NIAGARA MOHAWK POWER CORPORATION
Syracuse, New York

# EVALUATION OF THE ANGLED SCREEN FISH DIVERSION SYSTEM AT OSWEGO STEAM STATION UNIT 6

INTERIM REPORT

APRIL 1982

LMSE-82/0091&191-058

LAWLER, MATUSKY & SKELLY ENGINEERS
Environmental Science & Engineering Consultants
One Blue Hill Plaza
Pearl River, New York 10965

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## EXECUTIVE SUMMARY

The studies reported here were undertaken by Lawler, Matusky & Skelly Engineers (LMS) for Niagara Mohawk Power Corporation (NMPC) in the first year of a two-year study to evaluate the effectiveness of the fish diversion system at Oswego Steam Station Unit 6. The effectiveness of the system is defined by the ability of the system to divert, alive, the fish entrapped in the circulating cooling water from the primary screenwell back to the source water body.

The fish diversion and transport system installed at Oswego Unit 6 is based on simulations and biological testing of the system components conducted over several years at Alden Research Laboratories by Stone and Webster Engineering (S&W). Unit 6 is an oil-fired steam generator with a rating of 816 MWe and a maximum gross output of 890 MWe. Cooling water (20.5 $m^3/s$) is taken from Lake Ontario via a submerged inlet, circulated through the condensers, and returned to the lake through a submerged jet diffuser. Fish entering the screenwell with the cooling water flow pass through trash racks and are guided by four angled, flush-mounted traveling water screens into a bypass.

The bypass flow from the primary screenwell is the suction side of the primary peripheral jet pump which discharges into a secondary screenwell where the fish are guided across one angled traveling screen into another bypass. The secondary bypass slot converges at the secondary jet pump, which in turn discharges into a pipe embedded in the roof of the intake tunnel for a distance of approximately 300 m (1000 ft) where it rises vertically and terminates as a horizontal discharge approximately 2 m (6 ft) off the bottom.

As part of the evaluation of the system operation, a study was conducted to evaluate the physical performance of the diversion

system relative to the design parameters. The conclusion is that the overall system is functioning satisfactorily but that some modifications to reduce turbulence in the secondary screenwell may be necessary. Flow to the primary screens is reasonably uniform and the entry velocity to both the primary and secondary bypasses is on the order of 60 cm/s (1.0 ft/s). The lifts being provided by the two jet pumps, however, are far from the design conditions, especially in the case of the primary jet pump. Nozzle pressures and flows seem to be somewhat lower than the design values used in 1975, but are within 20% of the values used in the 1978 and 1979 calculations.

Turbulence created by the flow into the secondary screenwell undoubtedly causes stress to the organisms that, depending upon species and/or age, may result in reduced survivals. Based on low survival results of juvenile alewife and smelt (see Section 3.2.2.2), modifications to the system will be investigated in an attempt to reduce turbulence in the secondary screenwell and thereby increase survival.

The fish collections demonstrated a definite seasonal pattern. Spring collections were dominated by adults, while fall and early winter collections were dominated by juveniles. At the outset of the program (April-May 1981), adult alewife predominated (76 and 123 fish/hr), with lower numbers of adult rainbow smelt (12 and 5 fish/hr) and an occasional mottled sculpin, white perch, and trout perch. An additional 13 species were collected, but typically at rates of less than 0.2 fish/hr. Rates dropped significantly throughout the summer; collections were dominated by emaciated post-spawn alewives and infrequent numbers (less than 1/hr) of spottail shiners and smallmouth bass.

Fall collections saw an influx of juvenile alewife, rainbow smelt, and gizzard shad, with lower numbers of emerald shiner, spottail shiner, and white perch. Alewife density dropped in November and December, while rainbow smelt densities in December reached peak levels (170/hr).

Based on this presentation, approximately 34% of the alewives and 75% of the rainbow smelt that enter the plant in April will be returned alive to the source water body. This number drops off to approximately zero in May. This coincides with a significant decline in the entrapped population. In light of the low diversion and survival of juvenile alewife and smelt in the early fall, less than 20% of the entrapped juveniles can be expected to be returned alive to the source water body. By November and December, 30 to 40% of the alewife entrapped are saved but less than 10% of the smelt.

Five other species showed variable total efficiencies, with gizzard shad and white perch typically falling between 30 and 60%, and spottail shiner, emerald shiner, and yellow perch typically exceeding 80% total efficiency (Table ES-1). Overall survival of brown trout and smallmouth bass was 94 and 83%, respectively.

TABLE ES

MONTHLY TOTAL PLANT EFFICIENCY BY SPECIES

Oswego Steam Station Unit 6 - April-December 1981

| SPECIES | | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Alewife | Est. Entrapment[a] | 54,432 | 91,810 | 42,768 | 20,088 | 670 | 20,952 | 81,989 | 7,704 | 1,042 | 321,455 |
| | % of Total | 17 | 28 | 13 | 6 | <1 | 7 | 26 | 2 | <1 | 100 |
| | Total Plant Eff. | 33.7 | 1.5 | 9.9 | 24.0 | 8.3 | 2.5 | 17.3 | 43.5 | 33.1 | 9.6 |
| | Est. Return Alive | 18,344 | 1,377 | 4,234 | 4,821 | 56 | 524 | 14,184 | 3,351 | 345 | 30,726 |
| Rainbow smelt | Est. Entrapment[a] | 8,280 | 3,422 | 432 | 74 | 0 | 7,704 | 78,194 | 80,280 | 126,554 | 304,940 |
| | % of Total | 3 | 1 | <1 | <1 | - | 3 | 26 | 26 | 41 | 100 |
| | Total Plant Eff. | 75.2 | 4.2 | 3.8 | 3.8 | - | 10.3 | 20.4 | 12.7 | 5.1 | 13.1 |
| | Est. Return Alive | 6227 | 144 | 16 | 3 | - | 794 | 15,952 | 10,196 | 6,454 | 39,786 |
| Gizzard shad | Est. Entrapment[a] | 144 | 0 | 72 | 0 | 0 | 1,440 | 14,136 | 4,896 | 818 | 21,506 |
| | % of Total | 1 | - | <1 | - | - | 7 | 65 | 23 | 4 | 100 |
| | Total Plant Eff. | 48.2 | - | 48.2 | - | - | 57.0 | 60.9 | 38.9 | 36.1 | 54.6 |
| | Est. Return Alive | 69 | - | 35 | - | - | 821 | 8,609 | 1,905 | 295 | 11,734 |
| Spottail shiner | Est. Entrapment[a] | 144 | 74 | 72 | 298 | 372 | 216 | 3,125 | 360 | 74 | 4,735 |
| | % of Total | 3 | 2 | 2 | 6 | 8 | 5 | 65 | 7 | 2 | 100 |
| | Total Plant Eff. | 90.6 | 90.6 | 84.0 | 84.0 | 84.0 | 76.8 | 85.7 | 84.4 | 86.7 | 85.1 |
| | Est. Return Alive | 130 | 67 | 60 | 250 | 312 | 166 | 2,678 | 304 | 64 | 4,031 |
| Emerald shiner | Est. Entrapment[a] | 72 | 74 | 72 | 0 | 0 | 4,824 | 5,952 | 2,736 | 818 | 14,548 |
| | % of Total | <1 | <1 | <1 | - | - | 33 | 42 | 19 | 6 | 100 |
| | Total Plant Eff. | 94.4 | 94.4 | 94.4 | - | - | 91.9 | 91.4 | 85.3 | 79.3 | 89.8 |
| | Est. Return Alive | 68 | 70 | 68 | - | - | 4,433 | 5,440 | 2,334 | 649 | 13,062 |
| White perch | Est. Entrapment[a] | 432 | 149 | 72 | 74 | 0 | 0 | 3,497 | 1,800 | 74 | 6,098 |
| | % of Total | 7 | 2 | 1 | 1 | - | - | 58 | 30 | 1 | 100 |
| | Total Plant Eff. | 39.8 | 39.8 | 39.8 | 39.8 | - | - | 49.2 | 26.4 | 26.4 | 41.1 |
| | Est. Return Alive | 172 | 59 | 29 | 29 | - | - | 1,721 | 475 | 20 | 2,505 |
| | | PRIMARILY ADULTS | | | | PRIMARILY JUVENILES | | | | | |

[a]Based on continuous unit operation.

CHAPTER 1.0

# INTRODUCTION

This interim report summarizes the results from the first year of a two-year study to evaluate the effectiveness of the fish diversion system at Oswego Steam Station Unit 6. The effectiveness of the diversion system is defined as the ability of the system to divert, alive, the fish entrapped in the circulating cooling water from the primary screenwell back to the source water body. The report is not intended to provide a comprehensive discussion of the results nor comparison with other investigations presented in the literature but rather to provide the results from the first year and the recommended plan of study for the second year. A comprehensive interpretive report will be submitted at the conclusion of the project.

In order to determine total efficiency of the system, investigations were made of the effectiveness of the screens in physically diverting the organisms entrapped in the screenwell and the mortality by species associated with the diversion process. These initial studies concentrated on survival subsequent to passage through the diversion system but prior to transport back to the source water body. Special studies were also conducted to determine hydraulic conditions in the system and fish residence times within each of the two screenwells. Initial offshore collections were made to evaluate the feasibility of using a discharge net to determine ultimate survival of fish returned to the source water body.

Chapter 2.0 of this report provides a description of the physical system as well as the important hydraulic characteristics. Chapter 3.0 provides the results of the biological testing program, while Chapter 4.0 discusses the recommended program for the second year of

studies. Chapter 5.0 gives a brief description of the materials and methods employed during the first-year studies.

# CHAPTER 2.0

## SYSTEM DESCRIPTION

### 2.1 SYSTEM DESIGN

The Oswego Unit 6 intake, screenwell, and associated fish guidance and transportation systems are shown in Figures 2.0-1 through 2.0-4. These systems are based on the results of simulations and biological testing of the system components conducted over several years at Alden Research Laboratories by Stone and Webster Engineering (S&W).

Unit 6 is an oil-fired steam generator with a rating of 816 MWe and a maximum gross output of 890 MWe. Cooling water is taken from Lake Ontario via a submerged inlet, circulated though the condensers, and returned to the lake through a submerged jet diffuser. The intake structure is a hexagonally shaped velocity cap located approximately 370 m (1200 ft) from the existing shoreline (Figure 2.0-1). At the low water datum of 243 ft (International Great Lakes Datum 1955), the water is 6.7 m (22 ft) deep and the clearance between the top of the intake structure and the water surface is 3.7 m (12 ft). A 1 m (3 ft) sill at the bottom minimizes silting of the intake. Each side of the hexagonal intake has a 1.5 m high by 6.5 m wide (5 x 21 ft) aperture (Figure 2.0-2). Intake apertures are outfitted with heated bar racks to prevent the formation of frazil ice. The intake is designed such that the horizontal approach velocity is approximately 30 cm/s (1.0 fps) at maximum circulating water flow.

The circulating water flow (cooling water, service water and fish diversion flow) is delivered to the plant through a single 11.2 $m^2$ (121 $ft^2$) tunnel. The design circulating water pump flow rate is 20.5 $m^3/s$ (724 cfs). Since some of the pump flow is recirculated through the diversion system to the screenwell, the velocity in

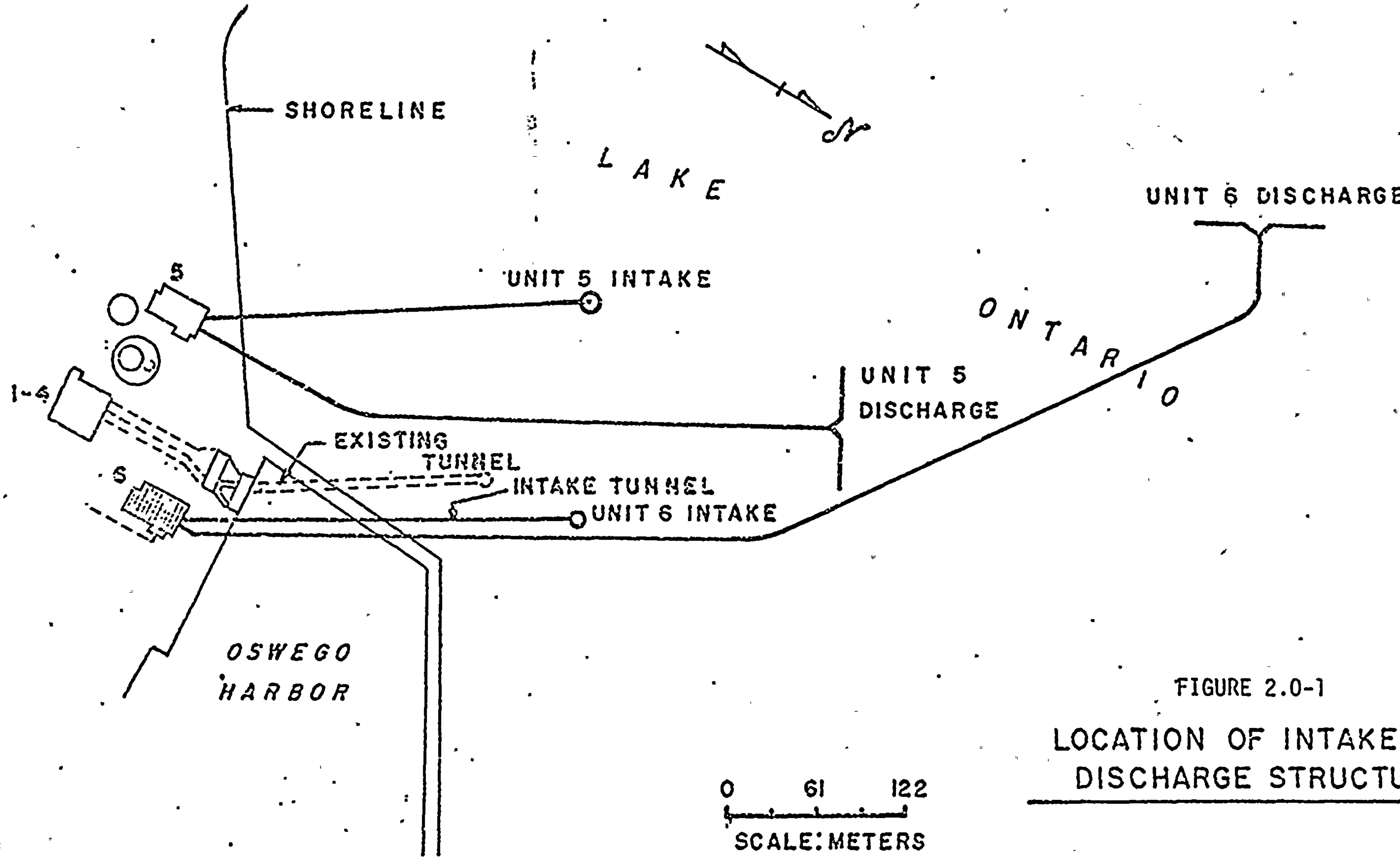
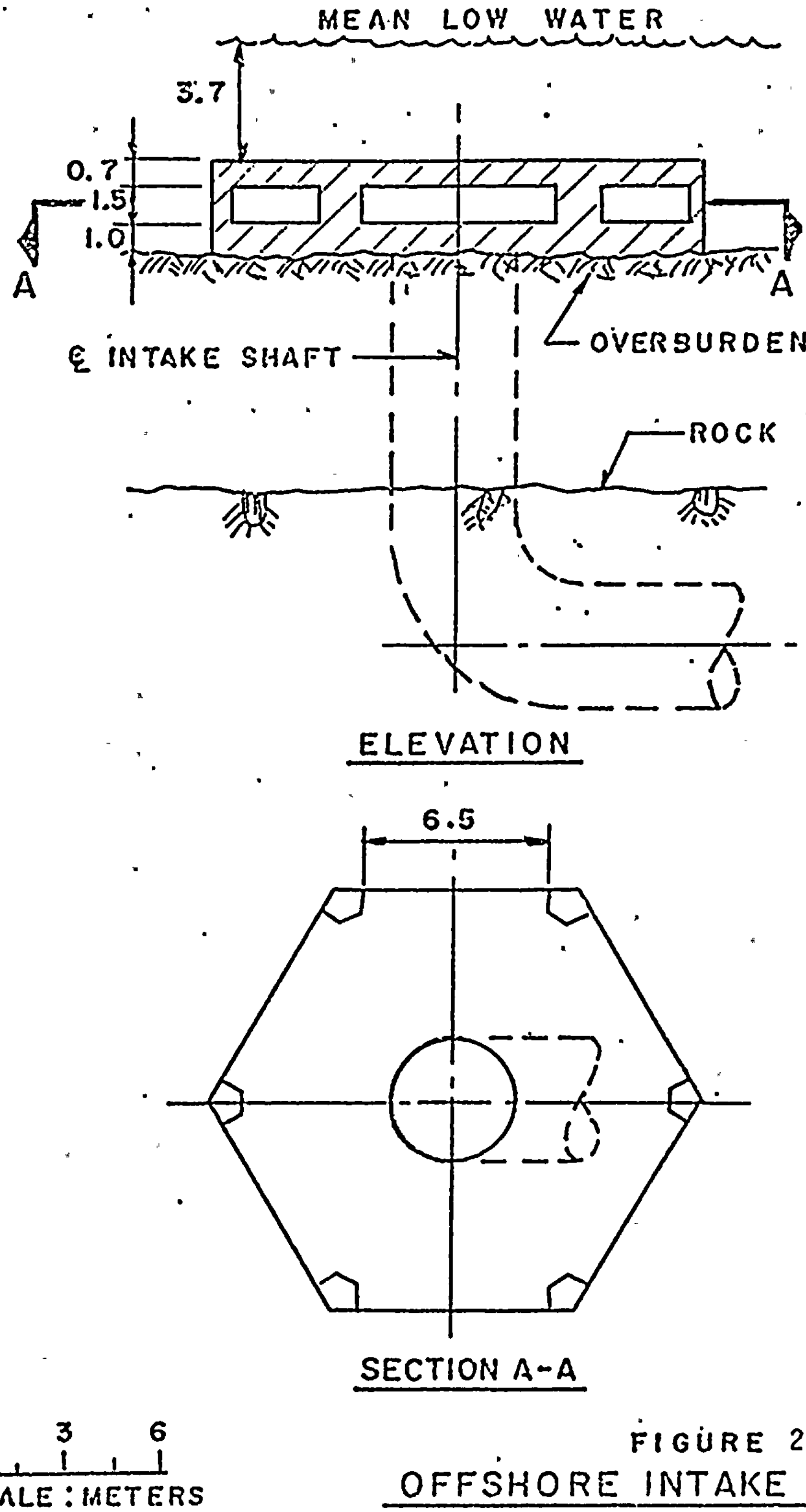



FIGURE 2.0-1

LOCATION OF INTAKE AND DISCHARGE STRUCTURES




ALL DIMENSIONS IN METERS

FIGURE 2.0-2
OFFSHORE INTAKE STRUCTURE
UNIT NO.6 OSWEGO STEAM STATION
NIAGARA MOHAWK POWER CORPORATION

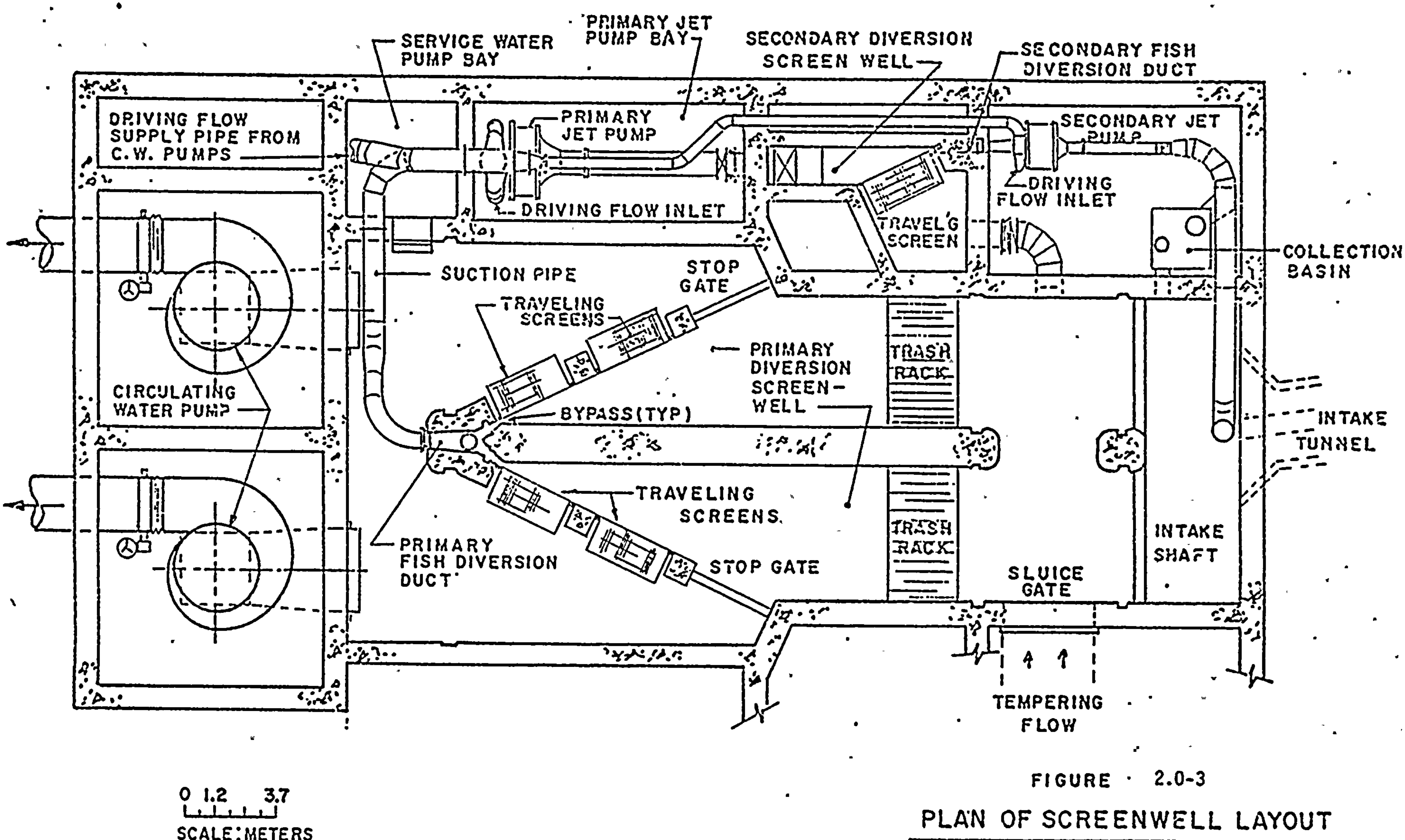
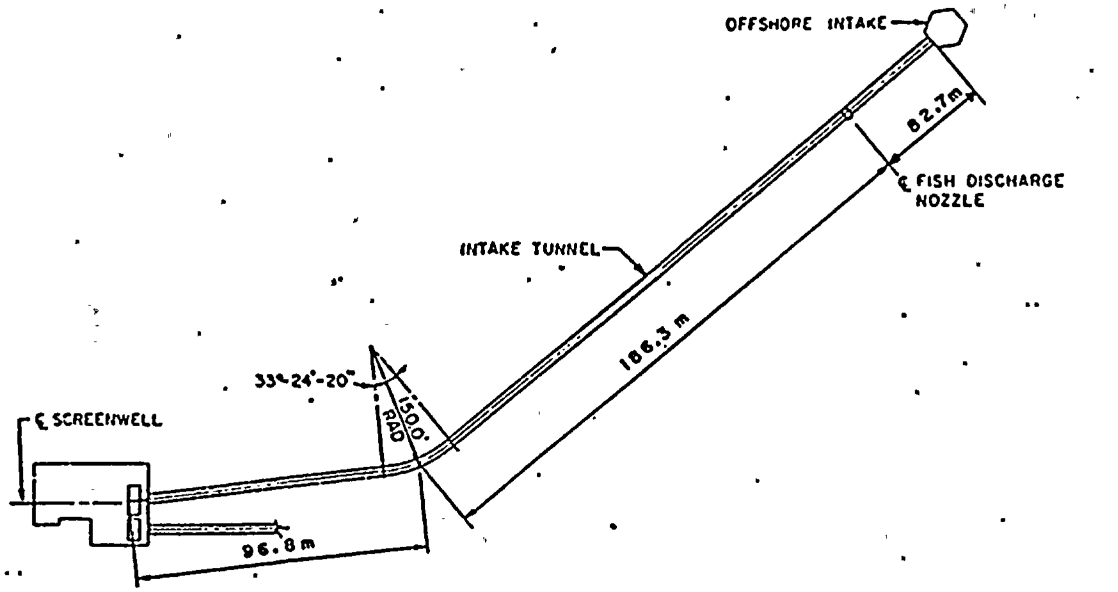



FIGURE 2.0-3

PLAN OF SCREENWELL LAYOUT

UNIT NO.6 – OSWEGO STEAM STATION




KEY PLAN
CIRC WATER INTAKE TUNNEL
NO SCALE

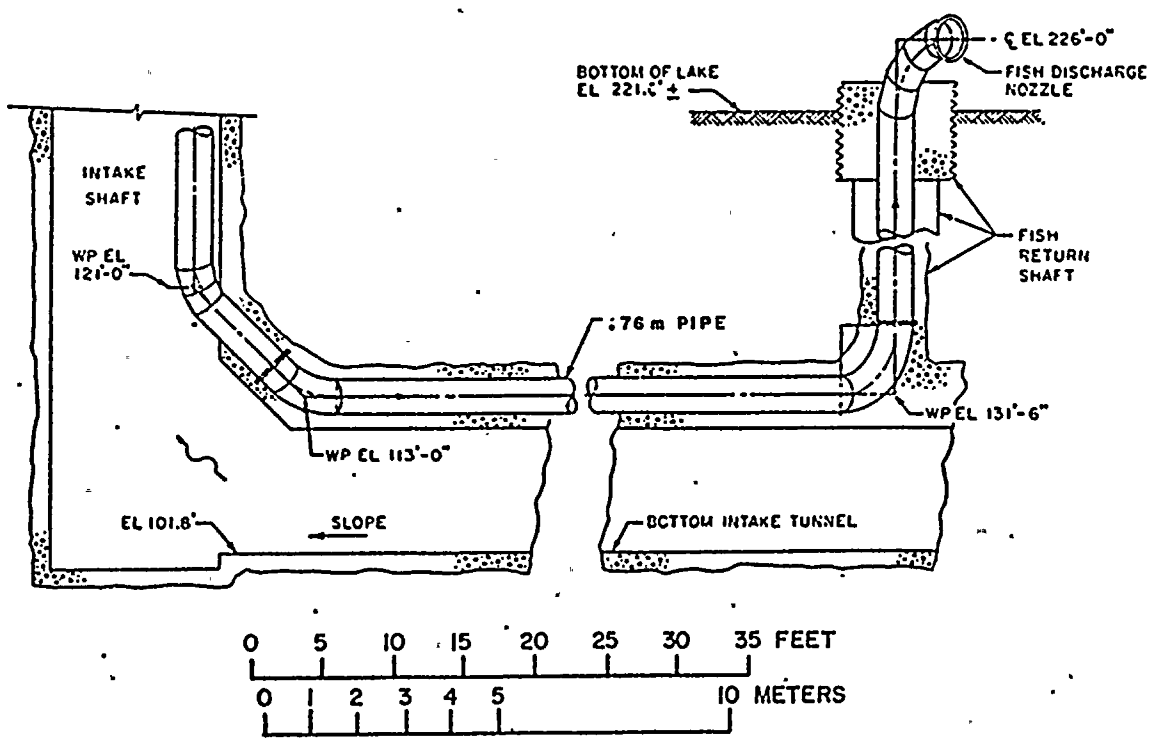



FIGURE 2.0-4
FISH RETURN PIPE
UNIT NO. 6 – OSWEGO STEAM STATION

the tunnel is less than 182 cm/s (6.0 fps). The circulating water water flow enters the intake screenhouse through a vertical intake shaft rising approximately 30 m (100 ft) in 20 sec. From there the water flows into two screenbays in the primary screenwell, each 5.2 m (17 ft) wide with a water column depth that varies from 7.3 to 10.1 m (24 to 33 ft).

Fish entering the screenwell pass through trash racks with 7.6-cm (3-in.) clear spacings, and are guided by angled, flush-mounted traveling screens into a 15-cm (6-in.) wide bypass. Each bay is sized to accept three 3-m (10-ft) wide traveling screens separated by 1-m (39-in.) wide concrete piers. At present, each bay is equipped with two screens, and the third opening is blocked off with stop gates for a possible future screen. The screens are angled 25° to the direction of flow with their downstream ends converging but separated by a 1.5-m (5-ft) wide pier (Figure 2.0-3).

Two dry-pit circulating water pumps draw the flow through the screenwell. Each pump suction opening is on the centerline of a screenbay and level with the bottom of the screenwell. The bypass suction flow is designed such that the ratio of the average screenwell approach velocity to the average bypass entrance velocity is 1:1. Each 15-cm (6-in.) wide bypass slot extends the full depth of the water column. The two slots converge in the horizontal plane while at the same time converging in the vertical plane at a 45° angle to two 0.6-m (24-in.) diameter pipes. The two pipes join into a single 0.8-m (32-in.) diameter pipe which becomes the suction pipe of the primary peripheral jet pump. The mixing tube of the primary jet pump is 0.9 m (36 in.) in diameter, resulting in an area ratio of driving nozzle to mixing tube of 0.18. The primary jet pump discharges to a 1.6-m (5.4-ft) wide secondary screenwell.

The secondary screenwell contains one angled traveling screen identical in design to the main screens except for its depth. The

water depth in the secondary bay varies from 2.4 to 4.6 m (8 to 15 ft), depending on lake elevation and the number of operating pumps. Most of the water discharged from the primary jet pump flows through the secondary screen and is returned to the primary screenwell through a 1.1-m (42-in.) diameter pipe. The fish are guided across the secondary screen into another 15-cm (6-in.) wide bypass slot. The secondary bypass slot converges in the vertical plane to a 46-cm (18-in.) diameter pipe. At the secondary jet pump, this pipe reduces to a 43-cm (17-in.) diameter suction pipe. The mixing tube of the secondary pump is 51 cm (20 in.) in diameter, yielding an area ratio of driving nozzle to mixing tube of 0.22. The ratio of the average secondary bay approach velocity to the average secondary bypass velocity varies from 1:1 to 1:1.3. The secondary jet pump discharges into a 76-cm (30-in.) diameter discharge pipe embedded in the roof of the intake tunnel for a distance of approximately 300 m (1000 ft) where it rises vertically and terminates as a horizontal discharge approximately 2 m (6 ft) off the bottom and 83 m (270 ft) from the intake (Figure 2.0-4).

Downstream of the secondary jet pump and prior to leaving the screenhouse, the discharge flow can be diverted into a 2.4 x 2.4 m (8 x 8 ft) sampling basin. A pair of electrically driven gate valves direct the flow either offshore during normal operation or into the basin during sampling. A description of the sampling basin is provided in Section 5.1.1.

## 2.2 PHYSICAL PERFORMANCE TESTING

As part of the evaluation of the system operation, a study was conducted to evaluate the physical performance of the diversion system relative to the design parameters discussed in Section 2.1. This performance testing was divided into three tasks: (1) documentation of velocity distributions, (2) verification of flow through

the jet pumps and transport pipe, and (3) determination of the flow rate into the fish sampling basin relative to the discharge to the lake.

### 2.2.1 Velocity Distributions

Velocity measurements were taken at the trash racks and at each of the five traveling screens - four in the primary diversion system and one in the secondary. Measurements were conducted under two-pump operation with the tempering gates closed. All valves on the jet pumps were opened completely and the total discharge flow was directed to the lake.

The velocity measurements were made with a Marsh-McBirney Model 511 electromagnetic water current meter. This instrument senses the two orthogonal components (two channels) of flow in a plane normal to the longitudinal axis of the probe.

Measurements made at the trash racks were conducted by mounting the probe on a specially designed frame that maintained proper probe orientation, i.e., one channel perpendicular to the bar racks and the other tangent to it. The frame and probe were then lowered to the desired depth and measurements were recorded.

Measurements performed at the traveling screens were conducted by mounting the probe directly on the face of the screen and rotating the screen in reverse until the probe was at the desired depth. In both cases, the probe was located 25 cm (10 in.) in front of the trash rack or screen.

Because of the limited space between the traveling screens and the concrete floor, the velocity probe had to be mounted on the screen from inside the screenwell. This was accomplished by LMS personnel

positioned in a boat within the screenwell. The size of the boat and the difficulty of operating it under these conditions precluded measuring at the downstream extremities of the screens where the primary screenwell tapered to the 15-cm (6-in.) bypass. The same factors allowed for the measurement of only one lateral location within the secondary screenwell.

At each location of the probe, five measurements and the velocity range (at a one second time constant) observed over a 45-60 sec interval were recorded for each channel. A schematic showing the screen numbering system is provided in Figure 2.0-5. The mean velocities for each set of measurements at a given location are presented in Tables 2.0-1 through 2.0-4. Velocities at the trash racks (Table 2.0-1) typically decrease with depth. Velocities in the upper 4 m (13 ft) of the water column exceeded 20 cm/s (0.65 ft/s), while those in the lower half were less than half those found near the surface. Non-uniform flow was evident.

The results of the measurements performed on the four screens located in the primary screenwell (Tables 2.0-2 and 2.0-3) indicate flow perpendicular to the screens between 7.0 and 19.8 cm/s (0.22 to 0.65 ft/s), with most measurements falling between 12 and 13 cm/s (0.39 to 0.42 ft/s). There are no areas of reverse flow and the velocities are within the range of variations expected in large open channels.

The guiding velocity (parallel to the screen) was between 23.0 and 65.0 cm/s (0.75 to 2.1 ft/s), with most measurements between 29.0 and 38.6 cm/s (0.95 and 1.24 ft/s). With the exception of the high velocities (65.0 and 51.6 cm/s [2.13 and 1.69 ft/s]) measured along the bottom of the northwest screen (No. 4), the velocities recorded parallel to the screens are near the 3 cm/s (1.0 fps) design criteria set by S&W. The resultant velocity, or the vector

FIGURE 2.0-5

# OSWEGO STEAM STATION UNIT 6

**Schematic**

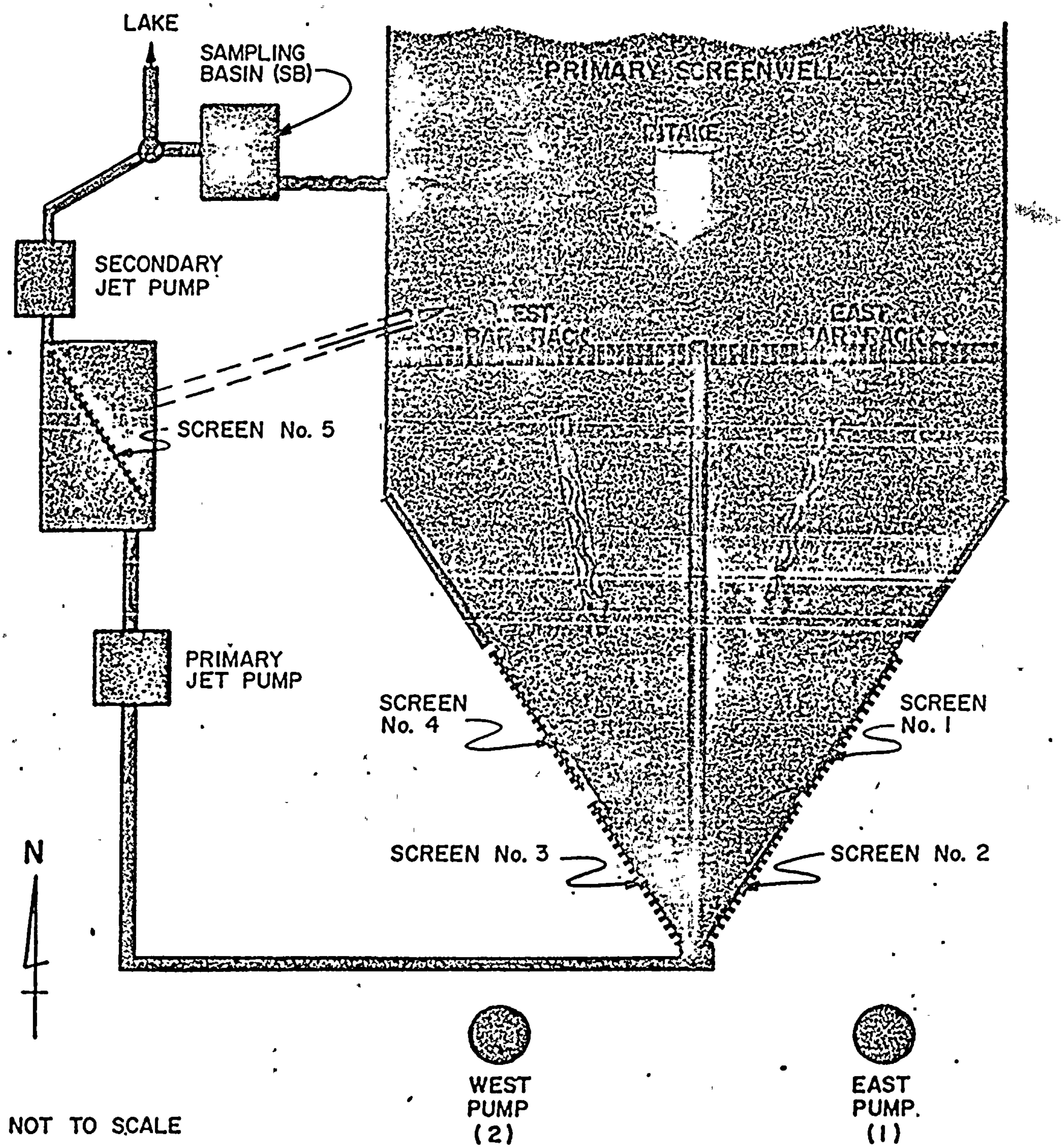


TABLE 2.0-1

TRASH RACK VELOCITIES (cm/s)

Oswego Steam Station Unit 6

| DEPTH (m) | CHANNEL | WEST TRASH RACK[a] | | | | EAST TRASH RACK[a] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | WEST | CENTER | EAST | MEAN | WEST | CENTER | EAST | MEAN |
| 0.2 | 1 | -25.8 | -16.0 | -40.8 | -27.5 | -24.8 | -31.0 | -30.0 | -28.6 |
| | 2 | -23.6 | -35.0 | - 9.4 | | + 3.2 | +18.0 | +21.2 | |
| 0.6 | 1 | -30.6 | -21.4 | -29.0 | -27.0 | -20.2 | -27.6 | -27.4 | -25.1 |
| | 2 | -11.2 | -22.2 | -13.4 | | - 5.4 | +16.0 | + 7.6 | |
| 2.1 | 1 | -29.8 | -19.0 | -22.4 | -23.7 | -27.6 | -25.2 | -29.4 | -27.4 |
| | 2 | - 1.2 | + 8.4 | + 1.0 | | - 8.6 | +10.4 | + 7.2 | |
| 4.3 | 1 | -22.4 | -24.4 | -24.8 | -23.9 | -25.6 | -20.0 | -17.2 | -20.9 |
| | 2 | +15.0 | +15.8 | + 8.6 | | - 9.2 | -13.2 | - 2.2 | |
| 6.4 | 1 | - 3.8 | -12.2 | -17.4 | -11.1 | -19.2 | -13.4 | - 9.6 | -14.1 |
| | 2 | + 7.0 | +12.8 | + 3.4 | | - 3.6 | - 6.6 | - 1.6 | |
| 8.5 | 1 | + 3.6 | - 2.6 | - 2.0 | - 0.3 | - 5.6 | + 6.8 | + 8.8 | + 3.3 |
| | 2 | + 7.6 | - 3.6 | + 3.6 | | + 4.2 | + 2.8 | - 0.8 | |

Channel 1 - Velocity perpendicular to the trash rack: (+) south to north (outflow)
(-) north to south (inflow)

2 - Velocity parallel to the trash rack: (+) east to west
(-) west to east

[a]See Figure 2.0-5.

TABLE 2.0-2

VELOCITIES (cm/s) AT THE TWO EASTERN IMPINGEMENT SCREENS

Oswego Steam Station Unit 6

| DEPTH (m) | CHANNEL[b] | SOUTH-EAST SCREEN[a] (No. 2) | | | | NORTH-EAST SCREEN[a] (No. 1) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SOUTH | CENTER | NORTH | MEAN RESULTANT[c] | SOUTH | CENTER | NORTH | MEAN RESULTANT[c] |
| 0.5 | 1 | NA | -13.6 | -12.8 | 39.3 | -13.4 | -19.8 | -17.6 | 39.1 |
| | 2 | NA | -33.4 | -40.6 | | -32.0 | -30.4 | -42.8 | |
| 1.9 | 1 | NA | -13.0 | -14.4 | 38.7 | -12.6 | -16.0 | -13.2 | 37.5 |
| | 2 | NA | -33.8 | -38.6 | | -30.0 | -33.8 | -40.6 | |
| 4.3 | 1 | NA | -13.8 | -13.8 | 38.4 | -12.8 | -17.2 | -12.8 | 35.3 |
| | 2 | NA | -32.8 | -38.8 | | -23.4 | -35.0 | -38.2 | |
| 6.1 | 1 | NA | -14.2 | -12.4 | 37.3 | -12.8 | -15.4 | -12.6 | 35.4 |
| | 2 | NA | -31.8 | -37.8 | | -27.6 | -32.2 | -38.2 | |
| 7.9 | 1 | NA | -16.4 | -16.6 | 36.9 | -12.0 | -14.6 | -13.0 | 34.8 |
| | 2 | NA | -32.8 | -33.2 | | -27.2 | -33.2 | -36.2 | |

[a]Figure 2.0-5.

[b]Channel 1 - Velocity perpendicular to the screen: (-) through the screen (inflow)
(+) away from the screen (outflow)

2 - Velocity parallel to the screen: (+) away from the bypass
(-) toward the bypass

[c]Mean Resultant represents vector sum of both channels.

NA - Not accessible.

TABLE 2.0-3

## VELOCITIES (cm/s) AT THE TWO WESTERN IMPINGEMENT SCREENS

Oswego Steam Station Unit 6

| DEPTH (m) | CHANNEL[b] | NORTH-WEST SCREEN[a] (No. 4) | | | | SOUTH-WEST SCREEN[a] (No. 3) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | NORTH | CENTER | SOUTH | MEAN RESULTANT[c] | NORTH | CENTER | SOUTH | MEAN RESULTANT[c] |
| 0.5 | 1 | -12.6 | -16.0 | -13.8 | 37.0 | -13.0 | -12.4 | NA | 41.9 |
| | 2 | -37.8 | -37.8 | -26.8 | | -42.6 | -37.2 | NA | |
| 1.8 | 1 | -11.8 | -15.4 | -11.6 | 32.5 | -12.2 | -10.8 | NA | 36.9 |
| | 2 | -35.4 | -30.4 | -23.4 | | -40.6 | -29.4 | NA | |
| 4.3 | 1 | - 8.0 | -13.6 | -13.6 | 33.6 | -12.2 | -11.0 | NA | 33.6 |
| | 2 | -38.4 | -32.0 | -23.0 | | -33.2 | -29.8 | NA | |
| 6.1 | 1 | - 9.2 | -15.0 | -11.8 | 36.5 | -13.2 | -11.4 | NA | 36.1 |
| | 2 | -43.6 | -34.0 | -25.2 | | -35.2 | -32.6 | NA | |
| 7.9 | 1 | - 7.0 | -12.6 | -10.6 | 49.4 | -14.8 | -11.8 | NA | 37.8 |
| | 2 | -65.0 | -51.6 | -27.8 | | -35.0 | -35.8 | NA | |

[a] See Figure 2.0-5.

[b] Channel 1 - Velocity perpendicular to the screen: (-) through the screen (inflow); (+) away from the screen (outflow)

2 - Velocity parallel to the screen: (+) away from the bypass; (-) toward the bypass

[c] Mean Resultant represents the vector sum of both channels.

NA - Not accessible.

TABLE 2.0-4

VELOCITIES (cm/s)
AT THE SECONDARY SCREEN

Oswego Steam Station Unit 6

| DEPTH (m) | CHANNEL[b] | SECONDARY SCREEN[a] (No. 5) CENTER | RESULTANT[c] |
|---|---|---|---|
| 0.5 | 1 | -13.0 | 62.6 |
| | 2 | -61.2 | |
| 2.4 | 1 | + 8.2 | 33.2 |
| | 2 | -32.2 | |
| 3.0 | 1 | +12.4 | 13.7 |
| | 2 | + 5.8 | |
| 3.6 | 1 | - 8.4 | 30.8 |
| | 2 | +29.6 | |

[a]See Figure 2.0-5.

[b]Channel 1 - Velocity perpendicular to the screen:
(+) Flow away from screen
(-) Flow into screen

2 - Velocity parallel to the screen:
(+) away from the bypass
(-) toward the bypass

[c]Resultant represents the vector sum of both channels.

sum of the perpendicular and tangent velocity components, averaged between 36.4 and 38.1 cm/s (1.19 and 1.25 ft/s). This represents the actual approach velocity to which a fish is subjected in the near field of the screen.

Although only one vertical velocity profile could be measured at the single secondary diversion screen, the data (Table 2.0-4) indicate a high level of turbulence with flow through the screen reversing direction. Near the surface and bottom, flow passes into the screen, while at mid-depth, the flow is reversed and moves out through the screen. The irregular flow distribution is produced by the introduction of flow into the secondary screenwell from the primary jet pump at a 30° angle off the bottom of the screenwell toward the screen and bypass. The high surface velocity along the screen (61.2 cm/s [2.0 ft/s]) exceeds the capacity of the bypass and produces a reversal of flow or countercurrent along the bottom of the screen.

### 2.2.2 Verification of Flows

The second task included in the physical performance testing program consisted of evaluating the operation of the jet pumps and transport pipe relative to the initial design criterion. The S&W information relating to the operation of the fish diversion system, as provided by Niagara Mohawk, includes several groups of calculations. The 1975 calculations are the most detailed and presumably form the basis for the design of the system. These calculations use a flow ratio (nozzle flow divided by suction flow) of 0.5. The lift through the primary jet pump (from the primary to the secondary screenwell) is 1.8 m (5.9 ft); the calculations assume that the secondary jet pump provides the remainder of the lift needed to overcome head losses in transporting fish to the lake.

The 1978 calculations derive calibration curves for the orifice plates but use different flows from those derived from the earlier calculations, presumably because more detailed data were available. In this case, the primary jet pump flow ratio is 0.83 and the secondary ratio is 0.47. In November of 1979 S&W derived the orifice plate and elbow flowmeter calibration curves and made measurements through the system. True lake level was not determined for the series of measurements and, therefore, the head loss associated with passage through the intake tunnel and the transport head loss from the secondary jet pump to the lake could not be calculated. It appears though that the tunnel head loss was less than the 1.3 m (4.4 ft) predicted in the 1975 calculations. Based on water levels in the primary and secondary screenwells, the primary jet pump was providing a lift of only 0.38 m (1.25 ft). The flow rates, however, were near those used in the design calculations. The remainder of the lift for the transport flow to the lake was provided by the secondary jet pump; the flow rate to the lake (0.52 $m^3/s$ [17 cfs]) was slightly lower than that used in the design calculations (0.54 $m^3/s$ [19 cfs]).

The observations by LMS in March 1981 were generally consistent with those made by S&W in November 1979. LMS also measured a lift between the primary and secondary screenwell of 0.38 m (1.25 ft), although the flows measured differ. We are in agreement with S&W that the primary jet pump is running with a flow ratio near 0.9; however, the secondary jet pump is running with a flow ratio near 0.7. The lake transport flow (0.40 $m^3/s$ [14 cfs]) measured by LMS is well below the design value and the secondary jet pump seems to be providing most of the lift for the system.

### 2.2.3 Sampling Basin Flow Rate

The final task included in the physical performance testing program consisted of evaluating the flow rate into the fish sampling basin.

Under two-pump operation, with the basin gate valve fully open and the lake discharge gate valve completely closed, the flow rate into the basin was 0.65 $m^3/s$ (23 cfs), with a basin water level of 246 ft. As previously mentioned, the flow rate to the lake with the sampling basin gate valve closed and the lake discharge gate valve open was 0.40 $m^3/s$ (14 cfs).

By closing down the sample basin drain valve 30%, the water level with the basin gate valve open and the lake discharge gate closed was raised to 246.9 ft and the flow into the basin was reduced to 0.40 $m^3/s$ (14 cfs). This operating condition provides a sampling condition representative of normal plant operation.

Our conclusion is that the overall system is functioning satisfactorily but that some modifications to reduce turbulence in the secondary screenwell may be necessary. Flow to the primary screens is reasonably uniform and the entry velocity to both the primary and secondary bypasses is on the order of 60 cm/s (1.0 ft/s). The lifts being provided by the two jet pumps, however, are far from the design conditions, especially in the case of the primary jet pump. Nozzle pressures and flows seem to be somewhat lower than the design values used in 1975, but are within 20% of the values used in the 1978 and 1979 calculations.

Turbulence created by the flow into the secondary screenwell undoubtedly causes stress to the organisms that, depending upon species and/or age, may result in reduced survivals. Based on low survival results of juvenile alewife and smelt (see Section 3.2.2.2), modifications to the system will be investigated in an attempt to reduce turbulence in the secondary screenwell and thereby increase survival.

# CHAPTER 3.0

## BIOLOGICAL TESTING

### 3.1 EXPERIMENTAL DESIGN

The biological testing program was designed with three distinct study objectives. These are to determine:

1. The efficiency of the angled screen
2. The effectiveness of the fish bypass
3. The viability of fish which enter the bypass system and are eventually returned to Lake Ontario.

In order to facilitate discussion, the following definitions will be used throughout this report:

- The efficiency of the angled screen (PRIMARY DIVERSION EFFICIENCY, PDE) is determined by the proportion of fish entering the primary diversion bypass as compared to the number of fish entering the screenwell. Trash rack fish are not included in this calculation.
- The effectiveness of the fish bypass (SECONDARY DIVERSION EFFICIENCY, SDE) is defined as the ratio of the number of fish entering the secondary diversion bypass to the number entering the primary diversion bypass. The difference between these numbers is the number collected on the secondary traveling screen.
- The overall effectiveness of the diversion system (TOTAL DIVERSION EFFICIENCY, TDE) is defined as the ratio of the number of fish entering the secondary diversion bypass to the number of fish entering the primary screenwell (PDE X SDE = TDE).
- The VIABILITY of organisms bypassed represents the ratio of organisms initially tested to the number surviving after 96 hrs and is measured at two locations. Collections from the fish sampling

basin determine the survival rate after bypass while collection of fish from the offshore lake discharge port measures the "ultimate" survival after transport to the lake.

- The TOTAL EFFICIENCY (TE) is defined as the product of the TOTAL DIVERSION EFFICIENCY and the VIABILITY and represents the estimated survival for the given species upon entrapment into the cooling water system.

These objectives focus on the evaluation of the diversion and transport system. The analyses of the data, however, must consider the effects of natural mortality, the possible effects of transport through the intake tunnel, and the effects of holding. One can conservatively estimate, i.e., overestimate, mortality by simply collecting fish from the system discharge and holding them to determine the mortality rate. The true mortality resulting from the diversion and bypass system is necessarily less than the observed mortality rate, which includes fish that died naturally, from passage through the intake tunnel, or from holding for 96 hrs. One can more accurately evaluate the system by the rigorous use of control and test fish, taking "credit" for control mortality (resulting from these effects) in evaluating the system. Since initial studies indicated a high survival rate, minimum testing was conducted to define control survival to account for these extraneous factors. Some experiments to define control survival were conducted during the summer with fish from hatcheries. Additional effort will be expended during the second year of the study to identify control survival during the period of lower survival (fall).

One of the difficulties encountered in virtually all survival studies is the low concentration of test organisms. Many of the species enter the intake at densities of much less than one fish per hour. The volume of water and the time sampled in a survival study are limited by the need to collect the organisms at low

velocity and over a short duration to minimize organism stress in the collection area. To weight all samples equally when estimating survival is not advisable since proportions based on only a few fish are extremely variable. Instead, where sample size was small, samples collected for each species (and age group) within each block were composited. Formulas for calculations of survival (or diversion) for any group of statistically similar data are then:

$$P_S = \text{Proportion Surviving} = \frac{\sum_{i=1}^{K} \text{No. live* in ith sample}}{\sum_{i=1}^{K} \text{Total no. caught in ith sample}}$$

where K = No. of samples in the block (month or season depending upon organism density);

$$95\%\ \text{CI for } P_S = P_S \quad 1.96 \sqrt{\frac{P_S\,(1-P_S)}{n}}$$

where n = No. of test fish in the block = $\sum_{i=1}^{K}$ Total no. caught in ith sample

The width of this confidence interval is maximized for a given number of fish (n) when survival ($P_S$) is 50%. When only a few organisms are collected, this formula is used to calculate the precision of the survival estimate; it also defines the maximum number of fish needed for any degree of precision in the survival estimate.

All fish collected from the sampling basin are initially classified as live - showing normal swimming orientation; stunned - demonstrating erratic swimming behavior or disorientation; or dead, showing no swimming behavior even on gentle prodding. Survival studies are then conducted on the live and stunned fish.

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*"Live" refers to those alive after 96 hrs.

The first year biological sampling program included seasonal preliminary intensive sampling and routine sampling. Special studies were also conducted, using tagged lake and hatchery fish.

At the beginning of the spring, fall, and winter seasons, an intensive three-day, 24-hr/day survey was conducted to determine the diel trends in fish distribution. Based on these results, a routine survey was performed three times per week in the spring, fall, and winter and once per week in the summer. The effort was reduced during the summer because of the low numbers of fish present. Each routine survey consisted of an 8-hr survey performed coincident with the diel period of highest fish abundances (as determined from the intensive survey).

During each intensive and routine survey there was a specific program of impingement, diversion abundance, and survival sampling. Table 3.0-1 provides a schematic of each survey. Detailed sampling procedures are described in Chapter 5.0. This synoptic sampling was then used to determine diversion efficiency as well as the concomitant survival.

## 3.2 RESULTS AND DISCUSSION

### 3.2.1 Community Structure

The population affected by the Oswego Unit 6 intake is best represented by the sum total of fish impinged (No./hr) on either the primary or secondary diversion screens and the number of fish diverted (No./hr) as represented by the sample basin abundance. This number is defined as the total collection rate. Since most of the fish entrapped in the offshore intake are eventually diverted rather than impinged (see Section 3.2.2), the total collection rate for any given time interval is primarily a function of the number of

TABLE 3.0-1

SAMPLING SCHEDULE

Oswego Steam Station Unit 6 - Apr-Dec 1981

| IMPINGEMENT | DIVERSION ABUNDANCE | SURVIVAL |
|---|---|---|
| INTENSIVE SURVEY: DURATION = 72 hrs | | |
| Continuous with 36 2-hr collections | Collections every 4 hrs (18 samples) | Collections every 4 hrs (18 samples) |
| ROUTINE SURVEY: DURATION = 8 hrs | | |
| Continuous with 1 8-hr collection | Collections at the start and finish (2 samples) | 6 collections during the survey (6 samples) |

diverted fish. Based on residence studies performed during 1981 (see Section 3.2.3), some species may remain in the primary screenwell for significant periods of time prior to diversion. Thus it is not surprising that diel trends in collection rate were not evident. Since the screenwell is constantly lighted, fish residing in the screenwell are isolated from their primary external cue, i.e., photoperiod. The large variation observed between collection rates for individual dates during the spring and late fall (Figure 3.0-1) were not related to specific photoperiod but did appear to be related to offshore weather conditions (Figure 3.0-2). This trend will be investigated further in 1982-1983.

The fish collections demonstrated a definite seasonal pattern (Table 3.0-2). Spring collections were dominated by adults while fall and early winter collections were dominated by juveniles (Figure 3.0-3). At the outset of the program (April-May 1981), adult alewife predominated (76 and 123 fish/hr), with lower numbers of adult rainbow smelt (12 and 5 fish/hr) and an occasional mottled sculpin, white perch, and trout perch. An additional 13 species were collected, but typically at rates of less than 0.2 fish/hr. Rates dropped significantly throughout the summer; collections were dominated by emaciated post-spawn alewives and infrequent numbers (less than 1/hr) of spottail shiners and smallmouth bass.

Fall collections saw an influx of juvenile alewife, rainbow smelt, and gizzard shad, with lower numbers of emerald shiner, spottail shiner, and white perch. Alewife density dropped in November and December, while rainbow smelt densities in December reached peak levels (170/hr).

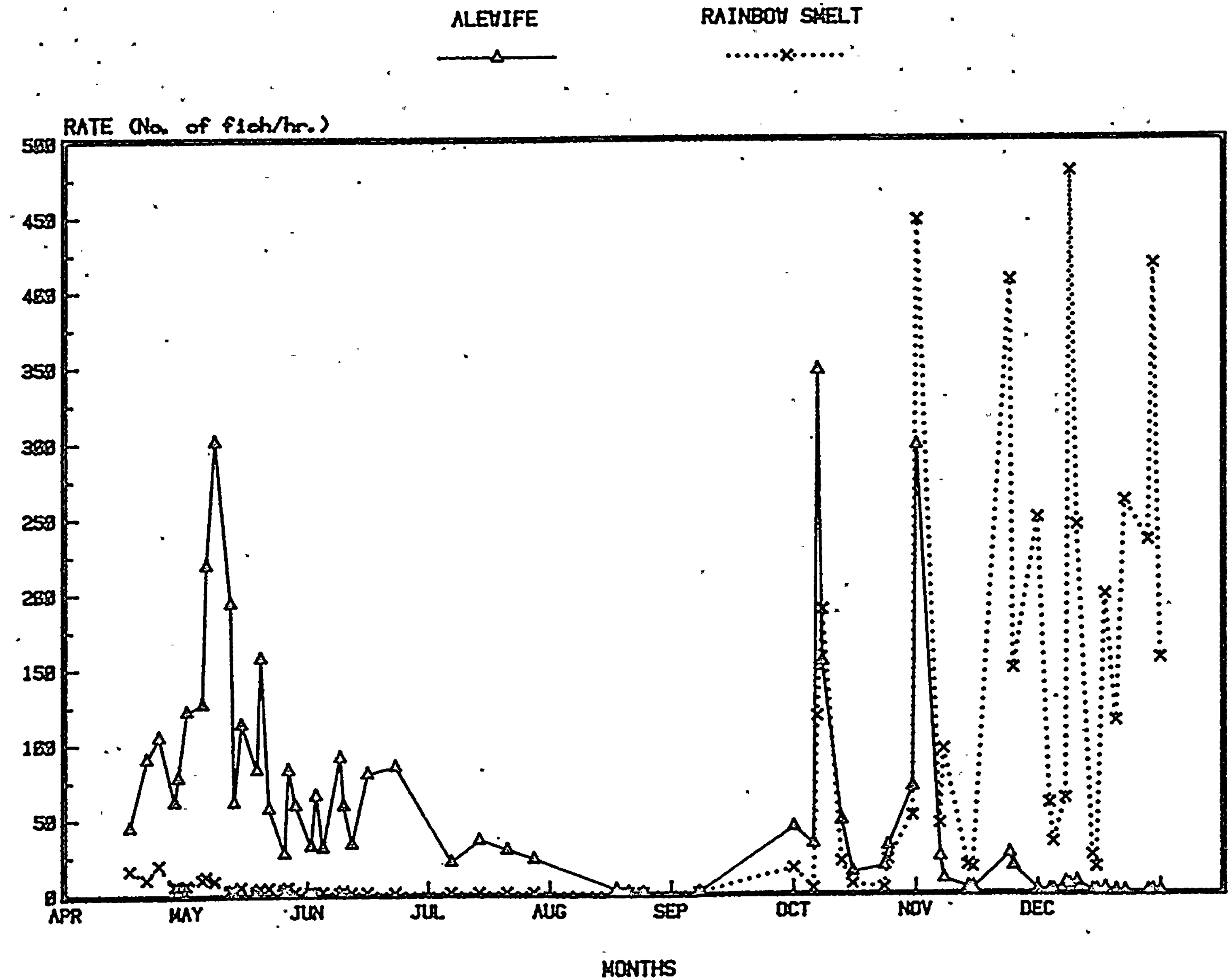
### 3.2.2 Routine Diversion and Survival Studies

3.2.2.1 Diversion. The predominant species collected throughout the year, alewife and rainbow smelt, will be discussed in

FIGURE 3

# TOTAL COLLECTION OF ALEWIFE AND RAINBOW SMELT

OSWEGO STEAM STATION UNIT 6 - 1981 (APRIL-DECEMBER)



FIGU 0-2

## STORM INDU D EFFECT

OSWEGO STEAM STATION UNIT 6 - 1981

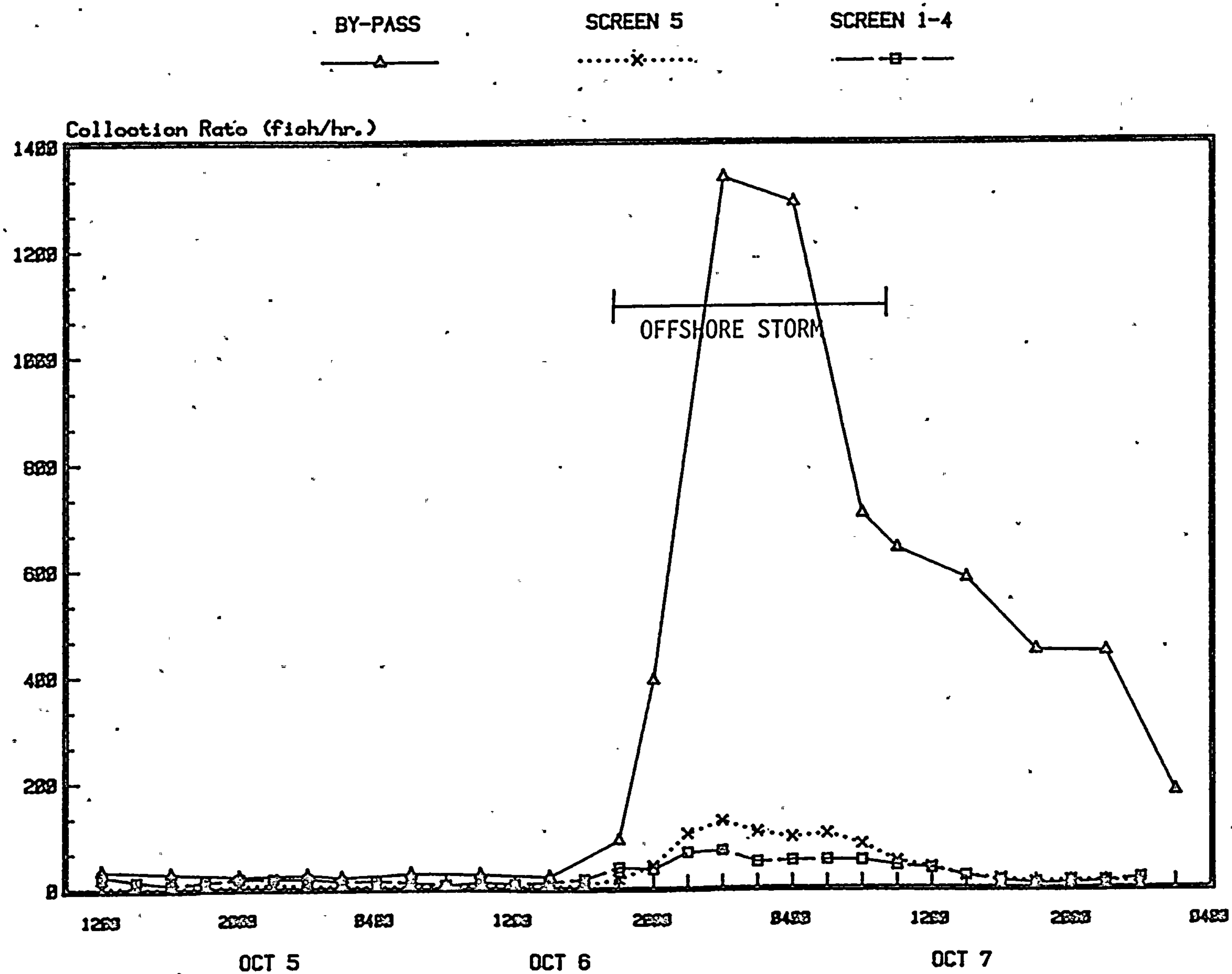


TABLE 3.0-2

MONTHLY MEAN COLLECTION RATE[a]

Oswego Steam Station Unit 6 - 1981

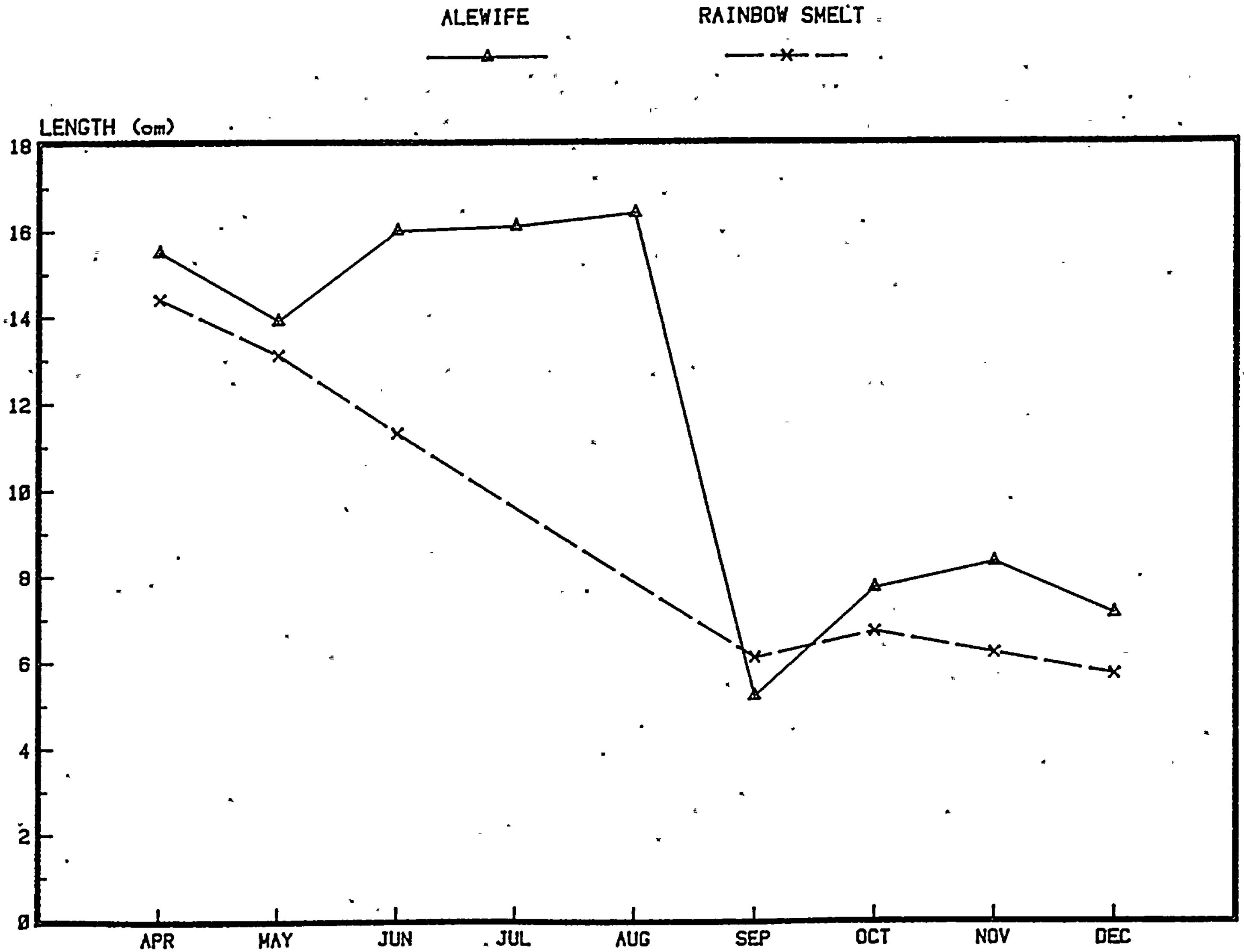
| SPECIES | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|
| Alewife | 75.6 | 123.4 | 59.4 | 27.0 | 0.9 | 29.1 | 110.2 | 10.7 | 1.4 |
| American burbot | b | - | - | - | - | - | - | - | b |
| American eel | - | - | b | - | - | - | - | - | - |
| Bluegill sunfish | 0.1 | - | b | - | - | - | 0.4 | 0.5 | - |
| Brook silverside | - | - | - | - | - | - | - | - | b |
| Brown trout | - | - | - | - | - | - | b | - | - |
| Chinook salmon | - | - | b | - | - | - | - | - | - |
| Creek chub | - | b | - | - | - | - | - | - | - |
| Cyprinidae | - | - | - | - | - | 0.4 | b | - | - |
| Emerald shiner | 0.1 | b | 0.1 | - | - | 6.7 | 8.0 | 3.8 | 1.1 |
| Gizzard shad | 0.2 | - | b | - | - | 2.0 | 19.0 | 6.8 | 1.1 |
| Goldfish | - | - | - | - | - | - | - | b | b |
| Johnny darter | - | 0.2 | 0.3 | - | - | 0.1 | 0.6 | - | - |
| Lake trout | - | - | - | - | - | - | - | - | b |
| Largemouth bass | - | - | - | - | - | b | - | - | - |
| Lepomis spp. | - | - | - | - | - | - | 0.1 | - | - |
| Logperch | - | - | - | - | - | - | b | - | - |
| Mottled sculpin | 0.2 | 0.2 | - | - | b | 0.3 | 2.1 | 0.9 | 0.4 |
| Pumpkinseed | - | - | - | - | - | - | b | - | b |
| Rainbow smelt | 11.5 | 4.6 | 0.6 | b | - | 10.7 | 105.1 | 111.5 | 170.1 |
| Rock bass | 0.2 | b | b | b | - | - | 0.2 | 0.1 | b |
| Smallmouth bass | - | - | - | 0.2 | 0.8 | - | b | - | - |
| Sea lamprey | b | - | - | - | - | - | - | b | 0.1 |
| Spottail shiner | 0.2 | b | b | 0.4 | 0.5 | 0.3 | 4.2 | 0.5 | b |
| Stonecat | - | b | - | - | - | - | b | - | - |
| Tessellated darter | - | - | b | - | - | - | - | - | - |
| Threespine stickleback | - | - | - | b | - | - | - | 1.4 | 3.9 |
| Trout-perch | 0.1 | 0.2 | b | - | - | - | b | b | b |
| White bass | b | - | b | - | - | - | - | - | - |
| White perch | 0.6 | 0.2 | - | b | - | - | 4.7 | 2.5 | 0.1 |
| White sucker | - | - | - | - | - | - | b | - | - |
| Yellow perch | 0.1 | b | b | - | 0.1 | b | 0.1 | b | - |
| Number of collections | 9 | 12 | 8 | 4 | 3 | 3 | 13 | 10 | 14 |

[a]No./hr (Sum total of impingement, abundance and viability studies).
[b]<0.1.
- Not collected.

FIGURE 3.0-3

# MONTHLY MEAN LENGTH OF SELECT SPECIES

OSWEGO STEAM STATION UNIT 6 - 1981 (APRIL-DECEMBER)



detail, with general comments on other species where relevant. Typically, the adult alewife and rainbow smelt (present in spring) diverted effectively through both the primary and secondary system, with slightly higher impingement rates observed in the secondary system (Figures 3.0-4 and 3.0-5). This is to be expected, considering the higher velocity and turbulence in the secondary screenwell. Throughout this period, impingement in the primary system was highest on the east side, in particular on screen 2 (Figure 2.0-5). This is most likely an artifact of the tempering that was in effect during this period, which produces unequal flow distribution in the primary screenwell.

Presence of the young alewife in the cooling water system occurred in late August when the organisms were approximately 2.5 to 3.5 cm in total length. Rainbow smelt juveniles approximately 4.5 to 6.5 cm followed in late September. At this size, many of these organisms are entrained through the 9.5-mm (0.38-in.) mesh traveling screen and all estimates of primary or secondary diversion efficiency as well as the mean lengths of the total populations are thus affected. Efficiencies and mean lengths are based only on organisms impinged or diverted; those entrained through the traveling screens are not included.

In contrast to the adult alewife and smelt, the juveniles (present in fall) were impinged in higher numbers in the primary system than in the secondary system (Figures 3.0-4 and 3.0-5). While this is probably related to reduced swimming ability of the juveniles relative to the adults, differential entrainment through the secondary screens as opposed to the primary screens may also contribute to the different observed impingement rates.

The lower incidence of impingment of juveniles on the secondary system is probably affected by the turbulence in the secondary

FIGU[illegible]0-4

## PERCENT DIVERSION EFFICIENCY OF ALEWIFE

OSWEGO STEAM STATION UNIT 6 - 1981 (APRIL-DECEMBER)

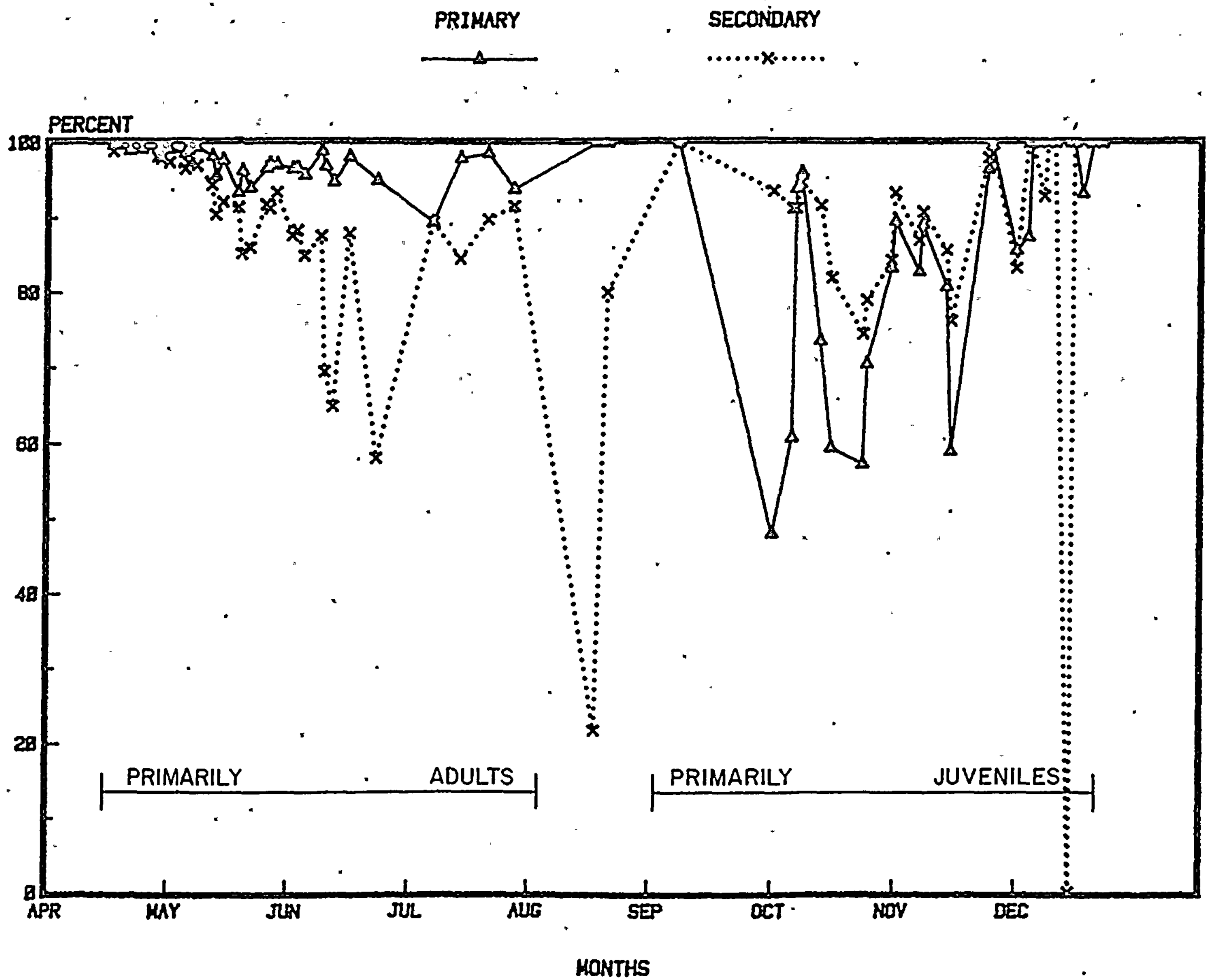
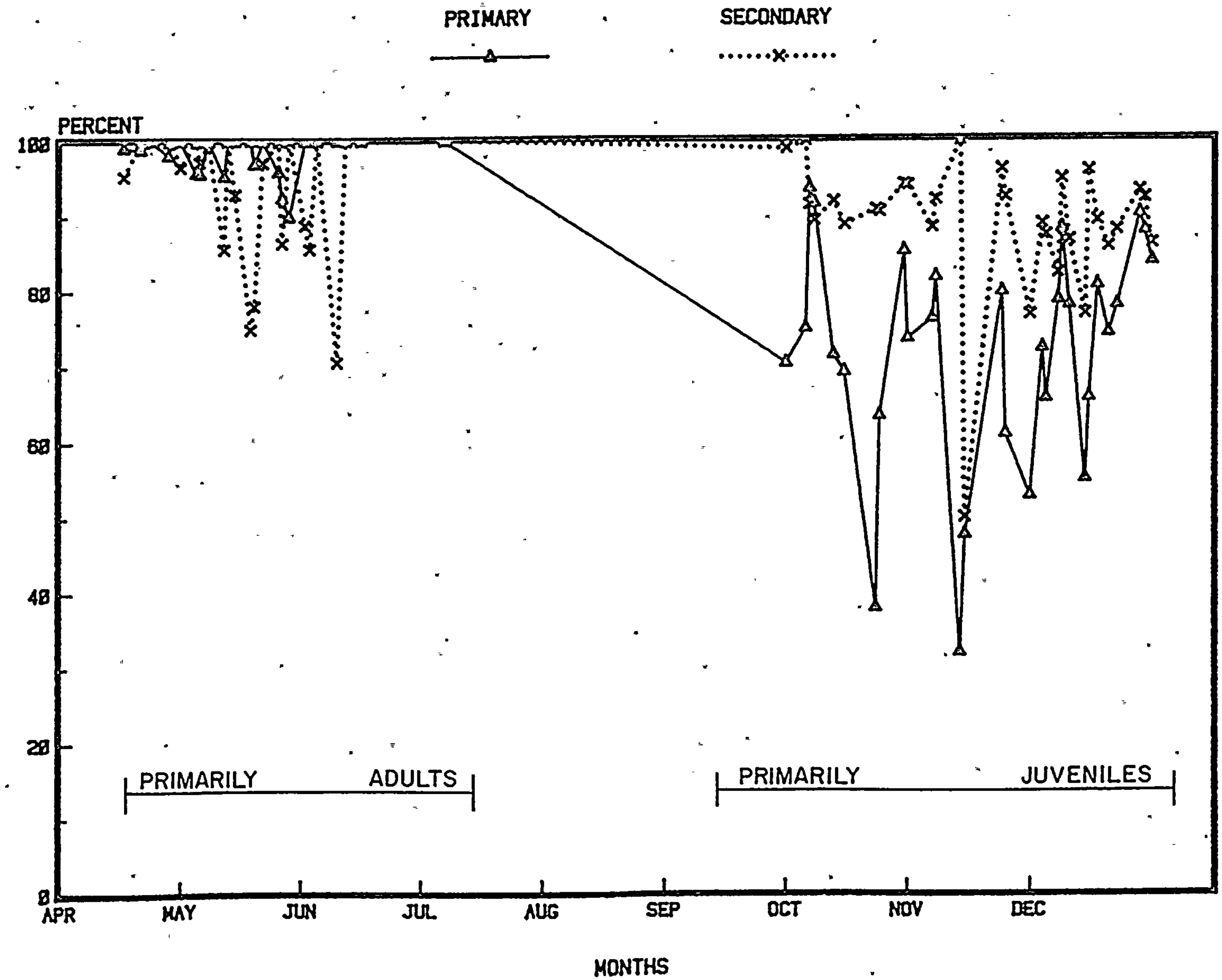


FIGURE [illegible]5

# PERCENT DIVERSION EFFICIENCY OF RAINBOW SMELT

OSWEGO STEAM STATION UNIT 6 - 1981 (APRIL-DECEMBER)



screenwell. Extrusion or entrainment through the secondary traveling screen is expected to be higher than on the primary screens because of the higher through-screen velocity and the excessive turbulence (see Section 2.2). Since the water passing through the secondary screen is discharged back into the primary screenwell, any organism entrained through the secondary traveling screen is recirculated to the primary screens, more specifically on the west side (Figure 2.0-5). This is further supported by the higher densities of smelt observed during this period on screens 3 and 4 (west side) relative to screens 1 and 2 (east side).

While the primary and secondary efficiencies are important in evaluating the individual components of the system, the total diversion efficiency or the total number of fish returned to the lake relative to the number entering the primary screenwell is the basic descriptor of the overall effectiveness in diverting the fish. Table 3.0-3 provides the monthly mean total diversion efficiency (TDE) for six representative species collected in the first nine months of the study. The TDE for white perch, emerald shiner, spottail shiner, and gizzard shad was above 85%, with most monthly values in excess of 90%. The TDE for alewife and rainbow smelt varied throughout the year, based primarily on life stage (length). During the spring, when adults predominated, values in excess of 90% were observed. These values fell during the summer and fall with the recruitment of young. By October the alewife mean length was 10.5 cm (vs 5.6 cm for September [Table 3.0-4]) and TDE was up to 80% from 48% the previous month. A continuous recruitment of juvenile smelt throughout the fall and mean lengths of 6.5, 7.2, 6.0, and 5.7 cm for September, October, November, and December, respectively (Table 3.0-4), provided TDEs of between 65 and 76%.

3.2.2.2 Survival. To assess overall survival of fish subsequent to transport through the diversion system, the initial condition upon

## TABLE 3.0-3

### MEAN MONTHLY TOTAL DIVERSION EFFICIENCY[a]

Oswego Steam Station Unit 6 - April-December 1981

| SPECIES | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|
| Alewife | 98.3 | 91.3 | 76.2 | 84.5 | 32.1 | 47.7 | 80.4 | 86.1 | 95.5 |
| Rainbow smelt | 96.3 | 92.3 | 85.1 → | → | → | 76.0 | 73.1 | 64.7 | 75.3 |
| Gizzard shad | 100.0 → | → | → | - | - | 90.0 | 96.1 | 96.2 | 98.7 |
| Spottail shiner | 92.6 → | → | → | → | → | 87.5 | 97.6 | 96.2 → | → |
| Emerald shiner | 94.4 → | → | → | - | - | 99.0 | 96.8 | 94.5 | 88.4 |
| White perch | 92.7 → | → | → | → | - | - | 88.9 | 85.9 → | → |
| No. of Efforts | 9 | 12 | 8 | 4 | 3 | 3 | 13 | 10 | 14 |

[a]Number of fish returned to the lake divided by the number of fish entering the primary screenwell.

\- None collected.

X——→ composited across months during periods of low abundance.

TABLE 3.0-4

MONTHLY MEAN LENGTH[a] OF DIVERTED FISH

Oswego Steam Station Unit 6 - April-December 1981

| SPECIES | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|
| Alewife | 16.4 | 13.7 | 16.1 | 16.7 | NA | 5.6 | 10.5 | 13.0 | 12.0 |
| n = | 1228 | 875 | 408 | 107 | NA | 70 | 434 | 120 | 28 |
| Emerald shiner | 5.6 | NA | NA | NA | NA | 5.2 | 6.0 | 6.3 | 5.3 |
| n = | 1 | NA | NA | NA | NA | 30 | 82 | 44 | 14 |
| Gizzard shad | 43.9 | NA | NA | NA | NA | 7.5 | 9.3 | 12.0 | 32.5 |
| n = | 2 | NA | NA | NA | NA | 11 | 226 | 102 | 22 |
| Rainbow smelt | 13.4 | 12.4 | 10.3 | NA | NA | 6.5 | 7.2 | 6.0 | 5.7 |
| n = | 422 | 53 | 10 | NA | NA | 53 | 501 | 392 | 1013 |
| Spottail shiner | 5.9 | 9.3 | 11.8 | NA | 6.4 | 10.7 | 7.3 | 9.6 | NA |
| n = | 1 | 1 | 1 | NA | 2 | 2 | 96 | 9 | NA |
| White perch | 8.7 | 9.0 | NA | NA | NA | NA | 6.2 | 7.9 | 7.4 |
| n = | 7 | 4 | NA | NA | NA | NA | 58 | 32 | 2 |
| Yellow perch | 22.4 | 15.9 | 17.0 | NA | NA | NA | 21.7 | 23.6 | NA |
| n = | 3 | 2 | 1 | NA | NA | NA | 1 | 1 | NA |

[a]Length in centimeters.
NA - None analyzed.

collection was classified as live, stunned, or dead. A portion of the live and stunned fish was then randomly selected and held separately for long-term (96-hr) observation. Table 3.0-5 provides the results of the initial survival observations by month for six selected species. As many as 30% of the diverted alewife and smelt were classified as dead at collection during May and June. In excess of 80% of the predominantly juvenile alewife diverted in September were dead at collection. Alewife initial survival increased in October, reflecting the increased size and improved swimming ability (Table 3.0-4). Smelt initial survival remained low throughout the fall, reflecting the continued recruitment of young smelt into the system (Table 3.0-4).

White perch and gizzard shad showed varable initial survival, while spottail shiner and emerald shiner typically demonstrated high initial survival.

Long-term survival results are provided by month in Table 3.0-6. Survival of alewife follows a definite pattern related to spawning cycle and recruitment of juveniles into the population. Survival of healthy adults in April was 34%, followed by a decline to 11% for primarily weakened post-spawn individuals entrapped in May. June, July, and August saw the entrapment of only an occasional adult alewife, with survivals between 30 and 40% for the initially live individuals. In September, the survival again dropped, this time to 14% because of the predominance of juveniles. With growth and presumably increased swimming capability, alewife survivals increased throughout the fall and early winter, attaining 79 and 60%, respectively, for November and December. Throughout the year, however, individuals classified as initially stunned fared poorly, with typical survivals below 20%.

Rainbow smelt followed a pattern similar to that exhibited by the alewife except that spring survival was as high as 78%, followed by

TABLE 3.0-5

## INITIAL SURVIVAL AS PERCENT LIVE, STUNNED, AND DEAD FOLLOWING DIVERSION

Oswego Steam Station Unit 6 - May-December 1981

| SPECIES | INITIAL CONDITION | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|
| Alewife | Live | 14.4 | 33.2 | 55.8 | → | 11.8 | 63.1 | 59.4 | 44.6 |
| | Stunned | 48.2 | 28.5 | 14.2 | → | 2.4 | 7.4 | 15.4 | 36.9 |
| | Dead | 37.4 | 38.3 | 30.0 | → | 85.8 | 29.5 | 25.2 | 18.5 |
| Rainbow smelt | Live | 41.6 | → | → | - | 31.6 | 61.0 | 40.5 | 31.2 |
| | Stunned | 30.6 | → | → | - | 0 | 4.6 | 11.7 | 18.8 |
| | Dead | 27.8 | → | → | - | 68.4 | 34.4 | 47.8 | 50.0 |
| Gizzard shad | Live | - | - | - | - | 80.6 | → | 59.6 | 33.3 |
| | Stunned | - | - | - | - | 9.7 | → | 27.7 | 51.8 |
| | Dead | - | - | - | - | 9.8 | → | 12.8 | 14.8 |
| Spottail shiner | Live | - | 92.7 | → | → | → | → | → | → |
| | Stunned | - | 2.3 | → | → | → | → | → | → |
| | Dead | - | 5.0 | → | → | → | → | → | → |
| Emerald shiner | Live | - | 100 | - | - | 92.8 | 94.1 | 86.8 | 74.5 |
| | Stunned | - | 0 | - | - | 0 | 3.3 | 6.6 | 17.6 |
| | Dead | - | 0 | - | - | 7.2 | 2.6 | 6.6 | 7.8 |
| White perch | Live | - | - | - | - | - | 66.1 | 20.3 | → |
| | Stunned | - | - | - | - | - | 8.3 | 25.4 | → |
| | Dead | - | - | - | - | - | 25.6 | 54.2 | → |

\- None collected.
X ——> combined across months during periods of low abundance.

TABLE 3.0-6

MONTHLY LONG-TERM (96-HR) SURVIVAL[a] BY SPECIES

Oswego Steam Station Unit 6 - April-December 1981

| SPECIES | INITIAL CONDITION | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|
| Alewife | IL | 34.3 | 11.2 | 32.4 | 49.0 | 41.4 | 14.3[b] | 33.2 | 79.5 | 60.0 |
| | IS | - | 0.0 | 7.7 → | → | 22.4 → | → | 7.9 | 21.4 → | → |
| Rainbow smelt | IL | 78.1 | 10.8[b] → | → | - | - | 43.0 → | → | 37.7 | 13.6 |
| | IS | - | 0.0[b] | - | - | - | - | 37.7 | 36.7 | 13.6 |
| Gizzard shad | IL | - | - | - | - | 72.0 → | → | → | 50.0 → | → |
| | IS | - | - | - | - | 54.8 → | → | → | 38.5 → | → |
| Spottail shiner | IL | 97.8 → | → | → | → | → | 94.7 → | → | → | → |
| | IS | - | - | - | - | - | - | - | - | 100[b] |
| Emerald shiner | IL | 100[b] → | → | → | - | - | 100 | 97.6 | 96.9 | 98.4 |
| | IS | - | - | - | - | - | - | 77.8 | 92.9 → | → |
| White perch | IL | 42.9[b] | - | - | - | 76.2 → | → | → | → | → |
| | IS | - | - | - | - | - | - | 60.0 → | → | → |

[a]Percent alive at 96-hr observation.
[b]Less than 10 fish tested.
\- None tested.
X———→ combined across months during periods of low abundance.
IL - Initially live.
IS - Initially stunned.

a general dearth of fish throughout the summer till October when the juvenile smelt moved into the area. Throughout the fall, survivals of smelt remained between 38 and 43%. In December, with the reduction of lake temperatures to below 3°C, smelt survival diminished to 14%.

The remaining four species presented can be classified into one of two groups: those having moderate survivals (between 45 and 75%), which includes gizzard shad and white perch; and those that are hardy and have good survival (above 75%), which includes spottail shiner and emerald shiner.

Survival results for other species which occasionally occur in collections and do not show a specific seasonal trend are presented in Table 3.0-7. Of the 14 species tested, only one species, stonecat (two specimens tested), showed a survival less than 90%. The three regulated game fish, brown trout, lake trout and smallmouth bass, showed no mortality attributed to the system.

3.2.2.3 Total Plant Efficiency. Total plant efficiency (TPE) is a function of the total diversion efficiency (TDE) and the long-term survival. The total efficiency by month was determined for the six prevalent species according to the following formula (Table 3.0-8):

$$TPE = [TDE] \times [(IL)(IL_{96}) + (IS)(IS_{96})]$$

where:

$IL$ = the proportion initially alive

$IL_{96}$ = the percent of the initially alive that survived through 96 hrs

Based on this presentation, approximately 34% of the alewives and 75% of the rainbow smelt that enter the plant in April will be

TABLE 3.0-7

SURVIVAL RESULTS OF SELECTED SPECIES

Oswego Steam Station Unit 6 - April-December 1981

| SPECIES | TOTAL TESTED | INITIALLY ALIVE | | | INITIALLY STUNNED | | |
|---|---|---|---|---|---|---|---|
| | | @ 0 (hr) | @ 96 (hr) | % SURV. | @ 0 (hr) | @ 96 (hr) | % SURV. |
| American burbot | 2 | 1 | 1 | 100.0 | 1 | 1 | 100.0 |
| Bluegill sunfish | 16 | 11 | 11 | 100.0 | 5 | 5 | 100.0 |
| Brown trout | 2 | 2 | 2 | 100.0 | 0 | 0 | - |
| Goldfish | 1 | 1 | 1 | 100.0 | 0 | 0 | - |
| Johnny darter | 12 | 12 | 12 | 100.0 | 0 | 0 | - |
| Lake trout | 1 | 1 | 1 | 100.0 | 0 | 0 | - |
| Mottled sculpin | 54 | 54 | 51 | 94.4 | 0 | 0 | - |
| Pumpkinseed | 1 | 1 | 1 | 100.0 | 0 | 0 | - |
| Rock bass | 15 | 14 | 14 | 100.0 | 1 | 1 | 100.0 |
| Smallmouth bass | 8 | 8 | 8 | 100.0 | 0 | 0 | - |
| Stonecat | 2 | 2 | 1 | 50.0 | 0 | 0 | - |
| Trout-perch | 10 | 10 | 9 | 90.0 | 0 | 0 | - |
| White bass | 11 | 11 | 10 | 90.9 | 0 | 0 | - |
| White sucker | 2 | 2 | 2 | 100.0 | 0 | 0 | - |

TABL[illegible]-8

MONTHLY TOTAL PLAN[illegible]CIENCY BY SPECIES

Oswego Steam Station Unit 6 - April-December 1981

| SPECIES | | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Alewife | Est. Entrapment[a] | 54,432 | 91,810 | 42,768 | 20,088 | 670 | 20,952 | 81,989 | 7,704 | 1,042 | 321,455 |
| | % of Total | 17 | 28 | 13 | 6 | <1 | 7 | 26 | 2 | <1 | 100 |
| | Total Plant Eff. | 33.7 | 1.5 | 9.9 | 24.0 | 8.3 | 2.5 | 17.3 | 43.5 | 33.1 | 9.6 |
| | Est. Return Alive | 18,344 | 1,377 | 4,234 | 4,821 | 56 | 524 | 14,184 | 3,351 | 345 | 30,726 |
| Rainbow smelt | Est. Entrapment[a] | 8,280 | 3,422 | 432 | 74 | 0 | 7,704 | 78,194 | 80,280 | 126,554 | 304,940 |
| | % of Total | 3 | 1 | <1 | <1 | - | 3 | 26 | 26 | 41 | 100 |
| | Total Plant Eff. | 75.2 | 4.2 | 3.8 | 3.8 | - | 10.3 | 20.4 | 12.7 | 5.1 | 13.1 |
| | Est. Return Alive | 6227 | 144 | 16 | 3 | - | 794 | 15,952 | 10,196 | 6,454 | 39,786 |
| Gizzard shad | Est. Entrapment[a] | 144 | 0 | 72 | 0 | 0 | 1,440 | 14,136 | 4,896 | 818 | 21,506 |
| | % of Total | 1 | - | <1 | - | - | 7 | 65 | 23 | 4 | 100 |
| | Total Plant Eff. | 48.2 | - | 48.2 | - | - | 57.0 | 60.9 | 38.9 | 36.1 | 54.6 |
| | Est. Return Alive | 69 | - | 35 | - | - | 821 | 8,609 | 1,905 | 295 | 11,734 |
| Spottail shiner | Est. Entrapment[a] | 144 | 74 | 72 | 298 | 372 | 216 | 3,125 | 360 | 74 | 4,735 |
| | % of Total | 3 | 2 | 2 | 6 | 8 | 5 | 65 | 7 | 2 | 100 |
| | Total Plant Eff. | 90.6 | 90.6 | 84.0 | 84.0 | 84.0 | 76.8 | 85.7 | 84.4 | 86.7 | 85.1 |
| | Est. Return Alive | 130 | 67 | 60 | 250 | 312 | 166 | 2,678 | 304 | 64 | 4,031 |
| Emerald shiner | Est. Entrapment[a] | 72 | 74 | 72 | 0 | 0 | 4,824 | 5,952 | 2,736 | 818 | 14,548 |
| | % of Total | <1 | <1 | <1 | - | - | 33 | 42 | 19 | 6 | 100 |
| | Total Plant Eff. | 94.4 | 94.4 | 94.4 | - | - | 91.9 | 91.4 | 85.3 | 79.3 | 89.8 |
| | Est. Return Alive | 68 | 70 | 68 | - | - | 4,433 | 5,440 | 2,334 | 649 | 13,062 |
| White perch | Est. Entrapment[a] | 432 | 149 | 72 | 74 | 0 | 0 | 3,497 | 1,800 | 74 | 6,098 |
| | % of Total | 7 | 2 | 1 | 1 | - | - | 58 | 30 | 1 | 100 |
| | Total Plant Eff. | 39.8 | 39.8 | 39.8 | 39.8 | - | - | 49.2 | 26.4 | 26.4 | 41.1 |
| | Est. Return Alive | 172 | 59 | 29 | 29 | - | - | 1,721 | 475 | 20 | 2,505 |
| | | PRIMARILY ADULTS | | | | PRIMARILY JUVENILES | | | | | |

[a]Based on continuous unit operation.

returned alive to the source water body. This number drops off to approximately zero in May. This coincides with a significant decline in the entrapped population. In light of the low diversion and survival of juvenile alewife and smelt in the early fall, less than 20% of the entrapped juveniles can be expected to be returned alive to the source water body. By November and December, 30 to 40% of the alewife entrapped are saved but less than 10% of the smelt.

The remaining four species showed variable total efficiencies, with gizzard shad and white perch typically falling between 30 and 60%, and spottail shiner and emerald shiner typically exceeding 80% total efficiency.

Although the numbers collected were low, the lack of any trout or bass impingement, coupled with the high survivals recorded for these species, indicates a high system efficiency for these species.

### 3.2.3 Special Studies

3.2.3.1 Tag, Release, and Recapture Studies. Two special studies were conducted to provide additional numbers of target species in order to evaluate survival and to investigate residence times in the screenwells. The first study was conducted from 1-3 July 1981 and concentrated primarily on hatchery-reared brown trout and smallmouth bass. The second, from 28-31 July, concentrated on locally caught populations of yellow perch, white bass, white perch, and a mix of rock bass and sunfish. Some hatchery-reared smallmouth bass were also tested.

In the first survey, differentially tagged and acclimated trout and smallmouth bass were released into each screenwell and individuals were collected from the sampling basin and offshore in a special

collection net (Section 3.2.3.2). In the second survey, releases were made only in the primary screenwell.

A summary of the numbers released in each screenwell and the respective recovery locations is presented in Table 3.0-9. Except for the yellow perch, which passed through the system within the two-day recapture period, generally between 40 and 50% of the tagged fish remained in the screenwell beyond the 48-hr test period. Smallmouth bass were recovered from the screenwell as long as 1269 hours after the time of release (Table 3.0-10) and then only because the unit was being dewatered and the fish were physically forced out of the screenwell.

Overall survival for brown trout released in the primary screenwell was 94% as compared to 73% for those released into the secondary screenwell (Table 3.0-10). The higher survival through the entire system, rather than through only the secondary system, is probably related to the reduced turbulence and increased residence period (acclimation) for those released in the primary screenwell.

Overall survival for smallmouth bass was 83 and 85% for releases into the primary and secondary screenwell, respectively. Although overall survival was similar, residency was much different. Smallmouth bass released in the secondary screenwell were typically recovered within the first 8 hrs, while those released in the primary screenwell typically remained in the system in excess of 48 hrs.

Only a few white perch were recaptured, but survival was zero. The low numbers recovered preclude forming any conclusions on this species at this time. The remaining species - white bass, yellow perch, and the rock bass/sunfish composite - demonstrate overall survivals of 64 to 69%.

TABLE 3.0-9

TAG/RECOVERY SUMMARY

Oswego Steam Station Unit 6 - 1981

| SPECIES | No. RELEASED PSW | SSW | IMPINGEMENT 1-4 | 5 | SB | OFFSHORE | PERCENT RECOVERY |
|---|---|---|---|---|---|---|---|
| Brown trout | 47 | 40 | - | - | 42 | 7 | 56 |
| Smallmouth bass | 60 | 90. | - | 1 | 59 | 5 | 43 |
| Yellow perch | 56 | - | - | 7 | 44 | - | 91 |
| White bass | 64 | - | - | 7 | 31 | - | 59 |
| White perch | 23 | - | 3 | 1 | 8 | 1 | 57 |
| Rock bass/sunfish | 29 | - | - | 1 | 19 | - | 69 |

PSW - Primary screenwell.
SSW - Secondary screenwell.
SB - Sample basin.

TAB[illegible]0-10

## TAG/RECOVERY SURVIVAL RESULTS

Osewgo Steam Station Unit 6 - 1981

### I. PRIMARY SCREENWELL

| SPECIES | OVERALL SURVIVAL | 0 TO 8 HRS No. | 0 TO 8 HRS % SURV. | 8 TO 24 HRS No. | 8 TO 24 HRS % SURV. | 24 TO 48 HRS No. | 24 TO 48 HRS % SURV. | > 48 HRS No. | > 48 HRS % SURV. | MAX. RESIDENCE HRS |
|---|---|---|---|---|---|---|---|---|---|---|
| Brown trout | 93.6 | 6 | 83 | 4 | 100 | - | - | 6 | 100 | 681 |
| Smallmouth bass | 83.3 | 7 | 57 | - | - | 1 | 100 | 10 | 100 | 1269 |
| Yellow perch | 63.7 | 37 | 65 | 3 | 33 | 4 | 75 | - | - | 48 |
| White bass | 67.8 | 2 | 0 | 10 | 30 | 11 | 91 | 8 | 100 | 651 |
| White perch | 0 | 6 | 0 | 1 | 0 | - | - | 1 | 0 | 546 |
| Rock bass/sunfish | 68.6 | 9 | 56 | 3 | 33 | 7 | 100 | - | - | 39 |

### II. SECONDARY SCREENWELL

| SPECIES | OVERALL SURVIVAL | 0 TO 8 HRS No. | 0 TO 8 HRS % SURV. | 8 TO 24 HRS No. | 8 TO 24 HRS % SURV. | 24 TO 48 HRS No. | 24 TO 48 HRS % SURV. | > 48 HRS No. | > 48 HRS % SURV. | MAX. RESIDENCE HRS |
|---|---|---|---|---|---|---|---|---|---|---|
| Brown trout | 72.8 | 17 | 76 | 3 | 67 | 4 | 75 | 2 | 50 | 703 |
| Smallmouth bass | 85.2 | 35 | 97 | 3 | 0 | 2 | 50 | 1 | 0 | 702 |

3.2.3.2 Offshore Collections. A specially designed net was constructed and deployed offshore to collect fish as they were discharged from the return conduit. Section 5.3 describes the sampling apparatus and procedures.

Three collections were made at the discharge, with qualitative observations being made for overall fish viability and specific long-term holding performed on selected species tagged and released in the primary or secondary screenwell (see Section 3.2.3.1). Although only small numbers of fish were collected (Table 3.0-11), those held for long-term observations indicate lower survival than corresponding collections from the sampling basin. Initial observations performed on alewife indicate a significant number of abraded and damaged fish. Since in each case predators were also present (eels and large brown trout), damage could not be directly assigned to a specific cause, such as transit through the pipe or predation in the collection net during the 24-hr set.

The primary objective of the offshore sets was to develop a methodology for sampling in the offshore environment, and this objective was met.

TABLE 3.0-11

OFFSHORE COLLECTIONS

Oswego Steam Station Unit 6 - 1981

| SPECIES | No. COLLECTED | % SURVIVING |
|---|---|---|
| Brown trout | 8 | 63 |
| Smallmouth bass | 2 | 0 |
| Rock bass | 1 | 100 |
| White bass | 1 | 0 |
| Yellow perch | 2 | 100 |

CHAPTER 4.0

RECOMMENDED STUDIES FOR 1982-1983

## 4.1 IN-PLANT STUDIES

### 4.1.1 Maintenance of the 1981 Data Base

To maintain the existing data base and to provide additional data necessary to refine and prove or disprove some of the preliminary premises, a portion of the 1982-1983 program will continue the program initiated in 1981-1982. Thus, the routine 8-hr. survey conducted in 1981-1982, consisting of concurrent impingement, abundance, and viability collections, will be continued in 1982-1983, but at a reduced frequency. The 130 routine surveys and three intensive surveys conducted in 1981-1982 will be reduced to 81 routine collections for the 1982-1983 sampling year. The schedule will consist of three collections per week during the peak abundance months of April and May, followed by one collection per week from June through September, two per month during the juvenile recruitment period October through December, and one per week from January through March. If warranted by unusual diurnal or seasonal cycles or species composition, additional or modified sampling will be conducted as necessary.

### 4.1.2 New Programs

4.1.2.1 Optimization - Hydraulics. Because of the obvious turbulence in the secondary screenwell, a program will be undertaken early in April of 1982 to evaluate the potential for optimization of the hydraulic conditions in the secondary screenwell. There are three valves that regulate flow through the diversion system:

1. A valve on the motive force to the primary jet pump
2. A valve on the motive force to the secondary jet pump
3. A valve on the return pipe from behind the secondary screen back into the primary screenwell (Figure 4.0-1).

The objective of the optimization program is to reduce the turbulence in the secondary screenwell. The level of turbulence will be determined by velocity profiles along the secondary screen during various settings of the three valves. Once an optimum setting, defined as the setting producing the most uniform velocity distribution in the secondary screenwell, is determined, the velocity profiles along the screens in the primary system under this condition will also be determined. Since the flow through the diversion system is less than 15% of the total flow through the primary screenwell, small adjustments on the diversion system should have minimal effect on the velocities in the primary system.

The optimum setting will then be used as a test condition through the 1982-1983 study year. During each routine 8-hr collection, half of the viability collections (three of them) will be conducted under the standard 1981-1982 operating conditions and the other half under the optimum flow conditions. At the end of the 1982-1983 study, an evaluation of the effectiveness of flow optimization on increasing survival can be completed.

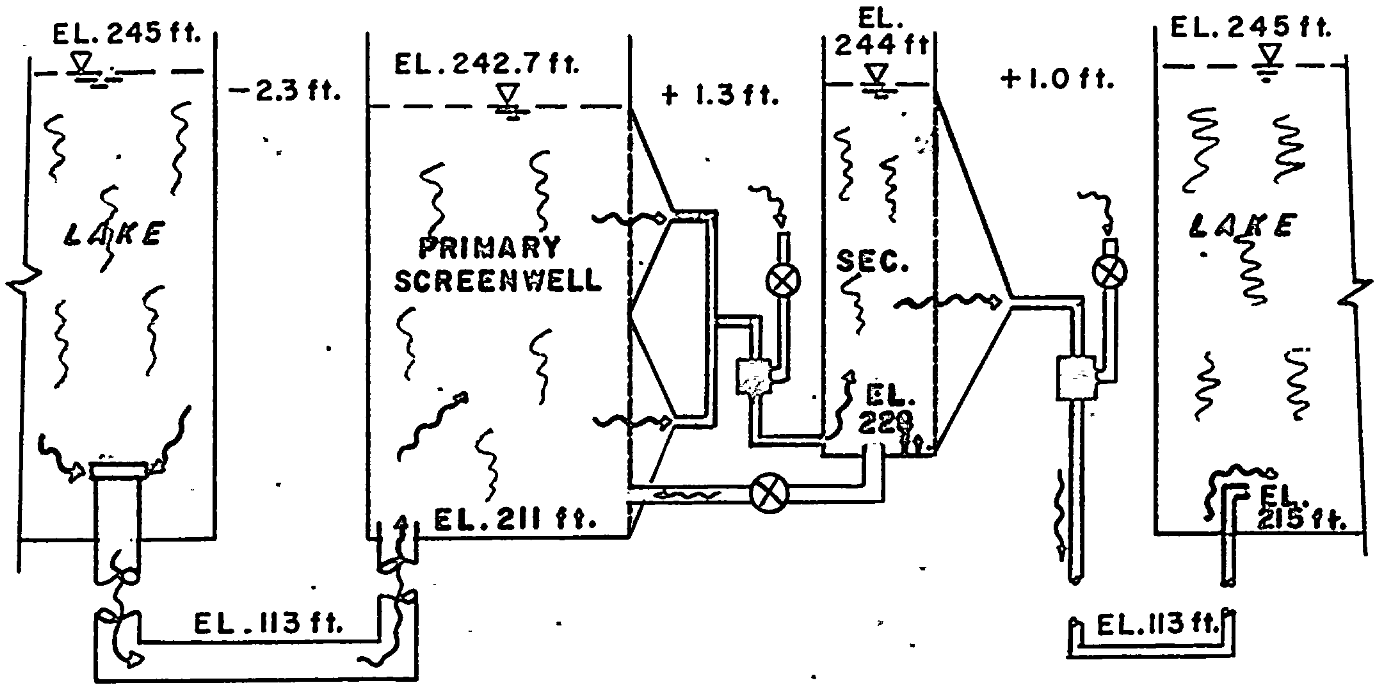
4.1.2.2 <u>Natural Diversion vs Induced Diversion</u>

4.1.2.2.1 <u>Effect on survival</u>. It has been found in preliminary studies performed in 1981 that reducing the light level in the screenwell to virtual darkness produces a rapid increase in

FIGURE 4.0-1

## OSWEGO STEAM STATION UNIT 6

### DIVERSION SYSTEM SCHEMATIC



the number of diverted fish. The actual mechanics of this phenomenon are unknown, but it is most likely related to a disorientation in the fish caused by a physiological change from photopic vision (daylight vision, which uses primarily the cones of the retina) to scotopic vision (night vision, which uses primarily the rods).

Again, preliminary observations indicate that a higher survival rate is shown by fish diverting in the dark (induced) than under natural conditions. When this observation is coupled with the long residency reported in Section 3.2.3.1, the actual diversion process becomes more complex.

It is the objective of this phase of the study to evaluate whether fish induced to divert have in fact a higher survival rate than those diverting under normal conditions. Once per week, at the end of a regularly scheduled routine collection, the screenwell will be darkened and a collection made of fish diverted in the dark. Survival results for these fish will be compared directly with those from the earlier collections. Thus, 52 comparisons will be made during the 1982-1983 study year.

4.1.2.2.2 Condition effect. In addition to comparing the survival results for fish diverted under the dark and light regimes, condition factor and stomach contents will also be determined for representative fish from each of the two groups. If a differential survival is encountered, the condition factor of the respective fish will demonstrate if one group is obviously more fit, i.e., greater weight per unit length, than the other. Residence time for a planktivore may be detrimental to its condition. Since the offshore intake withdraws from a

constant fixed depth, entrapment of vertically migrating plankton may be limited to a couple of short periods each day. Under natural conditions, the planktivore would seek out its food, which is not possible in an intake screenwell. On the other hand, residence for a predator may be advantageous since a continuous source of food is available. Thus, the condition factor may be an important tool descriptive of one species but not another.

In conjunction with the condition factor, stomach analysis will be performed on selected species from each group. These data will provide more information on the relative effect of residency on specific species.

4.1.2.3 <u>Recirculation</u>. A study will be conducted to evaluate the potential for recirculation of fish from the offshore discharge to the offshore intake. The proximity of the discharge to the intake (within several hundred feet) makes it feasible that a portion of the discharged fish are re-entrained into the intake, thereby affecting the estimated numbers impacted and the anticipated survival for fish subjected to multiple passes through the system.

To evaluate the degree of recirculation, 1000 live tagged adult rainbow smelt will be released in the Unit 6 secondary bypass in early April coincident with high, naturally occurring smelt abundances. Impingement and bypass fish will be monitored at Unit 6 for the next seven successive days. Impingement collections from Units 1-4 and Unit 5 will also be monitored for tagged rainbow smelt. If this study indicates a significant recirculation problem, a second survey using tagged emerald shiner may be recommended for the fall of 1982.

## 4.2 OFFSHORE STUDIES

### 4.2.1 Discharge Net Collections

Offshore collections will be conducted during April, May, June, September, October, and November using the techniques developed in 1981 (Section 5.4).

A total of five collections will be scheduled during each of the six selected months. The collection duration will vary from 1 to 12 hrs, depending upon densities of target fish. It is anticipated that short sets (1 hr) will be sufficient in April and May, while longer sets will be necessary during the remaining months.

At the termination of a given collection, the net will be brought to the surface; all fish will be concentrated in the holding portion of the net and the collection cone will be removed (see Section 5.4). The initially dead fish will be removed and stored for preliminary analysis. Predators will be segregated in another holding car and both will be covered and buoyed for long-term observations.

Since most of the mortality associated with the diversion process was manifested within the first 18 to 24 hrs following collection, and maintenance of holding cars in the offshore environment is extremely difficult because of weather and vandalism, the typical long-term observation period will be 48 hrs as compared to the 96 hrs used in-plant. As a control to assess latent mortality occurring between 48 and 96 hrs, the first collection during each survey will be held for the full 96 hrs.

Observations of latent effects will be made at 12-hr intervals throughout the holding period. At each observation, dead fish will

be removed and water temperature will be recorded. At the completion of latent observations, all fish will be identified, enumerated, and frozen for subsequent length analysis.

### 4.2.2 Release of Tagged Fish

To supplement catches of selected species occurring naturally in low numbers, LMS will release tagged fish into the offshore intake during the months of May, June, and October. These releases will be in conjunction with the offshore collections and will provide survival data and residence information on fish passing through the entire system. Species to be tagged include white perch, smallmouth bass, yellow perch, and white bass. Individuals of these species will be collected by seine, trapnet, and hook and line from the Oswego vicinity. All fish will be tagged and held for a minimum of 24 hrs prior to their release. A target number of 250 individuals per species will be tested during 1981.

### 4.2.3 Predation Survey

As part of the 1982-1983 studies, LMS will establish whether a significant predator population is developing in the near field of the return system discharge. To accomplish this objective, gill net and trot line collections from the nearfield area will be compared with an identical synoptic collection effort conducted in a similar habitat 0.8 km (0.5 mi) west of the discharge area.

In each location, a 61-m (200-ft) gill net consisting of a 7.6-cm (3-in.) and 12.7-cm (5-in.) stretch mesh panel will be deployed along with a 61-m (200-ft) trot line with baited hooks at 6-m (20-ft) intervals. A survey, consisting of one 12-hr day set and a corresponding 12-hr nighttime set, will be conducted during April, May, June, September, October, and November.

CHAPTER 5.0

# FACILITIES, EQUIPMENT, AND PROCEDURES

## 5.1 FISH SAMPLING BASIN AND IMPINGEMENT COLLECTIONS

### 5.1.1 Sampling Equipment

5.1.1.1 Sampling Basin Modifications. The sampling basin consists of a 2.4 x 2.4 m (8 x 8 ft) pit in the northwest corner of the screenhouse. A 76-cm (30-in.) intake pipe enters vertically through the floor of the pit (4.9 m [16 ft] below screenhouse elevation). A 46-cm (18-in.) discharge pipe returns the flow back to the primary screenwell. The fish sampling basin had to be modified to permit efficient sampling and to minimize fish handling. Since the basin could not be drained during certain pump operating conditions, a false floor was installed with a hinged counterweighted trap door over the inflow pipe to allow more control in regulating the water depth for sample collection. The Johnson screen on the 46-cm (18-in.) exit port was removed and replaced by a 0.3-cm (0.13-in.) mesh screen of approximately 3.0-$m^2$ (32-$ft^2$) surface area inclined at a 45° angle to the wall and the false floor. These modifications minimized debris clogging, allowed the water level in the basin to be lowered enough for efficient sorting of fish, and permitted a fish crowding device to be used to facilitate sorting and reduce handling. This device consists of a 2.4 by 0.6 m (8 x 2 ft) metal frame covered with 0.3-cm (0.13-in.) nylon mesh that is designed to slide down the drain screen and across the basin floor, maintaining a tight seal with the basin wall. It is used to crowd the collected fish gently to one side of the basin to permit identification and sorting of test fish.

5.1.1.2 Flow Indicators. Water level indicators were installed in the primary and secondary screenwells as well as in the sampling

basin. Piezometer tubes were installed on the upstream side of the primary jet pump and on the discharge pipe elbow just before the gate valves used to control discharge flow to the lake or to the sampling basin. These provide a monitor of the flow through the system.

5.1.1.3 Impingement Collection Modifications. To facilitate collection of the screen washings from each screen, special nets were constructed to fit into the fish/debris troughs. These were suitable under most sampling conditions; however, during periods of excessive debris, they filled rapidly and required almost constant attention.

5.1.1.4 Meters and Equipment. Field measurements and fish handling were performed with the equipment listed in Table 5.0-1. All collection and water chemistry equipment was checked regularly to ensure optimum performance.

TABLE 5.0-1

LABORATORY EQUIPMENT

| PARAMETER | EQUIPMENT USED | MAINTENANCE |
|---|---|---|
| Conductivity | YSI Model 33 SCT meter | Monthly KCL calibration, daily checks |
| Dissolved oxygen | YSI Model 57 DO meter | Weekly Winkler calibration, daily air calibration |
| pH | Analytical Measurements Model 707B | Weekly calibration |
| Temperature | Kessler partial immersion thermometers | Checked weekly against NBS ASTM |
| Fish handling | Labeled transfer buckets and fine mesh dip nets | Daily hypochlorite disinfection |
| Impingement collection | 0.3-cm (0.1-in.) mesh collection nets | Daily inspection for holes or rips |

### 5.1.2 Sampling Basin Collection Procedures (VIABILITY)

5.1.2.1 Viability Schedule. Routine viability collections included six 15-min samples taken at 1-hr intervals from the second through the seventh hrs of an 8-hr sampling period. Intensive viability collections consisted of 18 15-min samples collected at 4-hr intervals over three consecutive days at the beginning of the spring, fall, and winter seasons. All viability samples were collected concurrently with impingement collections and in conjunction with sample basin abundance collections.

5.1.2.2 Collection Procedure. Prior to the initiation of a sample, a reading was taken and recorded from the discharge pipe piezometer to determine the flow rate to the lake. When the sample was initiated by switching the lake discharge flow to the sampling basin, the piezometer tubes were monitored to assure that the water flow into the sampling basin equaled the previous lake discharge flow. Adjustment to the flow rate was accomplished through adjustment to the basin drain valve. During sampling, the primary screenwell water levels, sampling basin water levels, and sampling basin temperatures were recorded. At sample termination, the gate valve was switched, diverting the flow to the lake, and the basin was slowly drained to a depth of approximately 0.3 m (1 ft).

5.1.2.3 Sorting Procedure. A fish crowder was lowered along the inclined screen and manually slid across the basin floor to crowd the collected fish gently to one side of the basin for sorting purposes. Live (swimming normally) and/or stunned (swimming erratically) fish of the selected dominant species were sorted into labeled transfer buckets full of ambient basin water and immediately transferred to numbered latent effects tanks. Sorting was conducted under subdued light and with minimal handling to reduce shock.

Test fish were segregated by life conditions (live or stunned) and by predators and prey. Initial chemistry parameters were determined for each holding tank. The fish not held for latent survival were recorded by species and life condition (live, stunned, or dead) and frozen for subsequent analysis with the remainder of the sample.

### 5.1.3 Sampling Basin Collection Procedures (ABUNDANCE)

5.1.3.1 Abundance Schedule. Routine abundance collections included one 30-min sample taken during the first and last hour of an 8-hr sampling period. Intensive abundance collections consisted of 18 30-min samples collected at 4-hr intervals over three consecutive days at the beginning of the spring, fall and winter seasons.

5.1.3.2 Collection Procedure. The abundance collection procedure is identical to that described for the viability collection (Section 5.1.2.2) except that the sample duration is normally 30 min. However, under periods of either excessive fish numbers or very low abundances, the duration may be switched to 15 or 60 min, respectively.

5.1.3.3 Sorting Procedure. The same sorting procedure is employed as described for the viability collection (Section 5.1.2.3) except that all fish were normally frozen for analysis after initial sorting by life condition. However, specific target species collected in an abundance collection were held for latent viability observations.

### 5.1.4 Impingement Collection Procedures

5.1.4.1 Sampling Schedule. Impingement sampling was conducted in two modes, intensive and routine. Intensive sampling, performed at the beginning of the spring, fall, and winter seasons, consists of

32 2.5-hr samples from each of the five screens collected during three consecutive days. Routine sampling consisted of a single 8-hr collection from each of the five screens.

5.1.4.2 Collection Procedure. An impingement collection period was initiated upon completion of one full wash cycle (prewash). The fish from this prewash cycle were inspected for markings, tags, or fin clips. All non-tagged fish from the prewash cycle were discarded. Collection nets were then installed to sample each of the five screens individually. The collectors were checked upon completion of each wash cycle to prevent debris overload. At the completion of the wash cycle nearest to 8 hrs from the start time, the collection nets were removed and all organisms separated from the debris. All impinged fish were identified to species if possible, enumerated, recorded, and frozen for subsequent analysis. Field notes reflected general condition of fish, evidence of parasites, presence of invertebrates, and weather conditions.

### 5.1.5 Water Chemistry

At the beginning and end of each impingement collection, temperature and dissolved oxygen were measured in the east and west screenwells at surface, mid-, and bottom depths. Temperature, dissolved oxygen, pH, and conductivity were also measured in the secondary screenwell at mid-depth. Primary and secondary screenwell water levels as well as discharge piezometer tube readings were measured and recorded with the water chemistries.

## 5.2 SCREENHOUSE HOLDING FACILITIES

### 5.2.1 Equipment

The holding and latent survival observations of diverted organisms are conducted in a wet laboratory constructed in the screenhouse of

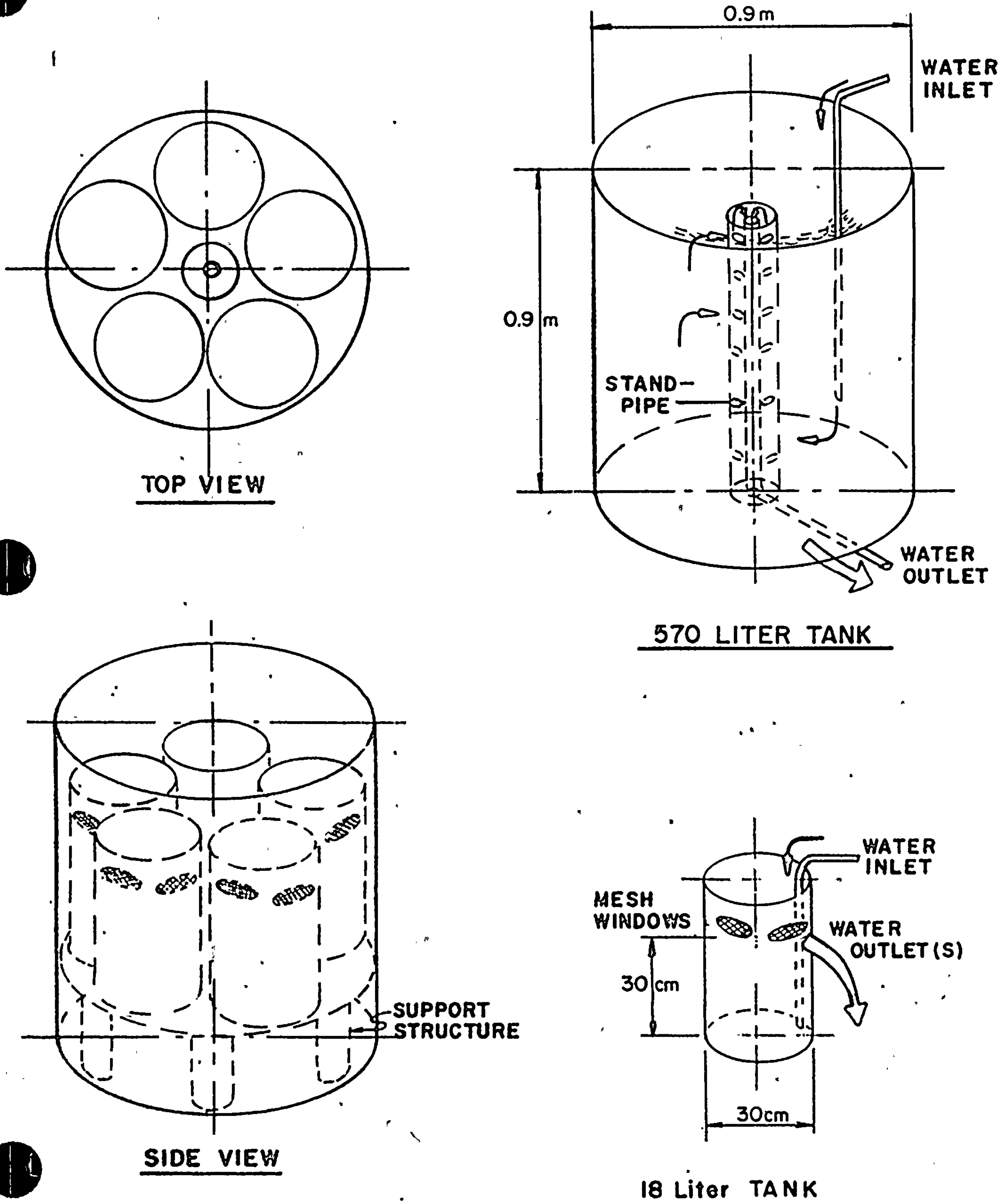
Unit 6. The space is divided into two areas: a holding tank area and an ancillary storage and work area. Ambient water from the screenwell is supplied to a sand filter in the holding area by NMPC service water pumps. The Airquatic Model FG24-FCA fiberglass sand filter with a filtration rate of 4 l/s (63 gpm) and filter area of 0.3 $m^2$ (3.1 $ft^2$) processes the entire flow prior to use. The filtered water flows through PVC pipes to valved attachment points at each 570 liter (150-gal) plastic holding tank. Each tank is operated on a flow-through system with adjustable standpipe (variable water depth). When needed to hold juveniles or small species, 18-liter flow-through containers are arranged within the 570-liter tanks (Figure 5.0-1). A Schramm Model 3/4 JS-B compressor supplies air to the holding facility.

### 5.2.2 Observation and Holding Procedures

Diverted organisms used for viability testing were collected, sorted, and transported to the holding area, using equipment and procedures described in Section 5.1.2. Test fish were transferred to either 570-liter or 18-liter containers, depending on their size and numbers. Holding capacity of each tank is based on 5 g of fish weight per liter of water. If large numbers of a species were collected, random subsampling of both live and stunned fish was performed to select test organisms.

Latent survival observations were conducted at 0, 12, 18, 36, 84, and 96 hrs following collection. At each observation, the holding tanks were checked for dead organisms. Any dead fish were removed, recorded, and frozen for subsequent analysis. At termination (96 hrs), all fish were sorted by life condition, recorded, bagged separately, and frozen. At initial and final (96-hr) observations, temperature, dissolved oxygen, pH, and conductivity measurements in

## FIGURE 5.0-1
## LATENT SURVIVAL HOLDING CONTAINERS




ARRANGEMENT OF 18 Liter TANKS IN 570 LITER TANK

the holding tanks were recorded. At all other observations, temperature measurements were recorded. Tanks were disinfected with 5% hypochlorite solution prior to each use.

Screenwell temperatures were monitored, and tank flow rates adjusted to minimize temperature fluctuations caused by Lake Ontario upwelling events or station operation.

## 5.3 LAKE DISCHARGE COLLECTIONS

### 5.3.1 Sampling Equipment

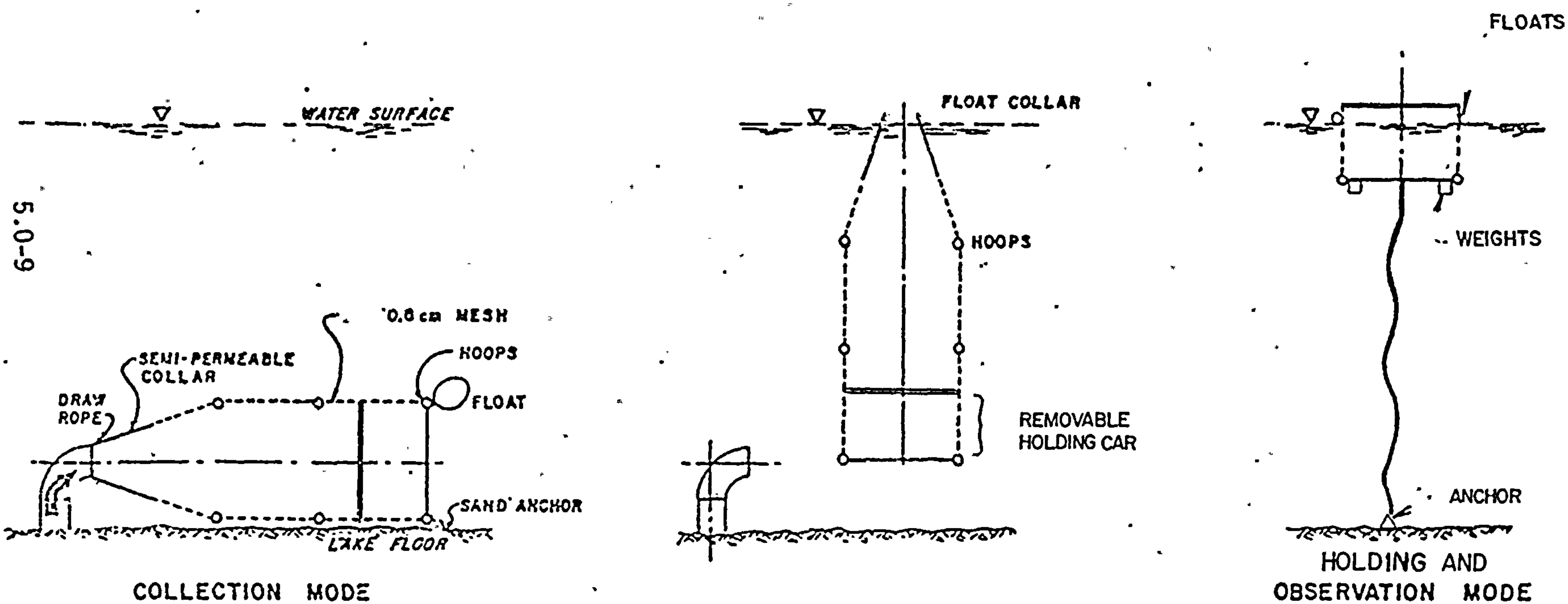
The offshore collection gear consists of a 6.1-m (20-ft) long, 0.3-cm (0.1-in.) mesh hoop net with fiberglass rings, approximately 1.8 m (6 ft) in diameter (see Figure 5.0-2). When in the collection mode, the net was oriented horizontally with its apex attached to the discharge port and the base anchored approximately 6.1 m (20 ft) away. The densely woven nylon base produces a stagnation area where fish can reside during the collection period. Small buoys attached directly to the fiberglass rings and anchor lines attached to the base of the net were used to maintain its shape and orientation along the axis of discharge flow. The net was set and retrieved by scuba divers. A 5-m (17-ft) Boston Whaler, modified with wooden gunwale struts designed to hold the net vertically at the water's surface, was used as the crew boat. Fine mesh dip nets and large aerated coolers were used to sort and hold fish until transfer to the holding facilities (see Section 5.2.1). During 1981, no in situ holding was conducted.

### 5.3.2 Discharge Net Collection Frequency

Lake discharge collections were done in conjunction with the release of live tagged (fin clips) fish into the primary and secondary

FIGURE 5.0-2

LAKE COLLECTION AND HOLDING NETS



screenwell. Three 24-hr collections were conducted on 1-2 July, 2-3 July and 30-31 July.

### 5.3.3 Lake Collection and Handling Procedures

Discharge net collections were performed with a lake crew that included two scuba divers and a crew chief in a boat anchored above the discharge port and an "in-plant" crew manning the discharge flow valves. At the designated time, the plant crew was signaled by radio to switch the lake discharge flow into the sampling basin. This allowed the divers to attach the discharge collection net as described in Section 5.3.1 with no flow from the discharge port. Once the net was deployed, the plant crew was instructed to switch the discharge flow back to the lake. At this time the divers checked the net to assure that it was functioning properly and to observe fish behavior.

At the end of the collection period, the flow was switched back to the sampling basin as described above and the divers removed the attachment cone from the discharge port and tied it closed. The net was then raised to the surface and the first fiberglass hoop attached to the gunwale struts on the boat. At this point the cylindrical net was hanging vertically in the water, with the first hoop held horizontally at gunwale level. The attachment cone was removed and fish were dip-netted out and sorted into aerated holding tanks. The collection net was then reattached for the next collection period. When properly deployed, the plant crew was signaled to switch the discharge flow back through the discharge port into the net. The collected fish were then immediately taken to shore, transferred to the holding facilities, and observed for 96 hrs according to the procedure described in Section 5.2.2.

## 5.4 TAG-RECAPTURE STUDIES

Smallmouth bass and brown trout purchased from John Grimm hatcheries in Rhinebeck, N.Y., were used to supplement yellow perch, white perch, white bass, rock bass, and sunfish collected by otter trawl and angling from Lake Ontario in the immediate vicinity of the Oswego Steam Station. Hatchery fish were trucked to the holding area (Section 5.2) in insulated, aerated tanks, fin-clipped, and held for 24 hrs prior to release. Fish collected by trawl or angling were transferred to the holding area in large aerated coolers, fin-clipped, and held for 24 hrs prior to release. Differential fin clips were used to identify each fish by its release point and time. Some of the tagged fish were held for latent survival testing as controls on our tagging and handling technique.

Tagged fish were lowered gently into the screenwell in containers of ambient water and released at the water's surface. Numbers and species released, release point and time, and all measurements normally taken during routine sampling (Section 5.1.2.1) were recorded. Sampling (basin and impingement) was conducted for 48 hrs after each release to determine residence time in the screenwells. The time of recapture and general condition of each tagged fish recovered were recorded. Tagged species collected in the sampling basin were held for latent survival testing as described in Section 5.2.2. A group of fish was also released directly into the sampling basin during a collection, allowed to reside there for 15 min (equal to a routine viability collection) and processed as described in Sections 5.1.2 and 5.2.2. This served as a control on our collection and holding techniques.

## 5.5 ANALYSIS PROCEDURE

### 5.5.1 Equipment

All fish length measurements were performed on standard fish measuring boards to 0.1-cm accuracy. Fish weights smaller than 250 g were measured on a Fisher Model XS-250 digital analytical balance to 0.1-g accuracy. Fish weights larger than 250 g were measured on a Fisher countertop balance to 1.0-g accuracy. All weights were determined on thawed fish that were blotted dry.

### 5.5.2 Preliminary Analysis

All samples received preliminary analysis prior to compositing for secondary analysis. Preliminary analysis consisted of species identification, enumeration, tag checks, and biomass determination. No damaged or decomposing fish were included in biomass measurements or compositing for secondary analysis.

### 5.5.3 Compositing Procedure

Routine impingement samples for screens one, two, three, and four were composited after preliminary analysis. Screen five (secondary diversion screen) was analyzed separately. Impingement samples collected at 2 1/4-hr intervals during the seasonal intensive collections were composited over each 24-hr period to yield a composite of screens one through four and a composite for screen five alone. All sample basin abundance samples from the same collection period were composited for secondary analysis. Fish collected in the sampling basin but not tested for latent survival were treated like fish in the sample basin abundance collections. All fish used for latent survival observations received individual secondary analysis.

### 5.5.4 Secondary Analysis

Secondary analysis consisted of individual length and weight measurements, a visual examination of gonad development and sex, and visual examination for parasites. Analysis was performed on all impingement and sample basin abundance composites with 100 or fewer individuals per species per composite. For impingement and sample basin abundance composites with more than 100 individuals per species, a random numbers table was used to generate a subsample of 60 to 170 individuals per species which received secondary analysis. All viability fish were identified, measured for length, weighed, and examined for general body condition, including gonad development and parasites.

## 5.6 AUXILIARY STORAGE AND WORK SPACE

LMS utilizes approximately 28 $m^2$ (300 $ft^2$) of workspace area at the 256-ft elevation near the north wall of the Unit 6 screenhouse. This includes laboratory workbenches, sample wash sinks, and a storage freezer east of the sampling basin. A steel storage shed and general storage area is maintained west of the sampling basin. All in-plant collections and analysis are performed in these areas. An LMS trailer adjacent to the screenhouse is used for office space.