MONTANA FISH AND GAME DEPARTMENT
FISHERIES DIVISION
HELENA, MONTANA

JOB COMPLETION REPORT
INVESTIGATIONS PROJECT

State of Montana

Project No. F-12-R-9 Name Western Montana Fisheries Study

Job No. III Title Aerator Evaluation

Period Covered June 30, 1962 to June 30, 1963

Abstract:

Browns and Georgetown Lakes were mechanically aerated in an effort to evaluate the effects of aeration on water temperatures and dissolved oxygen concentrations during winter and early spring.

Surface dissolved oxygen concentrations at all stations remained adequate for fish throughout the relatively mild winter of 1962-1963. Surface dissolved oxygen concentrations ranged from 5 to 7 ppm at Browns Lake and from 5 to 10 ppm at Georgetown Lake. No increase in dissolved oxygen concentrations were evident during aerator operations; however, mid-depth and bottom dissolved oxygen concentrations remained highest at stations near the aerators.

Dissolved oxygen concentrations at the control lakes (Upsata and Echo) and at stations in Browns and Georgetown which were isolated from the aerators progressively declined at mid and bottom depths but remained constant at the surface.

Mechanical aeration had no apparent cooling effect on the lakes. Water temperatures recorded at Browns and Georgetown Lakes showed no constant change before or during the period of aeration.

Recommendations:

The Curtis aerators should be operated again during the 1963-64 winter season, and sampling should continue with the following changes:

1. Stations in the control lakes and Station I in Georgetown Lake should be moved to where the depth is similar to the depth of stations near the air lines.

2. Stations II and IV on Georgetown Lake should be moved to at least one-quarter mile from each side of the air line, and Stations V and VI should be moved to one-half mile from each side of the air line.

Objectives:

The objective of this study is to determine the ability of two mechanical aeration systems to maintain adequate winter oxygen concentrations for sustaining fish life in Browns and Georgetown Lakes. These lakes are shallow, productive lakes with a history of periodic winter fish kills.

During the winter of 1961-62, a Hinde Air Aqua system was installed at Browns Lake. The system consisted of three Bell and Gossett compressors, each connected to 500 feet of feeder hose and 1000 feet of air hose. The air lines were set in 12 to 15 feet of water in three, parallel T-formations. This arrangement was recommended by the Hinde Company. The system began operating in November of 1961 and continued through March of 1962. During this period the Hinde aerators never opened water over their entire air lines, and during severe cold spells kept only a few 4- to 5-foot holes ice free.

Throughout the operation, dissolved oxygen samples were taken at five stations on Browns Lake, including one sample station 300 feet from the air line. Dissolved oxygen concentrations just below the ice dropped to less than 3.5 ppm at all stations by February 2, and less than 1.6 ppm by March 29. Mid-depth and bottom dissolved oxygen concentrations ranged between 1.8 and 0.0 ppm during the sampling period. A severe fish kill was discovered shortly after spring breakup.

In January 1962, a Curtis C-80 compressor with 4000 feet of air hose was installed at Georgetown Lake. The unit was able to maintain a strip of open water the entire length of its air line throughout the late winter and early spring. No dissolved oxygen samples were taken; however, the successful operation of this compressor in maintaining open water was coincidental with a spring ice breakup which occurred two weeks earlier than usual.

In view of the mechanical success of the Curtis air compressors in maintaining open water, it was decided to evaluate their ability to maintain an adequate winter dissolved oxygen concentration for fish life.

Techniques Used:

In the fall of 1963, two Curtis C-80 air compressors were installed at opposite sides of Georgetown Lake with their air lines (4000 feet for each compressor) meeting about the center of the lake, (see Figure 1). A third unit was installed at Browns Lake with a 3600-foot airline transecting about three-fourths the width of the lake, (see Figure 2). Each unit delivers 22 cubic feet of air per minute which is distributed through a 3/4 inch, plastic-pipe, air line. Small holes were punched in the plastic pipe at ten-foot intervals with a number 8 sewing needle. The pipe was laid by boat in 400-foot sections and weighted to the bottom by 3-foot lengths of 3/4-inch reinforcing rod, taped to the pipe at 17-foot intervals. The systems were installed in October 1962 and put into operation on March 11, 13, and 15, 1963.

The Hinde Air Aqua system, used at Browns Lake in the winter of 1961 - 1962, was installed at Georgetown Lake over one mile from the Curtis units and was put into operation on March 13, 1963.

Temperatures were recorded with an electric resistance thermometer, and dissolved oxygen determinations were made with a Hach oxygen kit. Oxygen and temperature data were collected at four stations on Browns Lake, six stations at Georgetown Lake and one each on Echo and Upsata Lakes. Data were collected at the surface, mid-depth (midway between the surface and the bottom) and the bottom.

The locations of the stations in relation to the air lines were: Georgetown Lake; Stations II, III, and IV near the Curtis air lines; Stations V and VI near the Hinde air lines; Station I in the outlet bay which is over one mile from the nearest airline and in a narrow bay. Browns Lake; Station II within 300 feet of the air line; Stations I and III in the main lake but approximately one-quarter mile north and south of the air line respectively; Station IV in the inlet bay, which is almost isolated from the main lake by a long point and a shallow weed bed.

Figure 1. Location of airline system and oxygen-temperature stations on Georgetown Lake

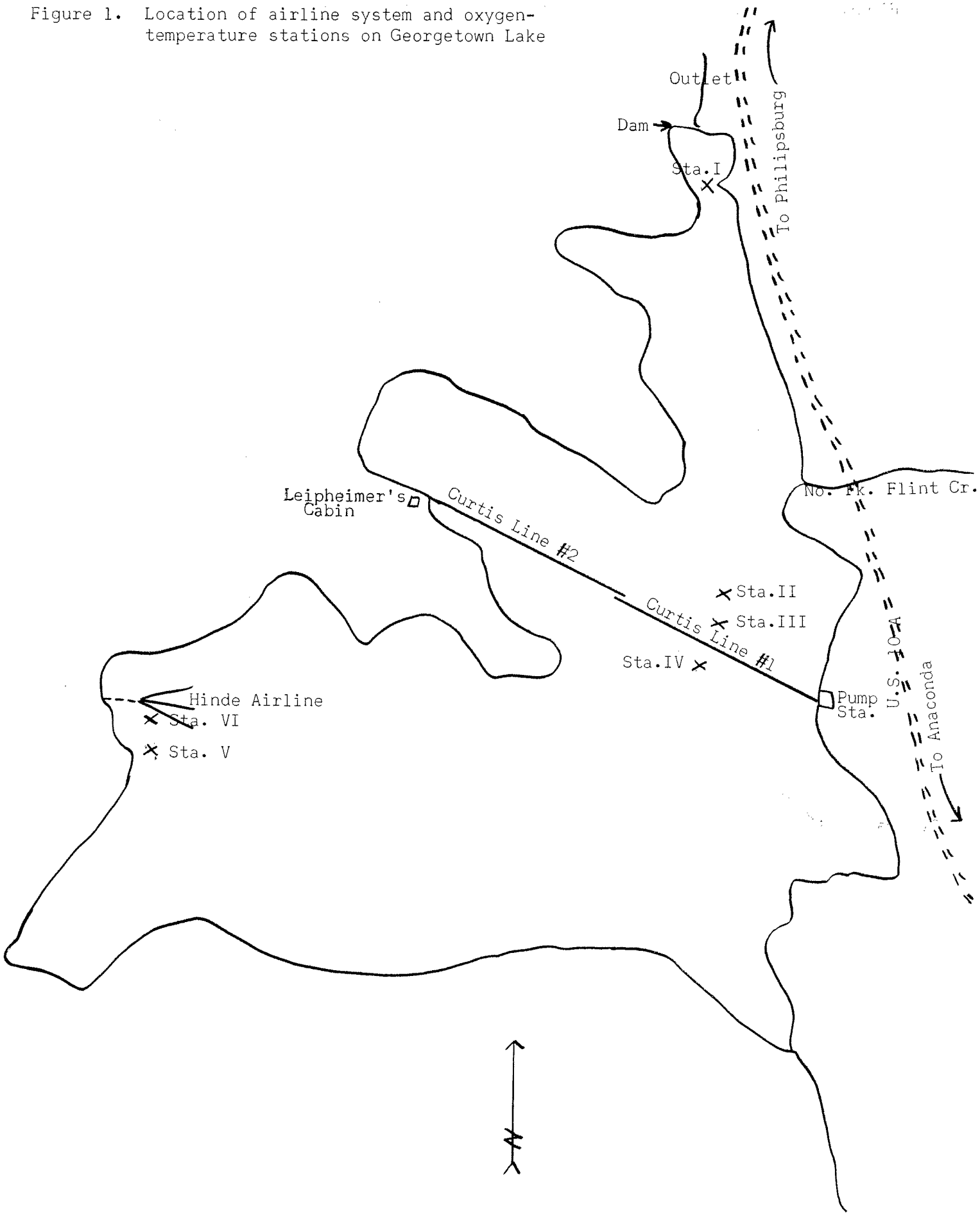
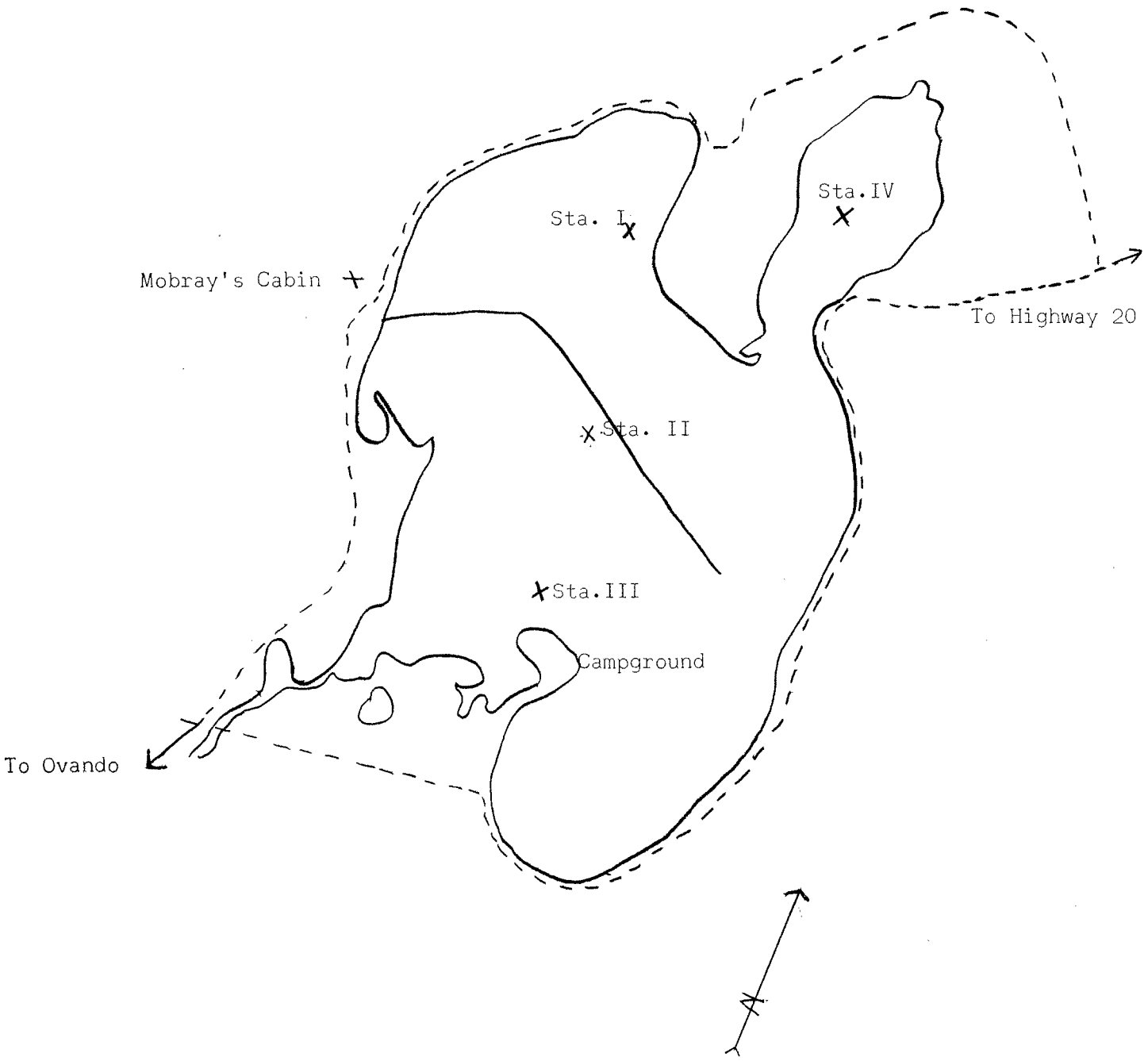


Figure 2. Location of airline system and oxygen-temperature stations on Browns Lake.



The oxygen and temperature series began February 5 at Browns Lake and February 15 at Georgetown Lake and continued through early spring. Sampling at the control lakes began February 10 at Echo Lake (control for Georgetown Lake) and February 12 at Upsata Lake (control for Browns Lake) and continued through March. Sampling was done at approximately two-week intervals.

Findings:

During the mild winter of 1962-63 it is likely that neither Browns nor Georgetown Lakes would have had a severe winterkill even had they not been aerated. Browns Lake had a maximum ice cover of 18 inches with snow depth ranging from 2 to 14 inches during the period of sampling. Georgetown Lake's maximum ice cover was 26 inches and its snow cover varied from 2 to 24 inches during the same period. Intermittent periods of warm and cold weather did not allow either lake to stand for long periods with heavy snow cover.

The Browns Lake aeration system began operating March 13 and continued until ice breakup on April 14. A week after aeration, a channel of open water approximately 1600 feet in length was visible. By April 1, the channel was open over the entire 3600-foot air line. Prior to ice breakup the channel had widened to an estimated 300 feet.

The Browns Lake oxygen series began February 13 and continued through March 26, (see Table 1). Surface dissolved oxygen concentrations at four stations varied between 5 and 7 ppm during the entire sampling period. Mid-depth dissolved oxygen readings, with the exception of Station IV, ranged between 4 and 6 ppm. The dissolved oxygen concentration at the lake bottom varied between 0 and 6 ppm.

No consistent increases in dissolved oxygen concentrations were noted at any one station prior to, or during, the operation of the air system. Surface dissolved oxygen readings of 6 ppm at Station II, 300 feet from the air line, remained constant during the course of the sampling period. Slight fluctuations in dissolved oxygen concentrations at the other stations were probably due to variations in photosynthetic activity as a result of various depths of snow cover on the ice from time to time.

Oxygen determination made at Upsata Lake (control for Browns Lake) between February 12 and March 21 ranged from 8 to 9 ppm (Table 2). A gradual decrease in the dissolved oxygen content at mid and bottom depths occurred throughout the sampling period.

One Curtis aerator at Georgetown Lake was put into operation March 11, the other on March 13, and both continued operating through May 15. By March 25 the open water had appeared over the 8000 feet of air line. The open channel averaged 150 feet in width on May 1. Ice breakup occurred on May 17.

The Hinde Air Aqua system was started on March 13. Small channels of open water were first observed over the three air lines on April 3. By May 1, the three small channels had formed one large channel approximately 200 feet wide and 1000 feet long. Surface dissolved oxygen readings recorded at Stations V and VI, 300 and 600 feet from the air line, remained at 10 ppm before and during the functioning of the air system. Although this system was successful in creating some open water, it could maintain an open strip over the full length of its airline only during mild weather.

The surface dissolved oxygen readings recorded at Echo Lake (control for Georgetown Lake) remained between 9 and 10 ppm from February 10 to April 23 (Table 4). Mid-depth samples progressively decreased from 9 to 2 ppm and bottom samples declined from 3 to 0 ppm.

Table 1. BROWNS LAKE WINTER OXYGEN (ppm) DATA 1963

	Feb. 13	Feb. 21	Mar. 4	Mar. 11*	Mar. 18	Mar. 26
Surface						
Sta. I	6	6	6	6	7	7
Sta. II	6	6	6	6	6	6
Sta. III	6	6	6	7	6	7
Sta. IV	5	6	-	5	5	5
Mid-Depth						
Sta. I (8 ft.)	6	6	6	4	6	4
Sta. II (10 ft.)	5	6	4	5	4	4
Sta. III (8 ft.)	6	5	6	6	5	5
Sta. IV (8 ft.)	3	1	-	1	1	2
Bottom						
Sta. I (15 ft.)	1	3	2	1	1	4
Sta. II (19 ft.)	1	1	4	2	2	4
Sta. III (13 ft.)	6	5	4	4	4	5
Sta. IV (15 ft.)	1	1	-	0	1	1

* Air System Began Operation

Table 2. UPSATA LAKE WINTER OXYGEN (ppm) DATA 1963

	Feb. 12	Feb. 26	Mar. 21
Surface	8	9	9
Mid-Depth (14 ft.)	5	4	2
Bottom (28 ft.)	2	1	1

Table 3. GEORGETOWN LAKE WINTER OXYGEN (ppm) DATA 1963

	Feb. 5	Feb. 18	Mar. 5	Mar. 13*	Mar. 19	Mar. 25	Apr. 16	Apr. 23
Surface								
Sta. I	8	10	10	10	7	6	6	5
Sta. II	9	10	10	--	-	-	-	-
Sta. III	10	10	10	--	-	9	6	-
Sta. IV	9	10	10	10	-	9	7	-
Sta. V	10	10	10	10	10	10	-	10
Sta. VI	10	10	10	10	10	10	-	10
Mid-Depth								
Sta. I (15 ft.)	7	2	1	1	1	0	2	1
Sta. II (9 ft.)	-	-	-	-	-	-	-	-
Sta. III (7 ft.)	-	-	-	-	-	9	6	-
Sta. IV (7 ft.)				7	-	9	6	-
Sta. V (7 ft.)			10	10	7	9	-	8**
Sta. VI (7 ft.)			10	10	7	10	-	6**
Bottom								
Sta. I (29 ft.)	2	0	0	0	0	0	0	0
Sta. II (17 ft.)	5	6	6	-	-	-	-	-
Sta. III (13 ft.)	6	6	6	-	-	5	5	-
Sta. IV (13 ft.)	5	5	6	4	-	6	4	-
Sta. V (13 ft.)	6	6	3	2	4	5	-	3**
Sta. VI (13 ft.)	7	3	4	4	5	6	-	2**

* Aerators Began Operation March 11 and 13
** Inaccessible, Samples Taken Within 300 Feet of Original Location

Table 4. ECHO LAKE WINTER OXYGEN (ppm) DATA 1963

	Feb. 10	Feb. 18	Mar. 9	Mar. 19	Apr. 16	Apr. 23
Surface	10	10	10	10	10	9
Mid-Depth (12 ft.)	9	9	6	4	4	2
Bottom (24 ft.)	3	3	2	1	3	0

Dissolved oxygen concentrations remained relatively high at Georgetown Lake throughout late winter and early spring (Table 3). Surface dissolved oxygen samples taken at six stations ranged between 5 and 10 ppm from February 5 through April 23. With the exception of Station I, mid-depth samples varied between 6 and 10 ppm and bottom oxygen concentrations ranged from 2 to 7 ppm. A gradual decline in surface dissolved oxygen readings occurred after March 13 at Stations I, III and IV but no consistent changes in mid-depth and bottom dissolved oxygen were observed.

Even though there was no constant increase in dissolved oxygen concentrations at any station on Georgetown and Browns Lakes, when the stations are grouped by their proximity to the air lines, it is apparent that the final, mid-depth and bottom level dissolved oxygen concentrations were highest in those portions of the lake that could have been affected by the air lines. Table 5 shows the range of final, mid-depth and bottom level dissolved oxygen concentrations for stations from all lakes under study, grouped into four categories.

TABLE 5. Final dissolved oxygen concentrations by four types of stations, all study lakes.

Type station	Range of final, mid-depth and bottom-level dissolved oxygen concentrations
Stations in vicinity of Curtis Aerators Georgetown II, III, IV. Browns I, II, III.	4-7 ppm
Stations in vicinity of Hinde Aerators Georgetown V, VI.	2-8 ppm
Stations in aerated lakes but isolated from air lines Georgetown I Browns IV	0-2 ppm
Stations in control lakes	0-2 ppm

Thus, even though it was not possible to determine the ability of the aerators to maintain adequate dissolved oxygen concentrations during a severe winter, it appears that they did maintain dissolved oxygen concentrations at an adequate level for fish life at mid-depth and bottom levels up to a distance of one-quarter mile from the air lines. Although this was during a mild winter, similar stations in unaffected areas of the aerated lakes and in control lakes did not have a high enough dissolved oxygen concentration to sustain fish life at the mid-depth and bottom levels. The mid-depth and bottom dissolved oxygen concentrations at the two isolated stations in the aerated lakes were either lower at the start of sampling, or dropped sooner than at the stations in the control lakes. This is to be expected because Browns and Georgetown Lakes are more productive than Echo and Upsata Lakes and have a history of periodic winterkills.

The temperature series for the four lakes are shown in Tables 6, 7, 8 and 9. All readings are in Fahrenheit. No consistent drop in temperature is evident in any of the lakes.

Table 6. BROWNS LAKE WINTER TEMPERATURES(°F) 1963

	Feb. 13	Feb. 21	Mar. 4	Mar. 11*	Mar. 18	Mar. 26
Surface						
Sta. I	--	35	34	34	34	36
Sta. II	34	32	34	35	35	37
Sta. III	32	34	34	35	34	36
Sta. IV	--	34	--	35	34	35
Average	33	33	34	35	34	36
Mid-Depth						
Sta. I (8 ft.)	--	36	37	37	37	38
Sta. II (10 ft.)	35	36	37	37	36	38
Sta. III (8 ft.)	35	36	37	37	37	38
Sta. IV (8 ft.)	--	37	--	38	39	38
Average	35	36	37	37	37	38
Bottom						
Sta. I (15 ft.)	--	38	38	39	39	38
Sta. II (19 ft.)	35	38	38	38	37	38
Sta. III (13 ft.)	36	37	38	38	38	38
Sta. IV (15 ft.)	--	39	--	39	40	40
Average	36	38	38	39	39	39

* Air System Began Operation

Table 7. UPSATA LAKE WINTER TEMPERATURES (°F) 1963

	Feb. 12	Feb. 26	Mar. 21
Surface	32	34	35
Mid-Depth (14 ft.)	38	38	36
Bottom (28 ft.)	38	39	37

Table 8. GEORGETOWN LAKE WINTER TEMPERATURES (°F) 1963

	Feb. 5	Feb. 18	Mar. 5	Mar. 13	Mar. 19	Mar. 25	Apr. 16	Apr. 23
Surface								
Sta. I	33	34	34	33	34	33	34	34
Sta. II	34	34	34	--	--	--	--	--
Sta. III	33	34	34	--	--	34	35	--
Sta. IV	34	34	34	33	--	35	36	--
Sta. V	33	34	34	34	34	34	--	34*
Sta. VI	33	34	34	34	34	33	--	34*
Average	33	34	34	34	34	34	35	34
Mid-Depth								
Sta. I (15 ft.)	--	37	37	37	38	37	38	38
Sta. II (9 ft.)	--	--	--	--	--	--	--	--
Sta. III (7 ft.)	--	--	--	--	--	34	36	--
Sta. IV (7 ft.)	--	--	--	36	--	35	36	--
Sta. V (7 ft.)	--	--	36	38	37	37	--	37*
Sta. VI (7 ft.)	--	--	37	37	37	37	--	37*
Average	--	37	37	37	37	36	37	37
Bottom								
Sta. I (29 ft.)	39	40	38	39	40	40	40	40
Sta. II(17 ft.)	39	38	37	--	--	--	--	--
Sta. III(13 ft.)	39	37	36	--	--	37	37	--
Sta. IV (13 ft.)	38	38	37	37	--	37	37	--
Sta. V (13 ft.)	39	38	37	38	39	39	--	39*
Sta. VI (13 ft.)	37	38	38	39	39	39	--	40*
Average	38	38	37	38	39	38	38	40

* Aerators Began Operation March 11 and 13.

Table 9. ECHO LAKE WINTER TEMPERATURES (°F) 1963

	Feb. 10	Feb. 18	Mar. 9	Mar. 19	Apr. 16	Apr. 23
Surface	34	33	34	33	34	32
Mid-Depth	38	38	38	38	39	39
Bottom	38	40	39	39	40	39

Prior to aeration on March 11, the surface temperatures at the four Browns Lake stations averaged 35° as compared to 36° when the final temperature series was recorded March 26.. Mid-depth temperature before aeration 37° as compared to 38° recorded at the termination of the series. The average bottom temperature, 39° remained constant from March 11 through March 26.

The water temperature series for Upsata Lake is presented in Table 6. Water temperatures taken during the sampling period rose from 32° to 35° at the surface, decreased from 38° to 36° at mid-depth, and decreased from 38° to 37° on the bottom.

The average surface temperature at Georgetown Lake just prior to aeration on March 5 was 34°, Table 7. The surface temperature was still 34° on April 23, after aerators had been in operation for a period of 6 weeks. During the same period, average mid-depth temperatures ranged between 36° and 37° and bottom temperatures rose from an average of 37° to 40°.

Echo Lake water temperatures showed no appreciable change during the sampling periods. Surface temperatures ranged between 32° and 34°, mid-depth temperatures varied from 38° to 39° and bottom temperatures varied between 38° and 40°, Table 8.

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Date February 25, 1964

Approved by George D Holton