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WATER QUALITY IMPROVEMENT IN THE SPOKANE RIVER AS A RESULT OF ADVANCED WASTEWATER TREATMENT

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WATER QUALITY IMPROVEMENT IN THE SPOKANE RIVER AS A RESULT OF ADVANCED WASTEWATER TREATMENT

by

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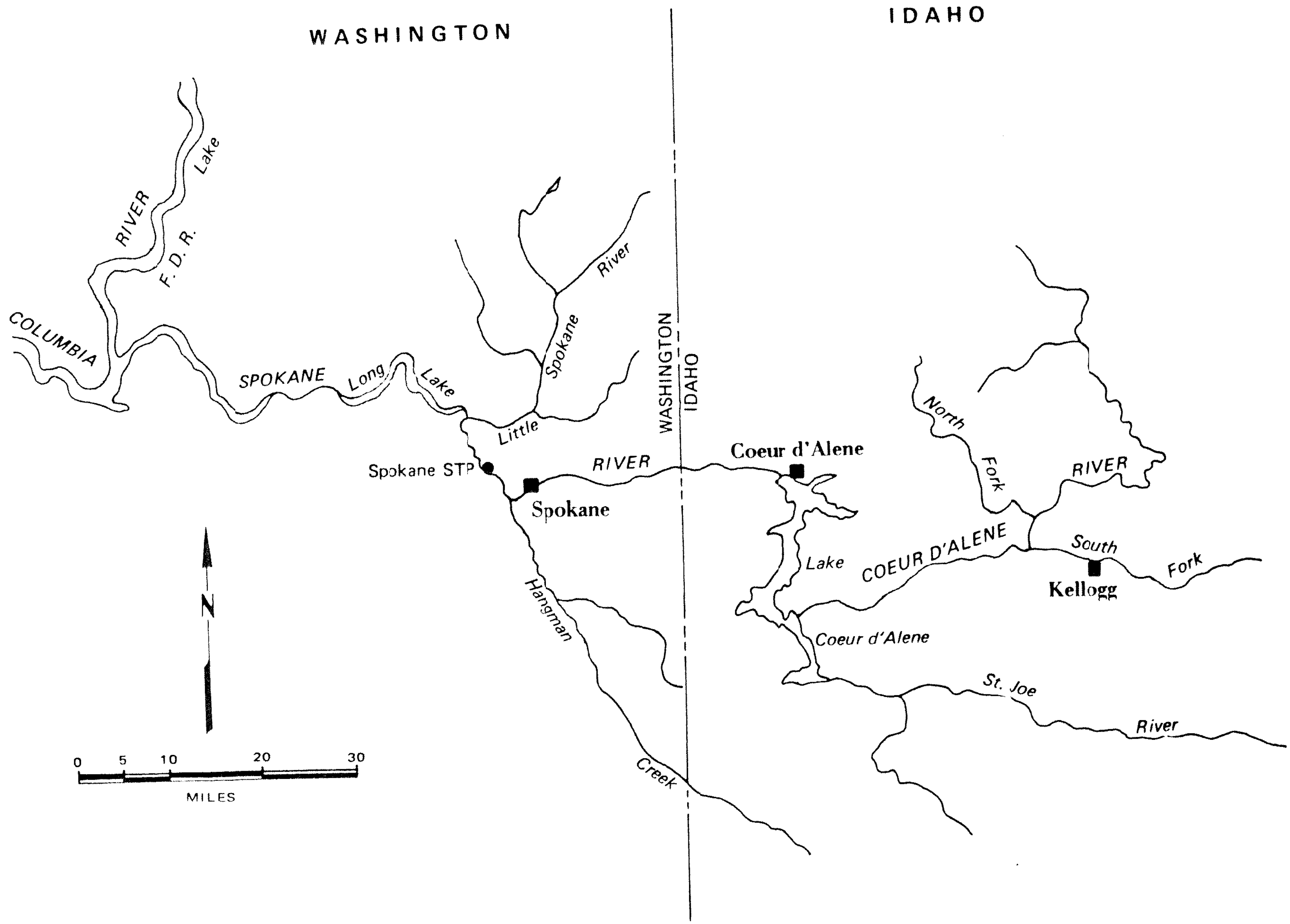

Figure 1. SPOKANE RIVER DRAINAGE SYSTEM

The primary treatment alleviated some of the problems such as sludge deposits and floating debris, but in a subsequent review of water quality data for the Spokane River, it was observed that low dissolved oxygen was frequently measured at the water quality monitoring station below Long Lake Dam. Studies were then conducted by the Washington State Pollution Control Commission in 1966 (Cunningham and Pine, 1969) and the Department of Ecology in 1970 (Bishop and Lee, 1972) to determine the cause of the low dissolved oxygen. These two studies and other studies funded by the U.S. Department of Interior and the Washington State Department of Ecology (Soltero et al., 1973 to 1976; and Soltero et al., 1978) determined that Long Lake became thermally stratified during the summer months and the deep waters became completely or nearly devoid of oxygen. The primary cause of the low dissolved oxygen in Long Lake was the large amount of algae in the reservoir which died, settled, and decayed, consuming the dissolved oxygen in the bottom waters. The concurrent thermal stratification prevented mixing of oxygenated surface waters and oxygen-depleted bottom waters. This heavy algae growth during the summer also reduced water clarity, aesthetic quality, and the attractiveness of the water for recreation. The heavy algae growth in Long Lake was caused by the excessive amounts of plant nutrients (phosphorus and nitrogen) flowing into Long Lake. The major portion of these nutrients (58 percent of the phosphorus and 31 percent of the nitrogen) was from the Spokane wastewater treatment plant (WTP) effluent (Soltero et al., 1982).

Several solutions were considered for preventing the dissolved oxygen depletion in Long Lake, but the only practical alternative was to remove the phosphorus from the Spokane sewage effluent. Removal of phosphorus from sewage effluents by advanced wastewater treatment (AWT) is an additional treatment expense but, in this case, the best solution for water quality problems in Long Lake and the Spokane River below Long Lake.

In 1970, the City of Spokane agreed to upgrade their primary WTP to meet the current effluent quality standards and to enhance the water quality of the Spokane River below the treatment plant. The construction of the AWT plant was begun in 1974 and secondary treatment began in August 1977. Phosphorus removal began in December 1977. The AWT plant removed 85 percent or more of the inflowing BOD, 85 percent of the suspended solids, and 85 percent or more of the influent phosphorus (City of Spokane, NPDES daily monitoring reports 1978 to date). The 44-million-dollar AWT plant was funded with federal (75 percent), state (15 percent), and local (10 percent) funds.

In 1981, a program of seasonal phosphorus removal was initiated to reduce operational costs of the AWT plant. Phosphorus removal is begun in April and continues through October each year to reduce available phosphorus in the reservoir during the critical algae growth period.

Water quality studies funded either by the Washington State Department of Ecology or the City of Spokane have been conducted each year since the initiation of AWT to determine effects of the AWT (Soltero et al., 1979 to 1983) on the water quality of Long Lake.

WATER QUALITY IMPROVEMENT

Several water quality parameters have shown immediate and consistent improvement as a result of the AWT in Spokane. The amount of phosphorus entering Long Lake reservoir during the critical season of June through October has decreased by 74 percent (Soltero, et al., 1979 to 1983) and the amount of soluble phosphorus measured in the waters of Long Lake has also declined by 73 percent (Figure 2). The reduction of phosphorus flowing into the reservoir has resulted in a 45 percent seasonal reduction of the algal growth in the reservoir measured as chlorophyll a, a photosynthetic pigment. The reduction in algal growth has, in turn, resulted in a 29 percent increase in water clarity, measured as Secchi disk depth (Figure 2) at the upper two reservoir stations where recreational use is heaviest.

The problem of low dissolved oxygen in the Spokane River below Long Lake and in the lower strata of the reservoir did not cease immediately after initiation of the AWT, but there are indications that conditions are improving. For example, the frequency of dissolved oxygen measurements of less than 8 mg/L (Class A standard) during the period July through November has declined greatly since 1979 at the river monitoring station below Long Lake Dam (WDOE, 1983). The magnitude of the oxygen deficiency (difference between the measured dissolved oxygen and 8 mg/L) has also been decreasing in this period. Multiplying the frequency of violation by the mean deficit for each year gives an index (percent mg/L) that incorporates the frequency and magnitude of dissolved oxygen which is less than the Class A standard of 8 mg/L. This index displays considerable year-to-year variation but has been consistently low for the period 1980 to 1983 with no violations recorded in 1982 or 1983 (Figure 3).

The dissolved oxygen data, as percent saturation for the Spokane River below Long Lake Dam (WDOE 1983), also show a decreasing magnitude of fluctuation around 100 percent saturation since 1978 (Figure 4). The high supersaturation (greater than 130 percent) in the years before AWT is indicative of the high algae growth which caused the low dissolved oxygen later in the season.

If the dissolved oxygen concentrations in the river below Long Lake Dam are indicative of dissolved oxygen concentrations in the reservoir, then a similar improvement would be expected in the reservoir. The volumes of water in the reservoir containing less than 5 mg/L and less than 1 mg/L were calculated for the period 1972 to 1982 to examine possible trends. The volume of water was estimated by planimetric methods with bathymetric maps supplied by the Washington Water Power Company (1974). The dissolved oxygen data are unpublished data from Soltero et al. (1972 to 1975; 1977 to 1982). The volume of water of less than 5 mg/L quantifies the loss of fisheries habitat since 5 mg/L dissolved oxygen is the approximate lower limit for trout utilization (U.S. EPA, 1977; Alabaster and Lloyd, 1980). One mg/L is apparently considered anaerobic for the method used for measuring dissolved oxygen (Soltero et al., 1982). Prior to AWT, the amount of anaerobic waters appears inversely correlated

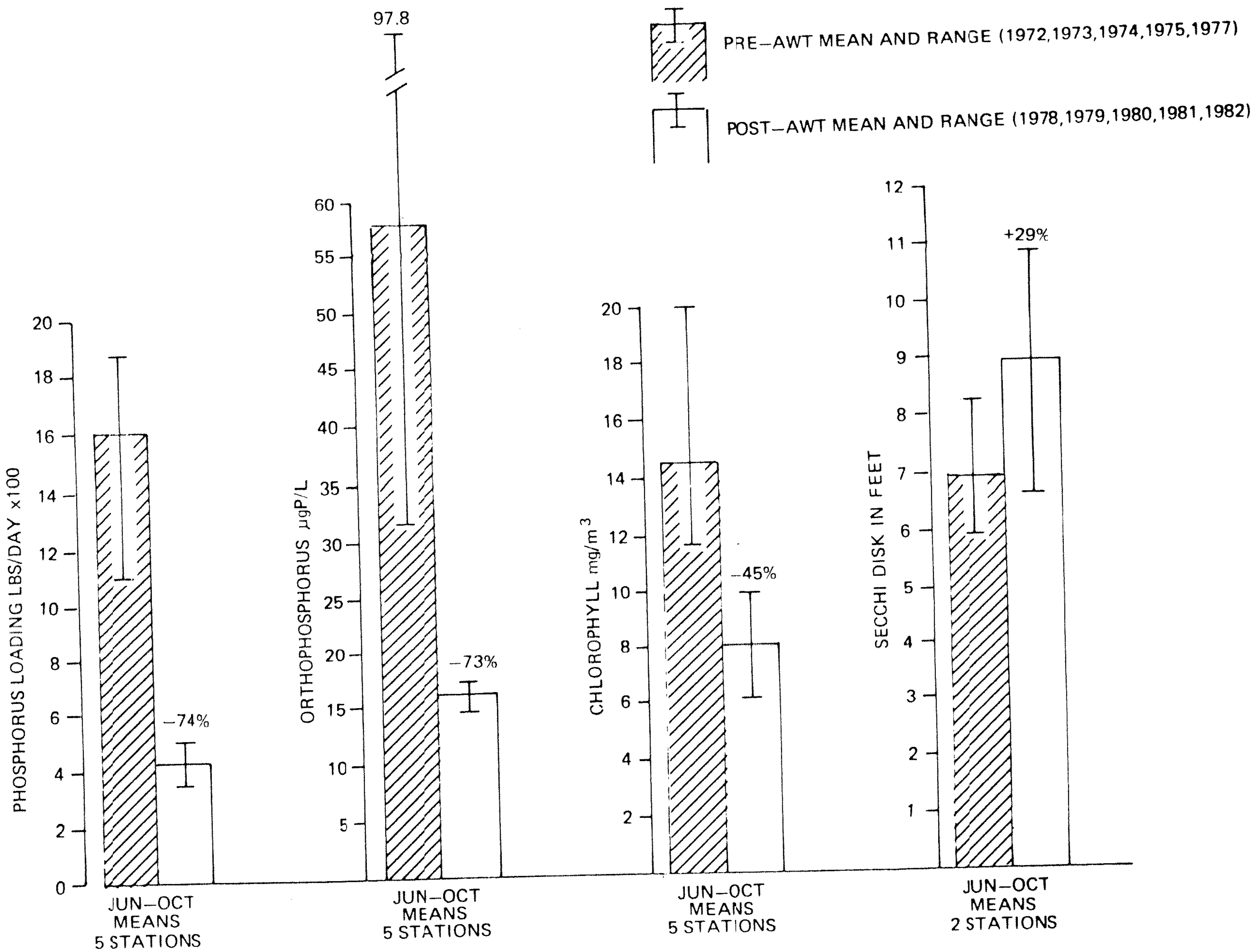

Figure 2. CHANGES IN SOME WATER QUALITY PARAMETERS IN LONG LAKE AFTER THE INITIATION OF ADVANCED WASTEWATER TREATMENT AT SPOKANE. DATA FROM SOLTERO et al, 1983.

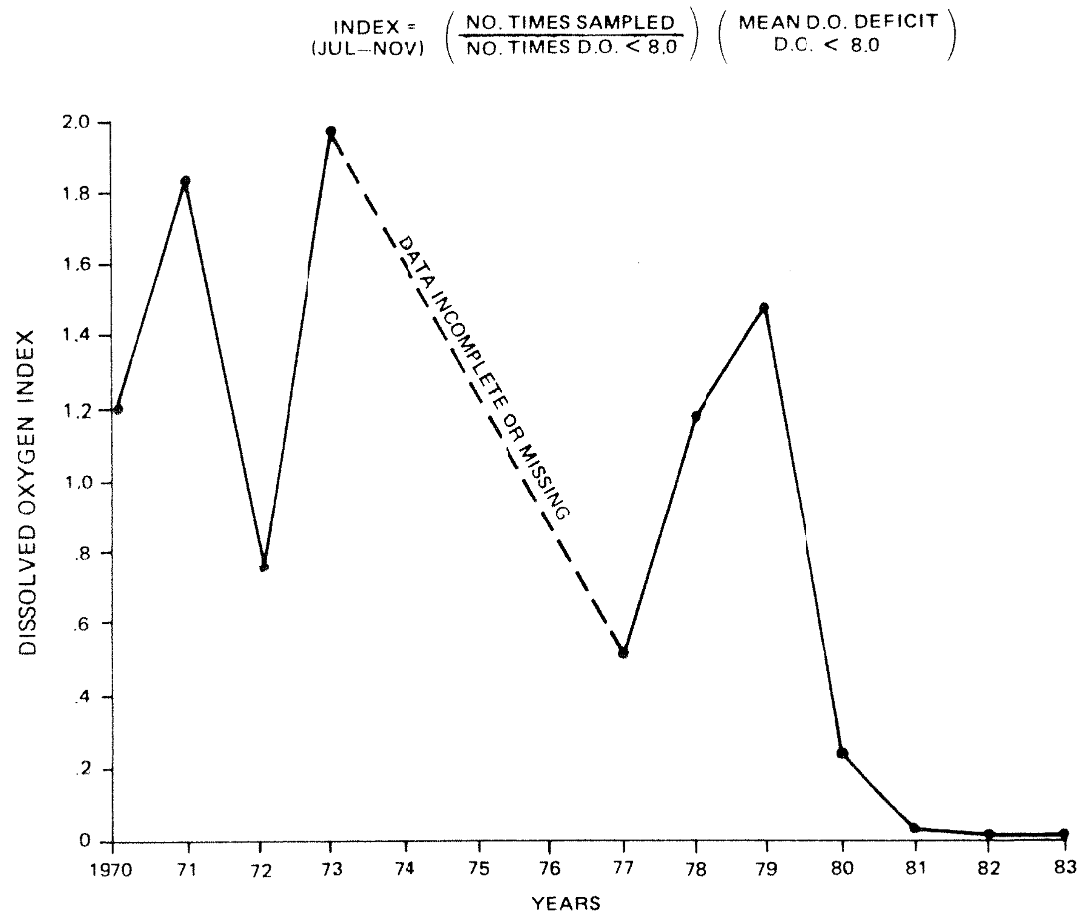

Figure 3. DISSOLVED OXYGEN INDEX FOR THE SPOKANE RIVER BELOW LONG LAKE (1970–1982).

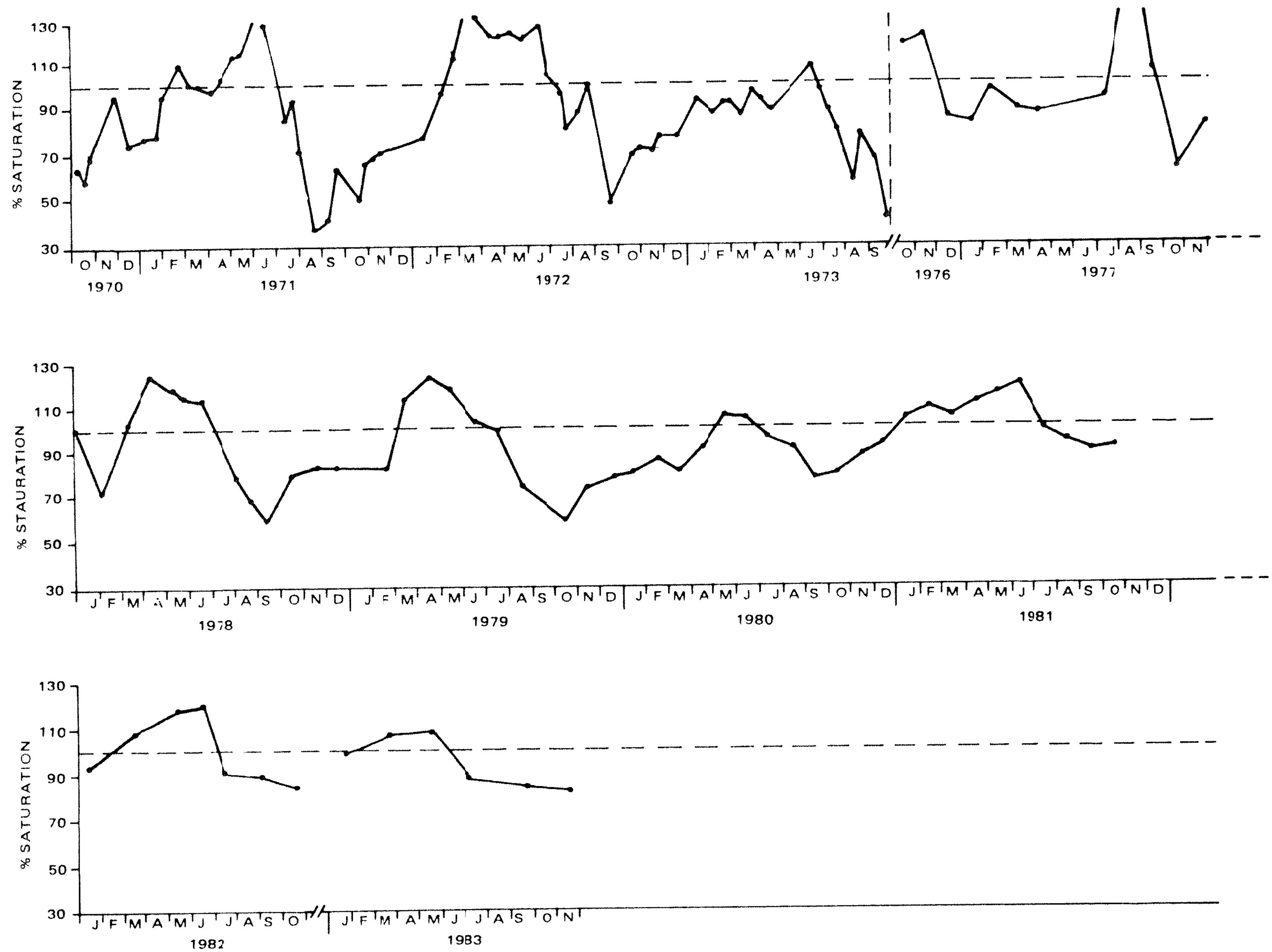

Figure 4. DISSOLVED OXYGEN AS PERCENT SATURATION IN THE SPOKANE RIVER BELOW LONG LAKE.

with flow (Figure 5). In August 1973, a low flow year, 46 percent of the reservoir volume was anaerobic and 66 percent contained less than 5 mg/L. A similar peak occurred in 1977. Since the initiation of AWT, the volume of anaerobic water appears to be decreasing in magnitude and duration. This is best illustrated by comparing the area under the curves. These areas, when plotted (Figure 6), show a trend that compares closely to the dissolved oxygen index developed for the river below the dam (Figure 3) for the 1980 to 1982 period.

This gradual yearly reduction in anaerobic water after AWT with consistent year-to-year summer flows and algae production indicates that some factor in the reservoir is changing. That factor is probably the decreasing oxygen demand of the bottom sediments. If other factors such as phosphorus loading and flow remain relatively constant for the next several years, the sediment oxygen demand should reach an equilibrium with current inputs such as algae decomposition and sediment deposition during high flow.

CONCLUSIONS

Although the year-to-year variations in water quality data for any water body often prevent detection of change, the great differences in several water quality parameters for Long Lake indicate significant improvement in water quality since the initiation of advanced wastewater treatment at Spokane. The data also indicate that water quality may continue to improve in the future.

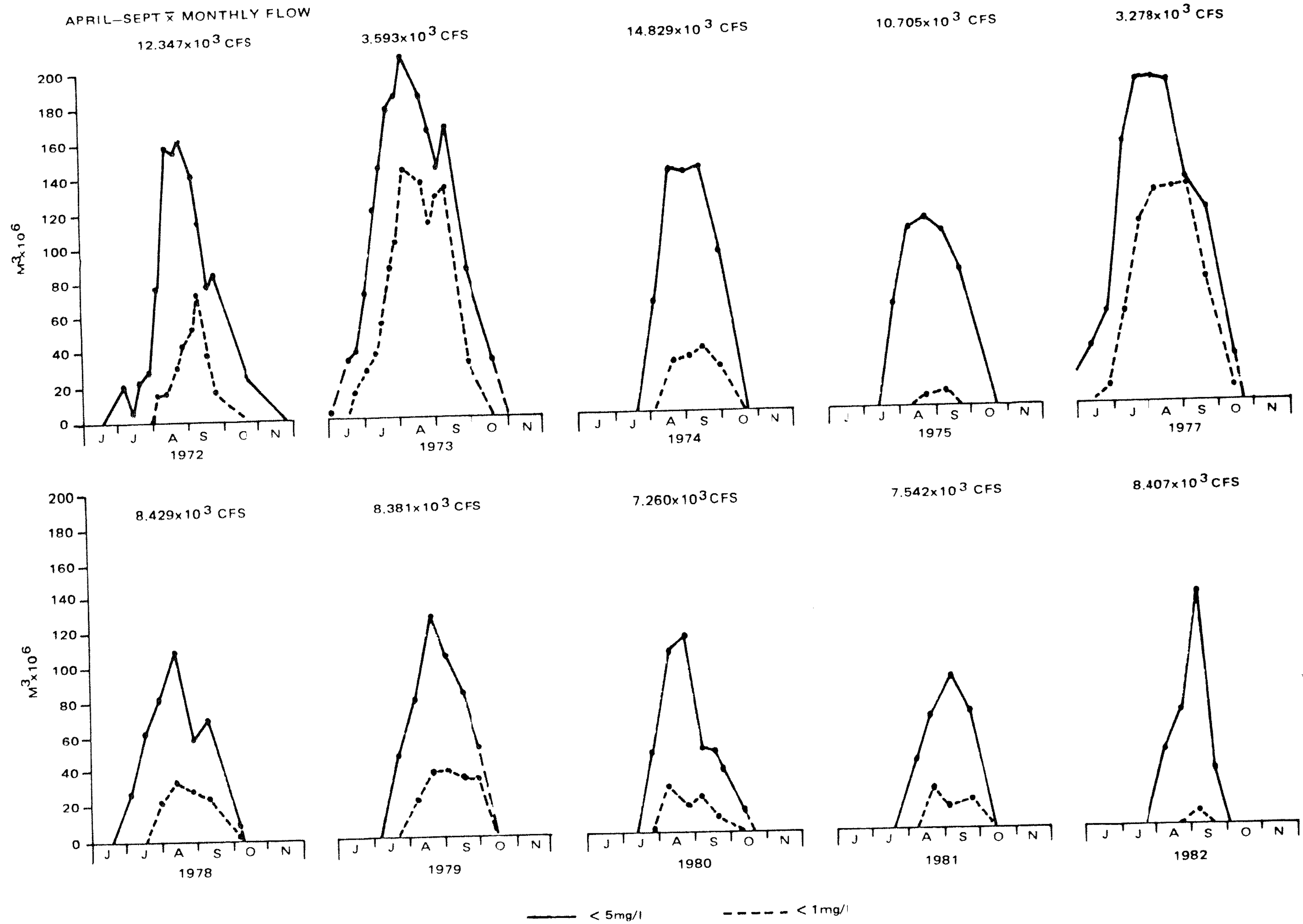

Figure 5. VOLUME OF WATER IN LONG LAKE OF LESS THAN 5mg/l AND LESS THAN 1mg/l DISSOLVED OXYGEN.

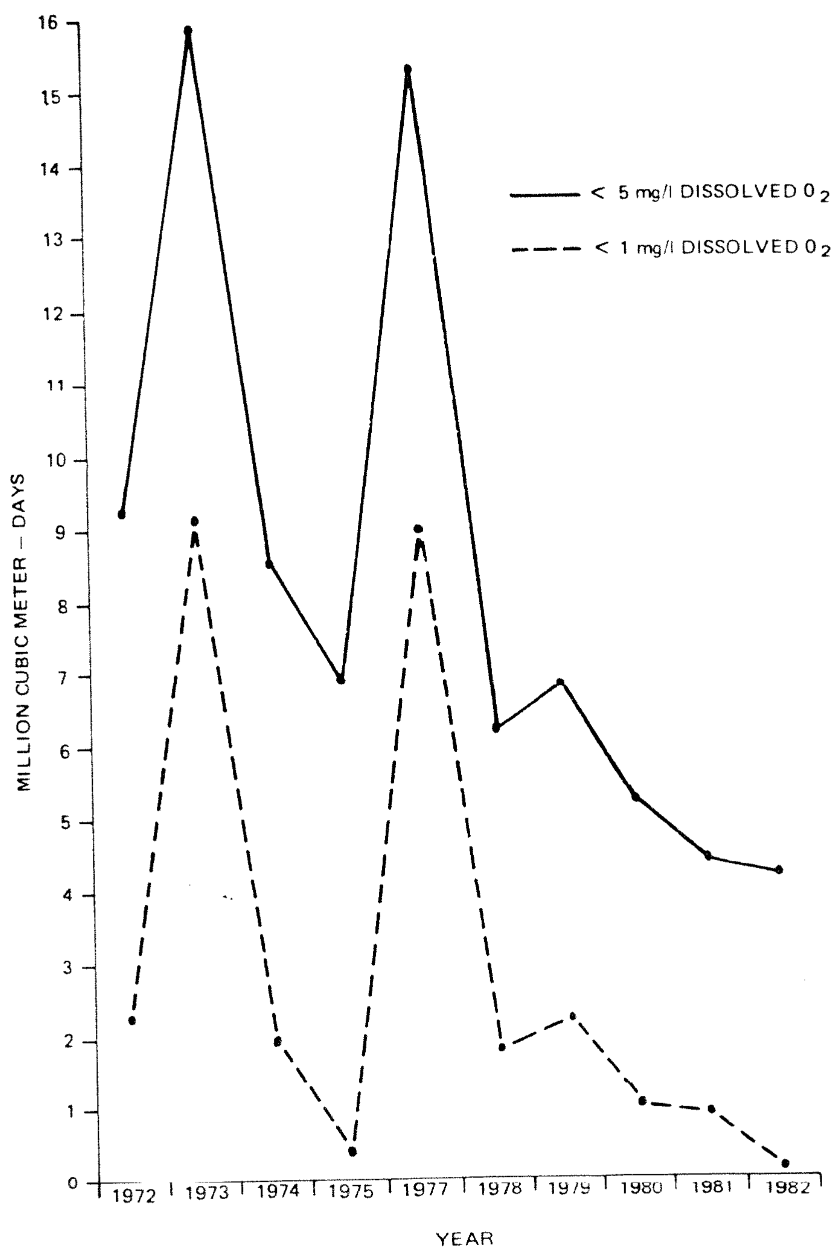

Figure 6. VOLUME – TIME OF WATER IN LONG LAKE RESERVOIR.

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GLOSSARY

Algae - Simple plants, usually microscopic, containing chlorophyll.

Algal bloom - A proliferation of living algae on the surface of lakes, streams, or ponds.

Anaerobic - The absence of free oxygen.

BOD (biochemical oxygen demand) - The amount of oxygen required for aerobic bacteria to oxidize the organic decomposable matter in water within five days at 20°C.

Chlorophyll _a_ - A photosynthetic pigment present in plants.

Nutrients - Elements, or compounds, essential as raw materials for organism growth and development; e.g., carbon, nitrogen, phosphorus, etc.

Percent saturation (oxygen in water) - The ratio of dissolved oxygen in water relative to its capacity at a given temperature, salinity, and pressure.

Secchi disk - A device used to measure visibility depths in water.

Suspended solids - Solid particulates suspended in wastewater.

Wastewater treatment, primary - The first step in wastewater treatment. Removes about 35 percent of the particulate material in wastewater by screening, grinding, settling, and/or chemical addition.

Wastewater treatment, secondary - Combines primary treatment with a microbial removal of dissolved organic material. The limitations on effluent from a secondary treatment process are 30 mg/L suspended solids and 30 mg/L BOD or 85 percent removal from the amount in the influent.

Wastewater treatment, advanced - Wastewater treatment which produces an effluent with 10 mg/L BOD, 10 mg/L suspended solids, and may include phosphorus or nitrogen removal.