al. 1980) will pollute the rest of the Buffalo River, the Niagara River and the Black Rock Canal. There is some evidence that mutagenic substances, probably from the Buffalo River, already do contaminate the Black Rock Canal (Black et al. 1980).

Downstream invertebrates (benthic and zooplankton) and fish will undoubtedly concentrate the toxicants. Since recreational fishing is common along the Black Rock Canal, the upper Niagara River and the mouth of the Buffalo River, additional mutagenic and carcinogenic substances entering the food web of man is possible.

Also, a water intake crib exists at the juncture of Lake Erie and the Niagara River about 1 to 1½ miles from the mouth of the Buffalo River. The likelihood of contamination entering the public water supply is dependent on flow rates from Lake Erie and the Buffalo River and is beyond the scope of work for this project. To some unknown extent this is probably already happening without project implementation. With project implementation increased amounts of toxicants may be remobilized from the sediments with dredging and redeposition and enter the water column.

Dredging: Ichthyoplankton

The most critical period of fish life history occurs from the time eggs are laid until juveniles mature enough to forage and to escape predators effectively. During this time, young fish are most vulnerable to outside disturbances. Dredging should not take place during the spawning and growing season of important game fish (centrarchids especially) if year classes are to remain strong.

Dredging activities would reduce ichthyoplankton numbers in the immediate vicinity of the operations. Most fish larvae are planktonic feeders for several weeks after hatching. It is during this period, usually the spring and early summer, when larvae unable to freely move in the water column are vulnerable to dredges, as they may be caught in the wash water processing of dredged materials (Herdendorf 1978) and be physically destroyed. In addition, damage to gills and other tissues of juveniles is more likely to occur than to those of adults (Morton 1976).

We found evidence of successful reproduction throughout the study area, as evidenced by ripe adults and the progression of larval stages over time. However, river ichthyoplankton samples were dominated by migrant lake species (yellow perch, emerald shiners) indicating that reproduction by river residents may be severely limited. Two pieces of evidence support this idea: (1) no ichthyoplankton were sampled farthest upstream at Station 14; and (2) few or none of the white suckers or bullhead adults captured in the river were gravid nor were any ichthyoplankton of these species sampled. It is unlikely that further dredging will have any significant adverse impact on reproduction of fish and survival of ichthyoplankton populations in the already depopulated river.

Inherent environmental harshness and instability make successful reproduction and larval survival of most species unlikely in the lake outside the breakwall. Whatever small ichthyoplankton populations that exist will suffer little as a result of dredging and/or spoil disposal in this area, as ample similar habitat exists nearby. Creation of shallow water habitat through spoil disposal might actually improve reproductive success and ichthyoplankton abundance and survival outside the breakwall.

If conducted judiciously, dredging can have little direct impact on the fish of the Outer Harbor. Confining dredging to existing deep-water areas, as planned in this alternative, will have little effect on shallow water spawners and their offspring. Pelagic spawners will be able to move to nearby undisturbed areas until the temporary disturbance ends (Mackin 1961, May 1973).

<u>Dredging: Fish - Buffalo River and Ship Canal</u> (Stations 10-14) (Fig. 1)

Because of their mobility, adult fish are less likely to experience the chemical and physical impacts of dredging. In fact, Herdendorf (1978) states that dredging activities have little direct impact on adult fish. The adults simply move away from the disturbance. Some species are known to avoid turbid waters; thus project implementation may affect fish migration. As the sediments in the project area are high in organic matter and would be expected to create a high turbidity if disturbed, some fish movements into or out of the river could be temporarily halted by dredging operations. Spring dredging, in particular, could adversely affect spawning movements of shiners, suckers and gizzard shad into the Buffalo River. Concern for any salmonids in the river is not warranted. They do not spawn in the river, were not observed upriver beyond Station 11, and in Lake Erie are completely supported by stocking. Even if adult salmon did move upstream through the Buffalo River, poor water quality and summer temperatures above salmonid lethal limits would prevent juvenile survival. Therefore, fall dredging will not adversely affect Lake Erie salmonid populations and is preferable to spring dredging when minnow, sucker and gizzard shad populations are semi-successfully utilizing the river for reproduction.

Natural fish shelters are few in the Buffalo River (see Habitat Description). Fish do concentrate in existing areas of shallow muddy substrate (e.g., Station 13) where trees or bushes overhang the river (e.g., Station 12) and near sunken or emergent pilings (e.g., Station 11). Attempts at spawning will probably take place in any shallow area along the shoreline, especially those areas with macrophytes or overhanging vegetation. These same areas will later become nursery beds for juveniles and foraging areas for adults. Bank to bank dredging will disrupt pumpkinseeds (and other less abundant centrarchids) populations as they shelter under branches overhanging the river and utilize sandy shoal areas along some banks as nesting areas. Any decrease in such shallow areas along shore (i.e., by dredging) will decrease already limited habitats suitable for fish reproduction and subsequent development of the young.

Populations of fish present in the river are not highly desired by sport fishermen. Also, abundance of forage fish for game species is low. In addition, the high incidence of tissue lesions on carp and goldfish, indicative of a fish population affected by chronic exposure to polycyclic aromatic hydrocarbons (Black et al. 1980), suggests that the fish are contaminated with pollutants.

In general, the effect of dredging on river fish populations are expected to be localized and temporary, and any such impairment would not be expected to have any long-term adverse impact on river fish populations. As mentioned above, we do recommend an autumn dredging operation to minimize effects on minnow, sucker and gizzard shad that are marginally successful in utilizing the river for reproduction.

Fish - Outer Harbor (Station 1-9) (Fig. 1)

High concentrations of suspended solids resulting from a dredging operation could result in direct damage to adult and larval fish which have not avoided the dredging area. Suspended particles in the water damage gills and filter-feeding apparatus by cutting and abrasion. Such damage can increase individual susceptibility to fungal and bacterial disease. However, only very high concentrations of suspended solids (several thousand ppm) cause damage in adult fish (EIFAC 1965).

High turbidity levels will reduce light penetration, thereby impairing underwater vision and thus feeding in visually feeding fish. Concentrations of suspended solids this high could be reached in the dredging operations, but adult fish would have ample opportunity to avoid such concentrations in an open system. The only filter feeders in the project area as adults are the alewife and the gizzard shad, both of which are lake residents and considered to be nuisance species.

Dredging may have an indirect effect on fish via reduction in food resources or in reduced ability to find food. Populations of zooplankton and benthic invertebrates (important as potential food items) may be temporarily reduced in the dredged areas. Small fish (used as food by large fish) then may be reduced in the area also. These effects, if they occur at all, are expected to be localized and temporary, and any such impairment would not be expected to have any long-term adverse impact on fish populations.

Deepening the existing harbor channel will cause some dislocation of adult fish. However, adjacent areas would easily be able to assimilate migrants during dredging operations. Adult fish will likely re-enter dredged areas shortly after the disturbance ceases. For most species, any adult mortality would quickly be replaced by lake immigrants. Juvenile mortality would be greatly reduced by delaying dredging until after the spawning/growth season. In any event, loss of a year class for the harbor is unlikely to be significant with lake populations nearby.

The Small Boat Marina (Station 3) represents a special harbor station due to its shallow, protected waters, higher temperatures and abundant aquatic macrophytes. It is a haven for perch and pike (early spring) and centrarchids (summer) and may be an important spawning area (ichthyoplankton results are inconclusive in this regard). No dredging should occur in this area.

Removal of Old Breakwater at South Entrance and Construction of New Breakwater: General Overview

Our sampling Station 1 (Fig. 1) was located where the proposed breakwater is to be constructed. Although this is a popular spot for sport ﬁsherment, our results suggest a low abundance of fish. Rock bass were most abundant and were found routinely throughout the spring and summer. Yellow perch and stonecat were found consistently but again in low numbers. Of the sport fishes, only one walleye and five smallmouth bass were caught over the year. Ichthyoplankton abundance was low (< 3 smelt/10 m^3) and observed on only one sampling date.

This area is not a nursery for fish nor is it suitable habitat for any important game fish. Removal of the old and construction of a new breakwater will have a minimal short-term impact. Adult fish will simply move from the area. The long-term impact is negligible especially since a similar breakwater (i.e., similar habitat) will be constructed but just at a different orientation.

One note of caution is suggested. This is one of the sites that we had consistent problems with fishermen cutting and destroying our nets. Sport fishermen may object to any removal and construction operations in this area.

Dredging: Ecosystem Considerations

Functionally, fish use the study area as a spawning and nursery site, as well as a feeding area. Basically, two assemblages of fish can be recognized within the project area: Lake Erie residents that seasonally enter the river or harbor, and harbor residents and river residents. For, example, emerald, spottail and golden shiners and gizzard shad are pelagic lake species that utilize the river for spawning, albeit with a low level of success. Other fish, such as carp, goldfish, bullheads, pumpkinseeds and some white suckers appear to be year-round residents with marginal reproductive success in the river. In the Outer Harbor, rock bass, smallmouth bass and yellow perch frequently exhibited abundance peaks during their expected spawning season. Within the Buffalo River and Ship Canal, we expect minimal impact on reproduction of fish and survival of ichthyoplankton in already depressed river populations consisting mostly of trash fish. In the Outer Harbor, dredging could have little impact on ichthyoplankton. Confining dredging to existing deep-water areas, as planned in this alternative, will have little effect on the shallow water spawners and their offspring. Minimal effect on ichthyoplankton in the Outer Harbor would be ensured by dredging in late summer or fall. In general, minimal effect is expected on Lake Erie populations that migrate into the study area to spawn.

Sport fish do forage within the study area. Muskellunge, walleyes, large and smallmouth bass, northern pike and an occasional salmonid forage on yellow perch, rock bass, shiners, gizzard shad and smelt in the study area. For example, in the Small Boat Marina we found large northern pike gorged with yellow perch.

Dredging operations will cause a turbidity plume which both prey and predator species will avoid. In this sense, the food chain will be interrupted during the dredging period. However, as the water clears, we expect adult fish to move back into the project area and the food chain to be reestablished.

A turbidity plume will be created throughout the project area with dredging. Besides affecting the project area, it will move into area ecosystems; that is, the turbidity plume will be carried into the Niagara River and Black Rock Canal. Siltation to an unknown extent of any spawning beds of fish in the upper Niagara River would be expected. In addition, turbidity of water will increase in intakes of any city or town using the Niagara River for a public water supply.

Within the plume, a decrease in dissolved oxygen and mobilization of heavy metals and organic toxicants is expected. These potential toxicants will be carried into the Niagara River and Black Rock Canal ecosystems. In addition, we would expect redeposition of these pollution sediments to downstream ecosystems. We can expect bioconcentration and biomagnification of these pollutants in invertebrates, fish and birds. Furthermore, since recreational fishing is common, potential mutagenic and carcinogenic substances may enter the food web of man. To some unknown extent this is probably already happening without project implementation due to frequent maintenance dredgings of the river. With project implementation, increased amounts of toxicants may be remobilized from the sediments with dredging and enter the water column.

Also, a water intake crib exists at the juncture of Lake Erie and the Niagara River about 1 to 1½ miles from the Buffalo River. The likelihood of contamination entering the public water supply is dependent on flow rates from Lake Erie and Buffalo River and beyond the scope of work of this study.

ALTERNATIVE IIa - OPTION 1: ASSESSMENT OF IMPACT

The following work items are planned with this option:

(1) Deepen the north entrance channel and Buffalo River entrance channel to 32 ft below low water datum; and

(2) Deepen major portion of Buffalo River and Buffalo Ship Canal to 28 ft below low water datum.

A detailed discussion on impacts of the proposed dredging in the Buffalo River and Ship Canal is covered in the following sections:

(1) Dredging: Physical Aspects (p. 66);

(2) Dredging: Chemical Aspects (p. 61);

(3) Dredging: Toxic Chemicals (p. 63);

(4) Dredging: Ichthyoplankton (p. 64);

(5) Dredging: Fish - Buffalo River and Ship Canal (p. 66); and

(6) Dredging: Ecosystem Considerations (p. 69).

In summary, dredging will create a turbidity plume throughout the river and Ship Canal portion of the project area. This plume will move downriver into the Black Rock Canal and the Niagara River. Within the plume, a decrease in dissolved oxygen concentrations and remobilization of the chemical constituents of the sediments, such as heavy metals and organic toxicants would be expected. Downstream invertebrates and fish will undoubtedly concentrate the toxicants in their tissues. Since recreational fishing is common along the Black Rock Canal, the Upper Nsagara River and the mouth of the Buffalo River, mutagenic and carcinogenic substances entering the food web of man is possible. To some extent this is already happening without project implementation. However, with project implementation, increased amounts of toxicants may be remobilized from sediments with dredging and enter the water column.

Dredging activities would reduce ichthyoplankton numbers in the immediate vicinity of dredging operations. However, it is unlikely that further dredging will have any significant adverse impact on reproduction and survival of already limited ichthyoplankton populations in the already disturbed river and Ship Canal. The effect of dredging on river and Ship Canal populations are expected to be localized and temporary, and any such impairment would not be expected to have any long-term adverse impact on river populations that consists mostly of undesirable fish species.

We do not anticipate any long-term impacts on fisheries if dredging takes place at the north entrance channel to the Buffalo River and Outer Harbor. Our sampling effort on this area did indicate that the following game species were present: walleye, muskellunge and smallmouth bass. Dredging will have the short-term impact of adult fish moving away from the turbidity plume. However, with completion of dredging, these fish should move back to this area almost immediately. This is not a spawning area or nursery area for fish. Numerous sport fisherment do fish this area during the summer.

ALTERNATIVE IId: ASSESSMENT OF IMPACT

The following work items are planned with this alternative:

(1) Remove 850 ft of existing breakwater at south entrance;

(2) Construct 450 ft of arrowhead breakwater at south entrance;

(3) Move north side light at south entrance channel;

(4) Deepen south entrance channel area to 32 ft below low water datum;

(5) Deepen Outer Harbor, new entrance channel to Buffalo River to 28 ft below low water datum while realigning river;

(6) Cut new river channel through Disposal Area 1 and through base of oxbow on Buffalo River south of Airco Products;

(7) Construct 5100 ft of conveyor through proposed Disposal Area 2 to move iron ore to Republic Steel;

(8) Remove Skyway (Route 5);

(9) Upgrade Ohio Street; and

(10) Build two causeways across Buffalo River and Ship Canal.

A detailed discussion of the proposed dredging of the south entrance channel, the Outer Harbor and the Buffalo River, and the planned removal and reconstruction of the south entrance breakwater is covered in the following sections:

(1) Disposal Area 3 (p. 47);

(2) Dredging: Physical Aspects (p. 60);

(3) Dredging: Chemical Aspects (p. 61);

(4) Dredging: Toxic Chemicals (p. 63);

(5) Dredging: Ichthyoplankton (p. 64);

(6) Dredging: Outer Harbor (p. 67);

(7) Dredging: Buffalo River (p. 66);

(8) Dredging: Ecosystem Considerations (p. 69); and

(9) Removal of Old Breakwater and Construction of New Breakwater at South Entrance: General Overview (p. 69).

In summary, dredging will create a turbidity plume throughout the river and Ship Canal portion of the project area. This plume will move downriver into the Black Rock Canal and the Niagara River. Within the plume, a decrease in dissolved oxygen concentrations and remobilization of the chemical constituents of the sediments, such as heavy metals and organic toxicants would be expected. Mobilization of toxicants from the sediments should not be of as much concern as in the Buffalo River. However, only results from sediment analyses will clarify the point.

Dredging activities would reduce ichthyoplankton numbers in the immediate vicinity of dredging operations. However, it is unlikely that further dredging will have any significant adverse impact on reproduction and survival of already limited ichthyoplankton population in the already disturbed river and Ship Canal. The effect of dredging on river and Ship Canal populations are expected to be localized and temporary, and any such impairment would not be expected to have any long-term adverse impact on river populations that consist mostly of undesirable fish species (i.e., trash fish).

Significantly higher catches of ichthyoplankton were found in the Outer Harbor compared to the Buffalo River and Lake Erie. However, if conducted judiciously, dredging could have little impact on the Outer Harbor. Confining dredging to existing deep-water areas, as planned in the alternative, will have little effect on shallow water spawners and their offspring. Pelagic spawners will be able to move to nearby undisturbed areas until the temporary disturbance ends. By delaying dredging until after the spawning/growth season, it would ensure that juvenile mortality would be greatly reduced.

Deepening the existing harbor channel will cause some dislocation of adult fish. However, adjacent areas would easily assimilate migrants during dredging operations. Adult fish would likely re-enter dredged areas shortly after the disturbance ceases. For most species, any adult mortality would be quickly replaced by lake immigrants. Removal, relocation and construction of a new breakwater in a different orientation at the south entrance will not have a significant impact on adult or juvenile fish in the area.

Proposed Disposal Area 1 (Fig. 2) and the Small Boat Marina represent unique harbor situations due to their shallow, protected water, higher temperatures and abundant aquatic macrophytes. They are a haven for many game fish and are important spawning and nursery areas. Although no dredging is planned in these areas under this alternative, we emphasize that no dredging should occur there.

Construction of Two Causeways across Buffalo River and Ship Canal

As noted elsewhere, the fish community of the Buffalo River and the Ship Canal consists of generally undesirable fish types. Contruction of the causeways may reduce ichthyoplankton in the immediate vicinity of construction. However, it is unlikely that construction will have any adverse impact on reproduction and survival of already limited ichthyoplankton population in an already disturbed highly polluted river and Ship Canal. Any effect on fish is expected to be localized and temporary, and any such impairment would not be expected to have any long-term adverse impact on river populations.

Construction of 5100 ft of Conveyor through Proposed Disposal Area 2 to Move Iron Ore to Republic Steel

Unloading of ships will take place at the west side of proposed Disposal Area 2 (Fig. 2) and transferred to a conveyor belt which is routed across the southern portion of the Disposal Area 2. Disposal Area 2 is one of the most environmentally sensitive sites studied by us. It is a refugium for species not generally expected in an urban ecosystem. It supports a reproducing population of pheasants and an endangered species, the peregrine falcon, which was observed on and near this site. Even without the endangered species, by virtue of its wildlife productivity, richness in vegetation and quality habitat, we are not able to recommend the use of this site. With project implementation, adverse impact would occur to the diverse community or organisms observed there. Also, see the section on Endangered Species (p. 49) for the legal implications of the sighting of an endangered species in this area.

Realignment of Buffalo River by Cutting New Channel through Disposal Area 3 and Base of the Oxbow South of Airco Products

There are no compelling biological reasons against cutting a new channel through Disposal Area 3. The area is a highly disturbed industrial area, bisected by a highway and railroad tracks. Some of the area has been filled with cinders. The westerly portion is wet, dominated by cattails. The easterly portion is drier and is dominated by clumped grasses, staghorn sumac, goldenrod, and red-osier dogwood. Cottonwoods and *Ailanthus* is interspersed. Only two vole burrows were observed in this area on 15 May 1982 (Table 8). Potentially, voles, rats, rabbits, and garter snakes may occur there.

ALTERNATIVE IIIf: ASSESSMENT OF IMPACT

The following work items are planned with this alternative:

(1) Deepen the south entrance channel to 32 ft below low water datum;

(2) Remove 850 ft of breakwater at the south entrance;

(3) Construct 450 ft of arrowhead breakwater at the south entrance;

(4) Move north side light at the south entrance channel;

(5) Deepen a portion of the Outer Harbor to 28 ft below low water datum;

(6) Deepen the Allen Boat Company slip to 28 ft below low water datum and enlarge it to 250 ft x 1000 ft;

(7) Fill the portion of the Buffalo Ship Canal that is not in the federal project; and

(8) Construct a transshipment system from the Allen Boat Company slip to General Mills, Standard Milling, Peavy and International Multifoods.

A detailed discussion of the proposed dredging of the south entrance channel and Outer Harbor and the planned removal and reconstruction of the south entrance breakwater is covered in the following sections:

(1) Dredging: Physical Aspects (p. 60);

(2) Dredging: Chemical Aspects (p. 61);

(3) Dredging: Toxic Chemicals (p. 63);

(4) Dredging: Ichthyoplankton (p. 64);

(5) Dredging: Outer Harbor (p. 67);

(6) Dredging: Ecosystem Considerations (p. 69); and

(7) Removal of Old Breakwater at South Entrance and Construction of New Breakwater: General Overview (p. 69).

In summary, dredging will create a turbidity plume carried by the currents northward of the dredging site into the Niagara River and Black Rock Canal. Within the plume, a decrease in dissolved oxygen concentrations and remobilization of the chemical constituents of the sediments, such a heavy metals and organic toxicants, would be expected. Mobilization of toxicants from the sediments should not be of as much concern as in the Buffalo River. However, only results from sediment analyses will clarify this point.

Significantly higher catches of ichthyoplankton were found in the Outer Harbor compared to the Buffalo River and Lake Erie. However, if conducted judiciously, dredging could have little impact on the Outer Harbor. Confining dredging to existing deep-water areas, as planned in the alternative, will have little effect on shallow water spawners and their offspring. Pelagic spawners will be able to move to nearby undisturbed areas until the temporary disturbance ends. By delaying dredging until after the spawning/growth season, it would ensure that juvenile mortality would not be high.

Deepening the existing harbor channel will cause some dislocation of adult fish. However, adjacent areas would easily assimilate migrants during dredging operations. Adult fish would likely re-enter dredged areas shortly after the disturbance ceases. For most species, any adult mortality would be quickly replaced by lake immigrants. Removal, relocation and construction of a new breakwater in a different orientation at the south entrance will not have significant impact on adult or juvenile fish in the area.

Proposed Disposal Area 1 (Fig. 2) and the Small Boat Marina represent unique harbor situations due to their shallow, protected water, higher temperatures and abundant aquatic macrophytes. They are a haven for many game fish and are important spawning and nursery areas. Although no dredging is planned in these areas under this alternative, we emphasize that no dredging should occur here.

Deepening of the Allen Boat Company Slip

We did not sample in the Allen Boat Company slip. It is relatively deep due to dredging at the west end with a shallow eastern portion formed by a concrete pavement used for boat launchings. We believe this slip to possess habitat analagous to the Ship Canal, although the water is not nearly as polluted. Some macrophytes were observed nearshore by the end of the summer. We do not believe that it is a spawning or nursery area for fish. It is unlikely that it should harbor any significant adult sport fishes. Even if it were a productive area for fish, complete destruction of the area would have minimal impact on the fish community becuase of the small area of the slip.

Filling of Portion of the Ship Canal not in the Federal Project Area

The Ship Canal is not a nursery or spawning area for fish. Adult fish populations are characterized by warm water trash fish (carp, white sucker, goldfish and goldfish x carp hybrids). Filling the southerly portion of the Ship Canal, south of the federal project area, should have no adverse impact on the fish community.

Construction of the Transshipment System

The transshipment system planned in this alternative originates south of the Allen Boat Company slip, moves eastward across Fuhrmann

Boulevard and Highway 5 across the filled southern portion of the Ship Canal and bifurcates northerly to General Mills, Inc. and easterly. The easterly segment bifurcates again to the Pillsbury Elevator and to International Malting, Inc. Our scope of work did not include any terrestrial studies along the route of the transshipment system. However, except for the area south of the Allen Boat Company slip and west of Fuhrmann Boulevard, the areas that the transshipment system would cross are highly developed industrial areas (i.e., parking lots, mill yards, railroad yards, etc.) with little or no natural open areas. Little impact from a biological point of view is envisioned in these areas.

The Area South of the Allen Boat Company Slip and West of Fuhrmann Boulevard

On 15 May 1982, we walked through this area and noted vegetation, birds, mammals, amphibians and reptiles (Table 8). The area is recently disturbed by filling and is presently utitlized in spots for an open dump. Essentially, the area is a weed, old-field community with peripheral cottonwoods to 9 m in height. In wet pockets, particularly east of the service road which parallels Fuhrmann Boulevard, *Phragmites* forms an almost pure stand that provides excellent cover for pheasants during the winter. Eight pheasants were noted in this area. Other birds observed are given in Table 8. Meadow voles, rats and rabbits were also observed.

Little impact from a biological point of view is envisioned for this entire area. However, the transshipment system is projected to move through the *Phragmites* stand, which provides cover for what appears to be a small reproducing colony of pheasants. Moving the transshipment system 60 meters to the east or west would avoid the pheasant colony. This area, if properly developed has more potential as a recreational area than as a transshipment area.

ALTERNATIVE IIIg: ASSESSMENT OF IMPACT

The following work items are planned with this alternative:

(1) Deepen the south entrance channel to 32 ft below low water datum;

(2) Remove 850 ft of breakwater at the south entrance;

(3) Construct 450 ft of arrowhead breakwater at the south entrance;

(4) Move north side light at the south channel entrance;

(5) Deepen a portion of the Outer Harbor to 28 ft below low water datum;

(6) Deepen the Allen Boat Company slip to 28 ft and enlarge it to 250 ft x 1200 ft; and

(7) Construct a transshipment system to Republic Steel.

A detailed discussion of the planned dredging of the south entrance channel and Outer Harbor, planned removal and reconstruction of the south entrance breakwater and the deepening of Allen Boat Company slip is covered in the following sections:

(1) Dredging: Physical Aspects (p. 60);

(2) Dredging: Chemical Aspects (p. 61);

(3) Dredging: Toxic Chemicals (p. 63);

(4) Dredging: Ichthyoplankton (p. 64);

(5) Dredging: Outer Harbor (p. 67);

(6) Dredging: Ecosystem Considerations (p. 69);

(7) Removal of Old Breakwater at South Entrance and Construction of New Breakwater: General Overview (p. 69); and

(8) Deepening of the Allen Boat Company Slip (p. 80).

In summary, dredging will create a turbidity plume carried by the currents northward of the dredging site into the Niagara River and Black

Rock Canal. Within the plume, a decrease in dissolved oxygen concentrations and remobilization of the chemical constituents of the sediments, such as heavy metals and organic toxicants, would be expected. Mobilization of toxicants from the sediments should not be of as much concern as in the Buffalo River. However, only results from sediment analyses will clarify this point.

Significantly higher catches of ichthyoplankton were found in the Outer Harbor compared to the Buffalo River and Lake Erie. However, if conducted judiciously, dredging could have little impact on the Outer Harbor. Confining dredging to existing deep-water areas, as planned in the alternative, will have little effect on shallow water spawners and their offspring. Pelagic spawners will be able to move to nearby undisturbed areas until the temporary disturbance ends. By delaying dredging until after the spawning/growth season, it would ensure that juvenile mortality would be greatly reduced.

Deepening the existing harbor channel will cause some dislocation of adult fish. Adjacent areas would easily assimilate migrants during dredging operations. Adult fish would likely re-enter dredged areas shortly after the disturbance ceases. For most species, any adult mortality would be quickly replaced by lake immigrants. Removal, relocation and construction of a new breakwater in a different orientation at the south entrance will not have significant impact on adult or juvenile fish in the area. Because of the small area involved with the Allen Boat Company slip, use of this area will have no major impact on fish populations in the project area.

Proposed Disposal Area 1 (Fig. 2) and the Small Boat Marina represent unique harbor situations due to their shallow, protected water, higher temperatures and abundant aquatic macrophytes. They are a haven for many game fish and are important spawning and nursery areas. Although no dredging is planned in these areas under this alternative, we emphasize that no dredging should occur here.

Construction of a Transshipment System

The transshipment system planned in this alternative originates south of the Allen Boat Company slip, moves eastward to Fuhrmann Boulevard, and swings southward along the west side of Fuhrmann Boulevard. At the Buffalo Port Authority, it moves eastward running between the existing railroad tracks of the Buffalo Creek Railroad and the Buffalo River. It then crosses the Conrail lines and runs adjacent to proposed Disposal Area 2 before following the southside of the oxbow in the Buffalo River to Republic Steel.

Our scope of work did not include terrestrial studies along most of the route of the transshipment system. However, except for the area south of Allen Boat Company slip and west of Fuhrmann Boulevard and the southern area of proposed Disposal Area 2, the areas that the transshipment system would cross are highly developed industrial sites (i.e., scrap iron and railroad yards, parking lots, mill yards, etc.) with little or no natural open areas. Little impact on fauna or flora is likely in these areas.

The Area South of the Allen Boat Company Slip and West of Fuhrmann Boulevard

On 15 May 1982, we walked through this area and noted vegetation, birds, mammals, amphibians and reptiles (Table 8). The area is recently disturbed by filling and is presently utilized in spots for an open dump. Essentially, the area is a weed, old-field community with peripheral cottonwoods to 9 m in height. In wet pockets, particularly east of the service road which parallels Fuhrmann Boulevard, Phragmites forms an almost pure stand that provides excellent cover for pheasants during the winter. Eight pheasants were noted in this area. Other birds observed are given in Table 8. Meadow voles, rats and rabbits were also observed.

Little impact from a biological point of view is envisioned for this entire area. However, the transshipment system is projected to move through the Phragmites stand, which could provide probable cover for some reproducing pheasants in the area. Moving the transshipment system 60 meters to the east or west would avoid the Phragmites stand. This area, if properly developed has more potential as a recreational area than as a transshipment area.

The Area Bordering Proposed Disposal Area 2

Proposed Disposal Area 2 is one of the most environmentally sensitive sites considered by us. It is a refugium for species not generally expected in an urban ecosystem. It supports a reproducing population of pheasants and an endangered species, the peregrine falcon, which was observed on this site. Even without the endangered species, by virtue of its wildlife productivity, richness in vegetation and quality habitat, we would not generally recommend disturbing this site in any manner. However, the proposed location of the transshipment system would be at the south margin of this productive terrestrial area. If construction were indeed limited to the area immediately adjacent to the railroad defining the southern boundary of this area (see Fig. 2), minimal or no effect on fauna and flora should occur over the entire area. In fact, there appears to be ample room on the elevated railroad bed at the south end of this area to construct the transshipment system. If this is done, little or no impact should occur to this productive terrestrial site.

ALTERNATIVE IIIh: ASSESSMENT OF IMPACT

The following work items are planned with this alternative:

(1) Remove 850 ft of existing breakwater at south entrance;

(2) Construct 450 ft of arrowhead breakwater at south entrance;

(3) Move north side light at the south entrance channel;

(4) Deepen the south entrance to 32 ft below low water datum;

(5) Deepen Hanna furnace slip (Union Canal) to 28 ft below low water datum, and enlarge the entrance up to the Father Baker Bridge; and

(6) Utilize existing rail lines or construct some type of transshipment system which may take a number of routes other than the one shown on the map entitled Buffalo Harbor Study: Alternative IIIh.

A detailed discussion of the dredging of the south entrance channel and planned removal and reconstruction of the south entrance breakwater is covered in the following sections:

(1) Dredging: Physical Aspects (p. 60);

(2) Dredging: Chemical Aspects (p. 61);

(3) Dredging: Toxic Chemicals (p. 63);

(4) Dredging: Ichthyoplankton (p. 64);

(5) Dredging: Outer Harbor (p. 67);

(6) Dredging: Ecosystem Considerations (p. 69); and

(7) Removal of Old Breakwater at South Entrance and Construction of New Breakwater: General Overview (p. 69).

In summary, dredging will create a turbidity plume carried by the currents northward of the dredging site into the Niagara River and Black Rock Canal. Within the plume, a decrease in dissolved oxygen concentrations and remobilization of the chemical constituents of the sediments, such as

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heavy metals and organic toxicants, would be expected. Mobilization of toxicants from the sediments should not be of as much concern as in the Buffalo River. However, only results from sediment analyses will clarify this point.

Significantly higher catches of ichthyoplankton were found in the Outer Harbor compared to the Buffalo River and Lake Erie. However, if conducted judiciously, dredging could have little impact on the Outer Harbor. Confining dredging to existing deep-water areas, as planned in the alternative, will have little effect on shallow water spawners and their offspring. Pelagic spawners will be able to move to nearby undisturbed areas until the temporary disturbance ends. By delaying dredging until after the spawning/growth season, it would ensure that juvenile mortality would be greatly reduced.

Deepening the existing harbor channel will cause some dislocation of adult fish. Adjacent areas would easily assimilate migrants during dredging operations. Adult fish would likely re-enter dredged areas shortly after the disturbance ceases. For most species, any adult mortality would be quickly replaced by lake immigrants. Removal, relocation and construction of a new breakwater in a different orientation at the south entrance will not have significant impact on adult or juvenile fish in the area.

Deepening and Widening of the Union Canal

Although we did not sample in Union Canal, some cursory observations were made. The water is extremely turbid and polluted and often chalky in appearance. There are no apparent shallow areas with macrophyte beds. It is relatively deep and appears to possess habitat analagous to the

Buffalo Ship Canal. We do not believe that it is a spawning or nursery area for fish and should not harbor any significant sport fishes. Project implementation should not have any major effect on the fish community.

Construction of the Transshipment System

Transshipment by rail or some type of transshipment system is planned. This area is a 33 m wide strip running from the Union Canal northeasterly to the north side of the Tifft Street railroad bridge; then easterly, parallel to the bridge to the edge of the railyard; then northerly, parallel to the railroad yard before moving easterly to Republic Steel.

Along the Union Canal, some grasses are mixed in with piles of coal, furnace tailings, scrap iron, etc. From the Union Canal to Tifft Street, the area is crossed by many unpaved roads and rail lines. Much of the area has been filled and from a wildlife habitat viewpoint is best described as in early old-field succession with clover and goldenrod. Occasional small trees and shrubs exist such as cottonwood and staghorn sumac (Table 8). The area has good potential for voles, shrews, rats and garter snakes. At present, little over-wintering cover exists and may account for the lack of pheasants in this area in May.

North of Tifft Street moving east into the Conrail Yards and then north into the Conrail Yard parallel to the tracks is a curious area of 25+ tracks that are dispersed between parallel pockets of marsh vegetation and fauna (Table 8) with some standing water. It appears that the Conrail Yard was built on a marsh with the rail beds elevated by fill. Between the tracks, medium height wet soil trees grow well (e.g. willow, poplar). Within the marsh vegetation, breeding American woodcock were observed, along with rabbits, rats and voles in our one day of observation (Table 8).

Construction of the proposed transshipment system will have, in general, minimal impact. Some clarification is required though. No impact is envisioned in the Union Canal area. In the Conrail Yard, some minimal impact will occur to the marsh vegetation fauna present, if the transshipment system is built in the area between railbeds. However, this impact could be minimized further by construction of the transshipment system on one of the abandoned elevated railway beds.

The area between the Union Canal and Tifft Street is more difficult to assess. At present, this large open area does not offer much cover for animals and will not be adversely impacted by construction. However, with time the habitat will develop and provide for a more abundant flora and fauna in the future if it is not continually disturbed.

ALTERNATIVE IV: ASSESSMENT OF IMPACT

The following work items are planned with this alternative:

(1) Remove 850 ft of existing breakwater at south entrance;

(2) Construct 450 ft of arrowhead breakwater at south entrance;

(3) Move north side light at the south entrance channel;

(4) Deepen south channel area to 32 ft below low water datum; and

(5) Deepen Outer Harbor area to 28 ft below low water datum.

A detailed discussion of the dredging of the south entrance channel, dredging of the Outer Harbor, and planned removal and reconstruction of the south entrance breakwater is covered in the following sections:

(1) Dredging: Physical Aspects (p. 60);

(2) Dredging: Chemical Aspects (p. 61);

(3) Dredging: Toxic Chemicals (p. 63);

(4) Dredging: Ichthyoplankton (p. 64);

(5) Dredging: Outer Harbor (p. 67);

(6) Dredging: Ecosystem Considerations (p. 69); and

(7) Removal of Old Breakwater and Construction of New Breakwater at South Entrance: General Overview (p. 69).

In summary, dredging will create a turbidity plume carried by the currents northward of the dredging site into the Niagara River and Black Rock Canal. Within the plume, a decrease in dissolved oxygen concentrations and remobilization of the chemical constituents of the sediments, such as heavy metals and organic toxicants, would be expected. Mobilization of toxicants from the sediments should not be of as much concern as in the Buffalo River. However, only results from sediment analyses will clarify this point.

Significantly higher catches of ichthyoplankton were found in the Outer Harbor compared to the Buffalo River and Lake Erie. However, if conducted judiciously, dredging could have little impact on the Outer Harbor. Confining dredging to existing deep-water areas, as planned in the alternative, will have little effect on shallow water spawners and their offspring. Pelagic spawners will be able to move to nearby undisturbed areas until the temporary disturbance ends. By delaying dredging until after the spawning/growth season, it would ensure that juvenile mortality would be greatly reduced.

Deepening the existing harbor channel will cause some dislocation of adult fish. Adjacent areas would easily assimilate migrants during dredging operations. Adult fish would likely re-enter dredged areas shortly after the disturbance ceases. For most species, any adult mortality would be quickly replaced by lake immigrants. Removal, relocation and construction of a new breakwater in a different orientation at the south entrance will not have significant impact on adult or juvenile fish in the area.

Proposed Disposal Area 1 (Fig. 2) and the Small Boat Marina represent unique harbor situations due to their shallow, protected water, higher temperatures and abundant aquatic macrophytes. They are a haven for many game fish and are important spawning and nursery areas. Although no dredging is planned in these areas under this alternative, we emphasize that no dredging should occur here.

DREDGING - RECOMMENDATIONS

1. The effect of dredging on the Buffalo River, Ship Canal and Outer Harbor adult fish populations is expected to be localized and temporary and would not be expected to have any long-term adverse impact, especially river populations that consist mostly of undesirable fish species. Significantly higher catches of ichthyoplankton were found in the Outer Harbor compared to the Buffalo River, Ship Canal and Lake Erie. However, if conducted judiciously, dredging could have little impact on Outer Harbor ichthyoplankton. By confining dredging to existing deep-water areas, as is generally planned in the various alternatives, little effect on shallow water spawners and their offspring is expected. To ensure that juvenile mortality is not significant, we recommend delaying dredging of the Outer Harbor until after the spawning/growth season (e.g., August).

2. Assuming there are no toxicants in the sediments of the project area, there is no environmental basis for choosing between the various dredging options provided in the work alternatives. In general, dredging should have no major impact in the Outer Harbor, Buffalo River and Ship Canal, especially if the above recommendation is followed. We also emphasize that no dredging should occur in proposed Disposal Area 1 or the Small Boat Marina. Once again a late summer dredging operation will help protect these spawning and nursery areas from siltation and associated effects as discussed in detail in the report.

3. If the alternative to dredge the Buffalo River and Ship Canal is chosen, dredging will have the positive effect of removing apparently

highly contaminated sediments (see section on Toxic Chemicals, page 63 for details). As part of this alternative, we recommend that all dumping into the Buffalo River and Ship Canal be ceased immediately after dredging is completed. The fishery in the Outer Harbor is diverse, rich in sport fishes and has recreational potential. This suggests that the Buffalo River with cleanup could support a similar fishery.

4. Our literature search strongly suggests that the sediments of the Buffalo River are polluted with mutagenic and carcinogenic substances. Further study of the sediments should be undertaken, if not already begun. Dredging of toxic sediments may unleash a toxic plume that will move downriver contaminating the Niagara River and the Black Rock Canal. Bioconcentration and biomagnification of pollutants in the food web could occur. Effects could be realized as far downstream as Lake Ontario. In addition, any public water supplies would be threatened.

Consideration of the effects of release of mutagenic and carcinogenic substances from sediments of the Buffalo River or Outer Harbor by dredging or leaching from a disposal area on downstream ecosystems and the general public should take precedent over any other biological, economical or political considerations. Further recommendations on the proposed disposal areas are noted on page 54, Disposal Areas: Ecosystem Considerations and Recommendations.

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Table 1. Approximate depths at which gill nets were set.

Station	Depth(m)
1	9
2	4-5
3	2-3
4	7-8
5	7-8
6	7-8
7	8-9
8	4-5
9	7-8
10	7-8
11	7-8
12	7-8
13	2-3
14	7-8

Table 2. Species diversity and average density of macrobenthic invertebrates at Disposal Areas 1 and 4. Diversity represents the number of taxonomic groups observed.

	Disposal Area 1		Disposal Area 4	
	Diversity	#/m²	Diversity	#/m²
June	25	20,680	9	47
September	26	11,050	8	56

Table 3. Relative abundance (%) of major taxonomic groups of macrobenthic invertebrates.

	Disposal Area 1		Disposal Area 4	
	June	September	June	September
Isopoda	0.00	1.60	0.00	0.00
Amphipoda	0.10	1.20	0.00	0.00
Trichoptera	0.03	0.50	0.00	1.90
Chironomidae	1.70	0.06	19.10	11.20
Gastropoda	88.60	87.90	30.30	25.90
Pelecypoda	8.90	4.00	40.40	53.60
Oligochaeta	0.60	4.60	10.10	7.4
Planaridae	0.06	0.20	0.00	0.00

Table 4. Summary of species lists and relative abundances of mammals, amphibians and reptiles at Disposal Areas during the study period. Densities based on signs and sitings represent conservative estimates. See Tables G1-G12 in Volume 2 for original data.

Genus and Species	Common Name	Sitings	Sign	Estimated Density
Disposal Area 1				
Microtus pennsylvanicus	Meadow vole	1	1 nest 1 carcass	3
Sylvilagus floridanus	Eastern cottontail	1	tracks	2
Procyon lotor	Raccoon		Scat	1
Canis familiaris	Dog	1	tracks	3
Disposal Area 2				
Microtus pennsylvanicus	Meadow vole	26m,25f	33+ runways 125+ burrows feces grass clippings	many
Sylvilagus floridanus	Eastern cottontail	38		
Marmota monax	Woodchuck		paths (~9 different ones)	9
Procyon lotor	Raccoon		carcass feces	>4
Blarina brevicauda	Short-tail shrew	4	1 carcass	
Sorex cinereus	Masked shrew	1f		
Rattus norvegicus	Norway rat		3 burrows	3
Mephitis mephitis	Striped skunk		ordor	3
Ondatra zibethicus	Muskrat	1	1 carcass 7 burrows 5 paths	14
Thamnophis sirtalis	Garter snake	4		>4
Chelydra serpentina	Snapping turtle	1		1
Chrysemys picta	Painted turtle	1		1
Rana pipiens	Leopard frog		calls	many
tadpoles		1000+		

Table 4 (continued).

Genus and Species	Common Name	Sitings	Sign	Estimated Density
Disposal Area 3				
Microtus pennsylvanicus	Meadow vole	1	5 runs 1 pile of feces 6 nests 19 burrows	26
Canis familiaris	Dog		tracks	3
Rattus norvegicus	Norway rat		6 burrows tracks	6
Sylvilagus floridanus	Eastern cottontail	4	tracks	5
Mephitis mephitis	Striped skunk		tracks	2
Previous Disposal Area				
Microtus pennsylvanicus	Meadow vole		2 fecal piles 10+ clippings runs 61 burrows	~48
Rattus norvegicus	Norway rat		8 burrows	8
Sylvilagus floridanus	Eastern cottontail	4	tracks	>4
Ondatra sibethicus	Muskrat		7 burrows	7
Mus musculus	House mouse	1		>1
Peromyscus leucopus	White-footed mouse		feces-2	>2
Chrysemys picta	Painted turtle	1		>1

Table 5. Gill netting data: Catch per unit effort and diversity indices (averaged within stations over all seasons).

Station	CPUE	H'*
River		
14	9.0	0.28
13	9.1	0.31
12	10.9	0.27
11	17.2	0.54
10	8.9	0.43
Harbor		
9	14.9	0.55
8	11.0	0.46
6	5.9	0.44
5	4.8	0.28
3	12.9	0.49
2	9.5	0.45
DA1	11.5	0.42
Lake		
7	7.4	0.45
4	10.3	0.37
1	5.4	0.35
DA4	13.6	0.59

* H' is the Shannon-Weaver Index and is described in the "Methods" section. Essentially, it is a measure of species diversity. A higher value for H' indicates a more diverse assemblage of fish relative to other stations sampled.

Table 6. Bottom characteristics of sample sites.

Station	Substrate
14	dark gray gyttja
13	chunks of dark gray clay
12	dark gray gyttja
11	dark gray gyttja
10	dark gray gyttja
9	dark gray gyttja
8	gyttja with sand
7	red clay
6	gyttja
5	cobble and sand
4	cobble and sand
3	cobble and gravel
2	large boulders
1	cobble

Table 7. Densities of ichthyoplankton in different lakes.

Site	Range(#/10m^3)	Dominant Group	Author
Maumee River (Lake Erie)	9.9	only walleye	Bartholomew 1980
Sandusky River (Lake Erie)	~6.0	only gizzard shad	Snyder 1978
Buffalo River	4.9	all species	This study
Outer Harbor	23.0	all species	This study
Lake Station	3.0	all species	This study

Table 8. Fauna and flora observed on transshipment system originating from the Union Canal, observed on the oxbow at the Airco Plant, and observed on the area south of the Allen Boat Company Slip.

Union Canal Transshipment Route

Plants

Common Name	Genus and Species	Common Name	Genus and Species
Goldenrod	Solidago spp.	Plantain	Plantago sp.
Common dandelion	Taraxacum officinale	Cinquefoil	Potentilla sp.
Aster	Aster sp.	Clover	Trifolium sp.
Wild carrot	Daucus carota	Sweet clover	Melilotus sp.
Sunflower	Helianthus sp.	Reed	Phragmites
Chicory	Cichorium intybus	Sow thistle	Soncus sp.
Forsythia	Forsythia sp.	Willow	Salix sp.
Burdock	Arctium sp.	Cattail (narrow)	Typha sp.
Various grasses	-	Alder	Alnus sp.
Grape	Vitis sp.	Poplar	Populus tremuloides
Staghorn sumac	Rhus typhina	Horsetail	Equisetum sp.
Cottonwood	Populus deltoides	Raspberry	Rubus sp.
Common evening-primrose	Oenothera biennis	Elder	Sambucus sp.
Common mullein	Verbascum thapsus	-	Pastinaca sativa
Red-osier dogwood	Cornus stolonifera	Mugwort	Artemisia vulgaris

Birds

Common Name	Genus and Species	Common Name	Genus and Species
European starling	Sturnus vulgaris	Swamp sparrow	Melospiza georgiana
Rock dove	Columba livia	Herring gull	Larus argentatus
Ring-necked pheasant (4m, 3f)	Phasianus colchicus	Ring-billed gull	Larus delawarensis
Song sparrow	Melospiza melodia	Unidentified gull	Larus sp.
Mallard (10m, 4f)	Anas platyrhynchos	Eastern meadow-lark	Sturnella magna
Killdeer	Charadrius vociferus	Red-winged black-bird	Agelaius phoeniceus
Yellow warbler	Dendroica sp.	American wood-cock (nest with 4 eggs)	Philohela minor
American robin	Turdus migratorius		
American kestrel	Falco sparverius		
Common flicker	Colaptes auratus		
Common grackle	Quiscalus quiscula		
Brown-headed cowbird	Molothrus ater		

Mammals, Amphibians and Reptiles

Near Union Canal

Common Name	Genus and Species	Noted
Meadow vole	Microtus pennsylvanicus	4 burrows
Norway rat	Rattus norvegicus	2 burrows

Table 8 (continued).

Union Canal Transshipment Route (continued)

Mammals, Amphibians and Reptiles (continued)

Between Union Canal and Tifft Farms

Common Name	Genus and Species	Noted
Meadow vole	*Microtus pennsylvanicus*	20^{+} burrows, 9 nests, runs

Conrail Yard

Common Name	Genus and Species	Noted
Rabbit	*Sylvilagus floridanus*	2 seen
Norway rat	*Rattus norvegicus*	1 seen
Meadow vole	*Microtus pennsylvanicus*	12 burrows, 3 nests, runs

Oxbow at the Airco Plant

Plants

Common Name	Genus and Species	Common Name	Genus and Species
Staghorn sumac	*Rhus typhina*	Cattail	*Typha* sp.
Cottonwood	*Populus deltoides*	Teasel	*Dipsacus* sp.
Tree of Heaven	*Ailanthus altissima*	Thistle	*Soncus* sp.
Willow	*Salix* sp.	Aster	*Aster* sp.
Red-osier dogwood	*Cornus stolonifera*	Goldenrod	*Solidago* sp.
Burdock	*Arctium* sp.	Mustard	*Brassica* sp.
Elder	*Sambucus* sp.		
Various unidentified grasses			

Birds

Common Name	Genus and Species	Common Name	Genus and Species
Song sparrow	*Melospiza melodia*	House sparrow	*Passer domesticus*
Ring-necked pheasant (2m)	*Phasianus colchicus*	American robin	*Turdus migratorius*
Ring-billed gull	*Larus delawarensis*	Yellow warbler	*Dendroica petechia*
Red-winged blackbird	*Agelaius phoeniceus*		
Rufous-sided towhee	*Pipilo erythrophthalmus*		
Mallard (1 f)	*Anas platyrhynchos*		

Mammals, Amphibians and Reptiles

Common Name	Genus and Species	Noted
Meadow vole	*Microtus pennsylvanicus*	2 burrows, 2 nests

Area South of the Allen Boat Company

Plants

Common Name	Genus and Species	Common Name	Genus and Species
Chicory	*Cichorium intybus*	Wild carrot	*Daucus carota*

Table 8 (continued).

Area South of the Allen Boat Company (continued)

Plants (continued)

Common Name	Genus and Species	Common Name	Genus and Species
Shepherd's purse	Capsella bursa-pastoris	Common mullein	Verbascum thapsus
Common dandelion	Taraxacum officinale		
Common evening-primrose	Oenothera biennis	Sow thistle	Soncus sp.
Buttercup	Ranunculus sp.	Beggar-ticks	Bidens sp.
Aster	Aster sp.	Goldenrod	Solidago sp.
Clover	Trifolium sp.	Sweet clover	Melilotus sp.
Reed	Phragmites	Teasel	Dipsacus sp.
Milkweed	Asclepias sp.	Hawkweed	Hieracium sp.
Burdock	Arctium sp.	Cottonwood	Populus deltoides
Various unidentified grasses			
Red-osier dogwood	Cornus stolonifera	Staghorn sumac	Rhus typhina
Mugwort	Artemisia vulgaris	Willow	Salix sp.
-	Pastinaca sativa		

Birds

Common Name	Genus and Species	Common Name	Genus and Species
Common flicker	Colaptes auratus	Killdeer	Charadrius vociferus
Common grackle	Quiscalus quiscula		
Ring-billed gull	Larus delawarensis	Herring gull	Larus argentatus
Spotted sandpiper	Actitis macularia		
Ring-necked pheasant (6m, 2f)	Phasianus colchicus	Unidentified gull	Larus sp.
		Rock dove	Columba livia
Mourning dove	Zenaida macroura	American crow	Corvus brachyrhynchos
Red-winged blackbird	Agelaius phoeniceus		
Eastern meadowlark	Sturnella magna	European starling	Sturnus vulgaris
Rufous-sided towhee	Pipilo erythrophthalmus		
Song sparrow	Melospiza melodia		

Mammals, Amphibians and Reptiles

Common Name	Genus and Species	Noted
Meadow vole	Microtus pennsylvanicus	4 nests, runs
Norway rat	Rattus norvegicus	2 seen, 11 burrows
Rabbit	Sylvilagus floridanus	2 seen

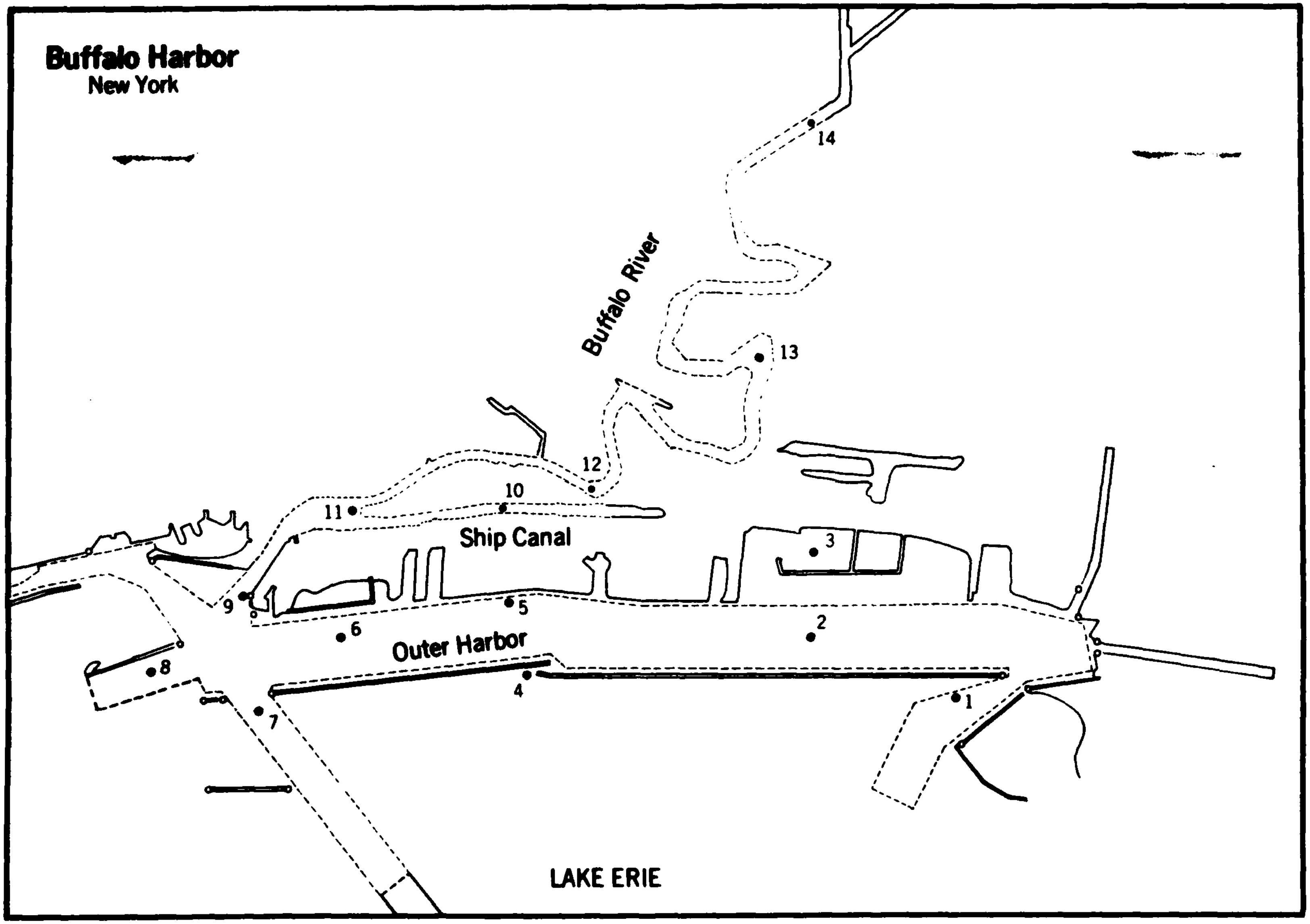

Fig. 1. Location of sampling sites (gill netting and ichthyoplankton) for fish on the Buffalo River and Outer Harbor of Buffalo. Electroshocking was done along shoreline of Stations 2, 3, 5, 6 and 9-14.

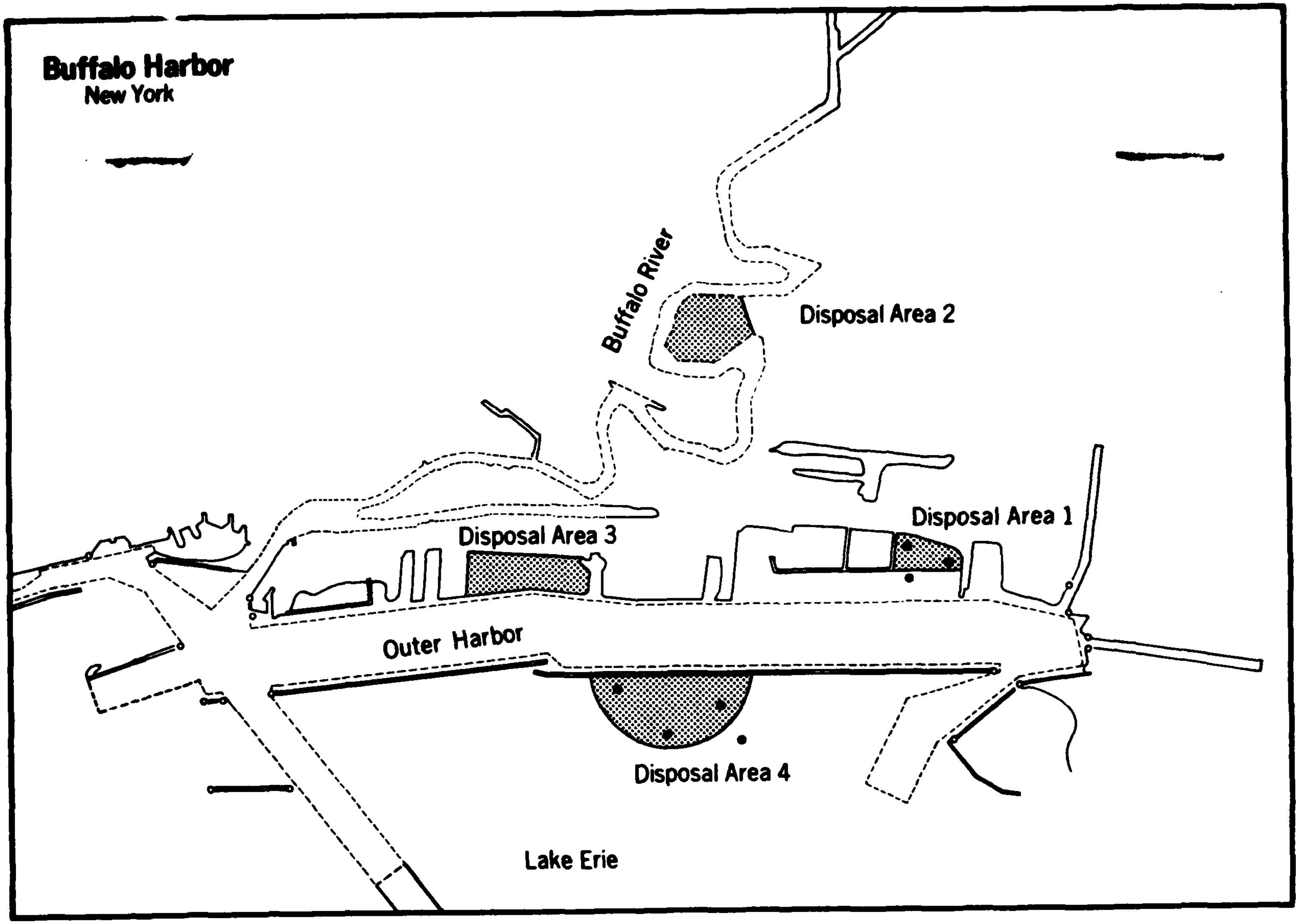

Fig. 2. Location of proposed disposal areas in the Buffalo River and Outer Harbor of Buffalo. Circles indicate location of benthic sampling sites.

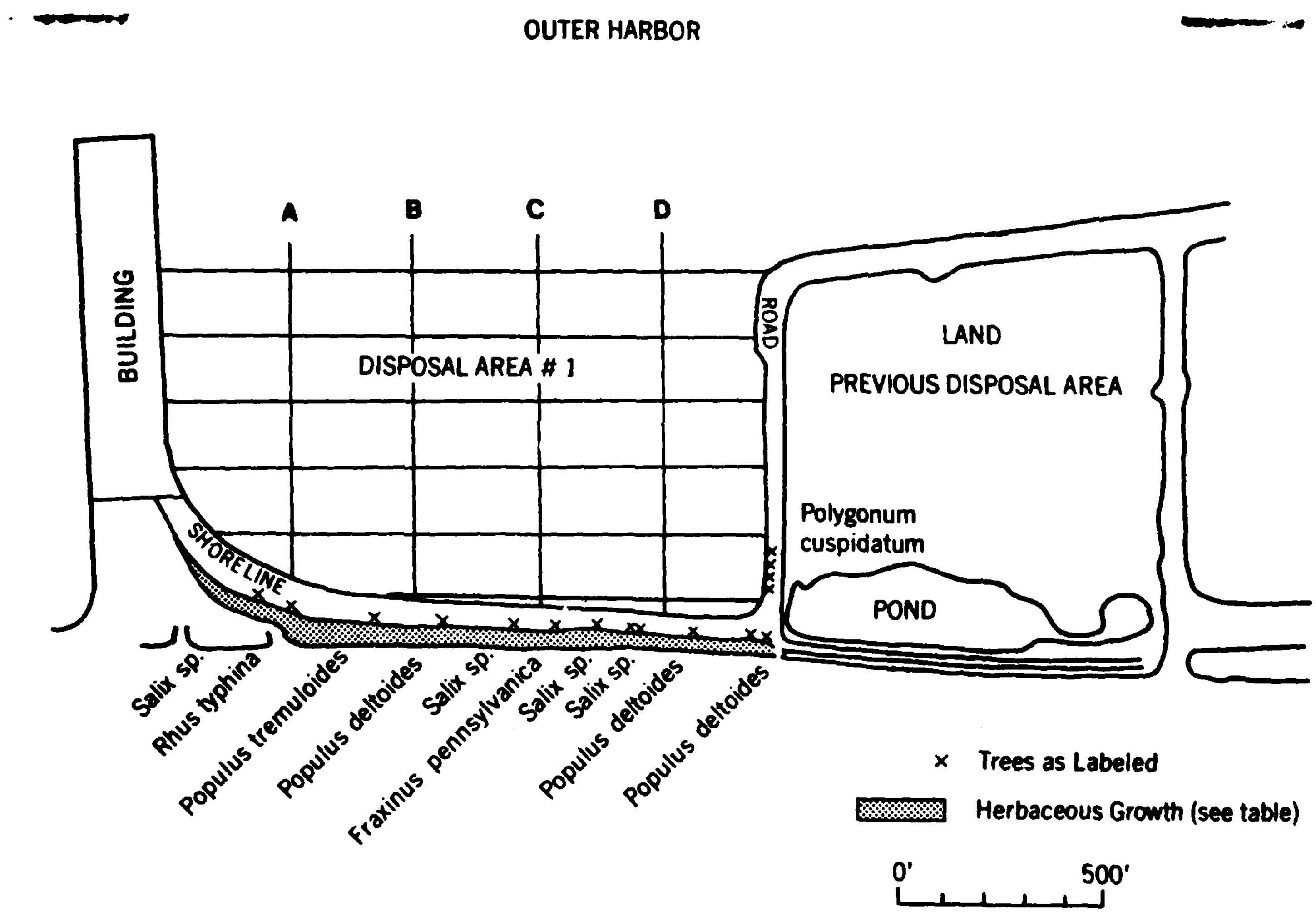

Fig. 3. Vegetation map of spring flora in Disposal Area 1, May 1981. The complete lists of spring and summer tree, shrub and herbaceous species observed are in Tables I4 and I5 in the Data Report,

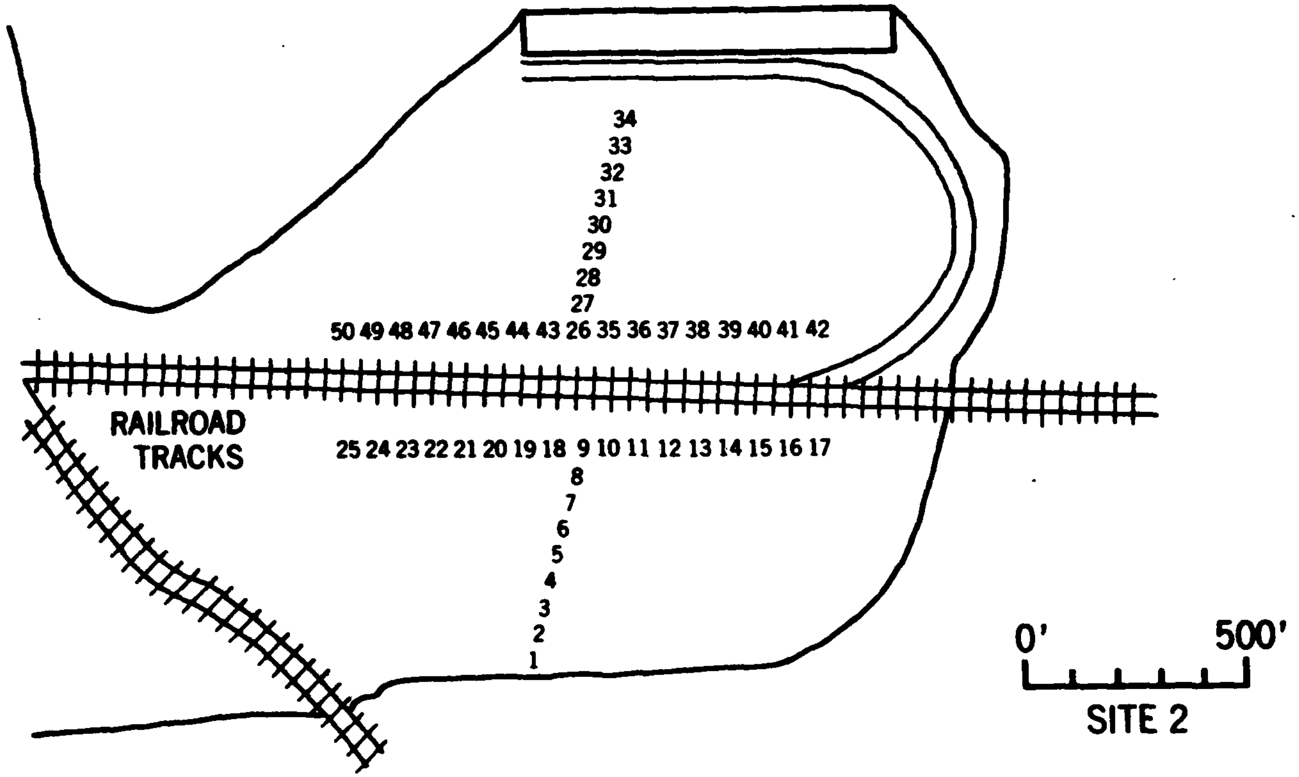

Fig. 4. Proposed Disposal Area 2 in the Buffalo River. Numbers indicate location of Sherman live traps at Disposal Area 2. Traps are 20 yards apart.

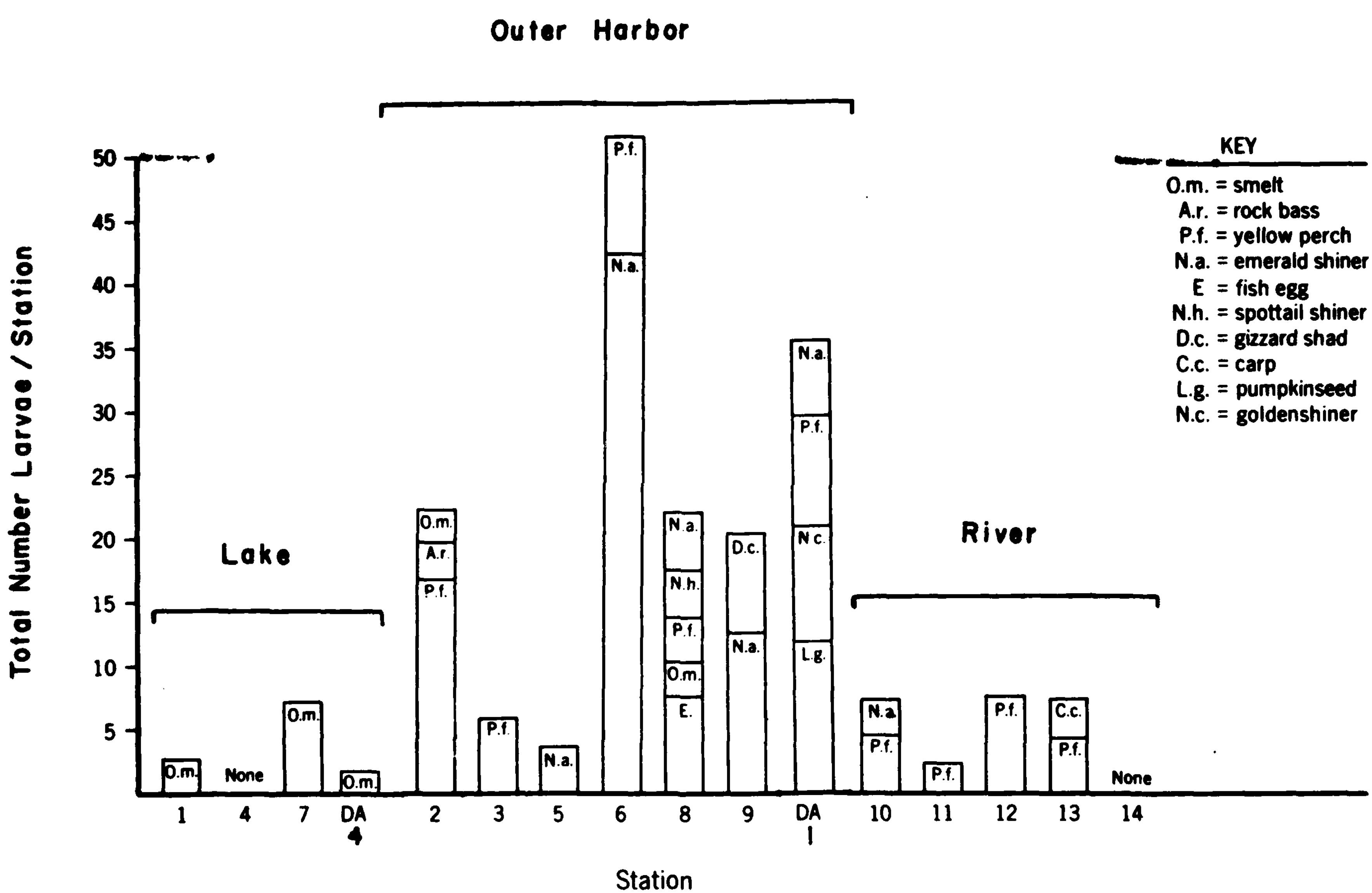

Fig. 5. Total seasonal abundance of ichthyoplankton. Sample volumes from each station have been normalized to number/10 m^3.

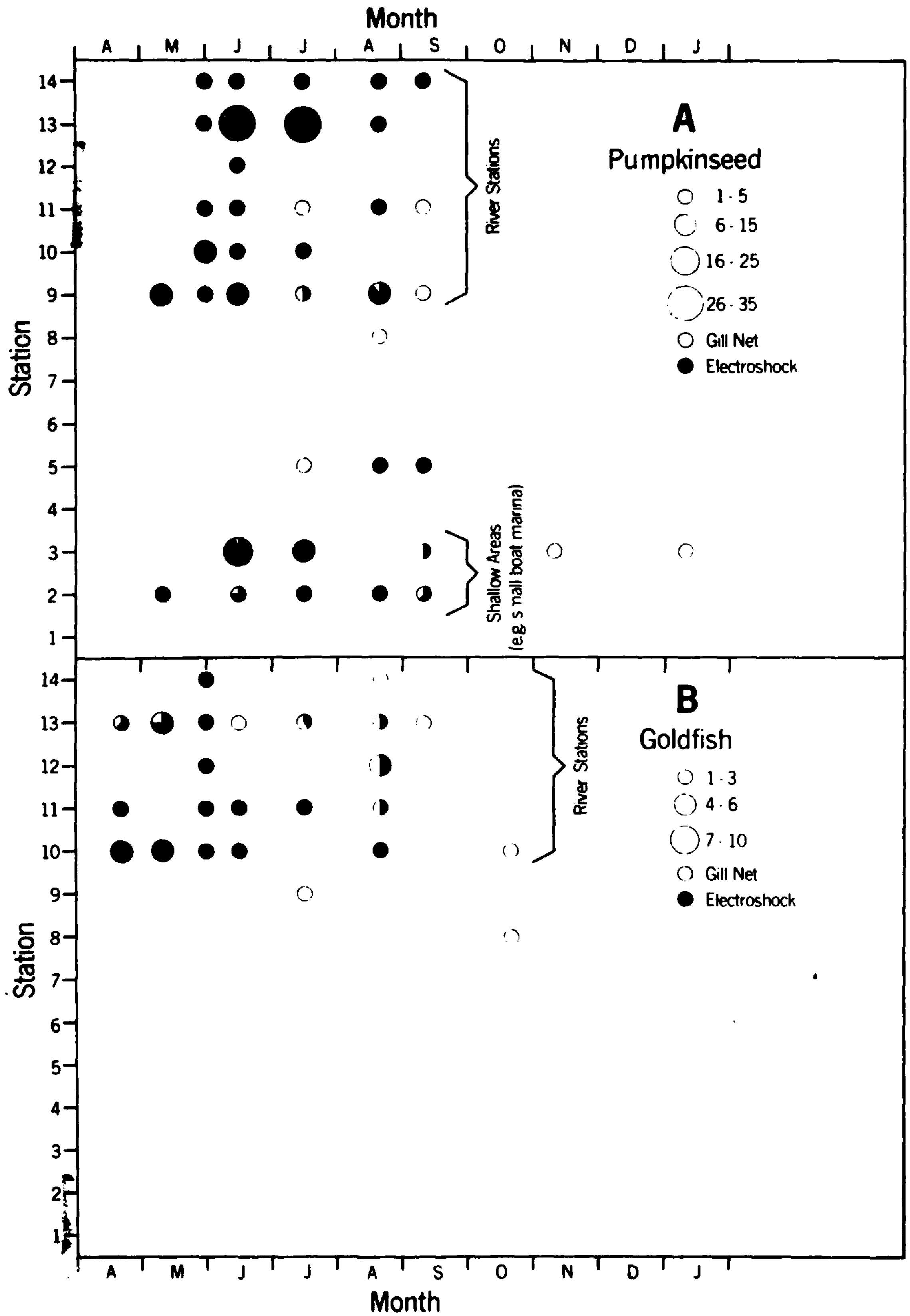

Fig. 6. Abundance and seasonal distribution of a shallow water resident (A) and a river resident (B) in the Buffalo River and Outer Harbor of Buffalo on Lake Erie. Circles represent the number of fish per 175' of gill net and/or the number of fish shocked/200' of shoreline.

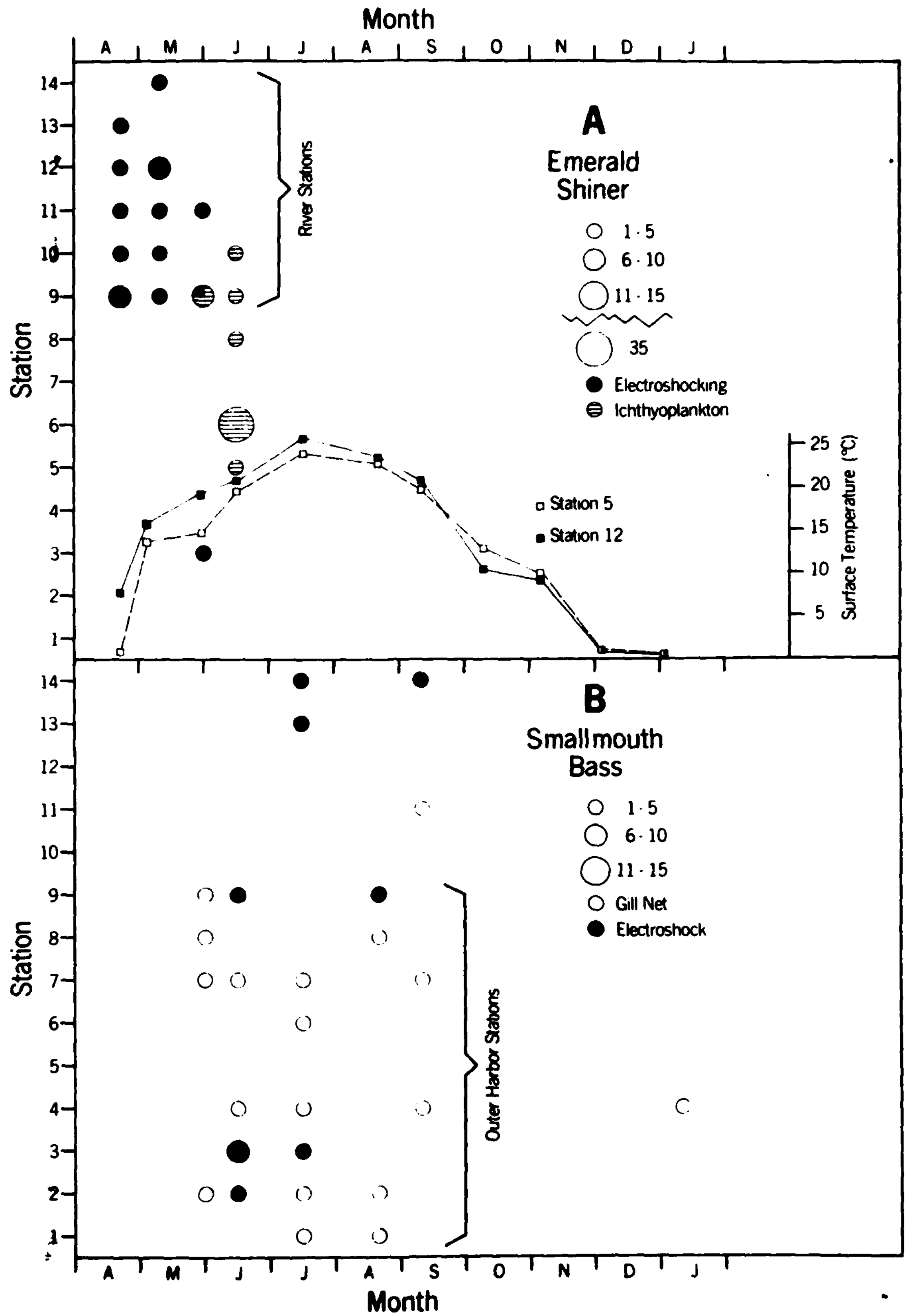

Fig. 7. Abundance and seasonal distribution of two lake residents that seasonally enter the river (A) or the Outer Harbor (B). Circles represent the number of fish per 175' of gill net, the number of fish shocked per 200' of shoreline, and/or the number of ichthyoplankton/10m^3.

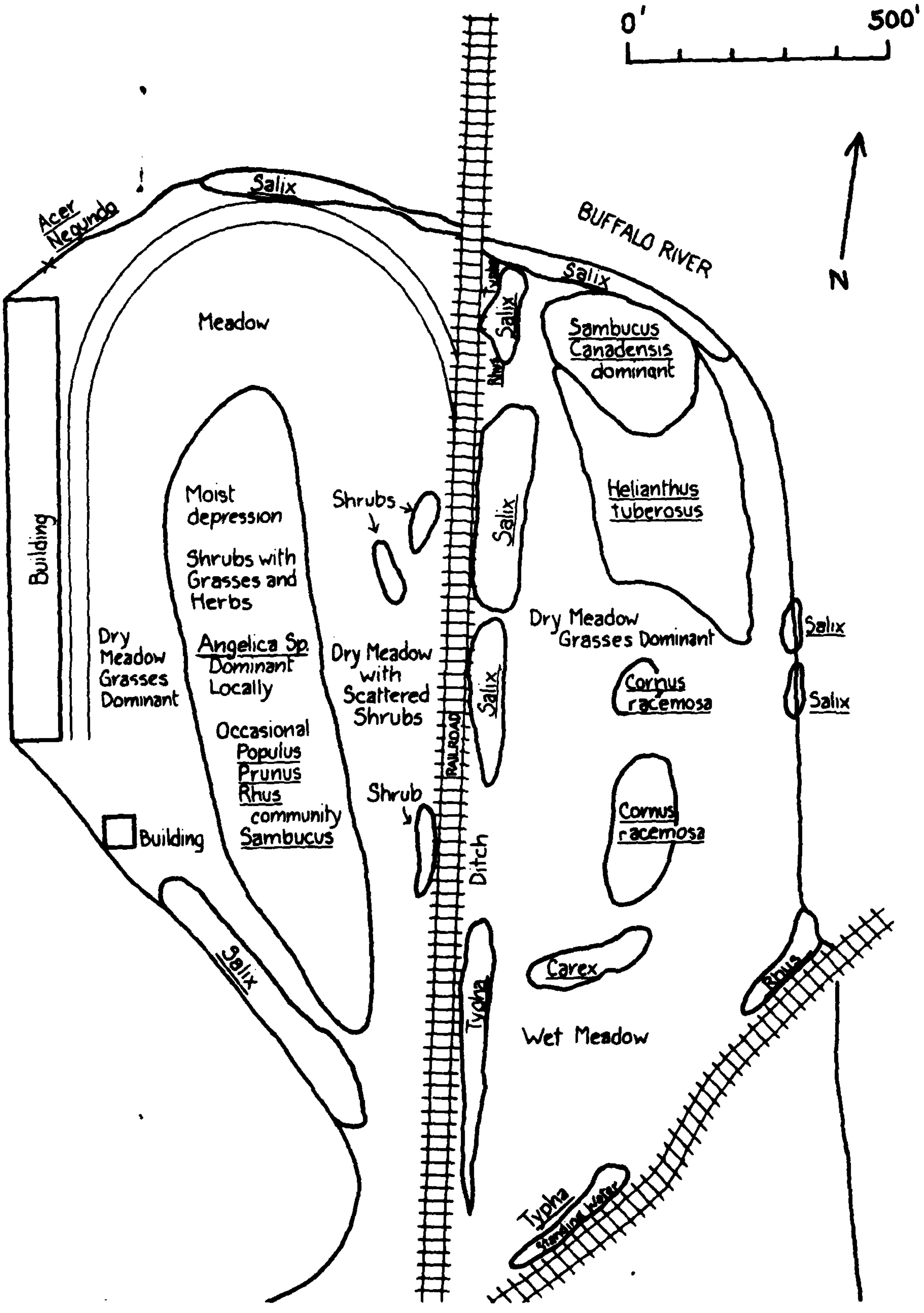

Fig. 8. Vegetation map of spring flora in Disposal Area 2, May 1981. The complete list of spring tree, shrub and herbaceous species observed is in Table I3 of the Data Report.

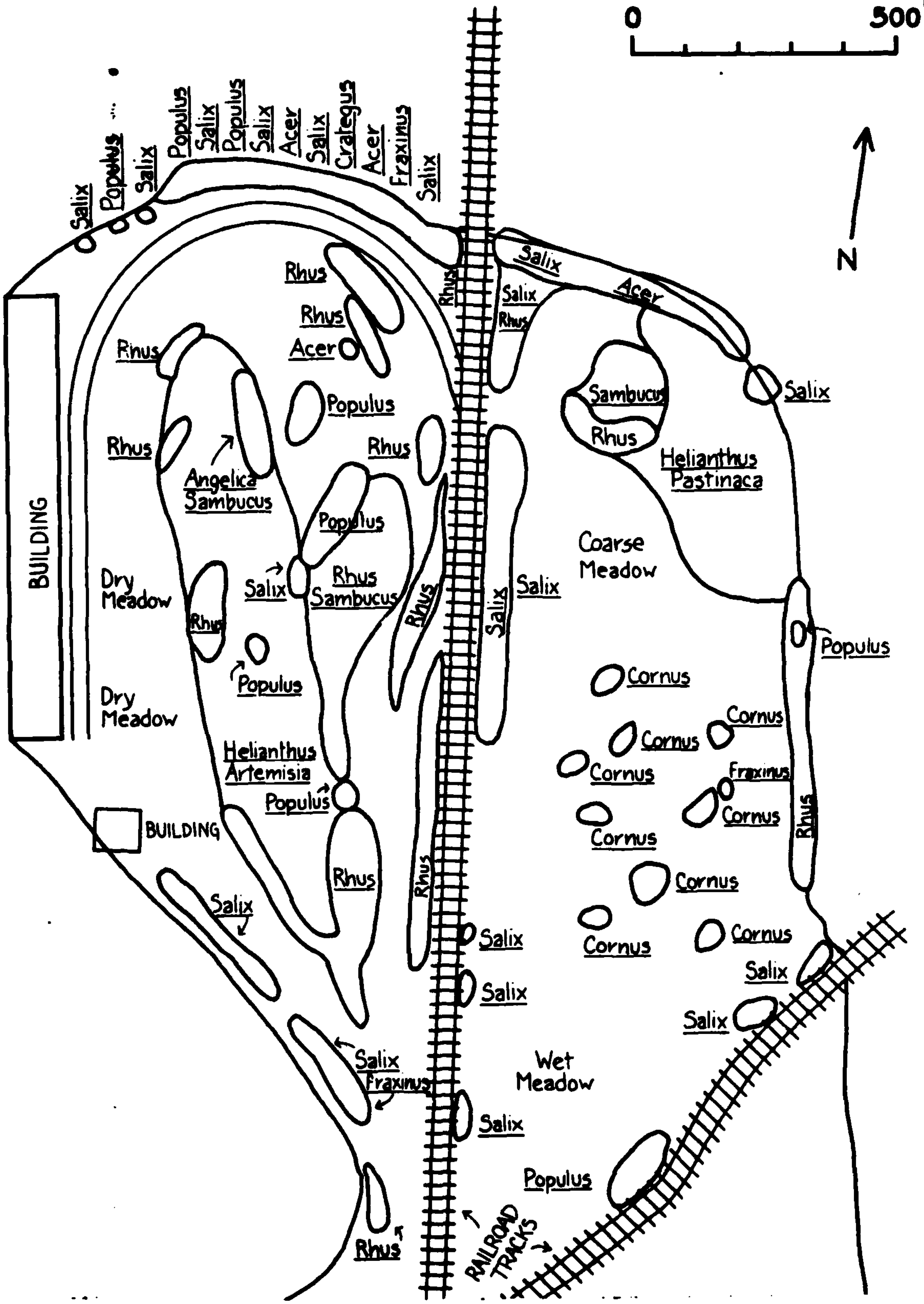

Fig. 9. Vegetation map of summer flora in Disposal Area 2, July 1981. The complete list of summer tree, shrub and herbaceous species observed is in Tables I5 and I6 of the Data Report.

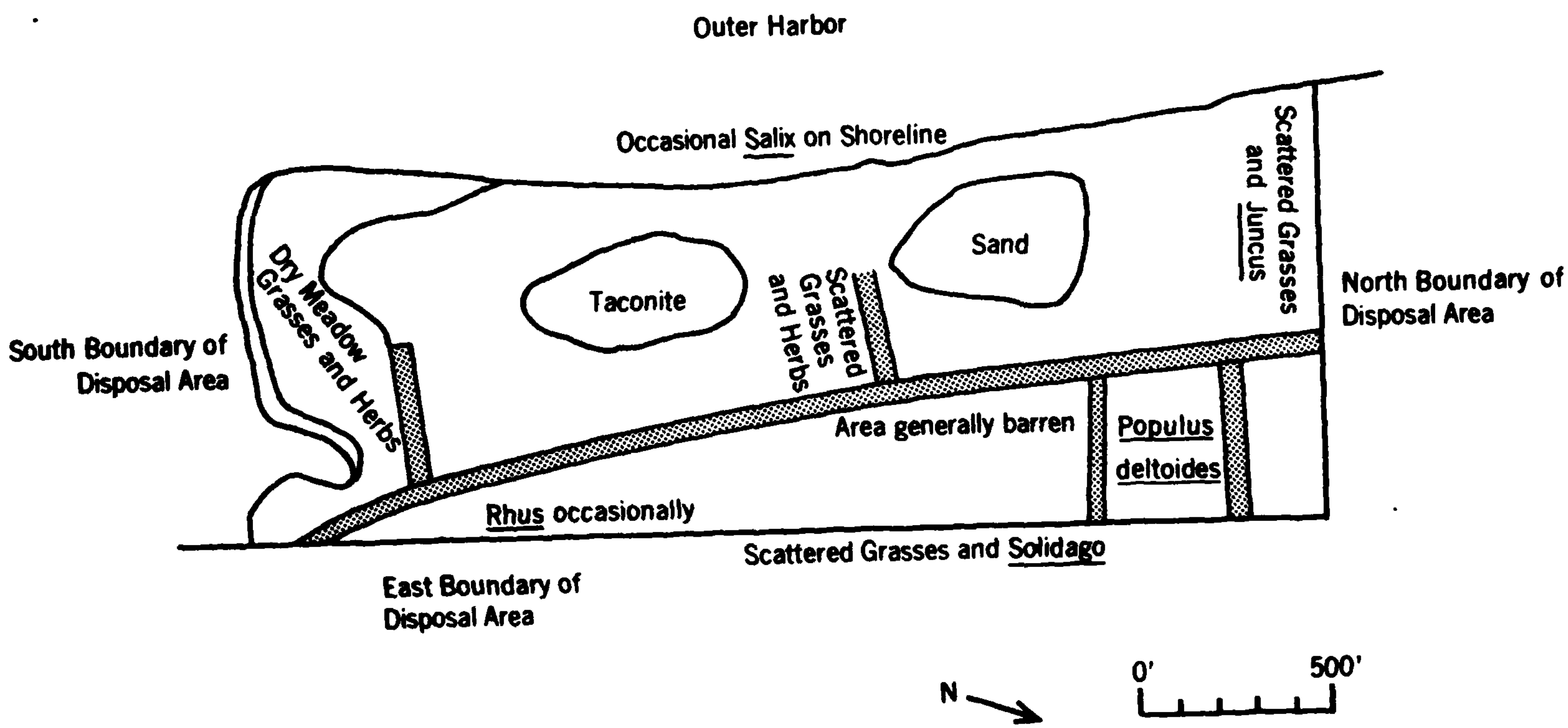

Fig. 10. Vegetation map of spring flora in Disposal Area 3, May 1981. The complete list of spring tree, shrub and herbaceous species observed is in Table I3 of the Data Report.

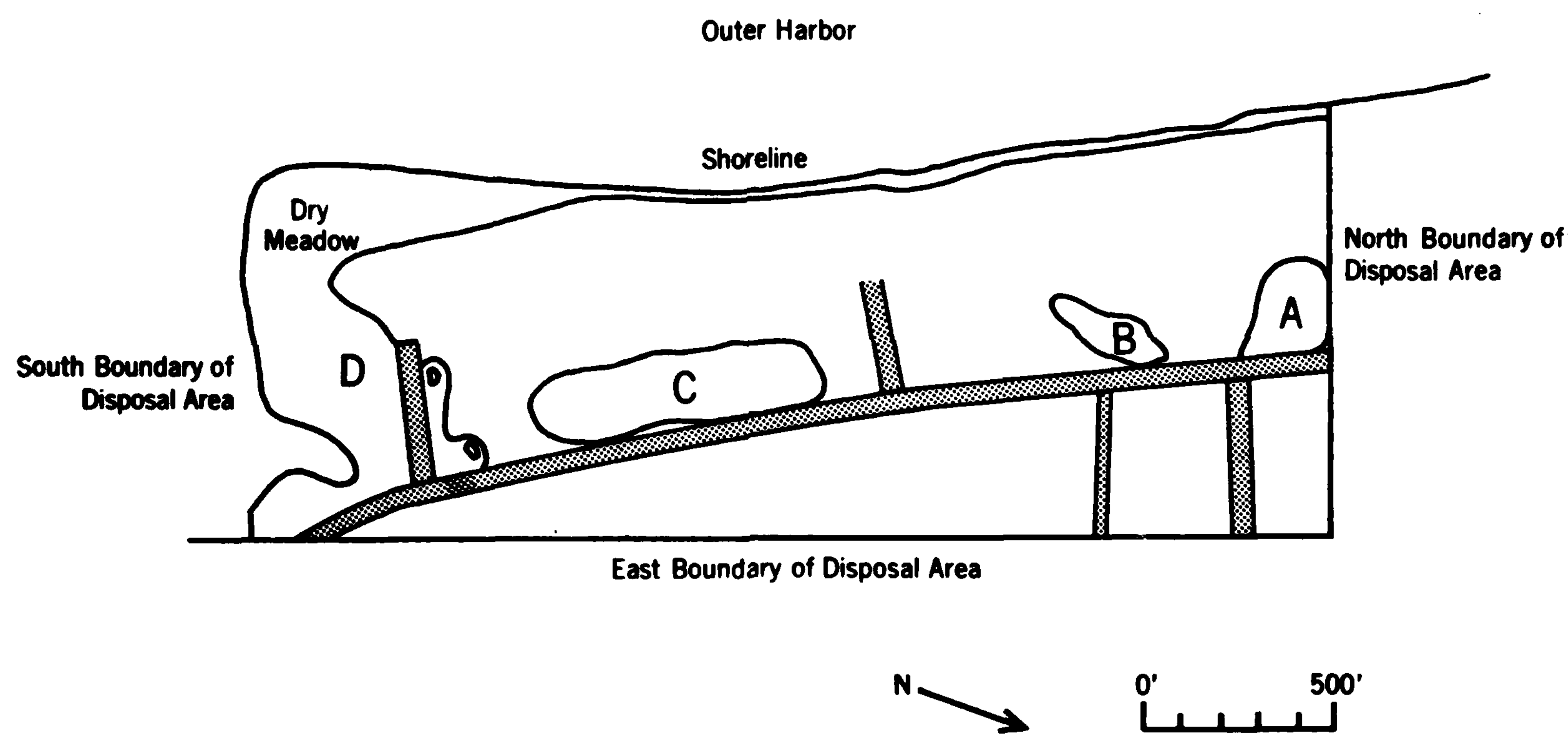

Fig. 11. Vegetation map of summer flora in Disposal Area 3, July 1981. The complete list of summer tree, shrub and herbaceous species observed is in Table I7 of the Data Report. Species in Areas A, B, C and D are listed in Table I7.