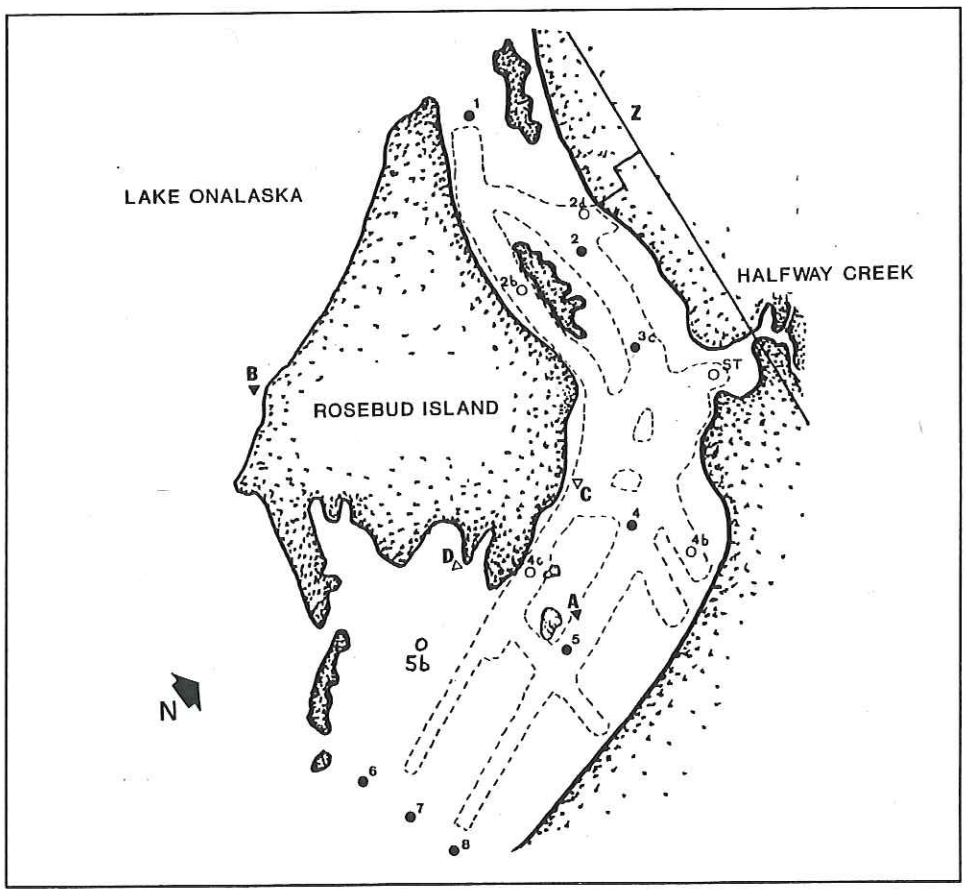
Pre- and Post- Water Quality Evaluation of the Lake Onalaska Dredge Cut, Pool 7, Mississippi River

A Habitat Rehabilitation and Enhancement Project
Under the Federal Environmental Management Program

Prepared for the St. Paul District
U.S Corps of Engineers
Contract No. LN 1343-0007



John F. Sullivan
Wisconsin Department of Natural Resources
La Crosse, Wisconsin
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SUMMARY

Water quality conditions in the Rosebud Island project area improved considerably as a direct result of a dredging project constructed as part of the federal Environmental Management Program's Habitat Rehabilitation and Enhancement Projects. Serious dissolved oxygen (DO) depletion, that once was a common occurrence in the project area, has not been a problem since completion of the dredging project. The improvements can be attributed to the freshwater inflows through the project area as a result of the dredge cut. Over 1 million yards^3 of sediment were dredged and resulted in the creation of a diversity of water depths with flowing channels and isolated deep-water habitats.

Continuous water quality monitoring during summer months have shown DO concentrations normally exceeding 5 mg/l in surface waters of the dredge channel. This has been a dramatic improvement over pre-project conditions when minimum DO concentrations approached 0 mg/l. Average diurnal temperature swings have decreased to about 2.5°C and has resulted in more favorable thermal conditions.

Thermal stratification of deep-water habitats (> 10 ft, 3 m) may contribute to DO reduction in some areas, especially isolated areas with no detectable current velocity. However, surface currents and associated mixing processes were normally sufficient to provide oxygenated water (> 5 mg/l) down to 11.5 ft (3.5 m) throughout the winter monitoring period. Similar vertical DO profiles were apparent during summer periods. Dredge channels were generally weakly stratified during summer surveys in response to wind mixing and flow through the project area.

Discharge through the project area has increased from essentially no flow prior to the dredging project to 600 cfs (17 m^3/s) post-project based on winter surveys in 1992. This represented a substantial increase over project design flow of 100 cfs (2.8 m^3/s). Average cross-sectional water current velocities ranged from 0.11 to 0.13 ft/s (3.4 to 4 cm/s) at the gaging site and were more than twice the design velocity. A recommendation was made to make additional discharge measurements during normal winter river flows. This information will be required to define the needed flow reductions to bring current velocities down to design conditions.

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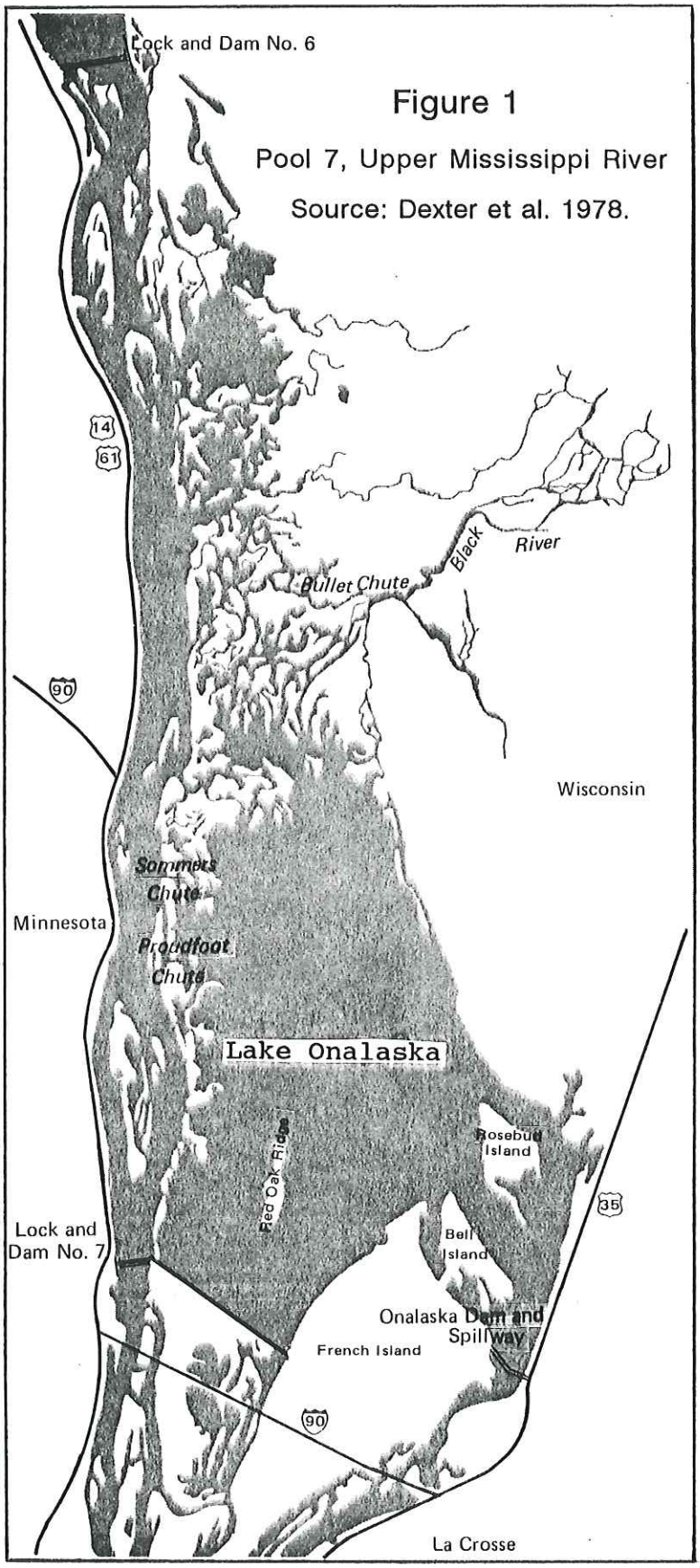


Figure 1

Pool 7, Upper Mississippi River

Source: Dexter et al. 1978.

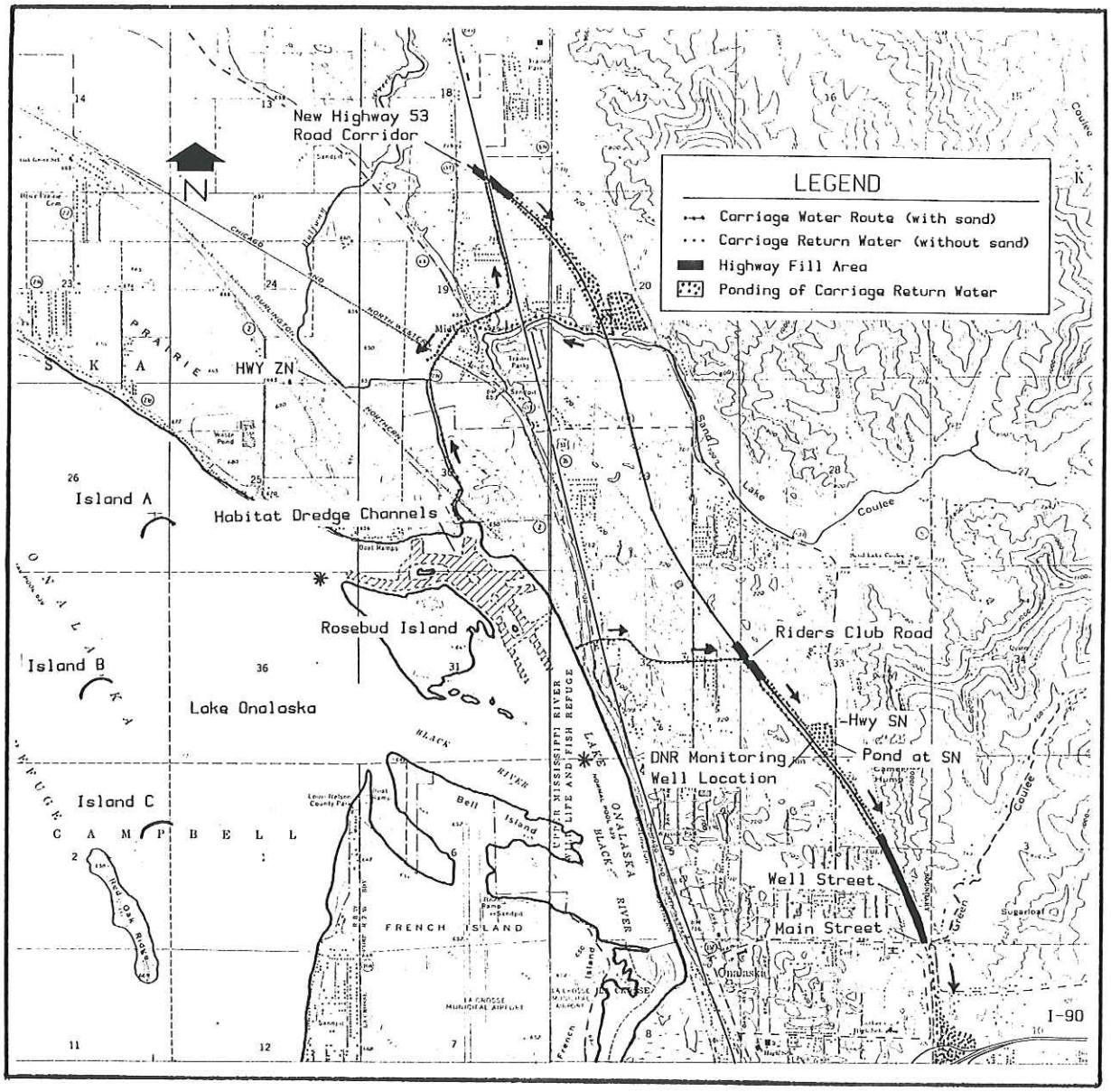


FIGURE 2. MAP OF THE LAKE ONALASKA HABITAT PROJECT FEATURES AND HIGHWAY CONSTRUCTION PROJECT. FROM: SULLIVAN, 1991b.

Construction of the Lake Onalaska HREP project began in May of 1989 and was completed in July of 1990. The dredging portion of the project was finished by November 1989. The project was constructed by the Wisconsin Department of Transportation under a Section 215 agreement with the Corps of Engineers. A detailed description of the project and associated design considerations have been described elsewhere (USCOE 1988, USCOE 1990). In summary, this project resulted in the dredging of about 1 million yards^3 of sand for roadfill materials and 170,000 yards^3 for constructing islands. Undesirable sediments (consisting of sand, silt and clay) were placed on a 30-50 acre confined disposal facility constructed on Rosebud Island. A description of the construction phase and associated water quality impacts was prepared by Sullivan, 1991b.

The purpose of this report is to evaluate pre- and post- water quality monitoring and hydraulic studies associated with the dredge cut near Rosebud Island. This review provides a summary of water quality monitoring activities conducted by the Wisconsin Department of Natural Resources in the Rosebud Island area since the winter of 1985-86. Particular emphasis is placed on identifying water quality and hydraulic changes attributable to the Rosebud Island dredge cut. An important component of this review is to determine if HREP project objectives for the dredge cut are being met and to provide recommendations for future operation and maintenance activities.

Lake Onalaska HREP Project Objectives

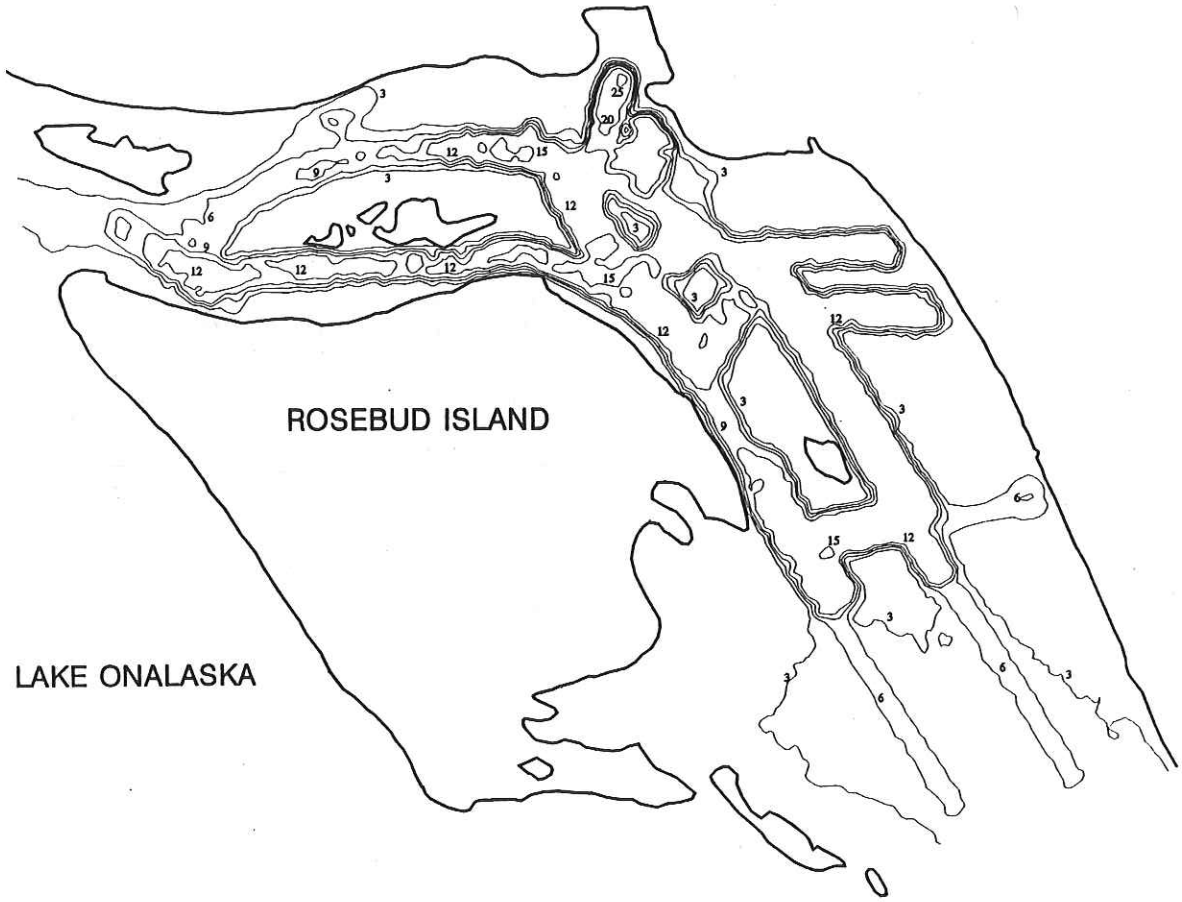
The operation and maintenance manual for the Lake Onalaska HREP project (USCOE 1990) has identified the following project objectives:

1. Create and maintain centrarchid habitat conditions in the 300 acre area north of Rosebud Island.

    A. A minimum of 60 acres of deep water habitat with stable water depths between 8-15 ft under normal discharge.

    B. Nocturnal dissolved oxygen at or above 5 mg/l and diel temperature swings within 2°C during late summer, high thermal conditions in a minimum of the 60 acres of deep-water (8-15 ft) habitat created and a minimum of 80 acres of adjacent shallow-water (2-4 ft) habitat.

FIGURE 3
BATHYMETRIC MAP OF THE ROSEBUD ISLAND DREDGE CUT AREA



N

SCALE

1/4 MILE

DEPTH RANGE (ft)	SURFACE AREA (acres)
0 - 3	161.2 *
3 - 6	74.6
6 - 9	25.6
9 - 12	15.7
12 - 15	56.4
15 - 20	6.0
20 - 25	3.6
> 25	0.1

DEPTH CONTOURS: 3, 6, 9, 12, 15 & 25 ft ARE INDICATED IN FIGURE.

* APPROXIMATE.

SOURCE: ROGALA, 1992.
FROM 1990 SURVEY.

RESULTS and DISCUSSION

Hydraulic Changes

Pre-project water depths north and east of Rosebud Island were about 1 to 4 ft (.3 to 1.2 m). The central area near Halfway Creek had a maximum depth of 2 ft (0.6 m), (Berkman and Von Ruden 1986). Flow through the area was normally restricted or absent due to shallow depths, vegetation or ice cover (Sullivan 1986, Schellhaass and Sullivan 1987a). A small boat channel (Figure 5) was capable of passing some water through the project area during summer conditions. However, it was often difficult to detect any current in this channel and the flow was essentially absent during normal summer and winter periods.

Halfway Creek provided an important source of oxygenated water to the central project area during winter and summer stagnation periods. However, due to it's relatively small discharge, about 10-15 cfs (0.3-.4 m^3/s) during normal conditions, the stream had minimal hydraulic influence and the beneficial affect on water quality was generally localized. Halfway Creek was found to flow to the west through the boat channel or along the northern shoreline during periods of ice cover (Sullivan 1986).

Flow through the project area was determined a few months after the dredging was finished (winter of 1989-90) and two years later (winter 1991-92), (Table 1). The winter period was selected for gaging since historically this represented a critical period of deoxygenation. In addition, ice cover provided a stable platform from which to make low velocity measurements. An example of the cross-sectional velocity and depth measurements for February 1990 and 1992 are illustrated in Figure 6 a,b and c.

Discharge through the project area increased dramatically as a result of the dredge cut. Total discharge was about 350 cfs (10 m^3/s) the first winter after dredging was completed (Table 1). The flow balance between the two channels within the dredge cut was not equal initially, indicating differences in hydraulic efficiency of these channels. Total discharge through the dredge cut was about 3.5 times greater than the design flow of 100 cfs (2.8 m^3/s).

Discharge measurements in January and February 1992 were about 75 % greater than the initial measurements made during the winter of 1989-90. Flows ranged from about 550 to 685 cfs (15.6 to 19.4 m^3/s). This discharge represents 34 to 43% of the maximum design flow of the Onalaska spillway low flow culverts at control pool elevation (639.00 ft), (USCOE 1971). Average cross-sectional velocities at the gaging site in the winter of 1991-92 ranged from 0.11 to 0.13 ft/s (3.4 to 4 cm/s) or about 2 to 2.5 times higher than the maximum project design of 0.05 ft/s (1.5 cm/s).

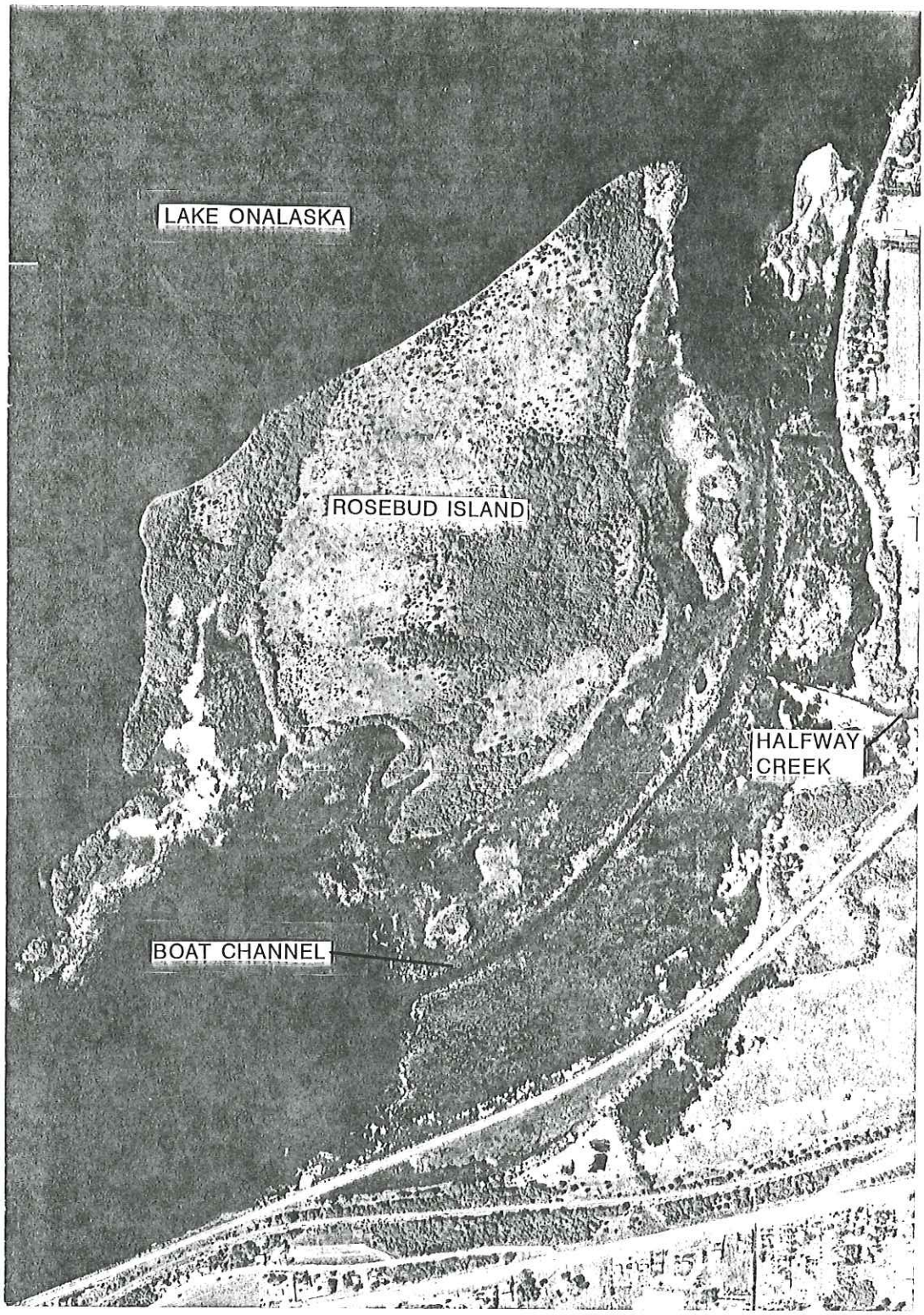


Figure 5. 1974 aerial photograph of Rosebud Island Area, Lake Onalaska, Pool 7, Upper Mississippi River.

TABLE 1. SUMMARY OF DISCHARGE MEASUREMENTS AND CROSS-SECTIONAL (X-SEC.) AREA AND VELOCITY DATA MADE AT THE ROSEBUD ISLAND DREDGE CHANNELS, LAKE ONALASKA, IN THE WINTERS OF 1989-90 AND 1991-92. TRANSECT LOCATED ABOUT 200 FT BELOW MOSEY'S LANDING NEAR SITES 2 AND 2B.

	OUTSIDE DREDGE CHANNEL				INSIDE DREDGE CHANNEL				COMBINED CHANNELS				MISS. RIVER L/D 7	
DATE	MAX. DEPTH (ft)	X-SEC. AREA (ft^2)	CHAN. FLOW (cfs)	AVG. VEL. (ft/s)	MAX. DEPTH (ft)	X-SEC. AREA (ft^2)	CHAN. FLOW (cfs)	AVG. VEL. (ft/s)	MAX. DEPTH (ft)	X-SEC. AREA (ft^2)	CHAN. FLOW (cfs)	AVG. VEL. (ft/s)	RIVER FLOW (cfs)	POOL ELEV. (ft)
12-06-89	10.8	3656	60	0.02	13.8	2589	314	0.12	13.8	6245	374	0.06	10800	639.18
02-08-90	10.6	3823	145	0.06	13.6	2600	193	0.08	13.6	6423	338	0.07	10100	639.04
01-03-92	9.9	3575	291	0.10	12.9	2563	315	0.14	12.9	6138	606	0.12	32700	639.00
02-06-92	10.1	3537	270	0.10	12.8	2589	277	0.12	12.8	6126	547	0.11	25200	639.07
02-28-92	10.0	3556	345	0.12	12.8	2518	340	0.15	12.8	6074	685	0.13	26500	639.07

NOTES: CROSS-SECTIONAL AREA (WITH ICE) DETERMINED GRAPHICALLY USING DIGITIZING SOFTWARE.

AVERAGE CROSS-SECTIONAL VELOCITY = CHANNEL FLOW / CROSS-SECTIONAL AREA (WITHOUT ICE).

RIVER FLOW AND POOL ELEVATION FROM THE U.S CORPS OF ENGINEERS FOR MID-DAY READINGS AT L/D 7.

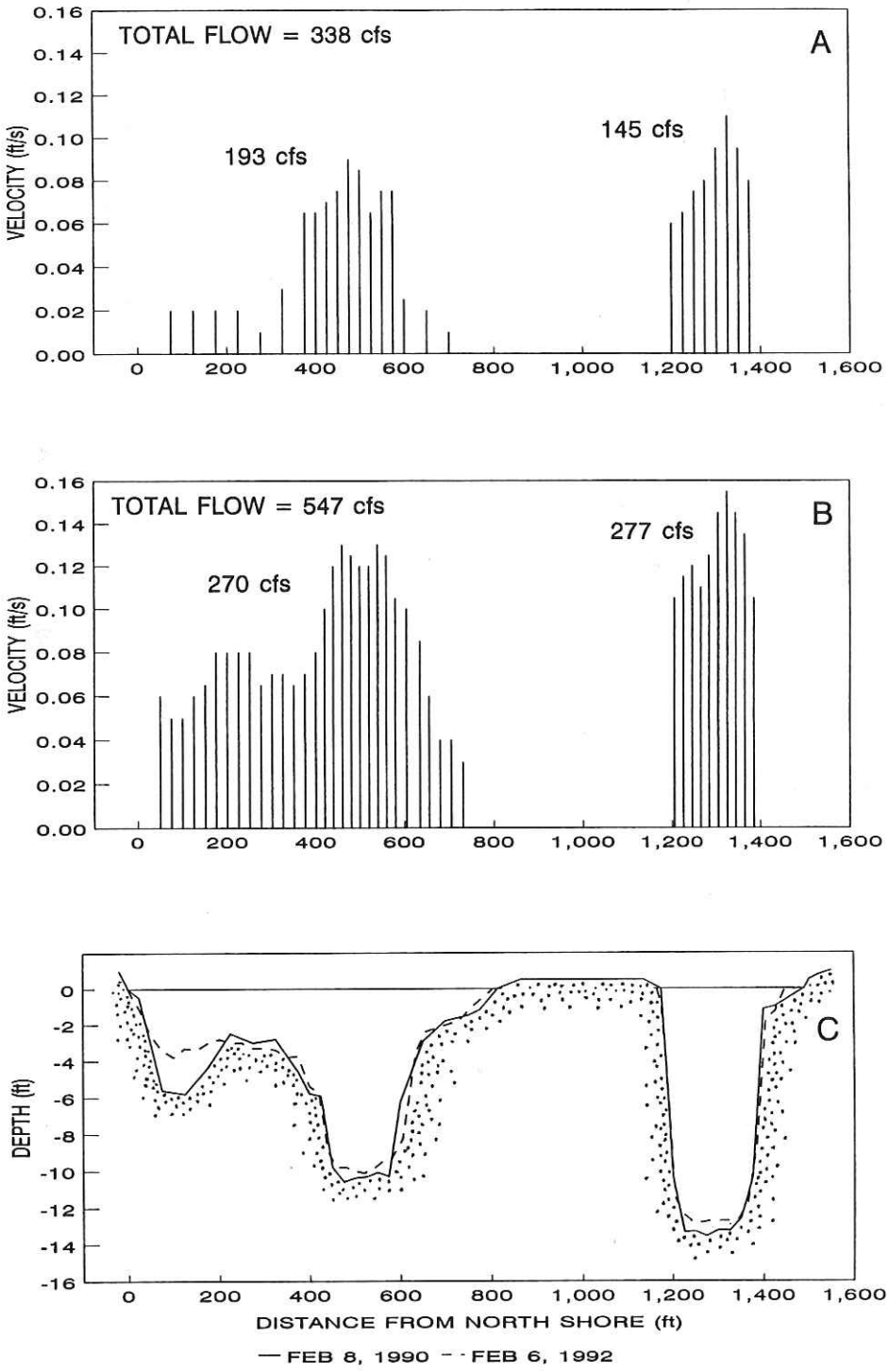


Figure 6. Cross-sectional velocity and depth profiles made at the Rosebud Island Dredge cut in February 1990 and 1992. A. Mean vertical current velocity on February 8, 1990. B. Mean vertical current velocity on February 6, 1992. C. Depth-cross sections on February 8, 1992 and February 6, 1990. Gaging transect located near Site 2 and 2b.

A marked increase in the average daily minimum DO was noted post-dredging. Average daily minimum DO ranged from 0.4 to 2.4 mg/l prior to the dredging project and increased to 5.1 to 6.7 mg/l after the project was completed (Figure 7a).

Dissolved oxygen concentrations fell below Wisconsin's water quality standard of 5.0 mg/l for 34% and 60% of the time respectively, during the first and second pre-project surveys at Site A. Following dredging, DO normally exceeded the standard with only 1 of 3 surveys indicating a small percentage of non-attainment (about 5% in June 1990), (Figure 7d). Average percent DO saturation appeared to increase at Site A (Figure 7d) and likely reflects higher minimum DOs as discussed above. The high average percent DO saturation measured in August of 1990 (136%) was believed to represent algal photosynthetic activity since macrophytes were essentially absent. Overall, the improved DO condition was attributed to flow introduced from Lake Onalaska and the loss of the macrophyte community at the monitoring site.

Average diurnal temperature fluctuation at Site A was about 4°C prior to the dredging project. Similar measurements post-project averaged 2.4°C (Figure 7b and c). Water depth is an important factor in explaining daily temperature change. Shallow water habitats (< 2 ft or .6 m) experienced largest daily temperature swings (Table 2) in response to daily variation in insolation. In contrast, the water flowing through the dredge cut area contained a substantially larger water mass which buffered daily changes in temperature.

Winter Dissolved Oxygen Surveys - Surface Waters

Winter water quality surveys were conducted in the Rosebud Island project area from the winter of 1985-86 to 1991-92. Pre-project water quality monitoring results have been described by Berkman and Von Ruden 1986, Schellhaass et al. 1987, Rogala and Sullivan 1988). Survey results of post-project monitoring data are provided in Appendix A.

Pre-project monitoring of winter DO in 1986 and 1988 identified periods of serious DO depletion in portions of the project area. This is illustrated from surface DO profiles through the project area in late January and February (Figure 8a). Lowest surface pre-project DO measurements were normally encountered in the central project area below Halfway Creek (Sites 4 and 5, Figure 4). This was generally the area with the shallowest water, contained a high density of macrophytes and was isolated from freshwater inflows. It was not uncommon for DO to approach anoxia in this reach during winters with normal snow and ice cover.

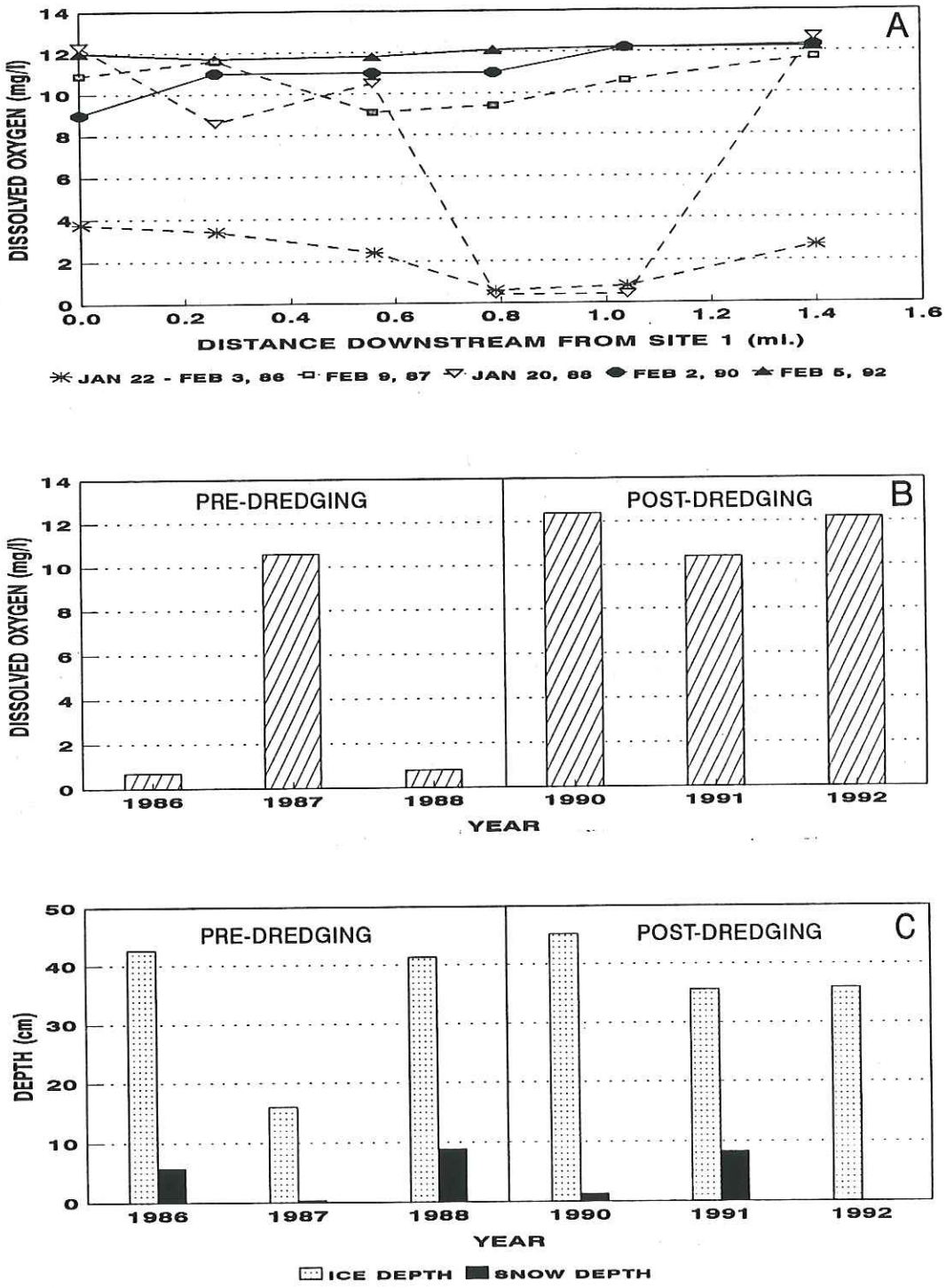


Figure 8. Summary of winter dissolved oxygen, snow cover and ice depth collected in the Rosebud Island study area between December 1985 and February 1992. A. Surface dissolved oxygen levels at Sites 1, 2, 3c, 4, 5, 6, 7, and 8 during mid-winter conditions. B. Average surface dissolved oxygen levels at Sites 4 and 5 during late January and early February. C. Average snow and ice depth at sites 4 and 5 during late January and early February.

Winter temperature measurements indicated inverse thermal stratification was present which is typical during ice cover (Wetzel 1975). Water current velocity and associated circulation processes were normally insufficient to provide isothermal conditions at deep-water sites. Thermal stratification was most pronounced in deep areas with no detectable current, but was also discernable in areas with current. The temperature differential between top and bottom waters was generally less than 2 °C in areas with highest surface or mid-depth current velocity (Sites 2b, 4c and 5, Figure 9 and 10). This indicates that water currents were important at influencing vertical temperature measurements in the dredge cut.

Winter DO levels normally exceeded 10 mg/l from surface down to 8 ft (2.5 m). DO concentrations usually fell below 5 mg/l at depths exceeding 11.5 ft (3.5 m), especially mid- to late winter. The most serious DO depletion (0-2 mg/l) was present in bottom waters with relatively warm water (3°C or greater) and low current velocity (0-0.03 ft/s, 0-1 cm/s). Bottom DO was depressed to low levels even in areas where mid-depth DO and velocity were high (Sites 3C, 4C and 5, Figure 10) indicating minimal mixing of oxygenated water with bottom waters in flowing channels.

The 26 ft (8 m) deep sediment trap area (Site ST) had remarkably high DO and weak thermal stratification in the winter of 1992 as compared to the previous year (Figure 11). The reason for this has not been established. It is possible that inflows from Halfway Creek may have resulted in improved DO conditions in the sediment trap area in 1992.

The vertical distribution of DO, temperature and conductivity during summer conditions is illustrated in Figure 12. Although profiles were made at only a few sites, some general findings can be presented. Thermal stratification was normally weak with surface and bottom temperatures normally differing by about 1 to 3°C at most sites (Figure 12). The exception was the deep sediment trap area (Site ST) which normally had surface and bottom temperature differentials of 5°C or larger.

Bottom water was anoxic on occasions at sites ST, 4B and 5 during periods of greatest thermal stratification (Figure 12). In general, the depth at which DO concentrations were less than 5 mg/l was about 10 ft (3 m) during summer. Monitoring sites in the dredge channel or susceptible to wind mixing (Sites 2B and 4) had generally higher DO in bottom waters than other deep water sites. Conductivity increased with depth and was most apparent during periods of thermal or DO stratification.

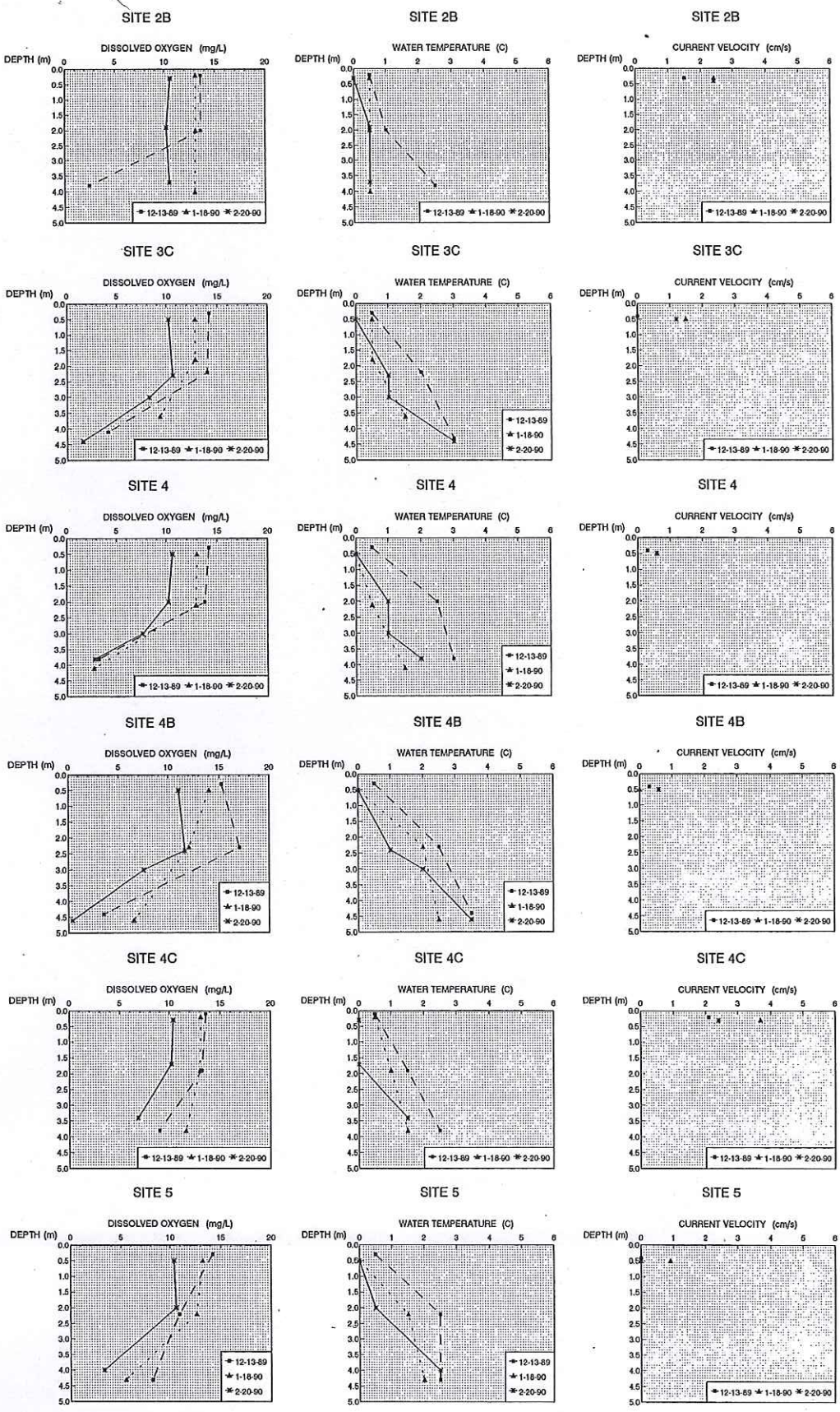


FIGURE 9. WINTER 1989-90 DISSOLVED OXYGEN AND WATER TEMPERATURE DEPTH-PROFILES AND SURFACE CURRENT VELOCITY MEASUREMENTS AT SELECTED SITES IN THE ROSEBUD ISLAND STUDY AREA.

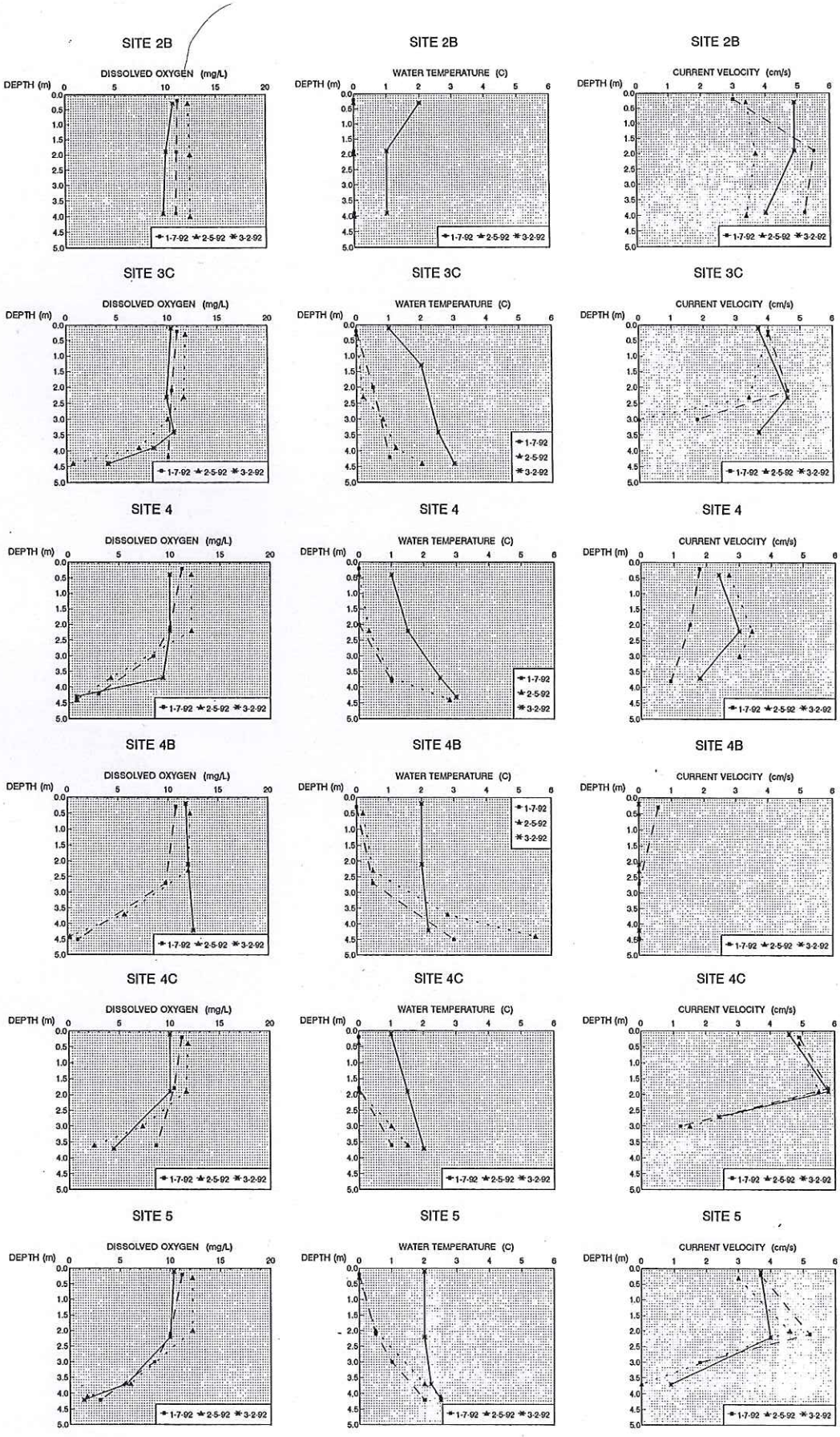


FIGURE 10. WINTER 1991-92 DISSOLVED OXYGEN, WATER TEMPERATURE AND CURRENT VELOCITY DEPTH-PROFILES COLLECTED AT SELECTED SITES IN THE ROSEBUD ISLAND STUDY AREA.

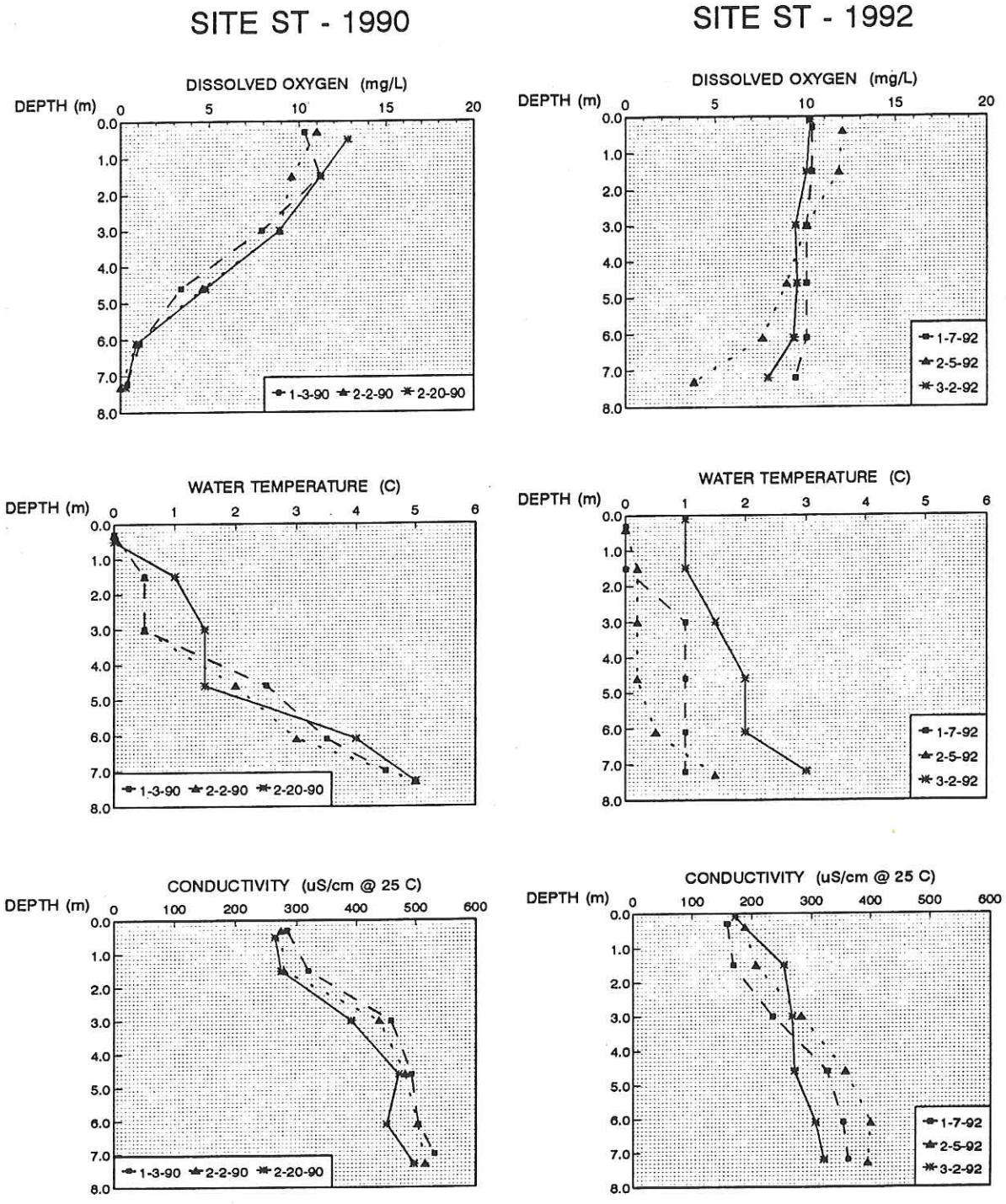


FIGURE 11. WINTER 1989-90 AND 1991-92 DISSOLVED OXYGEN, TEMPERATURE AND CONDUCTIVITY DEPTH-PROFILES AT SITE ST IN THE ROSEBUD ISLAND STUDY AREA.

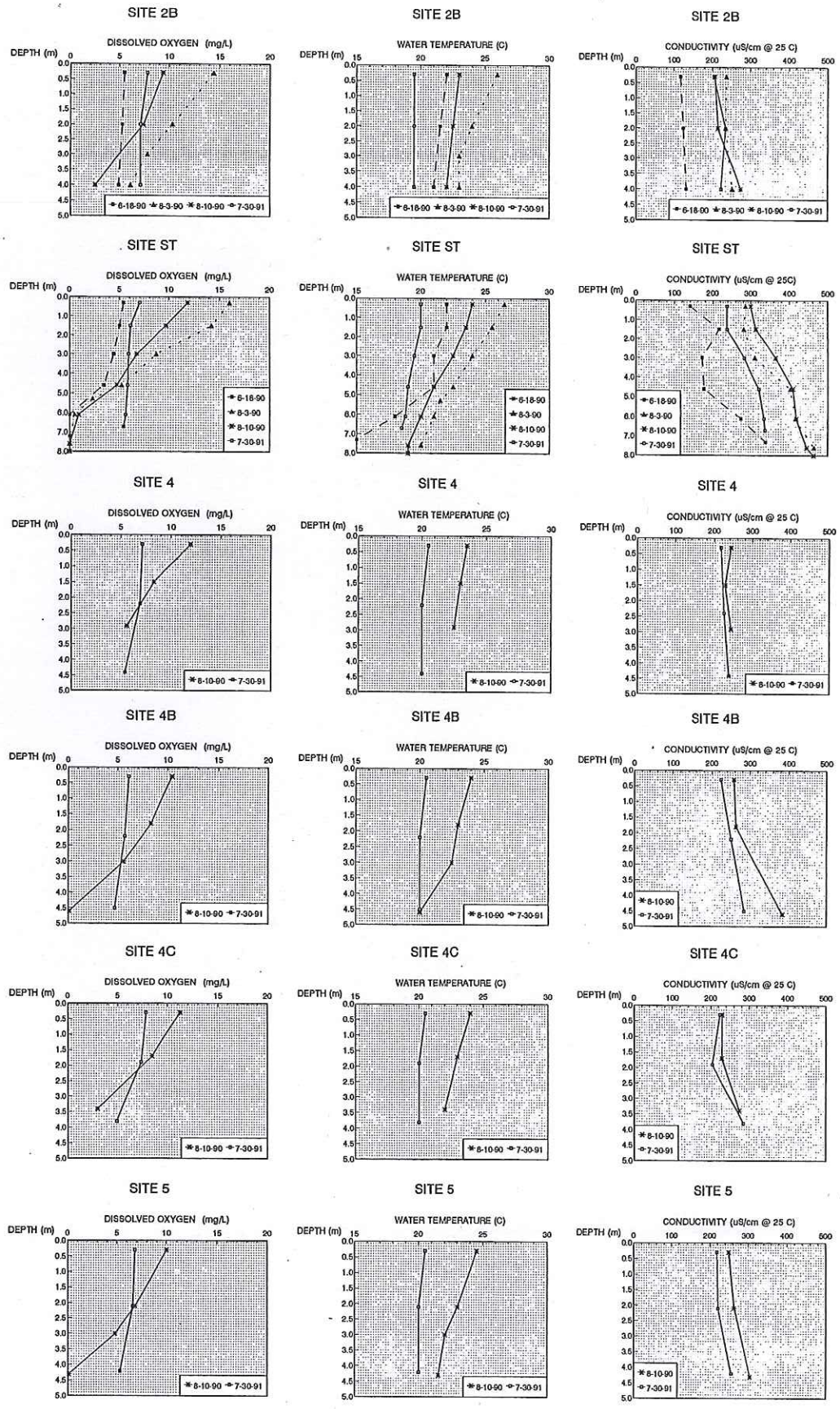


FIGURE 12. SUMMER 1990 AND 1991 DISSOLVED OXYGEN, WATER TEMPERATURE AND CONDUCTIVITY DEPTH-PROFILES COLLECTED AT SELECTED SITES IN THE ROSEBUD ISLAND STUDY AREA.

CONCLUSIONS AND RECOMMENDATIONS

The Rosebud Island dredge cut dramatically altered the physical habitat conditions in the project area. The dredge channels provide a substantial volume of oxygenated water through the project area during critical winter and summer periods. These flows have eliminated problems with serious DO depletion which were common prior to the dredging project. With respect to the HREP project objectives, the following conclusions and recommendations are made:

1. The Rosebud dredge cut resulted in the creation of about 70-80 acres of deep water habitat (8-15 ft, 2.4-4.6 m) which met project objective 1A.

2. Minimum daily DO in surface waters normally exceeded 5 mg/l during summer periods. Average summer diurnal temperature variation in the dredge channel was 2°C following project construction. These results indicate a general attainment of objective 1B.

3. Deep water DO (> 11.5 ft, 3.5 m) were not consistently greater than 5 mg/l. However, shallower depths exceeded this goal throughout the winter periods. Thermal and DO stratification was normally present in areas with depths exceeding 10 ft (3 m). Therefore, the objectives identified in 1C were only partially met.

4. Total discharge through the dredge cut was about 600 cfs (17 m^3/s) in the winter of 1991-92 and exceeded the project design by 6 fold. Average cross-sectional velocities at the gaging site exceeded the desired goal of 0.05 ft/s (1.5 cm/s) by more than 100 %. Project modification may be warranted to reduce the flows to meet the desired velocities for winter centrarchid habitat. This may result in increased thermal stratification and lowering of bottom and mid-depth DO. However, serious DO depletion will not be anticipated as long as sufficient oxygenated inflows are maintained.

Additional winter discharge measurements are needed in the dredge channels during normal river flows to evaluate project performance. Future flow measurements should include the channel south of Rosebud Island to better define the total flow available in the project area. This information will be useful to establish the needed flow reductions in the dredge channels to meet the project objectives for current velocity and DO.

Periodic water quality surveys should be conducted during critical winter conditions (deep, prolonged snow cover) or during low flow summer periods to document the habitat project performance.

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APPENDIX A

Table 1 - Winter 1989-90 water quality data

Table 2 - Winter 1990-91 water quality data

Table 3 - Winter 1991-92 water quality data

Table 4 - Summer 1990 and 91 water quality data

TABLE 1. CONTINUED.

DATE	TIME	SITE	SNOW DEPTH cm	ICE DEPTH cm	MAX DEPTH m	CURRENT VEL cm/s	CURRENT DIRECT (FROM)	DEPTH m	TEMP C	DO mg/l	COND @25 C uS/cm	COMMENTS
12-13-89	1316	8	0	27	1.13	1.2	N	TOP	0.5	14.9	289	
								MID	1.5	14.2	269	
								BOT	2.0	13.6	274	
12-28-89	1030	1	3	20	1.37	4.3	NW	TOP	0.5	11.8	309	BP. 743mm AT 900, 740mm AT 1300
								MID	0.5	11.6	319	CLOUDY, TEMP 32 DEG. F
								BOT	1.0	11.4	352	DO METER: YSI 54 EP
	1007	2	3	38	3.02	1.5	NW	TOP	0.5	12.0	299	SAMPLING CREW: SULLIVAN
								MID	1.0	11.6	333	FINAL DO CALIBRATION: 0.1 MG/L
								BOT	2.0	10.1	359	
	1051	2B	5	27	3.96	2.7	NW	TOP	0.5	12.5	339	
								MID	1.5	12.1	346	
								BOT	1.5	12.0	365	
	1110	3C	4	46	3.86	2.1	NW	TOP	0.5	12.2	309	
								MID	1.5	11.7	346	
								BOT	2.0	7.6	369	
1-3-90	1125	1	3	15	1.52	3.7	NW	TOP	0.0	10.0	264	BP. 739mm AT 730, 739mm AT 1300
								MID	0.5	9.8	269	TEMP. 35 DEG. F
								BOT	2.0	8.5	312	DO METERS: YSI 54 EP START; YSI 54
	930	ST	5	42	7.10	0.3	NW	0.3	0.0	10.3	284	FISH END
								1.5	0.5	11.2	319	SAMPLING CREW: SULLIVAN, MOODY
								3.0	0.5	7.9	458	FINAL DO CALIBRATION: -0.1 MG/L
								4.6	2.5	3.4	493	(YSI 54 FISH)
								6.1	3.5	1.1	504	
								7.0	4.5	0.4	531	
	950	4	4	46	4.05	0.3	NW	TOP	0.0	10.6	284	
								MID	0.5	10.2	339	
								BOT	1.5	5.0	442	
	1000	4B	5	44	4.79	ND		TOP	0.0	11.5	294	
								MID	1.0	10.8	333	
								BOT	2.5	7.5	400	
	1010	4C	3	18	3.90	3.0	N	TOP	0.0	10.3	304	
								MID	1.5	9.4	327	
								BOT	2.0	6.5	425	
	1020	5	4	38	4.48	1.2	N	TOP	0.0	10.0	304	
								MID	1.0	9.4	352	
								BOT	2.0	7.3	406	
	1030	6	3	43	1.37	1.5	N	TOP	0.0	10.8	325	
								MID	0.0	10.6	325	
								BOT	1.0	8.3	352	
	1050	7	3	47	1.46	1.5	N	TOP	0.0	10.4	304	
								MID	0.5	10.0	299	
								BOT	1.0	9.2	333	
	1105	8	4	39	1.13	0.9	N	TOP	0.0	10.2	294	
								BOT	1.0	8.8	303	
1-18-90	1000	1	0	18	2.13	2.1	NW	TOP	0.5	12.8	259	BP. 752mm AT 800, 753mm AT 1400
								MID	1.0	13.2	294	PARTLY CLOUDY, TEMP 30 DEG. F
								BOT	1.0	13.2	303	DO METERS: YSI 54 EP START; YSI 54
	945	2	0	41	2.93	2.7	NW	TOP	0.5	13.2	279	FISH END
								MID	1.0	13.2	294	SAMPLING CREW: SULLIVAN, CRAWLEY
								BOT	1.5	12.8	288	FINAL DO CALIBRATION: 0.1 MG/L
	1010	2B	0	25	4.11	2.4	NW	TOP	0.5	13.1	299	(YSI 54 FISH)
								MID	0.5	13.1	299	
								BOT	0.5	13.0	299	

TABLE 1. CONTINUED.

DATE	TIME	SITE	SNOW DEPTH cm	ICE DEPTH cm	MAX DEPTH m	CURRENT VEL cm/s	CURRENT DIRECT (FROM)	DEPTH m	TEMP C	DO mg/l	COND @25 C uS/cm	COMMENTS
2-2-90	1202	6	5	50	1.25	1.2	N	TOP	0.0	12.8	325	
								BOT	1.0	11.5	333	
	1211	7	3	50	1.46	2.1	N	TOP	0.0	12.8	314	
								BOT	0.5	11.6	339	
	1220	8	3	45	1.16	1.8	N	MID	0.0	11.3	284	
2-20-90	945	1	0	11	1.65	3.7	NW	TOP	0.0	10.2	264	BP. 759 AT 800, 755 AT 1430
								MID	1.0	9.8	274	CLEAR, WIND 10-20 MPH FROM S
								BOT	1.0	9.9	294	TEMP 20-30 C. DO METER: YSI 54 FISH
	930	2	4	39	3.02	1.8	NW	TOP	0.0	10.5	264	SAMPLING CREW: SULLIVAN, CRAWLEY
								MID	1.0	10.0	264	FINAL DO CALIBRATION: 0.5 MG/L
								BOT	1.0	10.0	294	
	955	2B	4	26	3.78	2.4	NW	TOP	0.0	10.6	304	
								MID	0.5	10.2	319	
								BOT	0.5	10.5	339	
	1056	3C	3	51	4.60	1.2	NW	0.5	0.0	10.2	264	
								2.3	1.0	10.6	274	
								3.0	1.0	8.2		
								4.4	3.0	1.6	457	
	1022	ST	3	54	7.44	ND		0.5	0.0	12.8	264	
								1.5	1.0	11.2	274	
								3.0	1.0	8.9	391	
								4.6	1.5	4.8	471	
								6.1	4.0	0.9	451	
								7.3	5.0	0.3	497	
	1036	4	3	55	3.96	0.6	NW	0.6	0.0	10.6	264	
								2.0	1.0	10.2	294	
								3.0	1.0	7.6		
								3.8	2.0	2.8	435	
	1050	4B	3	54	4.73	0.6	S	0.5	0.0	11.0	254	
								2.4	1.0	11.6	274	
								3.0	2.0	7.5		
								4.6	3.5	0.4	477	
	1105	4C	3	24	3.57	2.4	N	TOP	0.0	10.4	304	
								MID	0.0	10.2	325	
								BOT	1.5	6.8	423	
	1115	5	3	44	4.09	ND		TOP	0.0	10.4	284	
								MID	0.5	10.6	299	
								BOT	2.5	3.3	409	
	1128	6	3	48	1.10	0.9	N	MID	0.0	10.2	325	
	1136	7	3	53	1.37	2.1	N	TOP	0.0	10.2	304	
								BOT	0.5	9.6	319	
	1146	8	3	47	1.13	0.9	N	MID	0.0	10.6	264	

ND - NOT DETECTED.

APPENDIX A - TABLE 2

TABLE 2. WATER QUALITY DATA COLLECTED AT ROSEBUD ISLAND, LAKE ONALASKA, POOL 7, DURING THE WINTER OF 1990-91. WISCONSIN DEPARTMENT OF NATURAL RESOURCES, LA CROSSE, WISCONSIN.

DATE	TIME	SITE	SNOW DEPTH cm	ICE DEPTH cm	MAX DEPTH m	CURRENT VELOCITY cm/s	CURRENT DIRECT (FROM)	DEPTH m	TEMP C	DO mg/l	COND @25 C uS/cm	COMMENTS
1-17-91	834	2	7.6	27.9	2.99	2.1	NW	TOP	0.0	8.4	203	BP. 745mm AT 800
								MID	1.0	6.8	206	PARTLY CLOUDY, LIGHT WINDS
								BOT	1.0	7.6	235	TEMP 28 DEG. F
	910	ST	12.7	27.9	7.22	ND		0.3	0.0	8.6	183	DO METER: YSI 54 EP
								1.5	1.0	7.5	225	SAMPLING CREW: SULLIVAN
								3.0	1.0	7.0	274	FINAL DO CALIBRATION: -0.1 MG/L
								4.6	1.0	6.2	411	
								6.1	1.0	5.8	411	
								7.0	1.2	5.0	428	
1-29-91	1153	2	7.6	36.8	2.90	1.2	NW	TOP	0.0	10.5		BP. 752mm AT 900, 755mm AT 1600
								MID	0.3	9.5		OVERCAST, LT. SNOW, WINDS 10-15mph
								BOT	1.0	8.6		TEMP 10 DEG. C
	1204	1	2.5	26.7	2.01	7.3	NW	TOP	0.0	10.7		DO METER: YSI 57 WQ
								MID	0.5	10.0		SAMPLING CREW: SULLIVAN
								BOT	0.7	9.9		FINAL DO CALIBRATION: 0.2 MG/L
	1227	2B	5.1	36.8	3.90	1.5	NW	TOP	0.0	10.5		
								MID	0.0	10.4		
								BOT	0.5	10.1		
	1253	3C	5.1	43.2	4.42	ND		TOP	0.0	10.2		
								MID	0.5	8.4		
								BOT	0.7	6.4		
	1310	ST	10.2	41.9	7.25	ND		0.5	0.0	10.0		
								1.5	0.3	8.4		
								3.0	0.3	7.3		
								4.6	0.5	6.3		
								6.1	1.0	5.0		
								7.0	1.5	2.9		
	1345	4	11.4	28.6	4.39	0.6	NW	TOP	0.0	10.4		
								MID	0.5	9.6		
								BOT	1.2	4.4		
	1406	4B	10.2	34.3	4.51	ND		TOP	0.0	10.2		
								MID	0.5	7.8		
								BOT	1.2	4.6		
	1428	5	5.1	42.5	4.45	ND		TOP	0.0	10.3		
								MID	0.5	9.4		
								BOT	1.2	4.4		
	1450	4C	10.2	22.9	3.60	2.4	N	TOP	0.0	10.8		
								MID	0.0	10.2		
								BOT	0.5	10.0		

ND = NOT DETECTED

TABLE 3. CONTINUED.

DATE	TIME	SITE	SNOW DEPTH cm	ICE DEPTH cm	MAX DEPTH m	CURRENT VELOCITY cm/s	CURRENT DIRECT (FROM)	DEPTH m	TEMP C	DO mg/l	COND @25 C uS/cm	COMMENTS
1-21-92	1055	1	0	19	2.68	4.6	W	TOP	0.0	11.9	227	SITE 2 TURBID
						5.5	W	MID	0.0	11.8	227	SITE 1 ALL ICE-COVERED
						4.6	W	BOT	0.5	11.6	223	
	1110	2B	0	32	4.18	3.4	W	TOP	0.0	12.2	256	DO CAL OK
						3.7	W	MID	0.0	12.4	265	
						3.4	W	BOT	0.0	12.4	275	VELOCITY AT 11 FT (3.4m)
	1130	3C	0	30	4.05	2.7	W	TOP	0.0	11.9	246	DO CAL +0.5. SLIGHTLY TURBID
						3.7	W	MID	0.5	11.5	242	
						0.6	W	BOT	1.0	8.9	384	
	1150	ST	0	39	7.92	ND	--	0.4	0.0	11.7	246	DO CAL -0.1, SLIGHTLY TURBID
						--	--	1.5	0.5	11.7	251	
						--	--	3.0	0.5	9.8	344	
						--	--	4.6	0.5	8.8	400	
						--	--	6.1	1.0	7.0	567	
						--	--	7.6	3.0	0.2	1024	
	1218	4	0	43	3.99	1.5	NW	TOP	0.0	11.9	256	DO CAL -0.1
						0.9	NW	MID	0.0	12.2	265	
						ND	--	BOT	1.0	7.6	356	
	1240	4B	0	43	4.42	ND	--	TOP	0.0	12.1	256	DO CAL -0.2
						ND	--	MID	0.8	11.9	249	
						--	--	BOT	3.0	4.0	376	
	1250	5	0	30	4.24	2.4	N	0.3	0.0	12.6	265	DO CAL -0.5
						4.3	N	2.1	0.8	12.6	258	
						--	--	3.0	1.0	8.0	--	
						1.5	N	3.4	--	--	--	
						--	--	4.0	2.5	1.6	391	
	1315	5B	0	43	1.04	1.5	N	TOP	0.0	12.6	284	DO CAL -0.1
								BOT	1.0	12.2	274	
	1330	6	0	34	1.22	2.4	N	TOP	0.0	12.6	275	DO CAL -0.2
								BOT	0.5	12.2	279	
	1340	7	0	35	1.40	2.4	N	TOP	0.0	12.5	265	DO CAL -0.2
								MID	0.5	12.2	261	
						2.4	N	BOT	0.5	12.2	261	
	1355	8	0	39	1.07	2.1	N	TOP	0.5	12.0	251	DO CAL -0.1
						2.1	N	BOT	1.0	11.8	256	
	1420	4C	0	32	3.72	4.3	N	TOP	0.0	12.2	265	DO CAL -0.3
						5.5	N	MID	0.0	12.2	265	
						1.8	N	BOT	1.0	7.8	384	VELOCITY AT 11 FT (3.4m)
2-5-92	1040	2	0	25	2.93	3.7	NW	TOP	0.0	11.7	189	BP. 746mm AT 1040, 740mm AT 1615
						4.3	NW	MID	0.0	11.6	208	HAZY, SLIGHT WIND, 30 DEG. F
						2.1	NW	BOT	0.0	11.5	227	DO METER: YSI 57 WQ
												CREW: SULLIVAN, DUKERSCHEIN
	1100	2D	0	25	3.29	1.8	NW	0.3	0.0	12.0	189	FINAL DO CALIBRATION: +0.2
						1.5	NW	1.5	0.5	11.9	223	
						1.2	NW	2.4	3.0	5.8	--	
						ND	--	3.1	3.0	1.0	350	SLIGHTLY TURBID, DO CAL -0.3
	1130	1	0	15	1.34	4.3	NW	TOP	0.2	12.0	198	
						4.6	NW	MID	0.2	12.0	198	
						4.3	NW	BOT	0.3	12.0	206	
	1145	2B	0	32	3.96	3.0	NW	TOP	0.0	11.8	208	DO CAL +0.3, RECAL
						4.3	NW	MID	0.0	11.6	208	
						4.3	NW	BOT	0.0	11.6	227	

TABLE 3. CONTINUED.

DATE	TIME	SITE	SNOW DEPTH cm	ICE DEPTH cm	MAX DEPTH m	CURRENT VELOCITY cm/s	CURRENT DIRECT (FROM)	DEPTH m	TEMP C	DO mg/l	COND @25 C uS/cm	COMMENTS
2-19-92	1112	3C	5	25	4.51	2.4	NW	0.3	0.0	12.0	206	DO CAL -0.1
						4.6	NW	2.1	0.0	11.8	225	
						1.5	NW	2.7	--	--	--	
						ND	--	3.0	0.5	10.4	--	
						ND	--	4.4	3.0	1	473	
	1120	ST	6	45	7.44	--	--	0.3	0.0	13.2	206	OPEN WATER AT HALFWAY CREEK
						--	--	1.5	0.0	12.5	225	AND ALONG EAST SHORE
						--	--	3.0	0.5	10.8	332	
						--	--	4.6	0.5	9.8	387	
						--	--	6.1	0.5	9.0	737	
						--	--	7.2	1.5	6.4	747	
	1224	4	6	38	4.42	2.4	NW	0.4	0.0	12.3	225	DO CAL -0.1
						2.7	NW	2.2	0.2	12.2	233	
						2.7	NW	2.7	--	--	--	
						--	--	3.0	0.2	10.3	--	
						--	--	4.3	3.0	0.6	406	
	1200	4B	6	46	4.42	ND	--	0.5	0.0	13.0	216	DO CAL OK
						ND	--	2.2	0.5	13.9	387	
						--	--	3.0	1.2	12.1	--	
						--	--	4.0	4.0	1.2	--	
						--	--	4.3	5.5	0.2	359	
	1248	5	5	27	4.24	1.5	N	0.3	0.0	12.8	234	
						2.4	N	2.1	0.3	11.8	250	
						0.6	N	3.0	0.8	9.2	--	
						--	--	4.1	2.8	1.5	456	
	1232	4C	6	28	3.66	4.6	N	TOP	0.0	12.4	244	DO CAL OK
						4.9	N	MID	0.0	12.2	253	
						1.5	N	BOT	1.2	8.7	395	VELOCITY AT 9 FT (2.7m)
	1302	5B	5	47	1.22	1.2	N	TOP	0.0	13.0	244	DO CAL OK
						--	N	BOT	0.0	12.8	263	
	1314	6	5	38	1.07	2.4	N	TOP	0.0	13.0	244	DO CAL OK
						1.5	N	BOT	0.0	12.8	253	
	1325	7	6	38	1.49	1.5	N	TOP	0.0	13.0	234	
						2.1	N	MID	0.0	12.9	234	
						--	--	BOT	0.2	12.8	242	
	1337	8	5	39	1.10	1.5	N	TOP	0.0	13.2	225	DO CAL +0.1
						1.5	N	BOT	0.0	13.0	225	
3-2-92	1102	2D	0	18	2.07	3.4	NW	TOP	0.5	10.0	193	BP. 742mm AT 830, 745mm AT 1630
						1.8	NW	MID	2.9	9.9	195	SUNNY, 40 DEG. F, SLIGHT BREEZE
						1.2	NW	BOT	3.0	9.2	270	DO METER: YSI 57 WQ
												CREW: VON RUDEN & DUKERSCHEIN
	1124	2	0	18	2.74	1.8	NW	TOP	2.0	9.4	192	FINAL DO CALIBRATION: 0.1 MG/L
						1.8	NW	MID	1.0	10.0	208	
						1.5	NW	BOT	1.0	10.2	226	DO CAL OK
	1142	1	0	0	1.52	5.5	NW	TOP	1.0	10.6	181	OPEN WATER
						6.1	NW	MID	1.0	10.3	181	
						5.2	NW	BOT	1.0	10.2	181	
	1155	2B	0	26	3.90	4.9	NW	0.3	2.0	10.7	201	DO CAL OK, 0.0
						4.9	NW	2.0	1.0	10.0	208	
						4.0	NW	2.7	--	--	--	
						--	--	3.8	1.0	9.7	217	
	1219	3C	0	9	4.57	3.7	NW	0.1	1.0	10.4	199	
						4.6	NW	2.3	2.0	9.9	201	
						3.7	NW	2.7	--	--	--	
						--	--	3.4	2.5	10.6	249	
						--	--	4.0	--	8.6	--	
						--	--	4.4	3.0	4.1	363	

APPENDIX A - TABLE 4

TABLE 4. WATER QUALITY DATA FOR LAKE ONALASKA DREDGE CUT NEAR ROSEBUD ISLAND, POOL 7, COLLECTED DURING THE SUMMER PERIODS OF 1990 AND 1991 BY THE WISCONSIN DNR.

DATE	TIME	SITE	MAX DEPTH m	CURRENT VELOCITY cm/s	CURRENT DIRECT (FROM)	DEPTH m	TEMP C	DO mg/l	COND @25 C uS/cm	SECCHI DEPTH m	1% DEPTH m	COMMENTS
6-18-90	1015	1	3.54			0.3	22.0	5.9	89			BP 743 mm, YSI 54EP
	1030	2B	4.15			TOP	22.0	5.5	117	0.16		ROUGH WATER STRONG WINDS FROM NORTH
						MID	21.5	5.3	124			TURBID. WATER LEVEL UP FROM RECENT
						BOT	21.0	4.9	131			RAIN. CREW: SULLIVAN
	1047	ST	7.59			0.3	22.0	5.4	139	0.15		
						1.5	22.0	5.0	217			
						3.0	21.0	4.4	171			
						4.6	21.0	3.4	176			
						6.1	18.0	0.0	273			
						7.3	15.0	0.0	337			
6-26-90	1030	1	1.89	9.1	NW	TOP	25.0	8.6	142	0.18		BP 743 mm. SUNNY HOT LIGHT WINDS.
						MID	24.0	8.4	139			CREW: SULLIVAN
						BOT	24.0	7.4	145			
	1052	2B	4.47			0.3	25.0	9.2	147	0.18		
						2.1	24.0	7.7	139			
						3.0	23.0	6.7				
						3.7	22.0	3.6				
						4.3	21.0	2.1	193			
	1105	ST	8.32			0.3	26.5	9.8	153	0.15		
						1.5	24.5	7.2	170			
						3.0	23.0	5.9	240			
						4.6	21.0	3.1	284			
						6.1	19.5	0.2	317			
						7.6	17.5	0.0	380			
						8.2	17.0	0.0	403			
	1125	HWC				0.3	21.0	5.4	375			HALFWAY CREEK - TURBID
8-3-90	1355	ST	7.93			0.3	26.5	16.0	286	0.14		BP 742 mm, YSI 54EP, CLOUDY & HAZY
						1.5	25.5	14.2	281			LIGHT WINDS FROM S/SW
						3.0	24.0	8.7	310			CREW: SULLIVAN/JANVRIN
						4.6	22.5	5.2	402			
						5.2	21.5	2.3				MODERATE APHANIZOMENON
						6.1	21.0	0.5	421			
						7.6	20.0	0.0	464			
	1400	2B	4.05			0.3	26.0	14.4	237	0.15		
						2.0	24.0	10.3	235			
						3.0	23.0	7.8				
						4.0	23.0	6.1	251			
	1415	1	1.83	6.1	NW	TOP	25.5	11.6	302	0.14		
						MID	25.0	11.4	278			
						BOT	23.5	8.0	238			

TABLE 4. CONTINUED.

DATE	TIME	SITE	MAX DEPTH m	CURRENT VELOCITY cm/s	CURRENT DIRECT (FROM)	DEPTH m	TEMP C	DO mg/l	COND @25 C uS/cm	SECCHI DEPTH m	1% DEPTH m	COMMENTS
7-30-91	900	1	1.80			TOP	19.5	7.4	188	0.15	1.24	BP 750 mm, YSI57PDC, CALM, FOG
						MID	19.5	7.4	199			CREW: SULLIVAN/BARTSCH
						BOT	19.5	7.1	199			
	910	2B	4.12			TOP	19.8	7.8	204	0.19	1.43	MAYFLIES EMERGING
						MID	19.8	7.1	233			
						BOT	19.8	7.1	221			
	922	ST	6.86			0.3	20.0	7.0	238	0.19	1.44	
						1.5	20.0	6.1	238			
						3.0	19.5	5.9	282			
						4.6	19.0	5.8	320			
						6.1	18.8	5.6	333			
						6.7	18.5	5.4	336			
	935	4B	4.57			TOP	20.5	6.1	224	0.20	1.52	MACROPYTES PRESENT
						MID	20.0	5.7	250			COONTAIL, LILLY PADS, MYRIOPHYLLUM
						BOT	20.0	4.7	284			
	945	4	4.57			TOP	20.5	7.1	218	0.20	1.49	
						MID	20.0	6.9	226			
						BOT	20.0	5.4	238			
	950	5	4.27			TOP	20.5	6.8	218	0.20	1.41	
						MID	20.0	6.6	221			
						BOT	20.0	5.3	255			
	1000	7	1.45			TOP	20.0	7.2	221	0.18	1.35	NO VEGETATION
						MID	20.0	6.9	221			
						BOT	20.0	5.5	221			
	1010	4C	3.96			TOP	20.5	7.8	224	0.19	1.44	
						MID	20.0	7.3	203			
						BOT	20.0	4.9	284			