TECHNICAL PUBLICATION SJ 87-3

ESTABLISHMENT OF MINIMUM SURFACE WATER REQUIREMENTS FOR THE GREATER LAKE WASHINGTON BASIN

BY

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Palatka, Florida

February, 1987

Project No. 20 024 24

ACKNOWLEDGEMENTS

Brad Purcell provided assistance in graphics; Marvin Williams, Chris Mayberry and Palmer Kinser assisted in the analysis of aerial photography and the digitization and plotting of maps; and Phyllis Howard and Sherry Dearth typed the report. Drafts of the manuscript were critically read by Barbara Vergara, Edgar Lowe, Charles Tai, Don Rao, and Robert Massarelli (SBWA, Melbourne).

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EXECUTIVE SUMMARY

Lake Washington, a major lake in the Upper St. Johns River Basin in east-central Florida, is a valuable regional source of water for drinking, recreation, and wildlife habitat. A literature review indicates that degraded water quality and altered surface water hydrology, resulting primarily from the loss of wetland habitat, floodplain drainage, and pollutant loads from borrow canals and agricultural runoff, threaten the aquatic resources of the lake basin. These ecological concerns led the South Brevard Water Authority (SBWA) to question whether Lake Washington could provide good quality water in ever increasing quantities, and simultaneously meet the hydrologic requirements of the basin wetlands and biota. Because of these concerns, the SBWA submitted two proposals to the District, under the Regional Water Resource Assistance Program, requesting cost-shared investigations to determine the water supply potential of the lake under different management strategies. Two agreements were developed between the District and the SBWA based on these proposals. This report addresses the first agreement, the determination of minimum surface water flow and level requirements north of Lake Washington.

The objective of this agreement was to define the hydrologic criteria (i.e., the mean depth; the frequency of inundation; maximum and minimum depths; and the timing of fluctuations in water depth) required to maintain the ecological integrity of the marshflat flora and fauna downstream of the Lake Washington weir. During the developmental phase of the project, it became apparent that the scope of work should be expanded to include an assessment of minimum surface water requirements for Lake Washington, as well as for the area north of the lake. The expanded study area, the Greater Lake Washington Basin (GLWB), includes the floodplain between Lake Winder and US Highway 192. In addition to expanding the area of study, it was determined that the study should also address other non-consumptive uses of the resource as authorized in Section 373.042 FS and Section 17-40.08 FAC.

In order to examine the critical hydrologic/ecological relationships within the GLWB, two stations representative of the floodplain were selected for detailed analyses; a point 1.3 miles downstream of the weir (RM 253.1) and a point in the center of Lake Washington (RM 258.8). Using topographic, hydrologic, and biological data, minimum surface water level criteria were developed for each station to insure that alteration of the hydrologic regime did not adversely impact wetland functions and values. The hydrologic/ecological criteria developed for the protection of the GLWB are as follows:

Floodplain Vegetation and Soil

1. The mean water level and frequency of inundation for the central (mean) elevation of the marshflat (the central critical marsh elevation) should be such that there will be no net subsidence of organic soils.

   a. A mean water elevation no less than 0.25 ft. below the central critical marsh elevation must be maintained. The mean water elevation should not be less than 13.75 and 12.45 ft. NGVD for RM 258.8 and RM 253.1, respectively.

b. The cumulative frequency of inundation for the central critical marsh elevation, 14.0 and 12.7 ft. NGVD for RM 258.8 and RM 253.1, respectively, should equal or exceed 60 percent.

2. The natural timing of fluctuation in water depth should be retained.

3. Water levels in a typical year should both rise above and fall below the lower and upper critical marsh elevations, 13.0 and 15.0 ft. NGVD for RM 258.8 and 11.4 ft. NGVD and 14.0 ft. NGVD for RM 253.1.

4. Short-term (30-60 days) and infrequent (return interval greater than 10 years) minima are not considered detrimental.

Water Quality

In the case of Lake Washington, applicable water quality standards include those specified in Section 17-3.091, FAC (Class I Standards; potable water supplies). Of these standards only those for TDS and chloride appear to be directly affected by variation in water levels. However, in the absence of reliable empirical models, minimum levels appropriate to these parameters cannot be prescribed at this time. Until a minimum level based on these parameters can be established, mineralization of the water columns and the water budget of the lake should be primary considerations in regulation and management of the resource.

Transfer of Detrital Materials and Sediments

The existing structural configuration of the Lake Washington weir obstructs the downstream movement of sediments and detrital material. This has increased sedimentation in the river channel and disrupts downstream detrital foodchains dependent upon a continuous sediment load. To alleviate these problems, it is recommended that a permanent weir, if constructed, be designed with moveable gates located near the river bed. These can be opened during periods of high flow to allow scouring of accumulated upstream sediments.

Fish and Wildlife Habitat

The minimum level criteria established for the protection of floodplain soils and vegetation also provide for the maintenance of fish and wildlife habitat. There are, however, two areas of special concern: (1) passage of fish and (2) maintenance of adequate water depths to allow for the movement of fish and wildlife and provide refugia during droughts. The new weir design should provide for movement of aquatic wildlife and maintain a flow except during extreme droughts (greater than 10 year drought). As design directives it is recommended that:

1) One-day, 1:5 year low stages downstream of the weir equal or exceed 9.5 feet NGVD.

2) The following low stage frequencies apply for Lake Washington:
   a. one-day, 1:5 year low stage $\geq$ 11.5 ft. NGVD
   b. one-day, 1:50 year low stage $\geq$ 10.0 ft. NGVD.
   c. one-day, 1:100 year low stage $\geq$ 9.5 ft. NGVD.

Recreation and Navigation

Recreation and boating in the GLWB are inextricably linked. The present weir obstructs powerboat traffic when stages fall below 14.0 ft. NGVD. Any new weir should not prohibit the passage of small powerboats (16 to 17 ft. in length). Maintenance of navigation during extreme droughts is not warranted, therefore, minimum level criterion for navigation are not prescribed.

Aesthetic and Scenic Attributes

The design, construction and operation of a permanent weir, should, to the extent possible, minimize impacts to the aesthetic and scenic attributes of the area.

INTRODUCTION

Background and Scope

During the development of the St. Johns River Water Management District's budget for FY 84-85, efforts were made to coordinate program development with local governments. This coordination process was formally titled the Regional Water Resource Assistance Program (RWRAP), and through it, local governments assisted the District in the identification and the prioritization of water management problems.

The South Brevard Water Authority (SBWA), because of its water supply responsibilities, submitted two RWRAP proposals to the District - (1) Minimum Flow North of Lake Washington and (2) Evaluation of the Lake Washington Temporary Weir. Both proposals were for cost-shared investigations. The proposals stemmed from concern over declining water levels in Lake Washington which threaten the natural resources of the basin and the quality and quantity of the surface waters for consumptive uses. The results of the proposed investigations would provide information requisite to the determination of potential water availability from Lake Washington under different management strategies. Two agreements between the District and the SBWA were developed based on these proposals. These agreements were executed on May 6, 1985 (Appendix A). This report addresses the first agreement, Minimum Flow North of Lake Washington.

The objective of this agreement was to define the hydrologic criteria, i.e., the mean depth; the frequency of inundation;

maximum and minimum depths; and the timing of fluctuations in water depth, required to maintain the ecological integrity (function and structure) of the marshflat flora and fauna, downstream of the Lake Washington weir. During the developmental phase of the project, it became apparent, however, that the scope of work should be expanded to include an assessment of minimum surface water requirements for Lake Washington, as well as for the area north of the lake. Since these two reaches are ecologically connected, water management strategies developed for one reach will directly influence the hydrologic regime within the other. The expanded study area, which will be referred to as the Greater Lake Washington Basin (GLWB), includes the floodplain between Lake Winder and US 192 (Figures 1 and 2). In addition to expanding the area of study, it was determined that other non-consumptive uses authorized in Section 373.042 Florida Statutes and Section 17-40.08 Florida Administrative Code should be addressed.

It is anticipated that the results of this study will contribute to the development of a responsible surface water management plan for the GLWB. This will accomplish District objectives and benefit local governments.

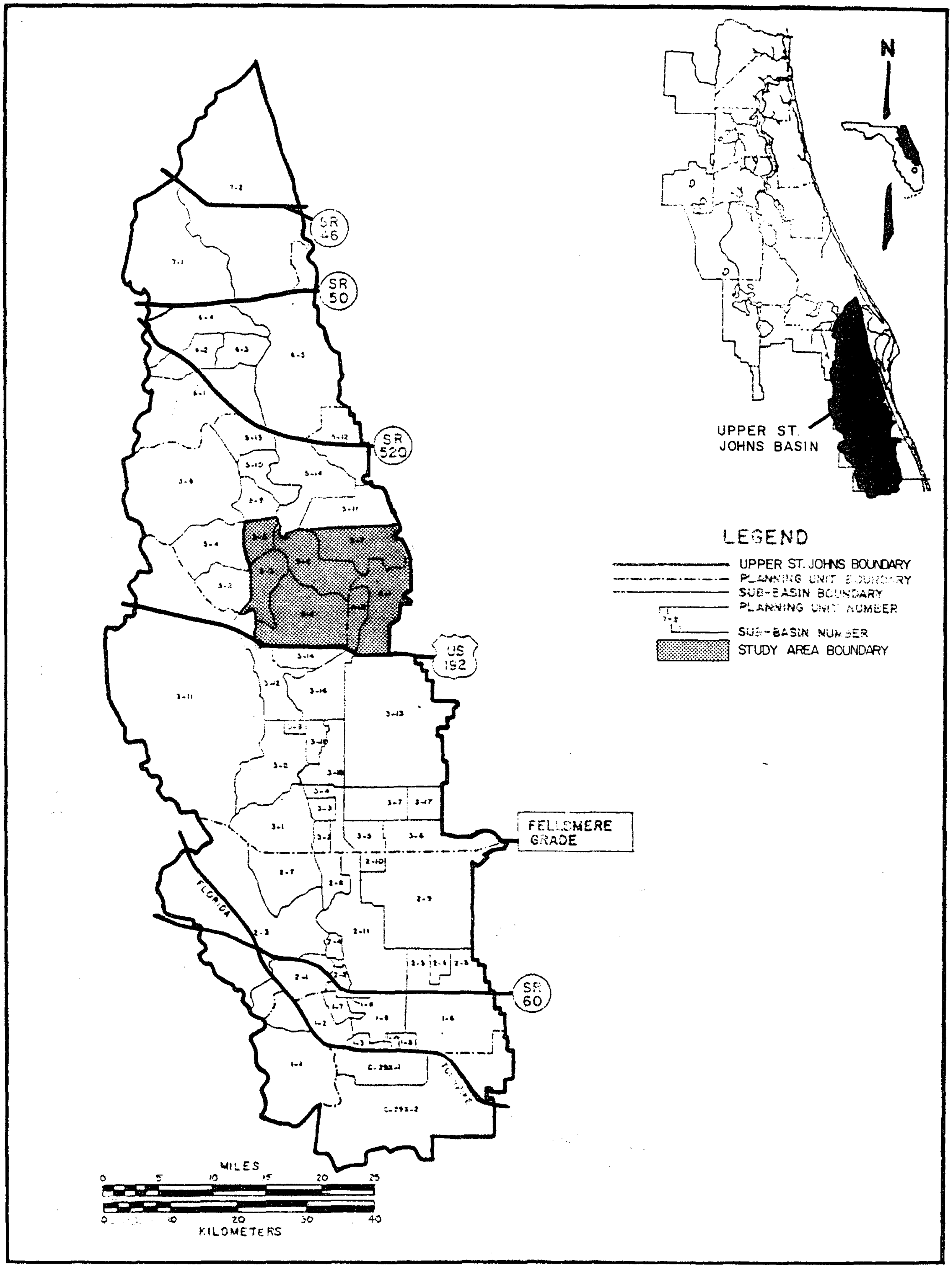

Figure 1. Map of the Upper St. Johns River Basin showing the study area.

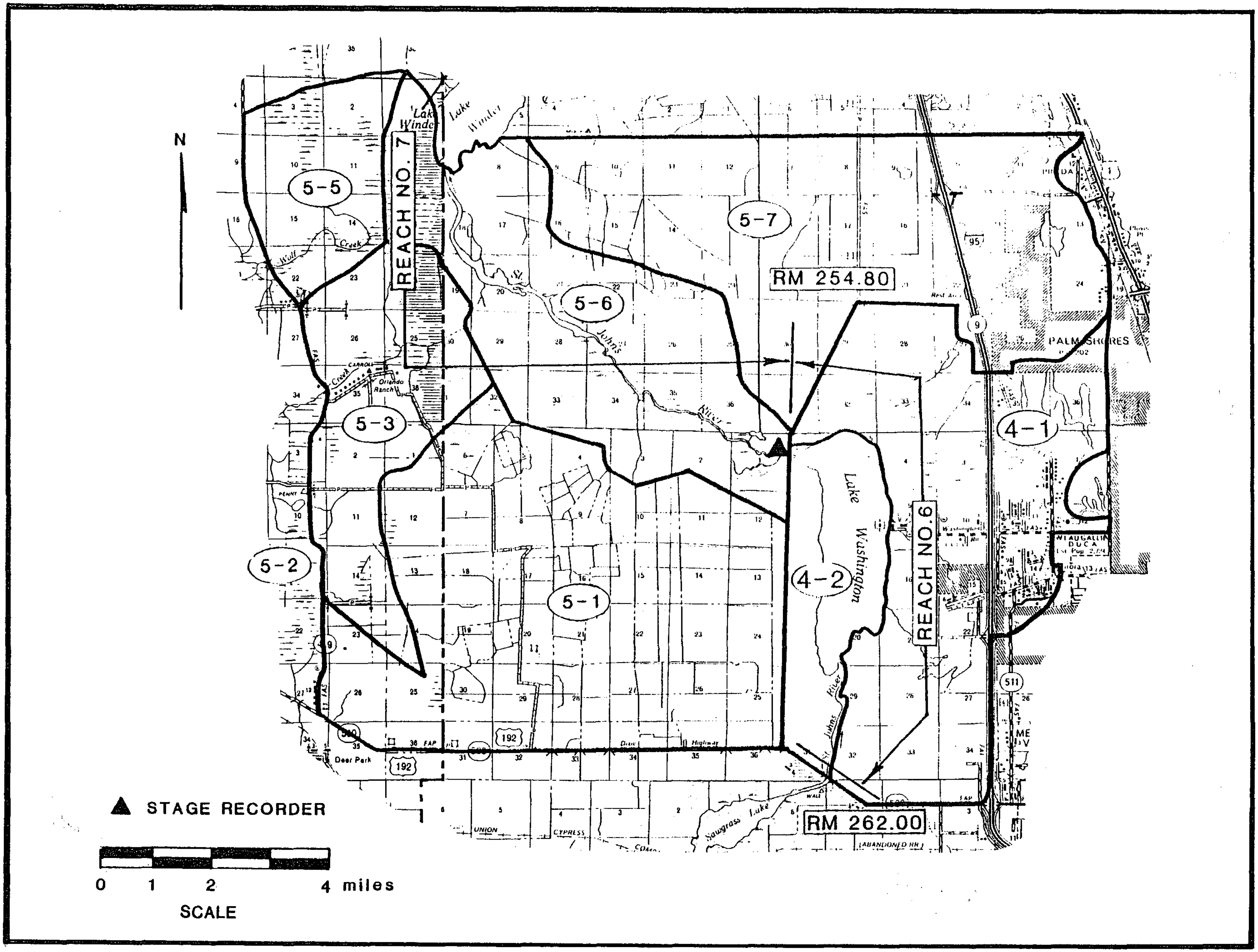

Figure 2. Map of the Greater Lake Washington Basin (GLWB).

The Study Area

Land-Use and Regional Importance

The surface waters of the GLWB constitute a valuable regional source of water for drinking, irrigation, recreation, and wildlife habitat. The City of Melbourne withdraws surface water from Lake Washington to provide drinking water for southern Brevard County. In recognition of its use as a potable water source, the Florida Department of Environmental Regulation designates the river and its tributaries in Brevard and Indian River Counties from Lake Washington south to State Road 60 as Class I waters (public water supply; Chapter 17-4, F.A.C.). Degraded water quality, resulting primarily from altered surface water hydrology; loss of wetland habitat; and pollutant loads from borrow canals and agricultural runoff have been prominent motives for restoration efforts in the Upper St. Johns River Basin (USJRB) (Brooks and Lowe, 1984).

Extensive portions of the river floodplain within the GLWB have been developed to support agriculture. Native range and improved pasture are the dominant land uses (Table 1). Greater than 70 percent of the basin is utilized for cattle production. Crop agriculture, while present in the basin, represents less than one percent of the total area and consists primarily of citrus.

Table 1. Summary of land use categories the St. Johns drainage basin between US 192 and SR520. Data from SJRWMD (1980).

Land-Use	Acreage (acres)	Percent
Open water	11,518	5
Freshwater marsh	18,956	8
Forested wetlands	28,591	12
Natural range and unimproved pasture	63,464	26
Improved pasture	119,192	47
Urban	5,586	2
Other	531	<1
Total	247,838	100

The extensive acreage of aquatic habitats (Table 1) is an important recreational resource for residents of Brevard and neighboring counties. Fishing, hunting, boating, frogging, and bird watching have grown in popularity with the establishment of recreation areas, boat ramps and other access points. These recreational activities have spawned an important local "industry" that provides services to the growing number of outdoor enthusiasts.

The GLWB contains important wildlife habitats. It is utilized by rare and endangered animal species such as woodstorks (*Mycteria americana*), snail kites (*Rostrhamus sociabilis plumbeus*), bald eagles (*Haliaeetus leucocephalus leucocephalus*) and Florida sandhill cranes (*Grus canadensis pratensis*). These birds and species of herons, egrets and ibis depend on the wetlands for nesting and feeding sites. Of the nine nesting sites for herons and their allies identified by Nesbitt et al. (1982) in the USJRB, two occur within the GLWB. The continued existence of many of these animals is critically linked to good water quality, the regular, seasonal inundation of the vegetated floodplain, and maintenance of the community structure of floodplain vegetation (Lowe et al., 1984).

Soils

The soils of the GLWB can be divided into floodplain and flatwood soils. The floodplain soils mostly occupy the 100 year floodplain, while the flatwoods soils occur between the river floodplain and the Atlantic Coastal Ridge to the east and the Osceola Plain to the west.

The floodplain soils are divided into peats and mucks--the Montverde-Micco-Tomoka association, and more sandy soils--the Felda-Floridana-Winder association (USDA, SCS, 1974; Figure 3). The soils of the Montverde-Micco-Tomoka association are nearly level, poorly drained, organic soils with sandy loamy material at a depth of 16 to 52 inches. Montverde and Micco peats contain about 80 percent fibrous organic material and occur mainly south of the outlet to Lake Washington. Tomoka muck is found generally north of Lake Washington, and consists of well decomposed organic material, with only 10-15 percent fiber. These soils are frequently flooded for long periods (USDA, SCS, 1974).

The soils of the Felda-Floridana-Winder association are nearly level, poorly drained, sandy soils underlain by loamy material. The water table is generally close to the soil surface and flooding is common (USDA SCS, 1974).

The flatwood soils are poorly drained, sandy soils occurring above the river floodplain. The water table is high, and undeveloped sites generally support a combination of pine, galberry, waxmyrtle, and saw-palmetto vegetation. The Myakka-EauGallie-Immokalee and the Pineda-Wabasso associations are the principal flatwood soils in this river reach. They cover much of

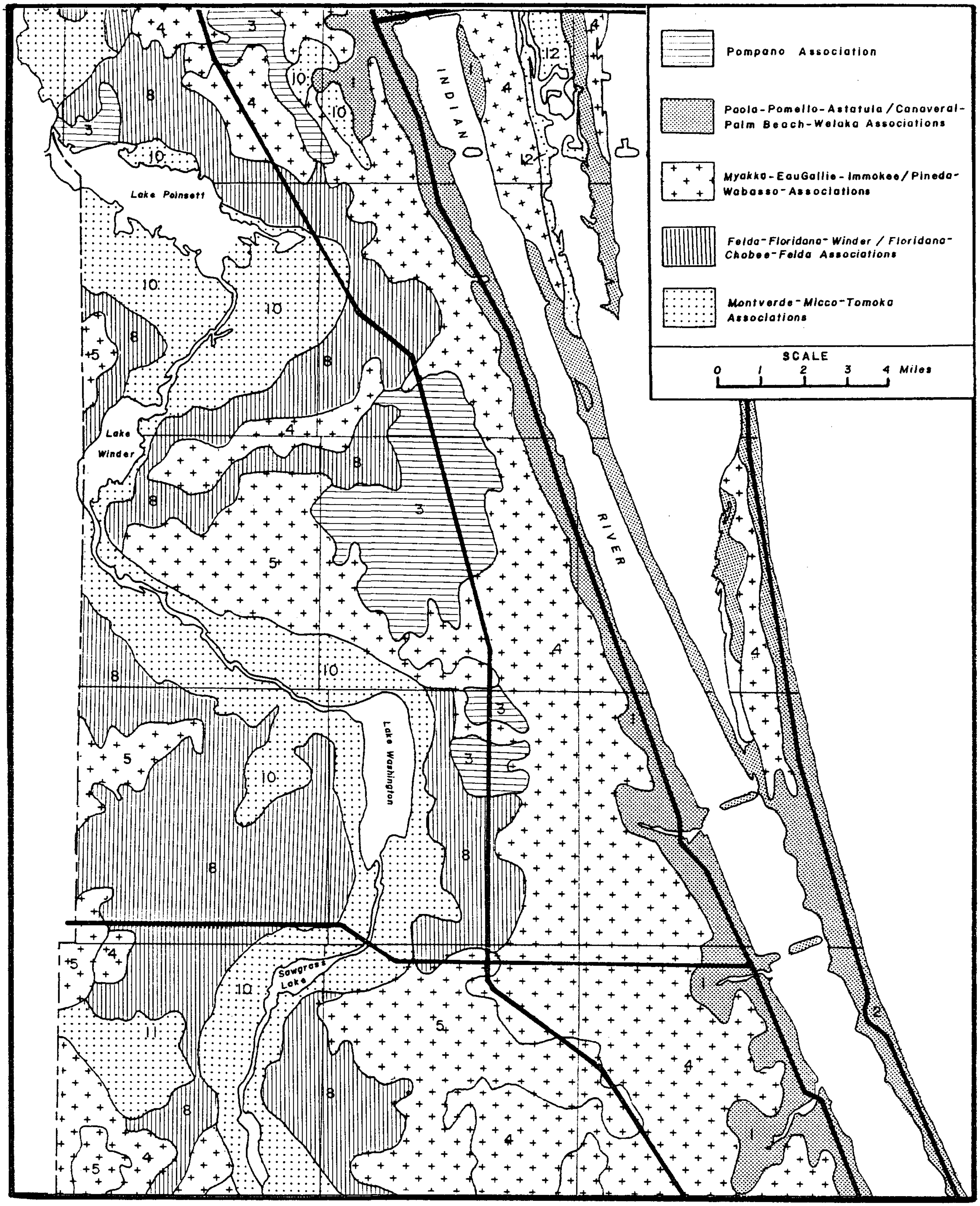

Figure 3. Soils of the Upper St. Johns River Basin (USDA, Soil Conservation Service, 1974).

the basin and have been developed into range, pasture or citrus (USDA,SCS, 1974; Figure 3).

Climate

The climate is sub-tropical (U.S. Dept. Commerce, 1978). Summers are long, warm and relatively humid; winters are generally mild because of the southern latitude and the proximity to the Atlantic Ocean.

Yearly rainfall averages 50.4 inches, with more than 60 percent occurring during the period June through October. Stream flow and water levels generally peak during October in response to the seasonally high rainfall (Lowe et al., 1984; Figures 4 and 5). Minimum flows and levels occur in April and May due to the declining rainfall during the fall and winter.

Rainfall within the USJRB has shown a long-term decline, which is accentuated by the five-year moving means of the total annual rainfall (Figure 6). Rainfall during the last 20 years (1966-1985) averaged 48.7 inches, 3.3 inches below the average rainfall observed during the previous 20 years (1946-1965), but only 1.7 inches below the 43 year average (1943-1985). The later time period included a two year drought (1980-1981) during which the average annual rainfall was 36.4 inches, about 14.0 inches below normal.

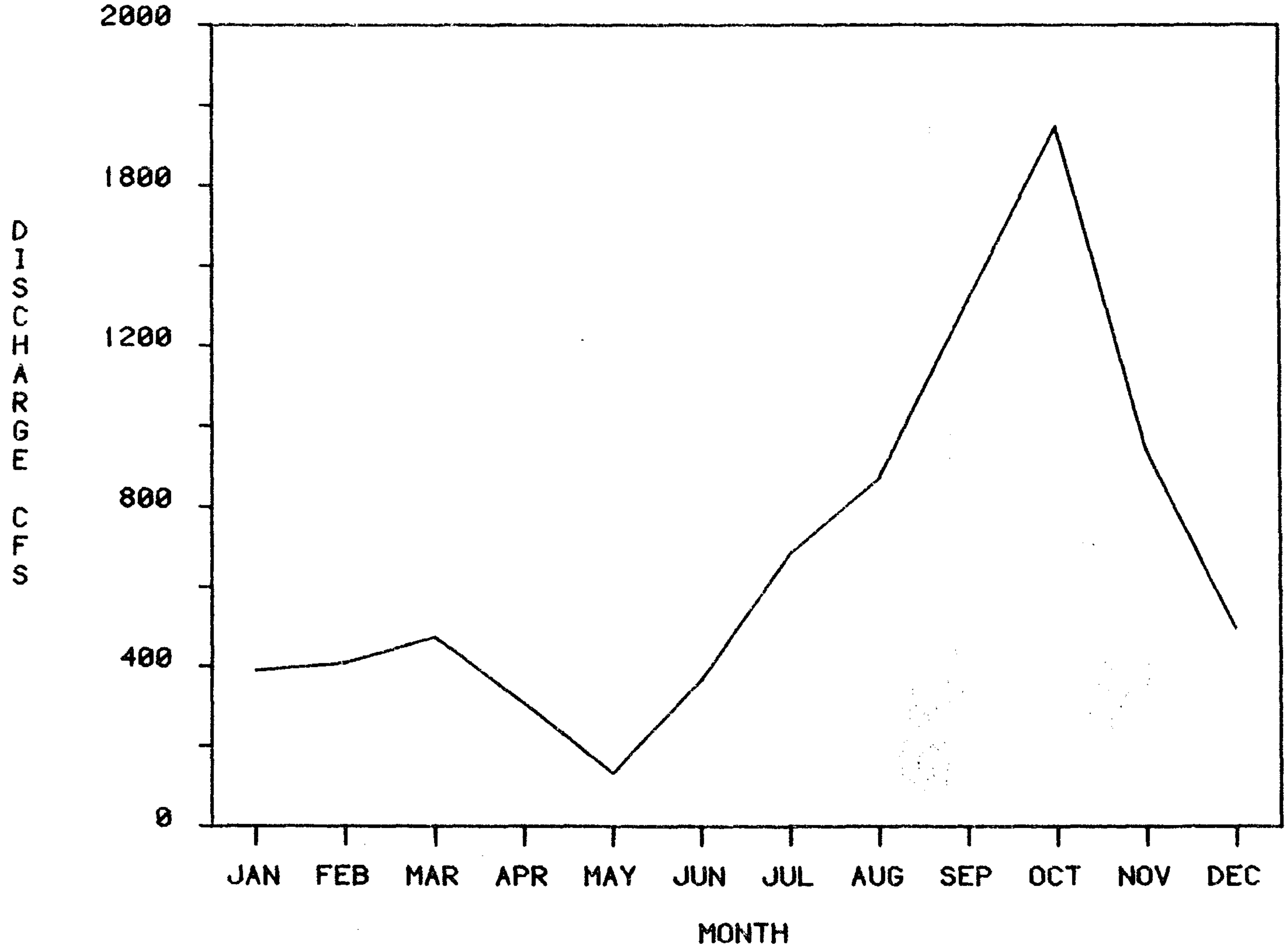

Figure 4. Mean monthly discharge (cfs) of the St. Johns River at US 192 (SR500), two miles south of Lake Washington, 1940 - 1984.

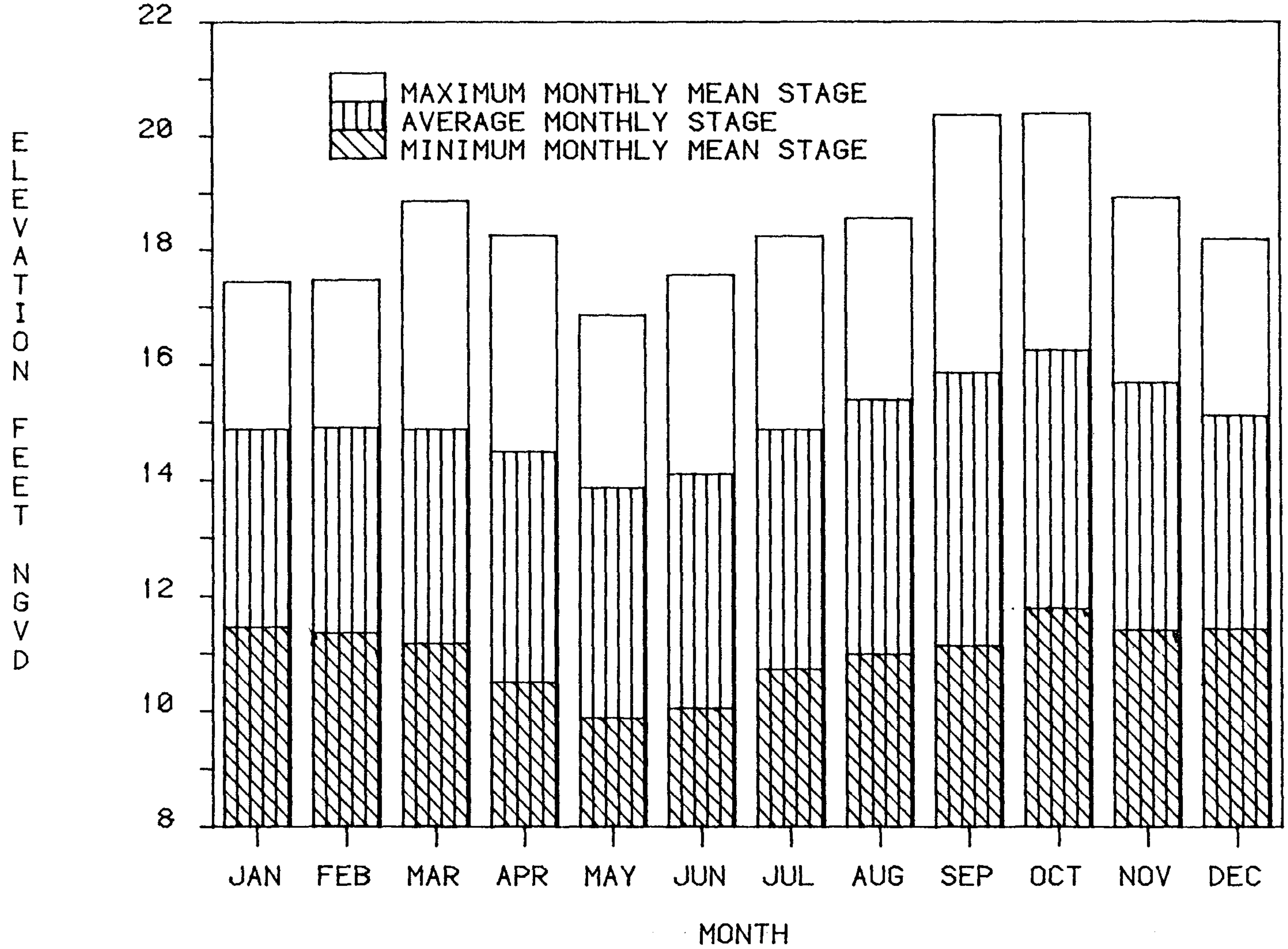

Figure 5. Monthly variation in mean, maximum and minimum lake elevation. Lake Washington, 1942-1984.

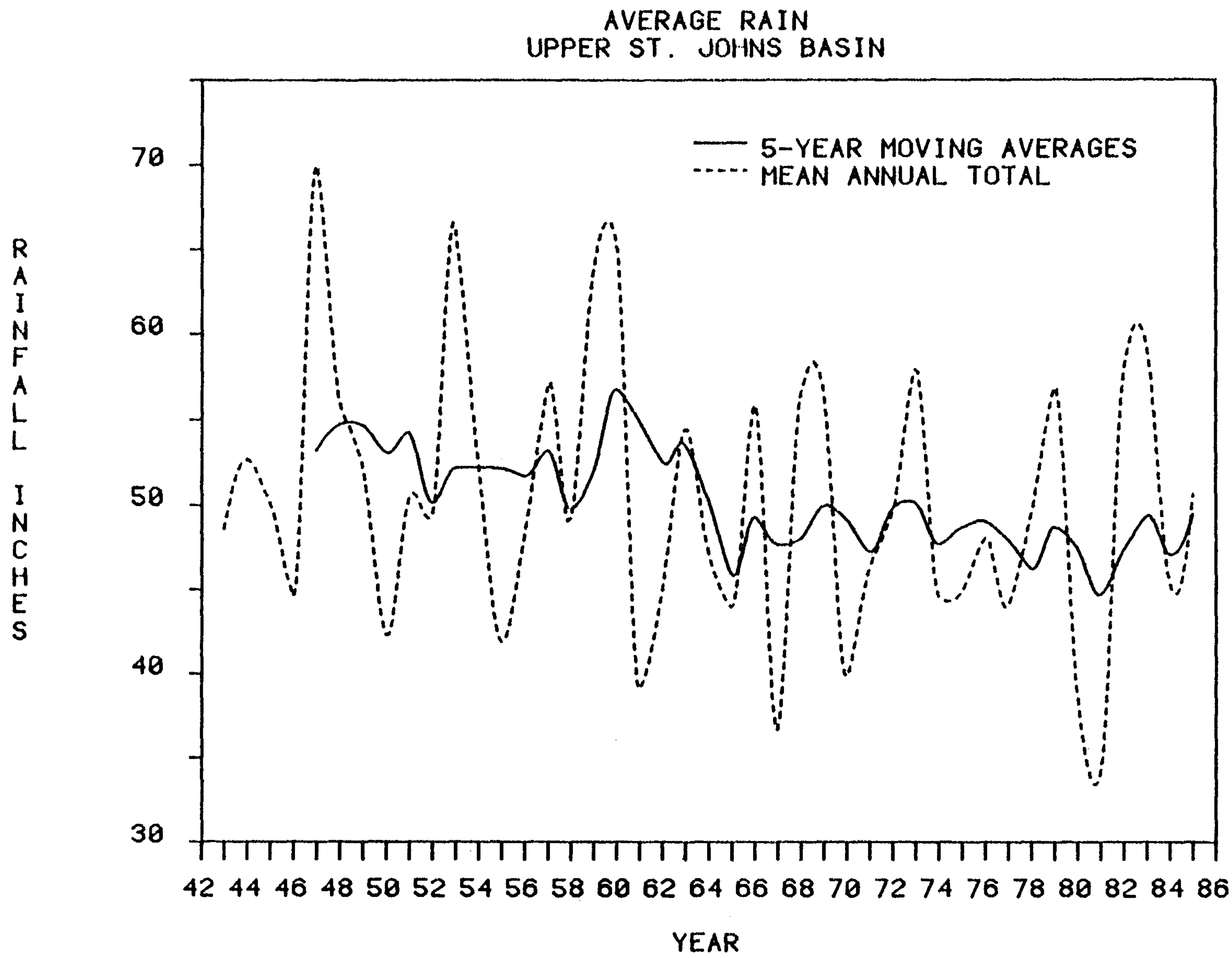

Figure 6. Mean annual and five-year moving averages of rainfall observed at five upper St. Johns River basin climatic stations, 1943-1985 (Melbourne, Ft. Drum, Fellsmere, Nittaw and Vero Beach).

Ecological Alteration of the Floodplain

Prior to 1952, environmental impacts within the GLWB were primarily limited to those associated with the construction of highways bisecting the floodplain (i.e., SR 500 [US Highway 192] and SR 520). Subtle alterations to the hydrologic regime in the GLWB were probably also occurring, due to the construction of major north-south drainage canals in the floodplain south of Lake Hell'n Blazes, however, hydrologic data for this period were not available prior to 1942.

The first major alteration with widespread ecological implications was the removal of the "jams" in 1952, (Cox et al., 1976) (Table 2). The jams were floating islands of peat and vegetation lodged in the river channel for several miles north of Lake Washington. They detained water in upstream areas, but probably released more water downstream during dry periods than does the existing weir. The jams were removed to improve navigation. Their removal, coupled with the expansion of upstream floodplain drainage canals, caused a marked decline in the average and minimum stages, an increase in the range of surface water fluctuations, and a closer correlation between rainfall and stage in Lake Washington (Lowe et al., 1984). The sustained lowering of the surface water levels and the mounting surface water requirements of growing municipalities, necessitated their replacement by man-made weirs (Table 2).

Table 2. A chronology of physical modification to the greater Lake Washington Basin. Data from Lake Washington Water Quality Improvement Technical Advisory Committee (1983) and Lowe et al. (1984).

Date	Modification
1952-1953	Removal of the Jams, natural vegetation dams blocking the river north of Lake Washington.
1953-1960	Agricultural encroachment into the Upper St. Johns Basin south of Lake Washington reduced the original floodplain from 680 to 250 square miles.
1961	Sandbag dam placed at the outlet of Lake Washington.
1962	Severe drought.
1962-1975	Original floodplain south of Lake Washington reduced to 100 square miles.
1975	Lowest recorded surface water elevation in Lake Washington (9.88 feet NGVD). Drought.
1976	Fixed-crest (13.5 feet NGVD) sheet pile weir constructed at outlet to Lake Washington.
1980-1981	Severe drought. River channel between the weir and Lake Winder experienced extended periods of no flow.

Agricultural encroachment into the floodplain occurred only relatively recently. While the encroachment has been significantly less than that which occurred in upstream reaches (Table 3), it has not been inconsequential (Figure 7). By 1953, only one percent of the 100 year floodplain had been developed. To date, an additional 25,500 acres (29 percent) have been removed by the construction of levees and canals. This is a cumulative loss of 27,000 acres, leaving only 70 percent of the historic 100 year floodplain available for water storage. Encroachment into the annual floodplain removed 4650 acres, or 11 percent, of the original riverine marsh (SJRWMD, 1980).

The most extensive single encroachment into the basin occurred during 1957, west of the valley. A continuous agricultural levee and canal system (North Mormon Outside Canal, NMOC) was constructed from US Highway 192, southwest of Lake Washington, to a point 1.3 miles southwest of Lake Winder (Figure 7). The NMOC eliminated 17,900 acres (20 percent) of the 100 year floodplain. In addition, it diverted water northward that would have normally sheetflowed across the marsh into Lake Washington and the river channel north of the lake. This probably intensified the dewatering of the floodplain and further altered the timing, frequency and duration of inundation of the marshflat.

Table 3. Tabulation of percent encroachment into the 100 year and annual floodplain of the upper St. Johns River south of SR 520, by geographical location.

Geographical Location	100 year Floodplain	Annual Floodplain
Florida's Turnpike to SR60	72	35
SR60 to Fellsmere Grade	66	52
Fellsmere Grade to US 192	82	36
US192 to Lake Washington weir	8	6
Lake Washington weir to SR520	35	14

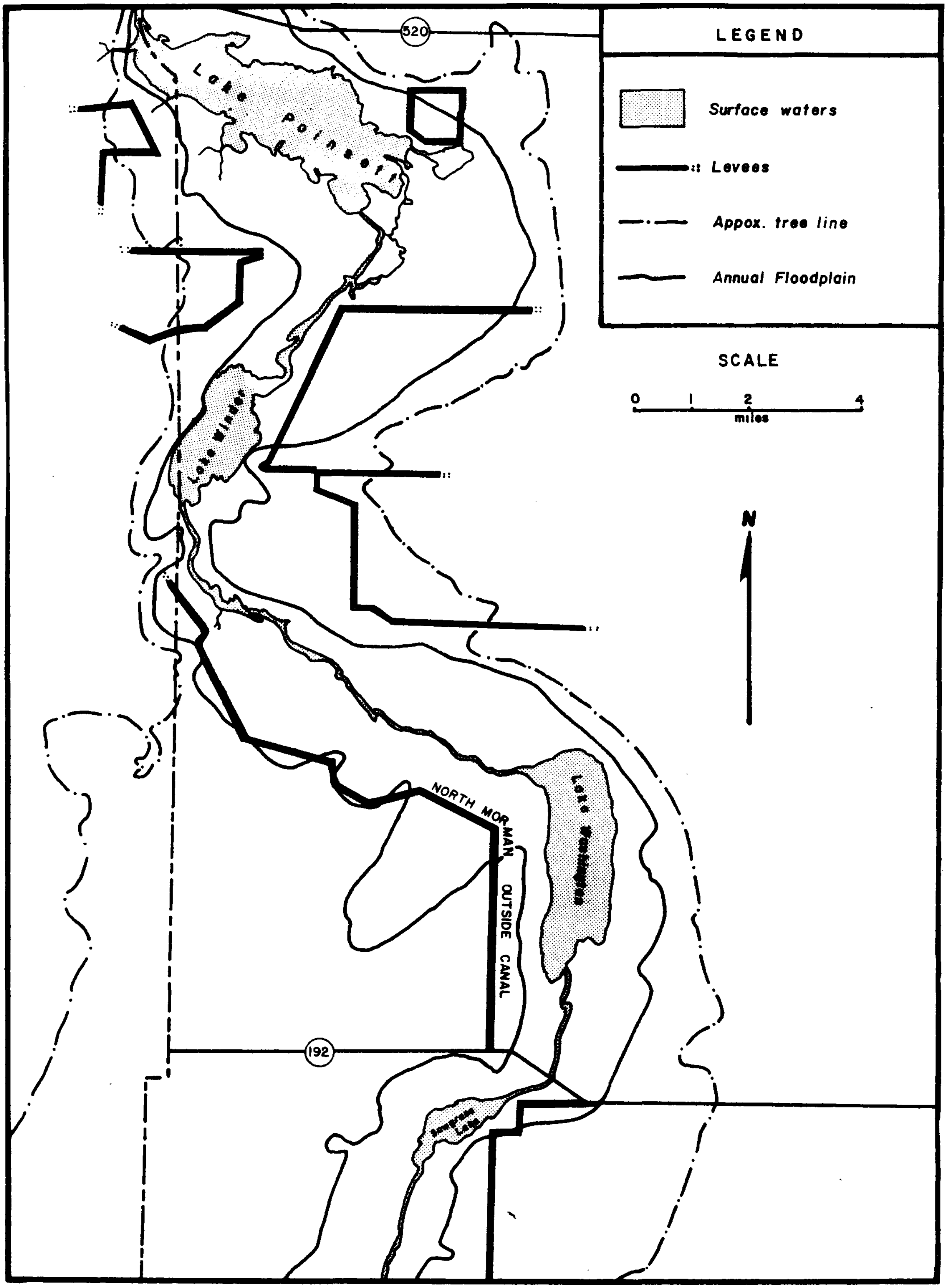

Figure 7. Map showing floodplain development within the GLWB.

Evidence indicates that in those areas experiencing the most severe hydrologic alterations, ecological damage has been the greatest. Cox et al. (1976) reported that terrestrial plant species and woody species, such as willow (Salix caroliniana), had colonized large areas in the USJRB that were previously dominated by herbaceous wetland vegetation. They postulated that the changes were caused by a reduction in floodplain inundation. Lowe et al. (1984) provided quantitative data to support the contention that plant communities had changed and examined the relationship between alteration in hydrology and vegetation changes.

The Florida Game and Fresh Water Fish Commission (FGFWFC, 1981) reported that the 1980 migratory bird populations in the USJRB had declined significantly from pre-1958 levels. They suggested that the decline was probably due to the loss of wetland feeding habitat. Similar trends have apparently occurred in basin wading bird populations (Lowe et al., 1984). Research in South Florida (Kushlan and White, 1977) indicated that, despite the protection of nesting sites, wading bird populations in the Everglades continued to decline as the acreage of feeding habitat dwindled.

Spatial variation in the standing crops of fish and temporal variation in fishing success indicated that fish populations have also declined from the Fellsmere Grade to below Lake Washington (Cox, et al., 1982; Lowe et al., 1984). One acre littoral zone block net samples taken by the FGFWFC in the period 1972 to 1978 indicated that, even before the drought of 1980-81, fish standing stocks in Lake Washington were significantly less than in Lake Poinsett or Blue Cypress Lake (Lowe et al., 1984). Cox et al. (1982) reported that the fishery decline was primarily due to a decrease in the extent of marsh inundation, a contention supported by the work of researchers in other areas who found a positive relationship between fish production and marsh inundation (Wegner and Williams, 1974; Martin et al., 1981; Polskey, 1982).

Declines in the quality of surface waters has apparently also accompanied basin development. The most severe, but intermittent problems are low concentration of dissolved oxygen and high concentrations of minerals (Lowe et al., 1984). A natural characteristic of the USJRB is that during low stages, mineralized ground water (surficial and artesian) flows more readily into surface water bodies (Brown et al., 1962). In addition, increased retention times, loss of dilution by rainfall and river flow, and an increase in the proportional contribution of mineralized waters from agricultural canals, further intensifies the concentrations of chlorides and total dissolved solids (TDS) (Fall, 1982). These factors caused concentrations of chlorides and TDS in Lake Washington to exceed Class I (potable water supplies) standards during the 1981 drought.

Evidence suggests that seasonal and diel fluctuations in the levels of dissolved oxygen are a significant ecological problem (Lowe et al., 1984). Yearly, seasonal and diel fluctuations in dissolved oxygen are undoubtedly natural, but Lowe et al. (1984) suggested that the alteration of hydrology caused by basin development (i.e., decrease in mean stage and increase in yearly range in stage) may have intensified yearly and seasonal fluctuations in oxygen concentrations. During low flows, sections of the river may become isolated and develop anoxic conditions resulting in fish kills. In addition, the accumulated sediments and organic detritus in canals above and below structures during periods of low flow may be resuspended during high flows. The resuspended materials remove dissolved oxygen from downstream waters because, of their high biochemical oxygen demand. Fish kills have been reported following the rapid release of water into canals that have been relatively stagnant for extended periods (Lowe et al., 1984).

Nutrient concentrations (phosphorus and nitrogen) indicate that much of the USJRB is eutrophic, but this is probably a natural eutrophy (Canfield, 1981; Lowe et al., 1984). While the high nutrient concentrations have not caused obvious ecological harm historically, they do indicate a potential for detrimental algal blooms. Such bloom conditions can increase the potential for fish kills and cause taste and odor problems which increase treatment costs for potable water supplies.

Surface Water Hydrology

The Floodplain Between the Lake Washington Weir and US Highway 192. Lake Washington and its associated marshlands are the dominant hydrologic features of the reach. No natural tributaries exist but five canal systems drain lands to the east of the lake.

Due to its relatively small size, the basin receives most of its water from upstream inflow. Water normally moves laterally into Lake Washington across the marsh as sheetflow, or through canals, and then flows north across the weir. During floods, the river flows north across the weir and through the adjoining marshes. At stages below 13.5 feet NGVD, discharge ceases and all water south of the fixed crest weir is impounded, essentially eliminating any hydraulic gradient within this reach (SJRWMD, 1980).

The hydrograph for Lake Washington (Figure 8) shows a strong downward trend in surface water elevations. Mean annual and mean minimum stages for the last 10 years of record (1975-1984) declined 2.63 and 3.01 feet, respectively, below corresponding values observed during the first 10 years of record (1942-1951). Concomitantly, the inundation frequency of the river floodplain was markedly reduced between the early (1942-1952) and recent (1953-1984) periods (Figure 9).

The decline in stages occurred in the early 1950s, coincident with the removal of the jams, the continued development of major north-south drainage canals south of Lake Hell'n Blazes, and the regional decline in rainfall. After 1955, the relationship between total annual rainfall and annual mean surface water elevations changed (Lowe et al., 1984). For an equivalent rainfall event in the early (1942-1952) and recent (1953-1984) periods, the expected mean annual surface water elevation was lower for the recent period (Lowe et al., 1984; Figure 8). In addition, mean surface water elevations for the recent period were more strongly influenced by variations in annual rainfall (Figure 8). Apparently, it was this change in the relationship between rainfall and water level rather than the decline in rainfall which caused the observed decline in mean surface water elevations (Lowe et al., 1984). Thus, in the absence of extensive floodplain alterations, water levels would have changed very little (Figure 10).

The Floodplain Between the Lake Washington Weir and Lake Winder. The western half of the basin is comprised of permanent tributary subbasins originating in the slopes of the Osceola Plain. The major tributaries are Wolf Creek and Pennywash Creek, and they contribute significant runoff directly to the St. Johns River. Intermittent surface water flow to the river is contributed by minor tributary subbasins draining the Atlantic Coastal Ridge.

The marsh floodplain, lakes, and St. Johns River profice the majority of the annual water conservation storage, annual flood storage, and flood flow conveyance for the basin. The hydraulic gradient of the river system and its floodplain is moderate,

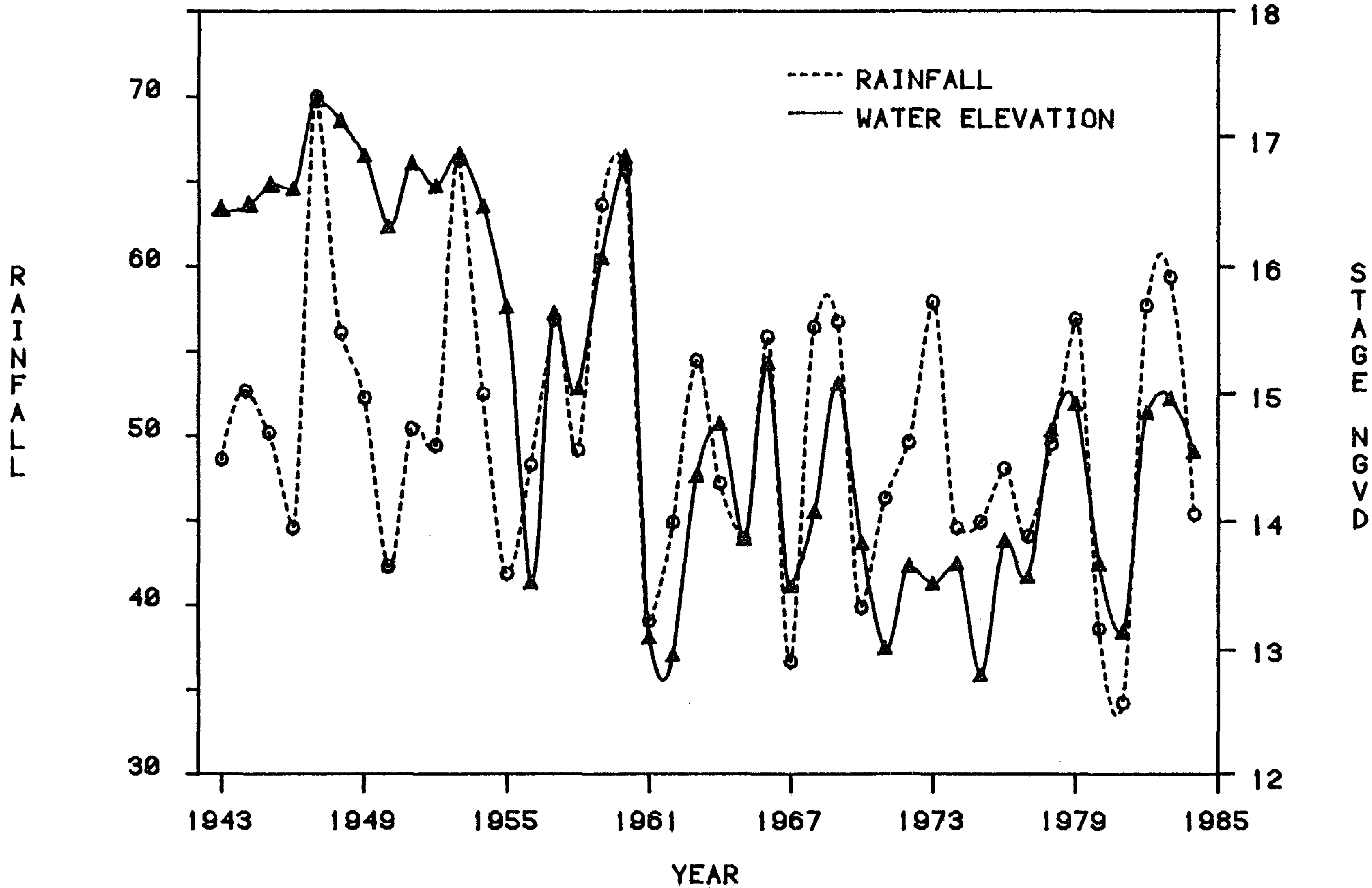

Figure 8. Variation in total annual rainfall and surface water elevation at Lake Washington from 1943-1984.

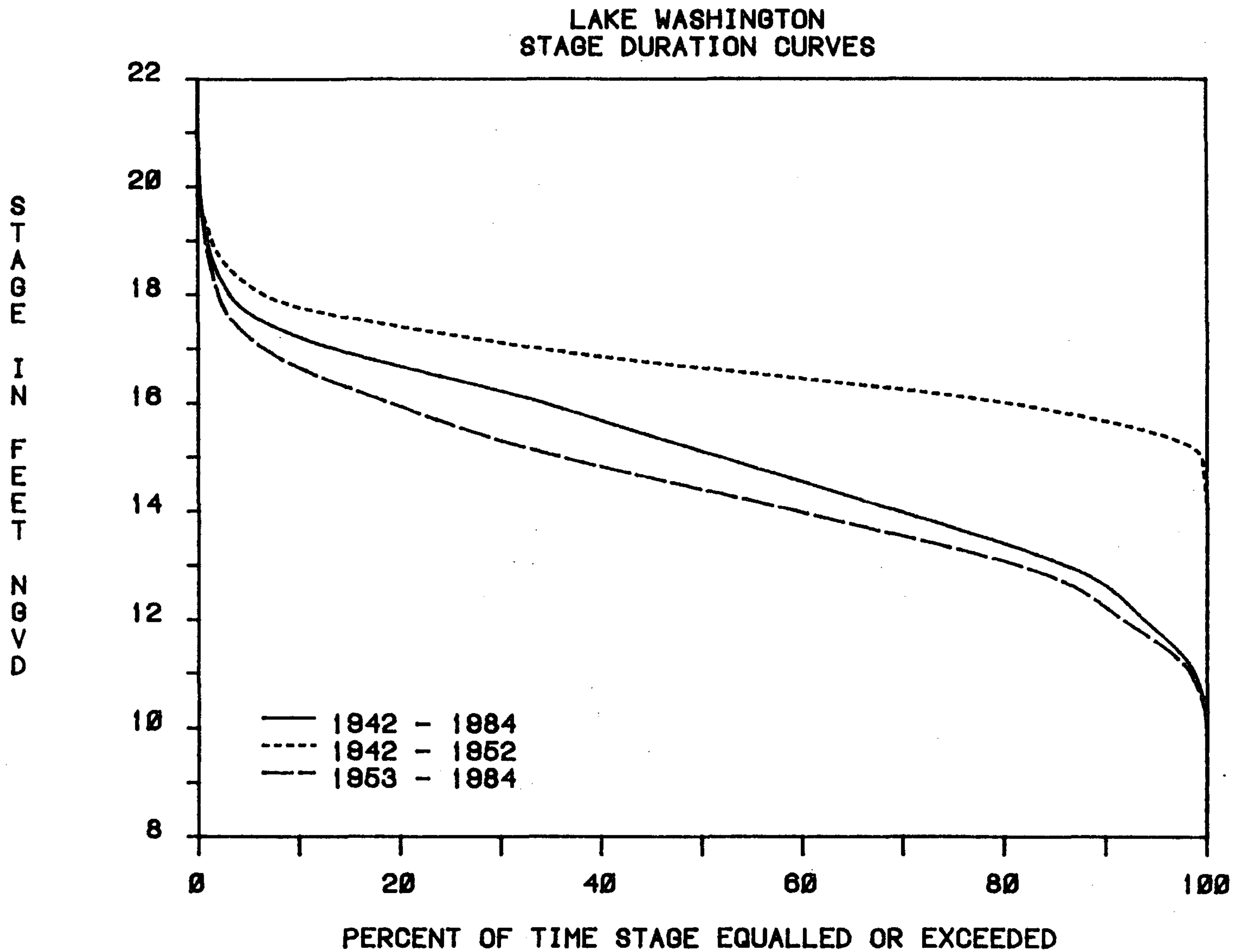

Figure 9. Stage duration curves for the St. Johns River at Lake Washington.

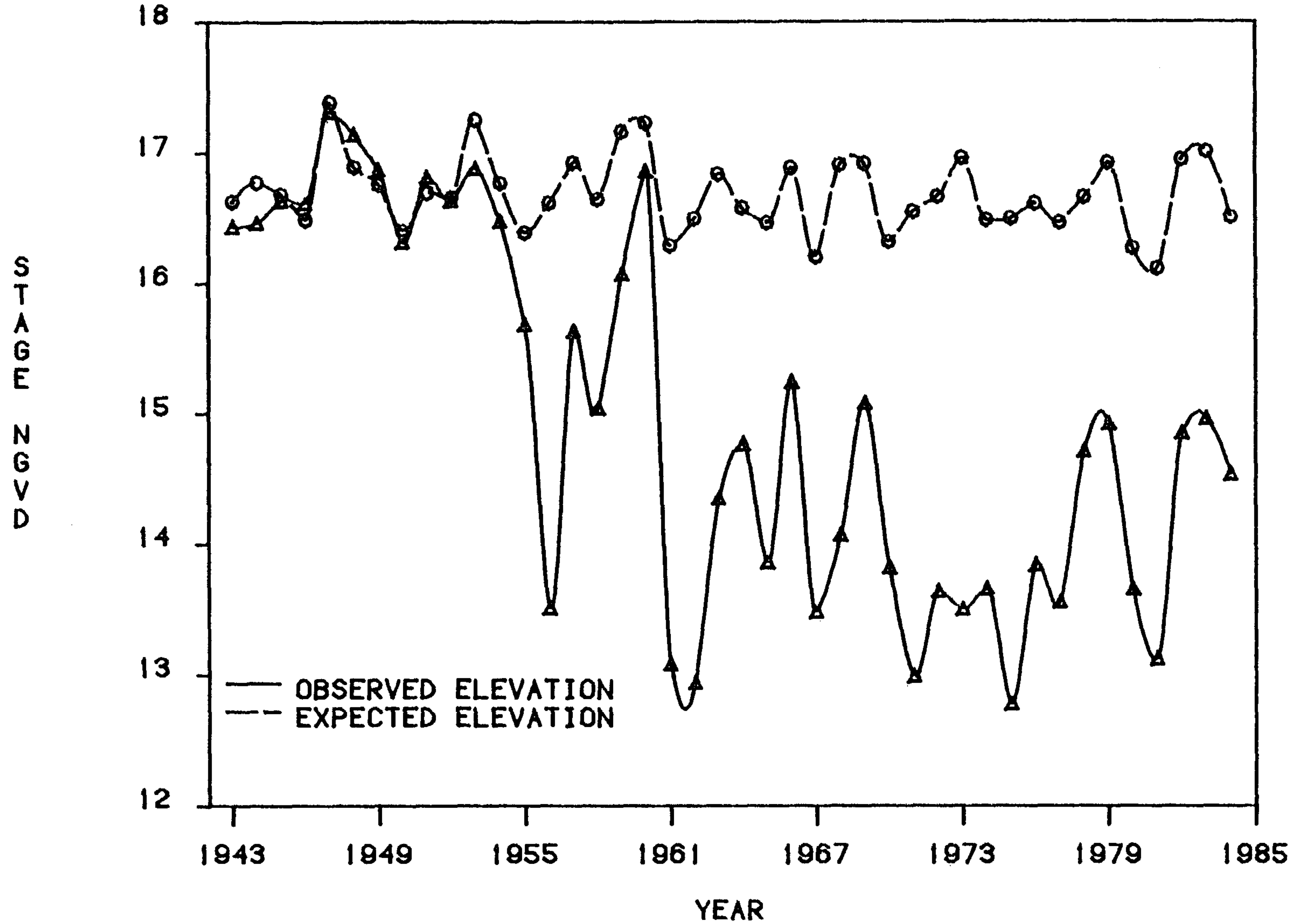

Figure 10. Observed and expected relationship between rainfall and surface water elevation at Lake Washington from 1943-1984. Expected stages were calculated using the formula, Stage = 14.9 + 0.0356 • Rainfall, determined using the regression of average stage vs. rainfall for the period 1943-1952 (R^2 = 0.72).

except in sections where construction of private levees has severely reduced the floodplain (SJRWMD, 1980).

The floodplain receives its inflow from two sources: surface runoff and streamflow across the Lake Washington weir. Under natural conditions, major storm events would have produced two distinct discharge peaks: one from surface runoff and a second due to the flood wave from upstream reaches (SJRWMD, 1980). Today the runoff pattern has been altered significantly by the construction of major levee systems. In addition, the installation of the fixed crest weir at the outlet of Lake Washington has substantially altered the flow regime.

Daily surface water elevations are gaged in the river channel immediately downstream of the Lake Washington weir. Data collection at the weir began during 1977. Surface water elevations between the weir and Lake Winder have apparently experienced the same sharp decline as Lake Washington. This is probably due to the dependence of water elevations in this reach upon upstream discharges. The weir maintains stages within the Lake Washington Basin at higher levels than would occur in its absence, but prevents downstream flow when levels drop below 13.5 feet NGVD. During the 1981 drought, the river channel downstream of the weir received no flow for approximately 5.5 months. Consequently, many sections of the channel went dry, and the yearly average stage was 11.09 feet, with a minimum of 8.86 feet (Figure 11).

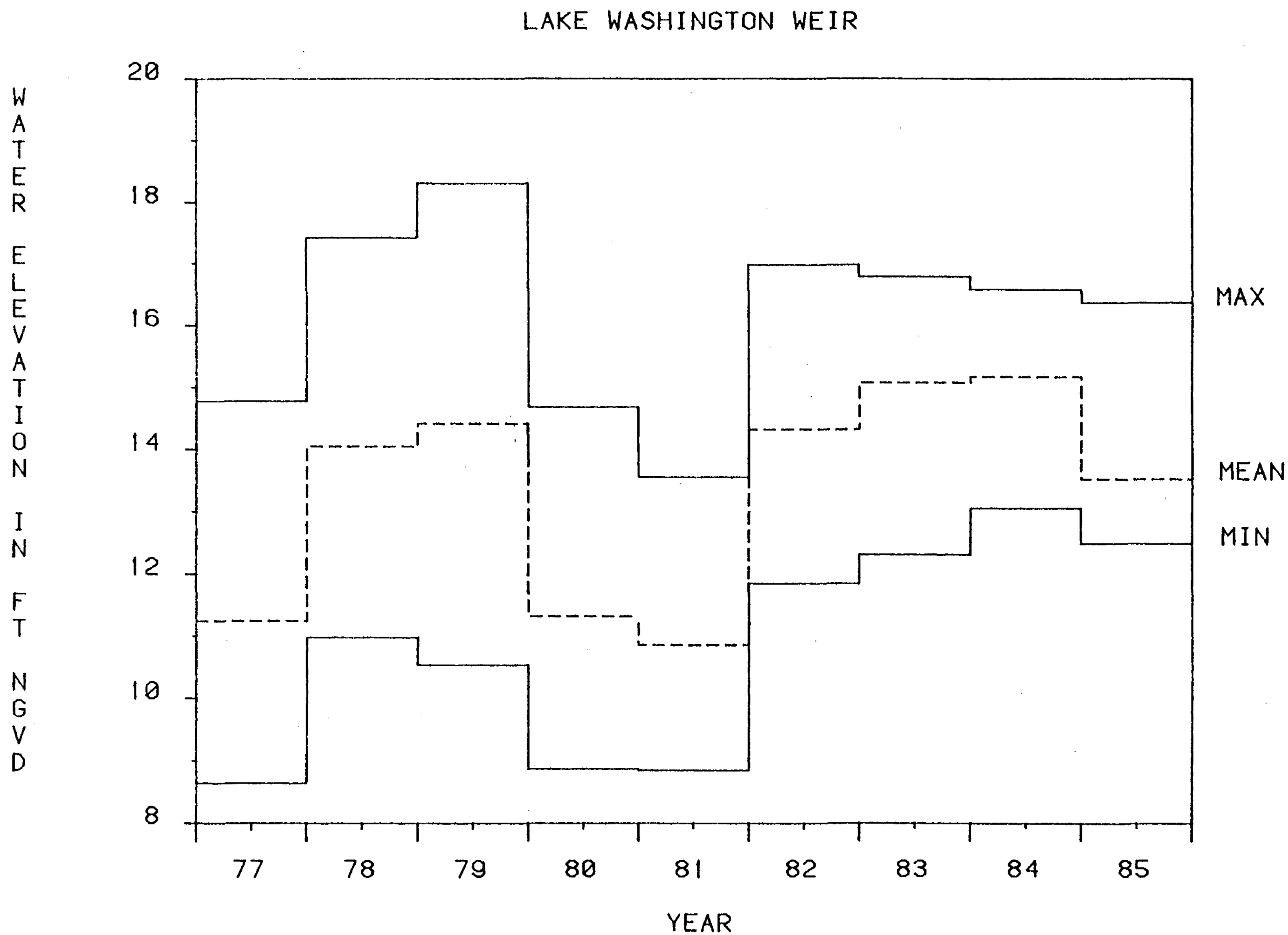

Figure 11. Yearly high, low and mean stages below the Lake Washington weir, 1977-1985.

METHODOLOGY

To accomplish the study objectives, the existing ecological conditions in the GLWB were examined and the ecological responses to long-term declines in surface water elevations were documented. Minimum level criteria were developed to maintain ecological functions and values and the non-consumptive uses outlined in Section 373.042 FS and Section 17-40.08 FAC.

Environmental Analyses and Minimum Level Criteria Development

Basin Morphometry

Temporal changes in the morphometry of the GLWB were evaluated by comparing topographic contour maps for 1954-1960 with those for 1985. The 1954-1960 map was reconstructed from cross-sections of the floodplain obtained by the U.S. Army Corps of Engineers (1954) and Central and South Florida Flood Control District (1960), and from U.S. Geological Survey 7.5 minute quadrangle maps (topography based on 1949-1953 data). Interpretation of the field data was completed by Mr. C. Kole (SJRWMD, June 1979).

The 1985 contour map was prepared from cross-sections of the floodplain (SJRWMD Survey Party, April-May 1985 and Briel & Associates, Land Surveyors, Vero Beach, Florida, 1985-1986) and from aerial photogrammetric mapping (Kucera and Associates, Photogrammetric Consultants, Lakeland, Florida, May 1985).

Floodplain Vegetation

In order to evaluate temporal changes in the floodplain plant community structure, vegetation maps were produced by interpreting black and white aerial photographs (scale 1:1666) taken during April 1943, and false color infra-red photographs (scale 1:2000) taken during December 1985 and January 1986. Plant communities and land features were delineated stereoscopically using a Bausch & Lomb, SIS-95 Stereo Interpretation System. Each delineated polygon was assigned to one of eleven cover classes (Table 4). The 1986 vegetation map was field verified.

The Environmental Systems Research Institute (ESRI), Geographical Information System (GIS) was used to digitize and assign numeric codings to the various map features. The GIS was then used to calculate areas for each cover type, to plot the cover maps, and to produce data tables.

Table 4. Description of cover classes used for analysis of aerial photographs.

Cypress	Forest communities dominated by bald or pond cypress and flooded annually for periods of long duration.
Hardwood Swamp	Forest communities dominated by a mixture of deciduous hardwoods and cypress. Subject to annual, seasonal periods of prolonged flooding.
Hydric Hammock	Forest communities dominated by a mixture of broad-leaved evergreen and deciduous tree species. Seldom inundated but with saturated soils during much of the year.
Shrub Swamp	Shrub communities dominated by willow or buttonbush. Subject to lengthy seasonal inundation.
Transitional Shrub	Shrub communities dominated by wax myrtle, *Baccharis*, or other shrub species with similar inundation tolerances. Hydrologic conditions similar to those of wet prairie or hydric hammock sites.
Deep Marsh	Herbaceous or graminoid communities dominated by water lilies or emergent vegetation. Inundated semi-permanently or permanently.
Shallow Marsh	Herbaceous or graminoid communities dominated by species such as sawgrass, maidencane, pickerel weed, arrowhead, or cattail. Subject to lengthy seasonal inundation.
Wet Prairie	Communities of grasses, sedges, rushes, and herbs, typically dominated by sand cordgrass, maidencane, salt grass, or a mixture of species. Usually inundated for a short duration each year; but with prolonged soil saturation.
Floating/ lakeshore emergents	Communities of grasses, sedges, rushes, and herbs, typically dominated by bulrush, torpedo grass, hyacinth, water pennywort and other species, along the littoral zone of lakes or river channels.
Open Water	Lakes, ponds and river channels.
Upland	All other categories of vegetation or land uses.

Minimum Level Criteria Development

Ecological-Hydrologic Criteria. The ecological-hydrologic criteria used in this study were developed by Brooks and Lowe (1984), as part of an EPA Clean Lakes diagnostic feasibility study of the USJRB to evaluate regulation schedules associated with the structural components of the recommended plan for the Upper St. Johns River Basin Project (USJRB Project). The intent of these criteria was to insure that alteration of the hydrologic regime did not adversely impact the functions and values of the floodplain wetlands.

The general ecological-hydrologic criteria for marshes with histosol soils are as follows:

1) The mean depth and frequency of inundation for the central critical marsh elevation should be such that there will be no net subsidence of organic soils. This criterion is extremely important in an area such as the USJRB, where there has already been considerable subsidence of organic soils. Studies in the Everglades (Stephens, 1974) demonstrate that to prevent subsidence a mean water table depth of approximately 0.25 feet below the marsh surface must be maintained (criterion 1a). This criterion alone, however, is not sufficient. In the work of Stephens (1974), water depth was held constant. Where water depth fluctuates, a frequency distribution of depths skewed toward the maxima could cause subsidence even though the mean depth of the water table is no lower than 0.25 feet below the marsh surface. In other

words, to prevent subsidence, the soil must also be saturated for some minimum length of time in a typical year (Brooks and Lowe, 1984). Assuming that the elevation of the peat has reached equilibrium with the historical hydrologic regime, duplication of the historic frequency of inundation should prevent subsidence.

Studies in the floodplain south of Blue Cypress Lake, an area with similar soils, indicate that the minimum frequency of inundation on the central critical marsh elevation should be 60 percent (criterion 1b). The central critical marsh elevation is the central elevation of the zone delimited by the upper and lower critical marsh elevations. The upper and lower critical marsh elevations are determined from the stage area curve and are defined as the upper and lower elevations of the marshflat. The critical zone thus contains the majority of the wetland acreage. Hydrologic constraints concerning long-term events (e.g., mean depth) will reference the central elevation.

2) The natural timing of fluctuation in water depth should be retained. Maintenance of a natural seasonality in water depth is essential to assure the breeding success of wading birds (Kahl, 1964) and other species with seasonal reproductive cycles such as the alligator (Fogarty, 1974), and black bass (Heiding, 1975). Thus, the minimum depth should occur between April 1 and June 30 and the maximum between September 1 and November 31 in a typical year (Figure 5).

3) Short-term (30-60 days) and infrequent (return interval greater than 10 years) minima are not considered detrimental.

4) A minimum range of fluctuation in water depth should be maintained. Specifically, the lower and upper critical marsh elevations should experience both exposure and inundation in a typical year. Fluctuation of water levels in the marsh is necessary for the maintenance of populations of drawdown dependent plant species and wading birds which depend on the concentration of fish and invertebrates during the dry season (Kushlan et. al, 1975; Kushlan, 1976). Drawdown is also necessary to support the seasonal bloom of productivity which accompanies wet season reflooding (DeSottele et.al., 1982).

5) The duration and intensity of maximum water elevations should not significantly damage or alter the plant communities at the lower critical marsh elevation. Vegetation tolerances of extreme water depths were established by analysis of historic stages relative to the distribution of the dominant plants along an elevation gradient in the Blue Cypress Lake marsh (Lowe, 1983; Brooks and Lowe, 1984). Maximum 30 and 60 day depths of 4.8 feet and 3.3 feet, respectively, are recommended to protect marsh vegetation within the USJRB.

Criteria 1a and 1b are regarded as primary criteria. The other criteria described are less critical and are considered as secondary criteria. These criteria are aimed primarily at protection of floodplain wetlands. The need for additional criteria was assessed with specific reference to water quality, transfer of detrital materials and sediments, fish and wildlife habitat, recreation and navigation, and aesthetics and scenic attributes.

RESULTS

Floodplain Alteration

Basin Morphometry

In the early period (1954-1960) the elevation of the annual floodplain in the Lake Washington Basin was between 14 and 16 feet NGVD (Figures 12 and 14). In the later period (1985) the annual floodplain lay between 13 and 15 feet NGVD (Figures 13 and 14). This is an average basin-wide loss of approximately one foot in elevation, over a 32 year period (1954-1985). Field observations indicate that soil subsidence on the order of two to three feet occurred in many areas north of the Lake Washington weir.

Thus, the present morphometry of the basin resulted from a reduction in the frequency of inundation of the floodplain since 1952 (Figure 9). The increased frequency of exposure and drying of the organic soils (histosols) caused subsidence through biological oxidation, erosion and shrinkage. In addition, some areas experienced an even greater loss of soil due to fires, which burned the peat. Such an event swept across the basin north of the weir during 1980-1981, compounding the effects of a severe drought.

Floodplain Vegetation

Early (1943) and late (1985-1986) vegetation maps of the GLWB (Figures 15 and 16) show the large scale changes that

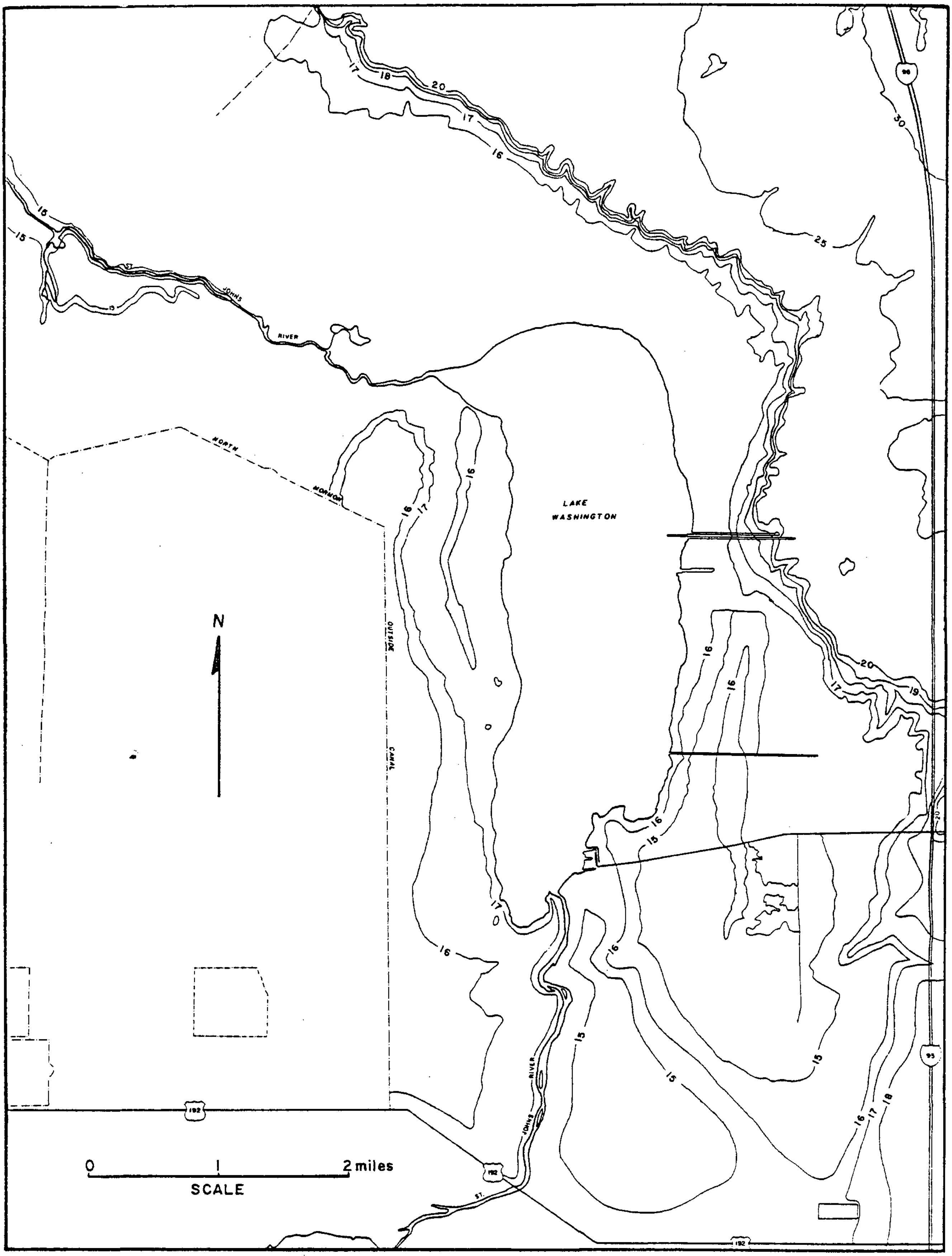

Figure 12. Map of the greater Lake Washington basin showing one-foot elevation contours for the time periods 1954-1960.

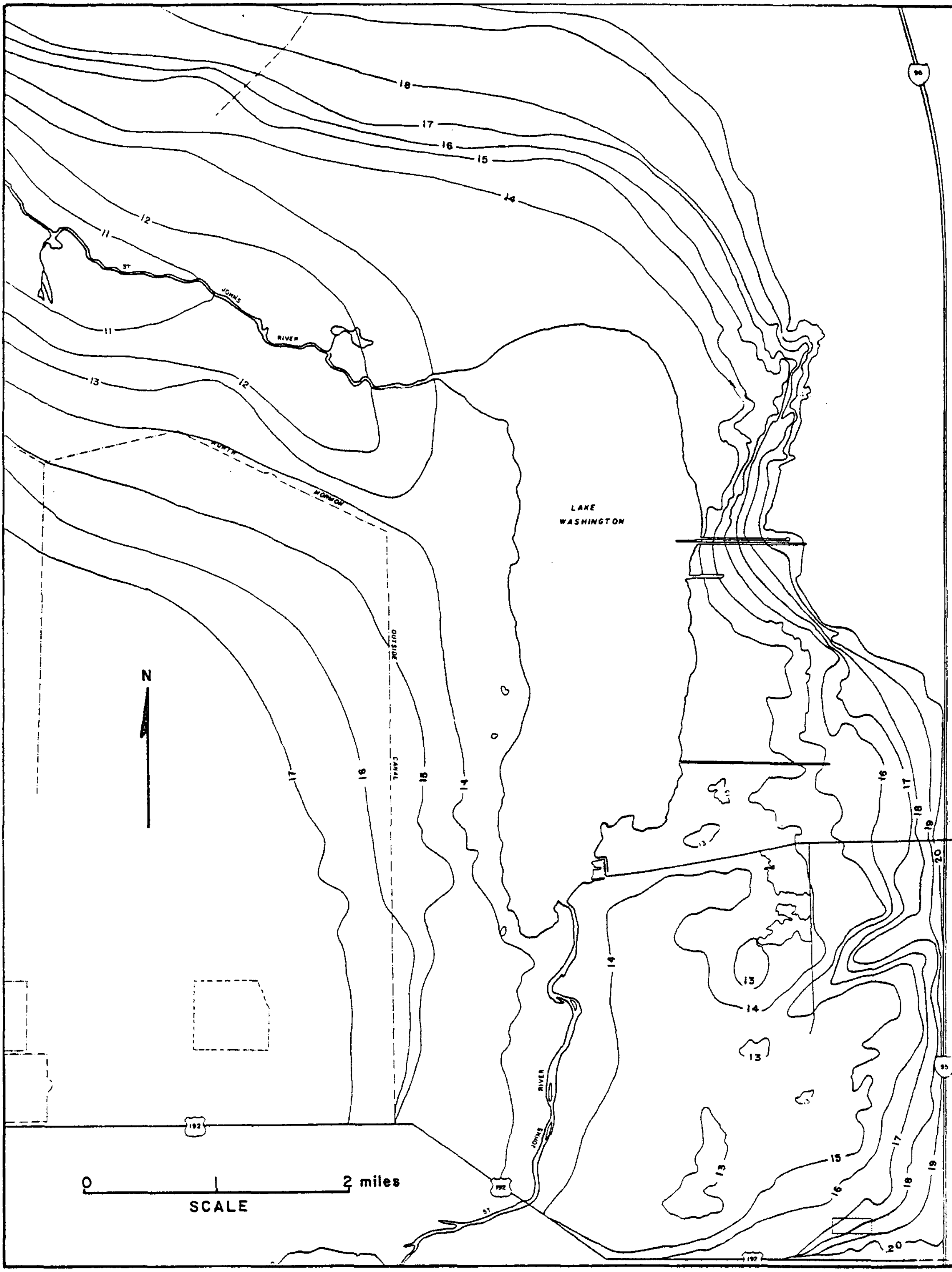

Figure 13. Map of the Greater Lake Washington Basin showing one-foot elevation contours for the time period 1985.

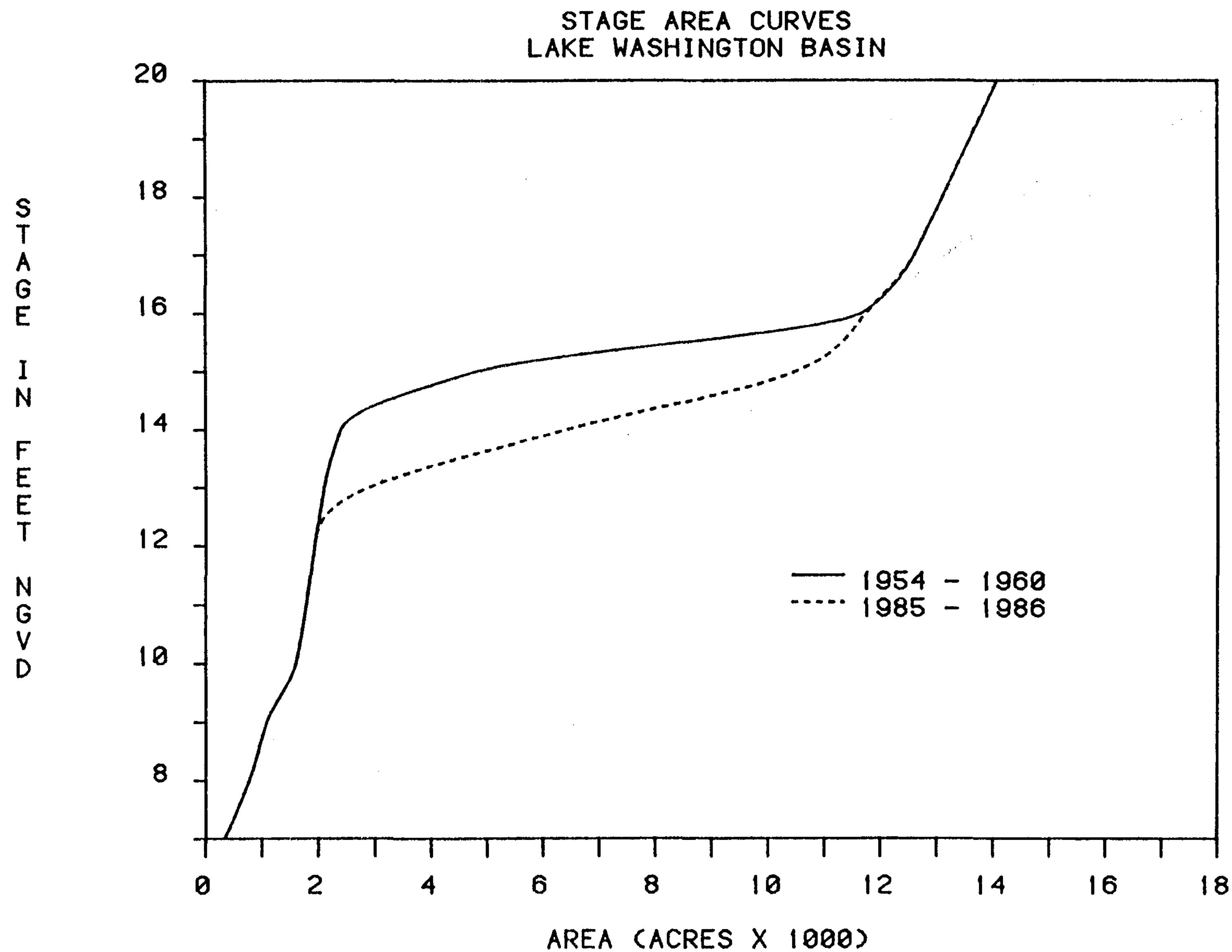

Figure 14. Stage area curve for the Greater Lake Washington Basin, 1954-1986.

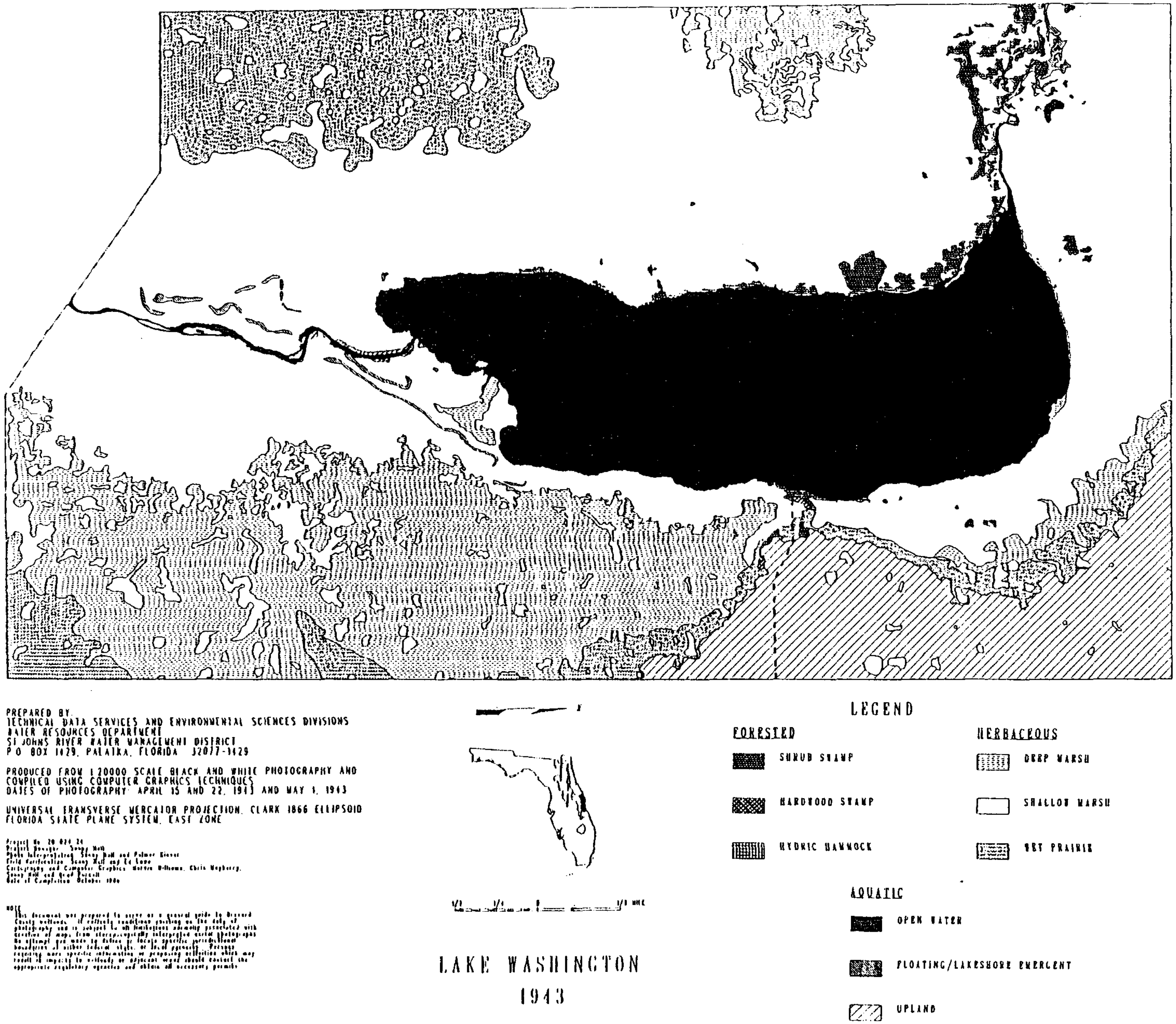

Figure 15. Wetland vegetation map for the Greater Lake Washington Basin, 1943.

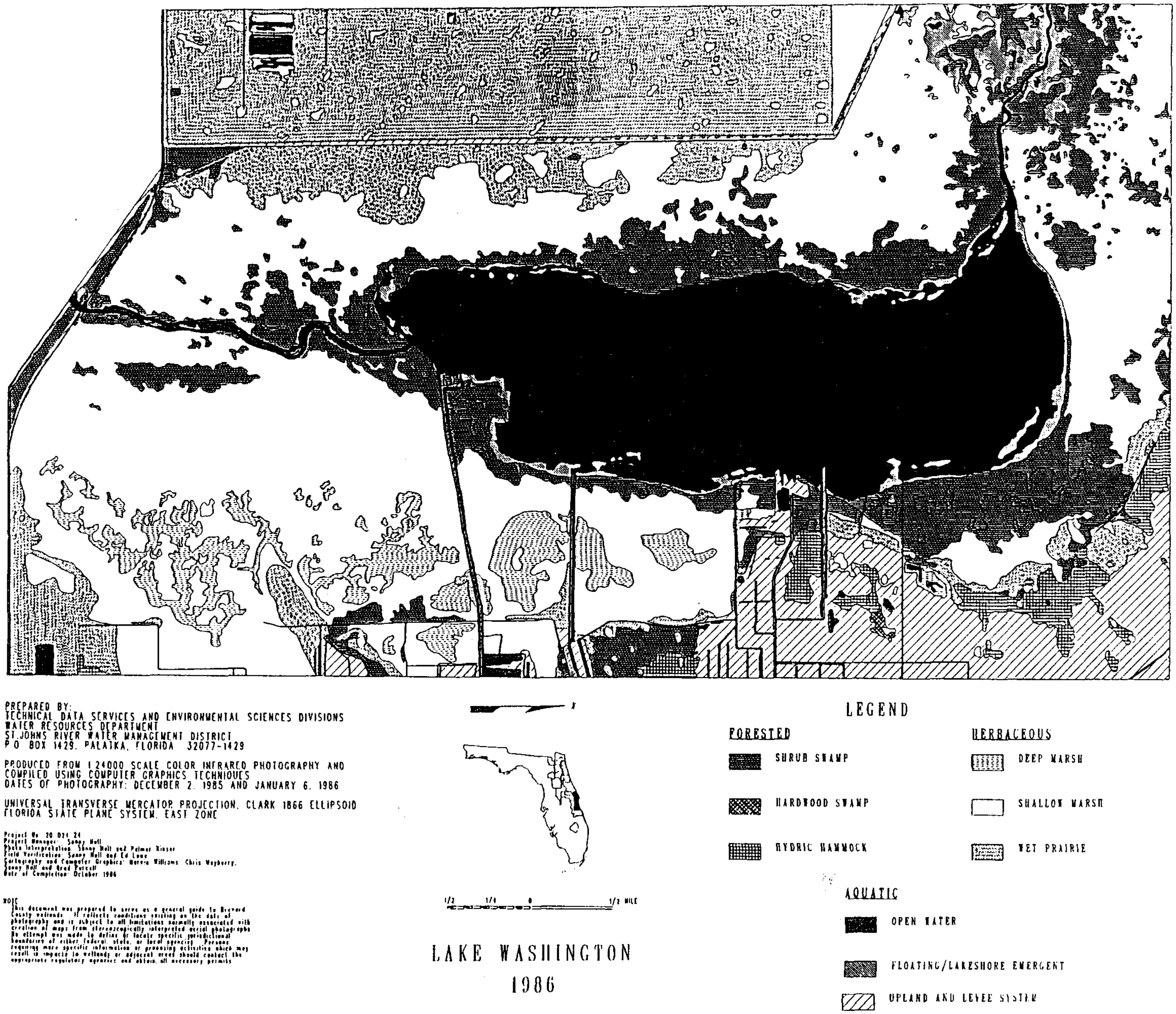

Figure 16. Wetland vegetation map for the Greater Lake Washington Basin, 1985 - 1986.

occurred in the floodplain plant communities concomitant with basin development and the reduction in floodplain inundation. In the early period (1943), shrub communities occurred primarily in transitional areas, such as lake or river shores or marsh margins, and disturbed areas, such as along road beds or levees (Figure 15). During the next 40 years the mean stage of the river declined and shrub communities became more widely distributed by expanding into areas which were previously dominated by herbaceous species (Figure 16). The areal extent of shrub communities increased by greater than 900 percent while shallow and deep marsh communities declined by 21% and 80%, respectively (Table 5). There was also a significant expansion in the areal extent of forested wetlands: hydric hammock (276%) and hardwood swamp (79%) (Table 5; Figure 16).

One of the most remarkable areas of change occurred between the weir and Lake Winder. Apparently, the frequency of inundation within this reach declined more than it did in areas to the north or south and woody plant communities expanded to the east and west, away from the higher ground of the river bank. To illustrate the magnitude of the changes that occurred in this reach, a 3.0 square mile area near the weir (Figure 17) was mapped separately. Here, the acreage of the shallow marsh was reduced by 34 percent, while the acreage of woody communities, shrub and swamp, increased by greater than 250 percent (Table 6).

Table 5. Relative cover (percent) of different types of vegetation and of open water during 1943 and 1985-86, as indicated by aerial photography of the Greater Lake Washington Basin.

Vegetation Cover Class	1943 Acres	1943 %	1985-1986 Acres	1985-1986 %	Percent Change
Open water	2,802	(17)	2,870	(17)	+ 2
Lakeshore emergent/ floating mat	80	(21)	352	(2)	+340
Deep marsh	2,989	(18)	605	(4)	- 80
Shallow marsh	7,870	(47)	6,190	(37)	- 21
Wet prairie	1,614	(9)	2,967	(17)	+ 84
Shrub swamp	220	(1)	2,235	(13)	+916
Hardwood swamp	14	(21)	25	(21)	+ 79
Hydric hammock	0	(0)	276	(2)	+276
Upland	1,288	(8)	1,353	(8)	+ 5
Total	16,877	(100)	16,873	(100)	--

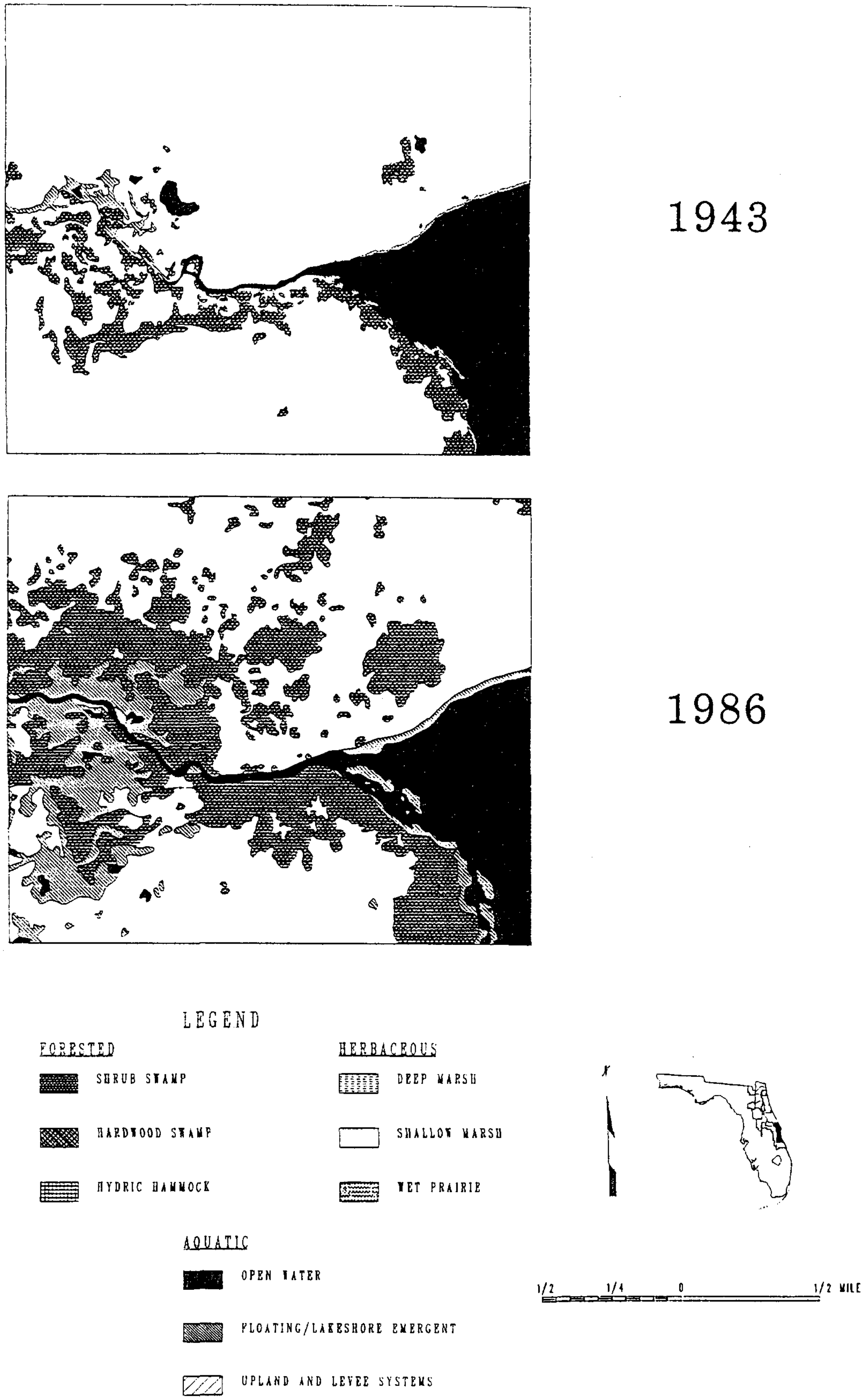

Figure 17. Changes in the distribution and composition of floodplain plant communities for a three square mile area along the St. Johns River, northwest of Lake Washington.

Minimum Level Criteria

Floodplain Vegetation and Soils

The low flow/stage requirements of the floodplain marsh adjacent to Lake Washington and downstream (i.e., north of the lake) are prime considerations in this study. To examine critical conditions within the GLWB, a point 1.3 miles downstream of the weir (RM 253.1) and a point in the center of Lake Washington (RM 258.8) were selected (Figure 18).

Using the 1985 topographic data, stage-area curves were developed for both localities and critical marsh elevations determined (Figure 19 and 20). Using these elevations and the general criteria previously described, ecological/hydrologic criteria specific to RM 258.8 and RM 253.1 were developed.

Primary Criteria

1. The mean water elevation shall not be less than 13.75 ft. NGVD and 12.45 ft. NGVD for RM 258.8 (Lake Washington) and RM 253.1, respectively.
2. The cumulative frequency of inundation for the central critical marsh elevation, 14.0 ft. NGVD and 12.7 ft. NGVD for RM 258.8 and RM 253.1, respectively, shall not be less than 60 percent.

Table 6. Relative cover (percent) of different types of vegetation and open water, during 1943 and 1985-86, for a three square mile area northwest of Lake Washington.

Vegetation	1943		1985-1986		Percent
Cover Class	Acres	%	Acres	%	Change
Open water	252	(13)	237	(12)	- 6
Lakeshore emergent/ floating	30	(2)	195	(10)	+550
Shallow marsh	1,550	(78)	1,024	(52)	- 34
Shrub swamp	145	(7)	521	(26)	+259
Upland	0	(0)	<1	(<1)	< 1
Total	1,977	(100)	1,977	(100)	--

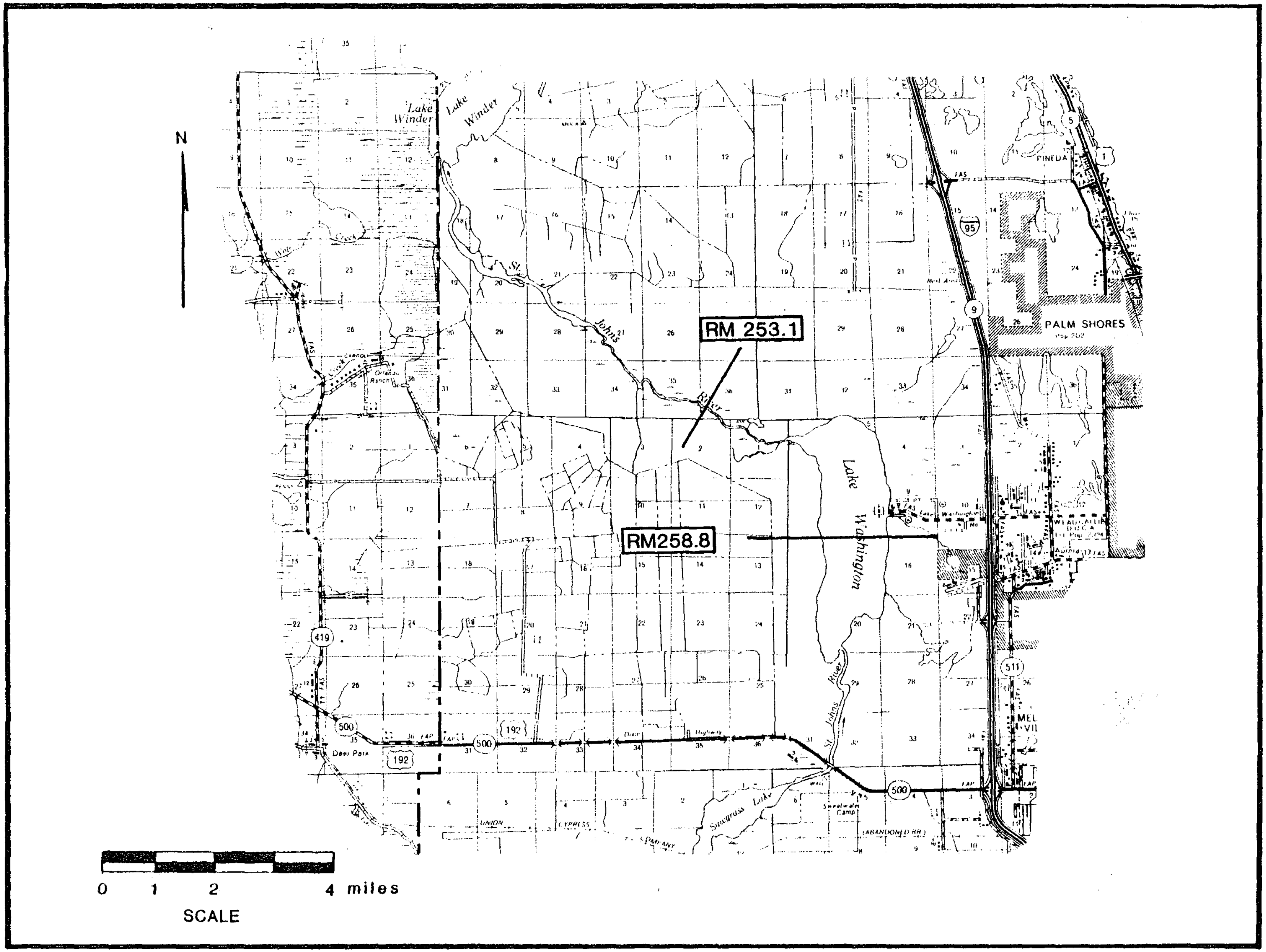

Figure 18. Map of the GLWB showing river miles used for hydrologic simulations and environmental analyses.

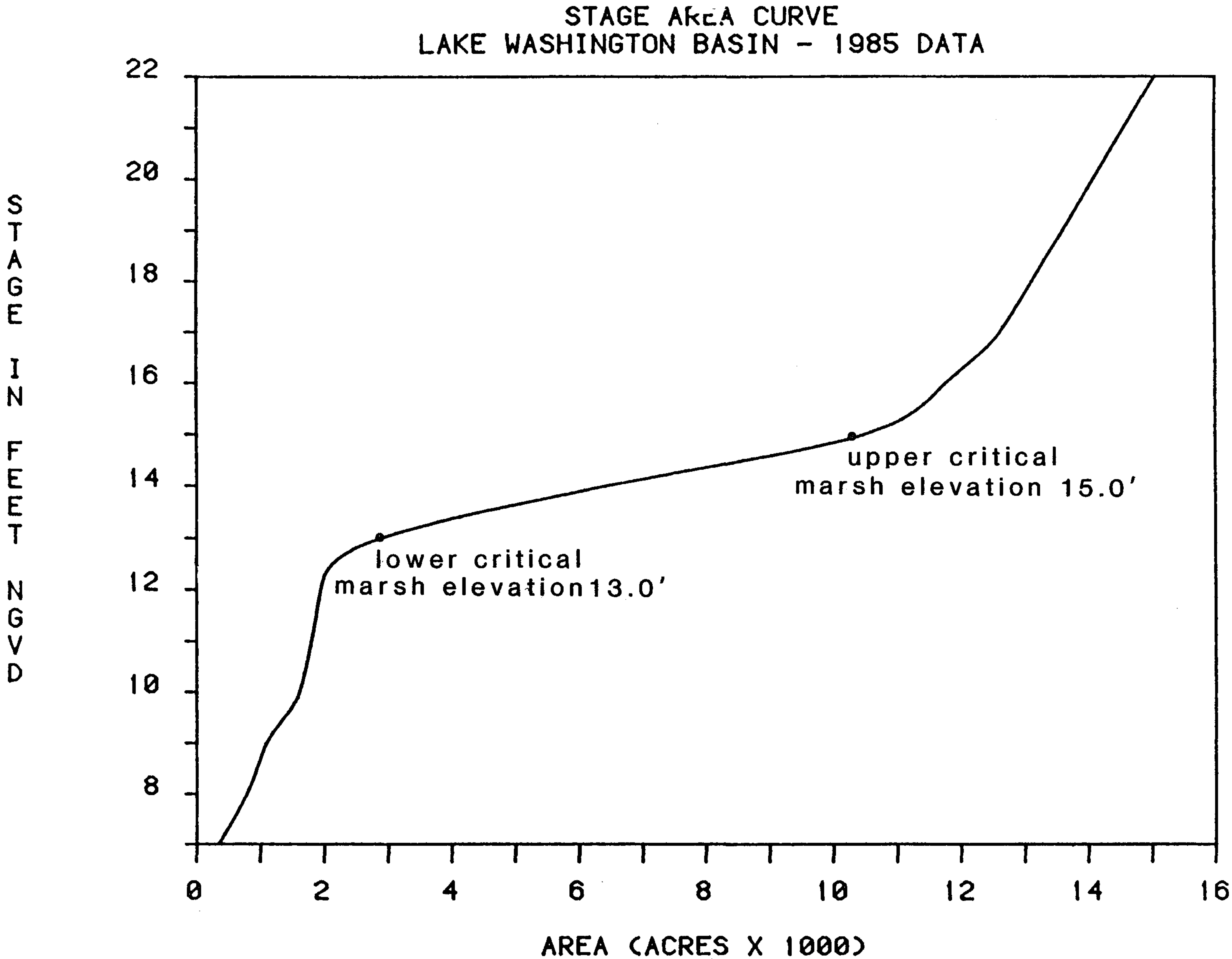

Figure 19. Stage area curve for the Lake Washington Basin.

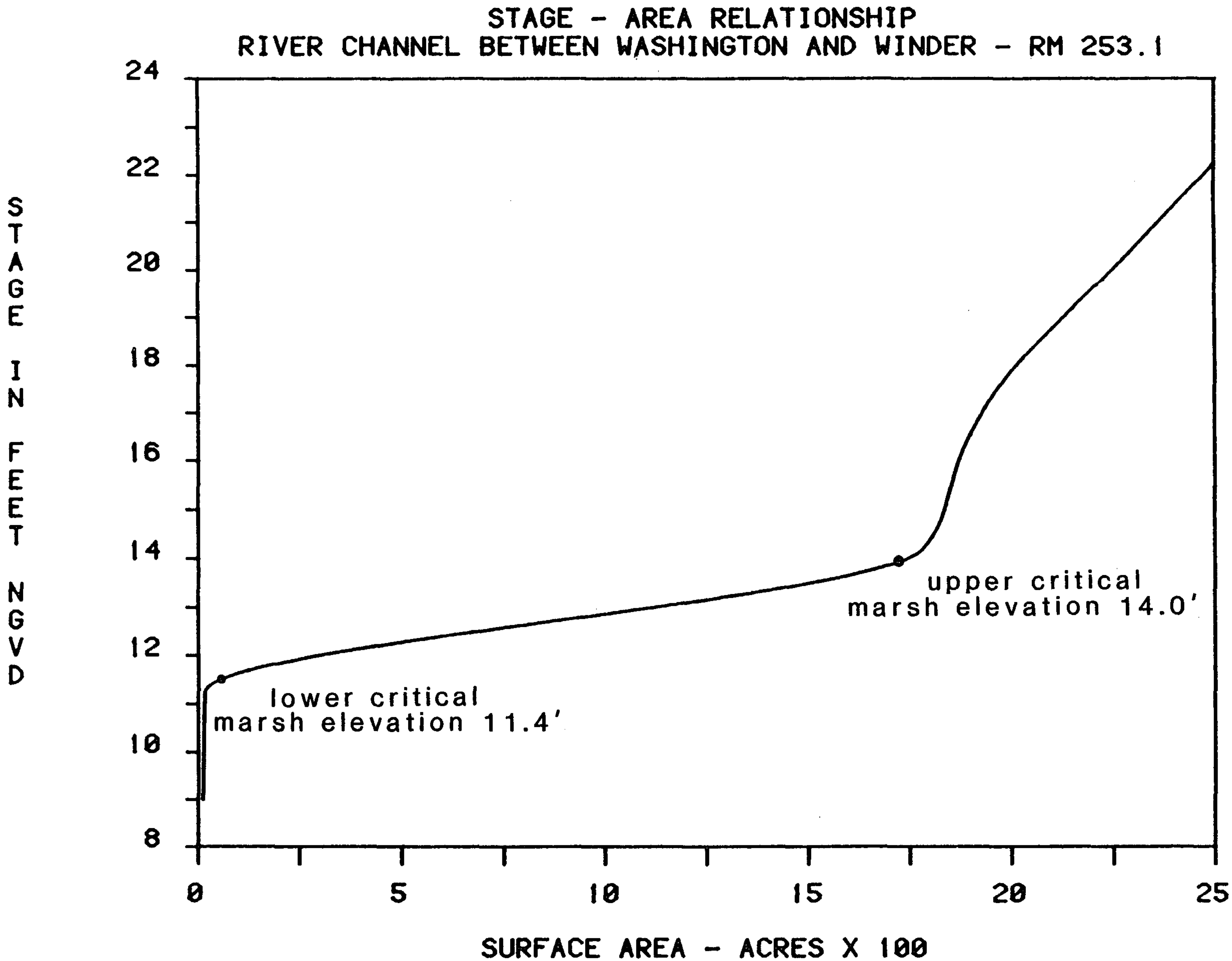

Figure 20. Stage area curve for RM 253.1, 1.3 miles downstream of the Lake Washington weir.

Secondary Criteria

3. The natural timing of fluctuation in water depth should be retained.
4. Water levels in a typical year should both rise above and fall below the lower and upper critical marsh elevations, 13.0 ft. NGVD and 15.0 ft. NGVD for RM 258.8 (Lake Washington) and 11.4 ft. NGVD and 14.0 ft. NGVD for RM 253.1.
5. Maximum 30 and 60 day elevations should not exceed 17.8 ft. NGVD and 16.3 ft. NGVD, respectively, for Lake Washington, and 16.2 ft. NGVD and 14.7 ft. NGVD, respectively for RM 253.1.

Water Quality

Lake Washington is classified as a potable water supply by the Florida Department of Environmental Regulation and is therfore, subject to Class I water quality standards (17-3.051, 17-3.061, and 17-3.091 FAC; Appendix B). Concentrations of chloride, TDS, iron and dissolved oxygen have not always met these standards. However, of these parameters, only chlorides and TDS are strongly correlated with water levels and, therefore, pertinent to this study.

The USJRB experienced a 30 inch rainfall deficit during 1981. This caused water levels to drop to near record minima and segregated the river into three sections separated by the

Fellsmere Grade and the Lake Washington weir. During this drought the water column of Lake Washington became more mineralized as the concentration of TDS increased (Figure 21). For 14 months the concentrations of chlorides and/or TDS in Lake Washington exceeded those levels permissible for Class I waters (Figures 21 and 22). These elevated concentrations caused no apparent ecological problems, however, they did cause concerns over the potable water supply for the City of Melbourne.

Examination of water quality data collected by personnel of the Lake Washington Water Treatment Plant indicates that the lake has become progressively more mineralized since 1960. The increased mineralization occurred simultaneously with marked declines in the mean annual stage (Figure 23). Regression analyses indicate that the past (1977-1985) relationships between stage and chlorides and stage and TDS were log linear and highly significant over a wide range in stage (Figure 24 and 25). According to equations, chloride standards should have been exceeded at stages below 12.3 ft. NGVD for the period 1977-1985. Monthly mean TDS standards should have been exceeded at stages below 12.7 ft NGVD. The predicted minimum surface water level at which chloride standards should be exceeded corresponds with the observed stage/chloride relationships. However, TDS standards were consistently violated at monthly mean stages as high as 14.13 ft NGVD.

Some of the long-term increase in mineralization was apparently caused by marked reductions in river stage. However, most of the increase occurred after the period when stages

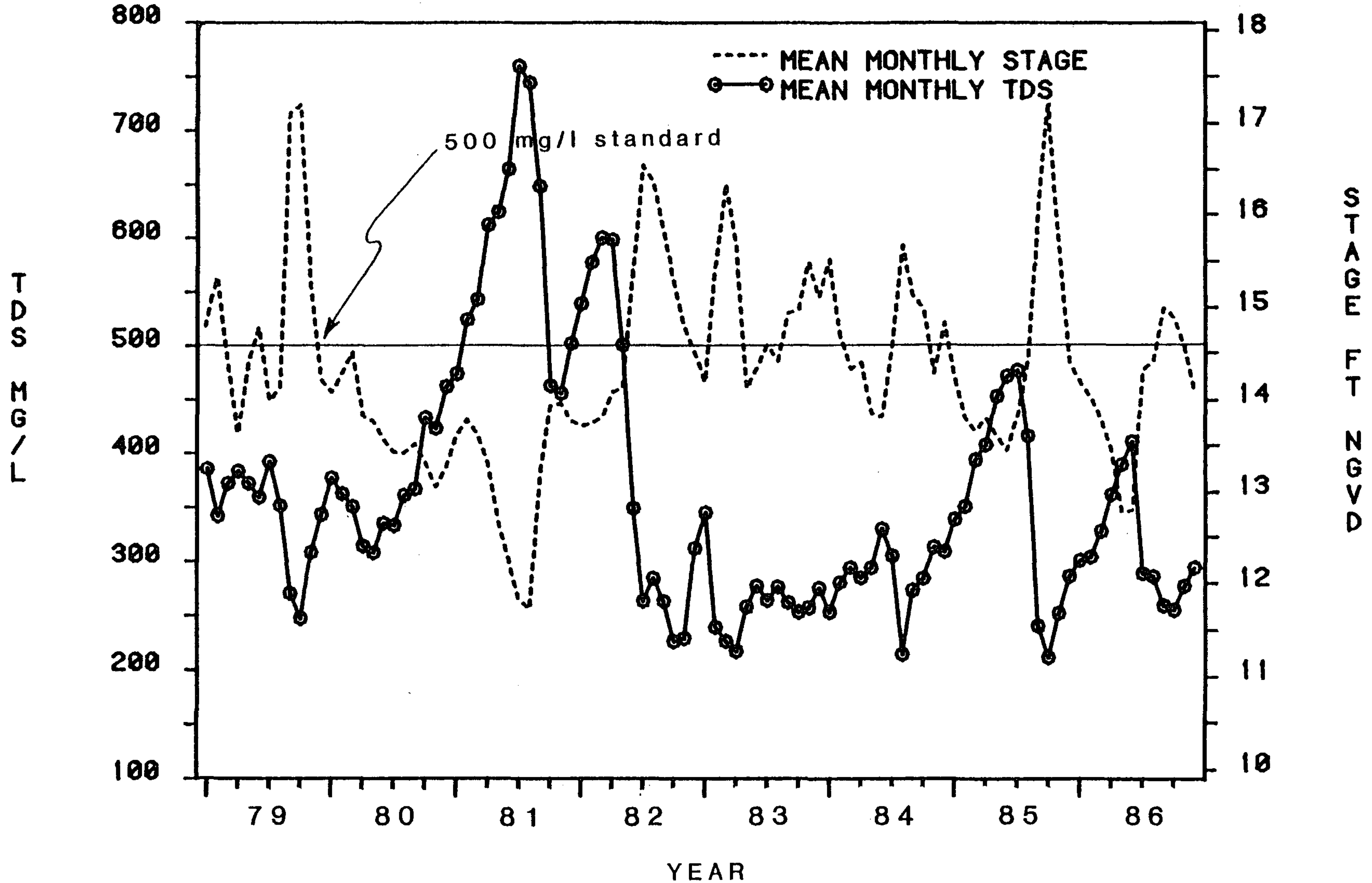

Figure 21. Trends in mean monthly total dissolved solids concentrations (TDS) and mean monthly stages in Lake Washington, 1978-1986.

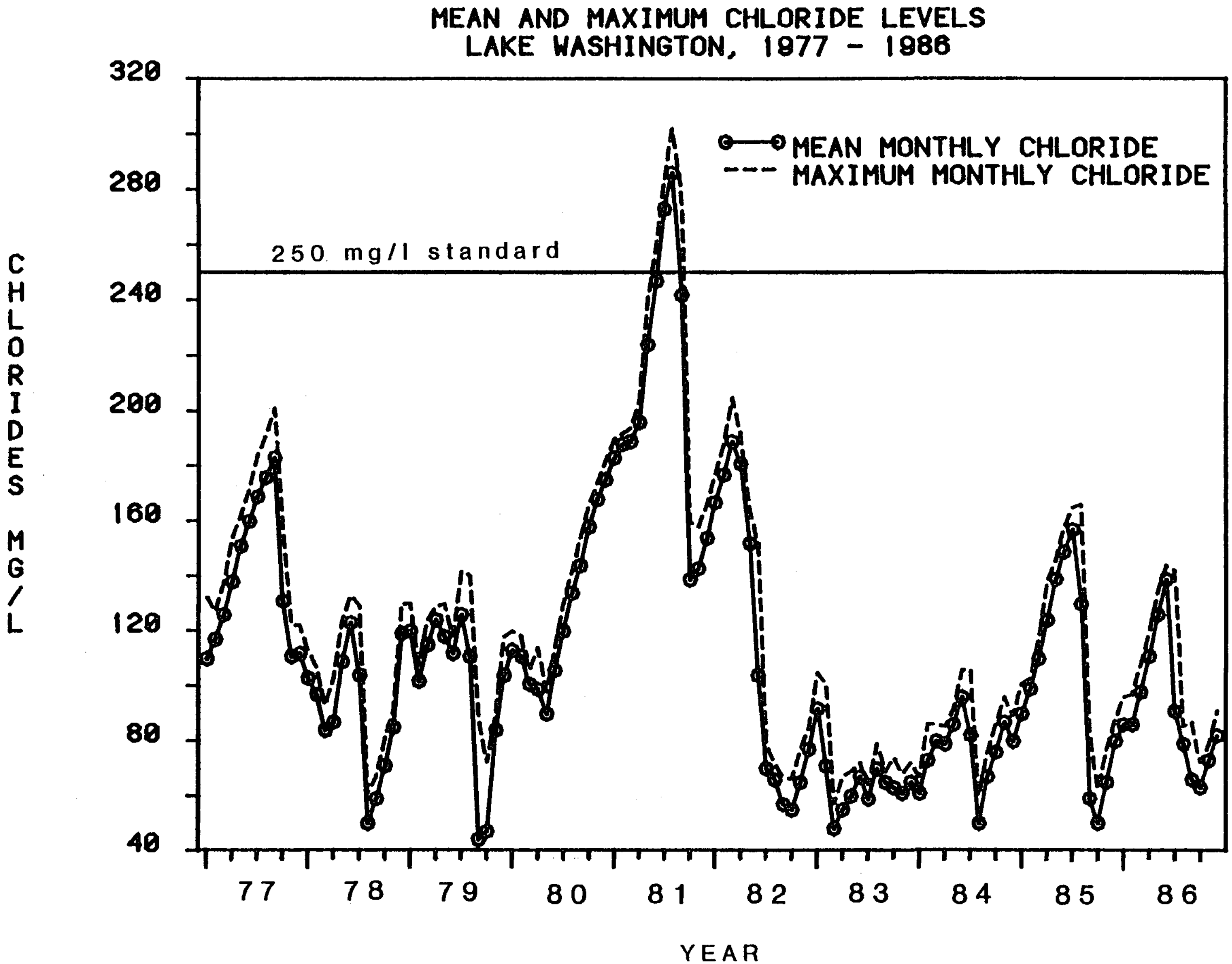

Figure 22. Trends in mean and maximum monthly chloride concentrations in Lake Washington, 1977-1986.

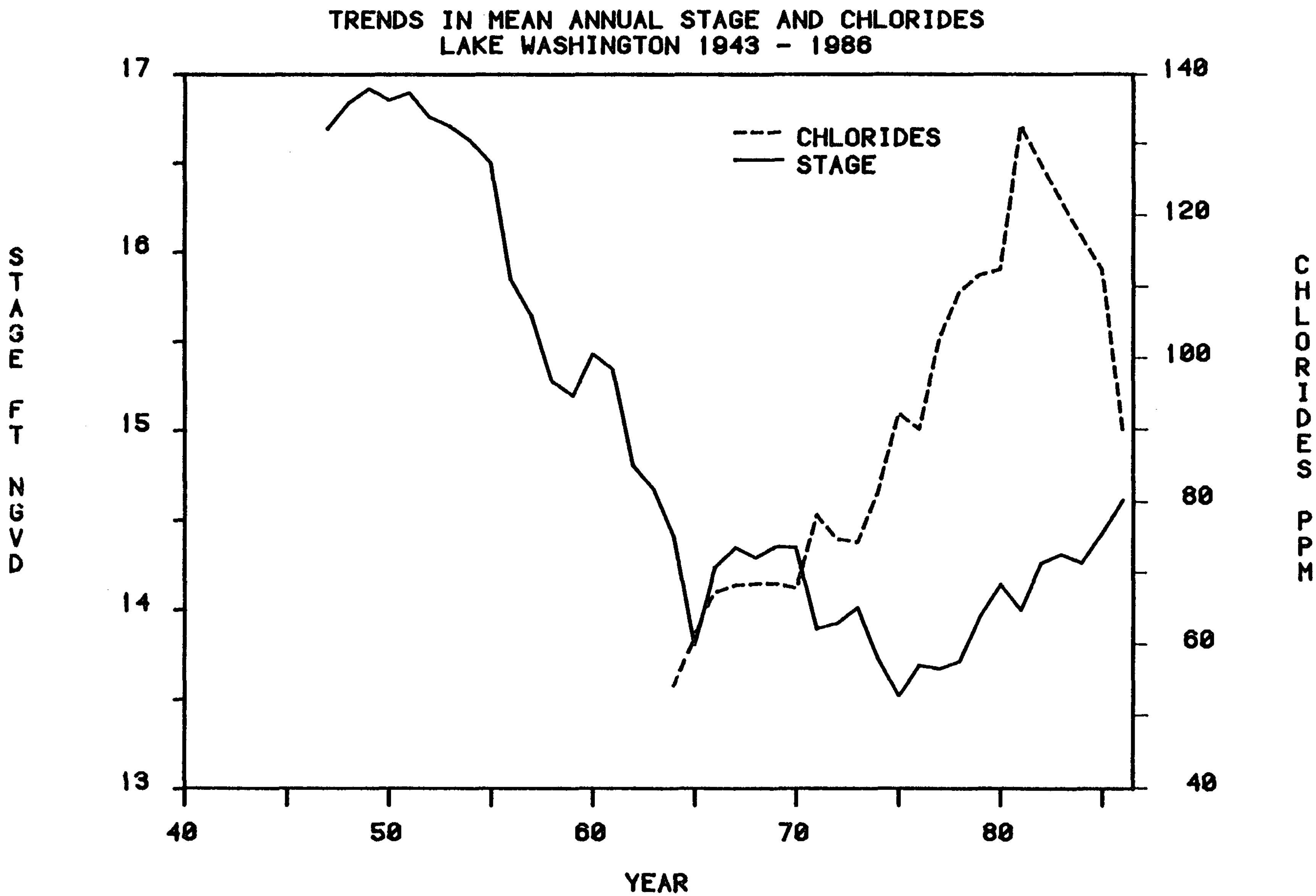

Figure 23. Variation in annual mean concentrations of chloride and annual mean lake elevation at Lake Washington, 1943-1986. Time series were smoothed using five-year running averages.

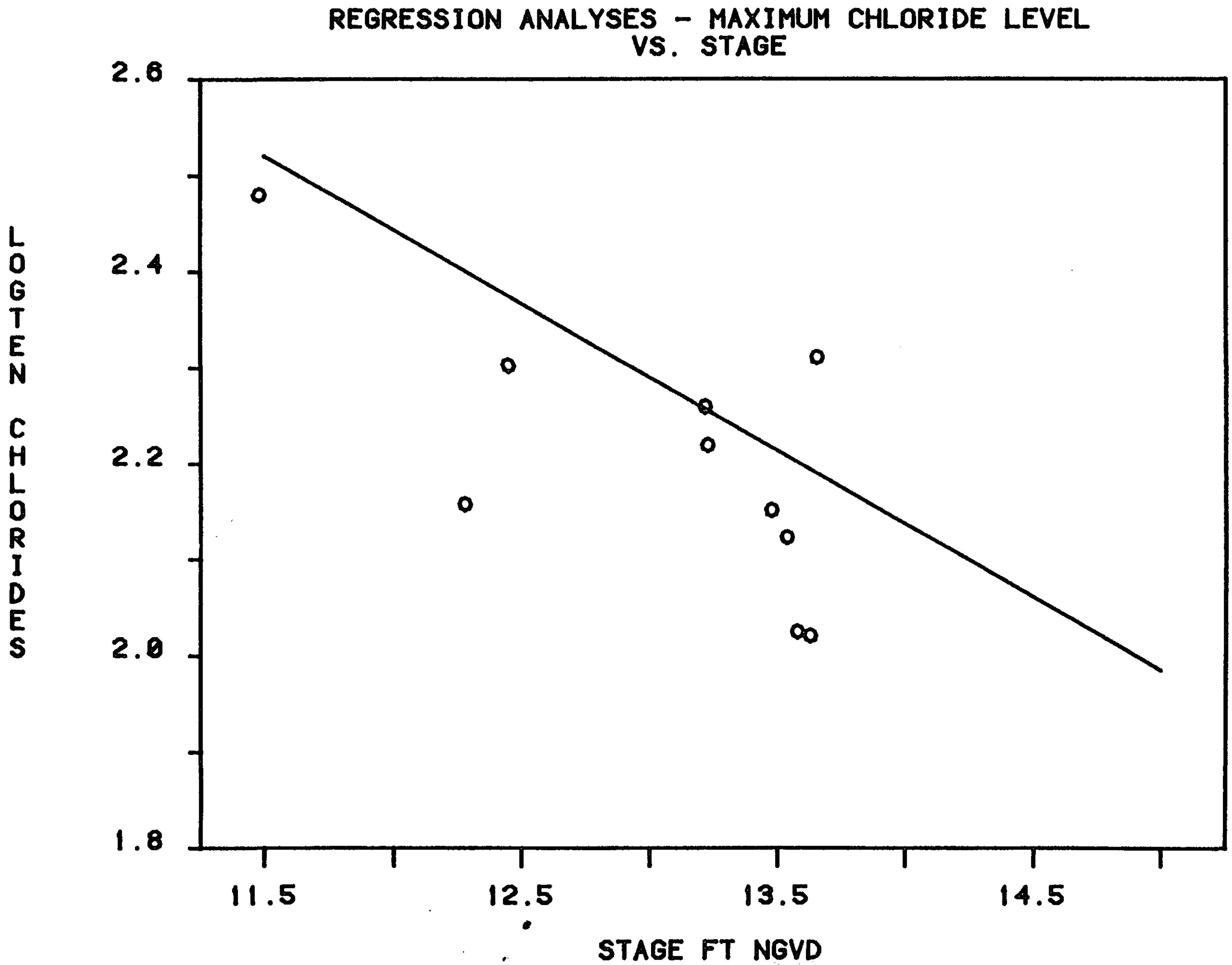

Figure 24. Relationship between annual maximum chloride concentrations and surface water stages in Lake Washington, 1977-1986. Regression equation: log chlorides (MGlℓ) = 4.28 - 0.153 (stage in ft. NGVD), $F_{1,8} = 15.93$, $p < 0.005$, $R^2 = 66.6$.

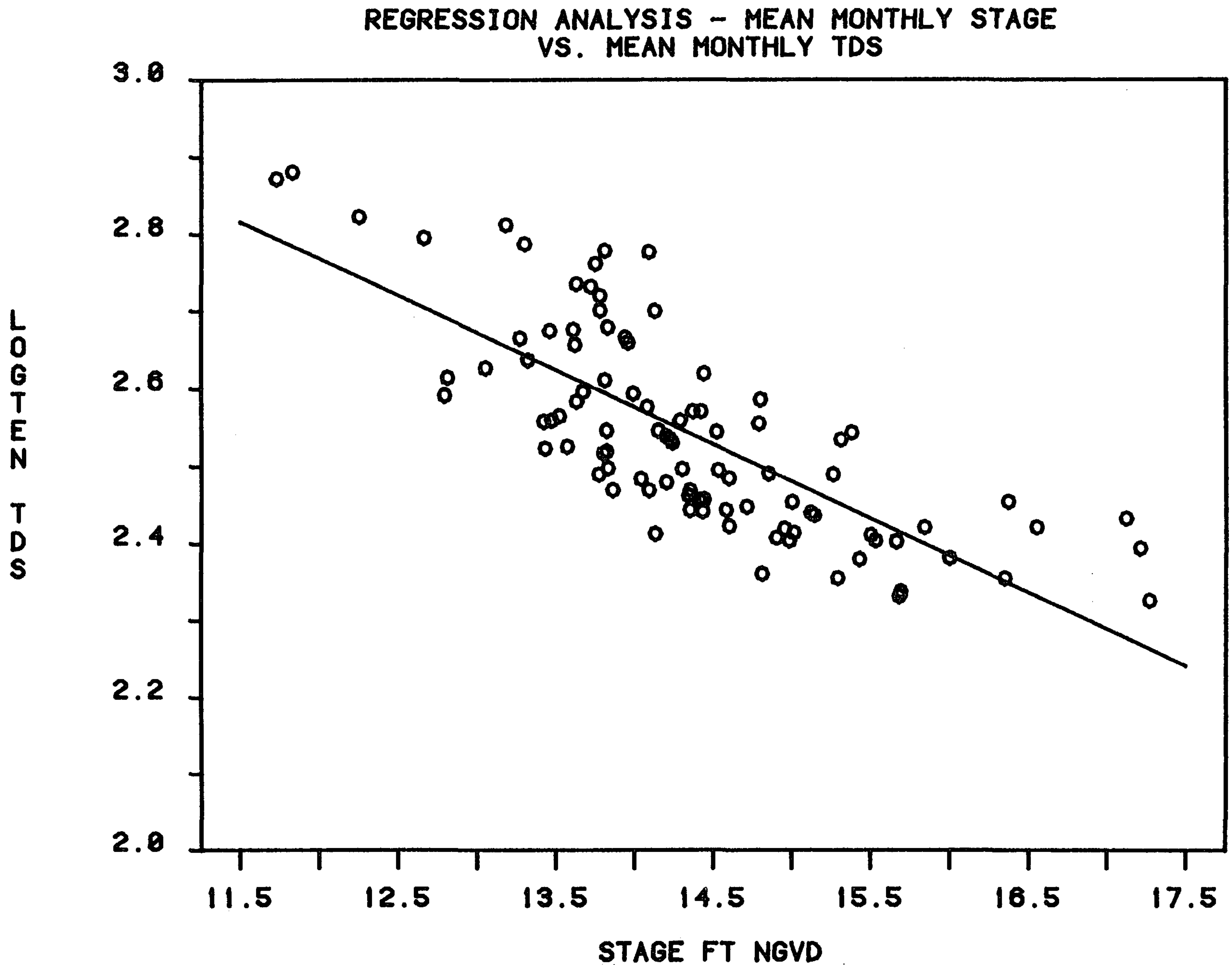

Figure 25. Relationship between monthly mean stage and monthly mean total dissolved solids (TDS) concentrations for Lake Washington (1979-1986). Regression equation: $\log_{10}$ TDS (mg/ℓ) = 3.916 - 0.0957 (stage in ft. NGVD), $F_{1,94} = 131.33$, $P < 0.0001$, $R^2 = 58.3$.

declined most dramatically (Figure 23). This suggests a change in the relationship between river stage and dissolved solids, a change which was probably caused by an increase in mineral loading due to channelization of the marsh and agricultural runoff and discharges (Lowe et al., 1984).

To investigate whether the relationship between river stage and dissolved soild concentrations had changed, annual mean chloride and stage data for Lake Washington were divided into pre-weir (1960-1976) and post-weir (1977-1986) periods. Linear regression equations were derived to represent the relationships between stage and chloride for each period (Figure 26). Statistical comparison of these regression lines indicated that they were significantly different ($F_{2,23} = 14.00$, $p<0.001$), and the corresponding chloride level for any surface water elevation would be expected to be higher during the post-weir period (Figure 26).

Therefore, the relationships between chloride and stage (and probably also TDS and stage) have changed, and will probably continue to change, as the basin's hydrology is altered by the implementation of the USJRB Project. For example, the construction of plugs in major drainage canals upstream of Lake Washington has already augmented surface water levels in the upstream marsh and will probably ameliorate low water levels in the lake during dry periods. This invalidates all models developed to predict future trends in these parameters from past

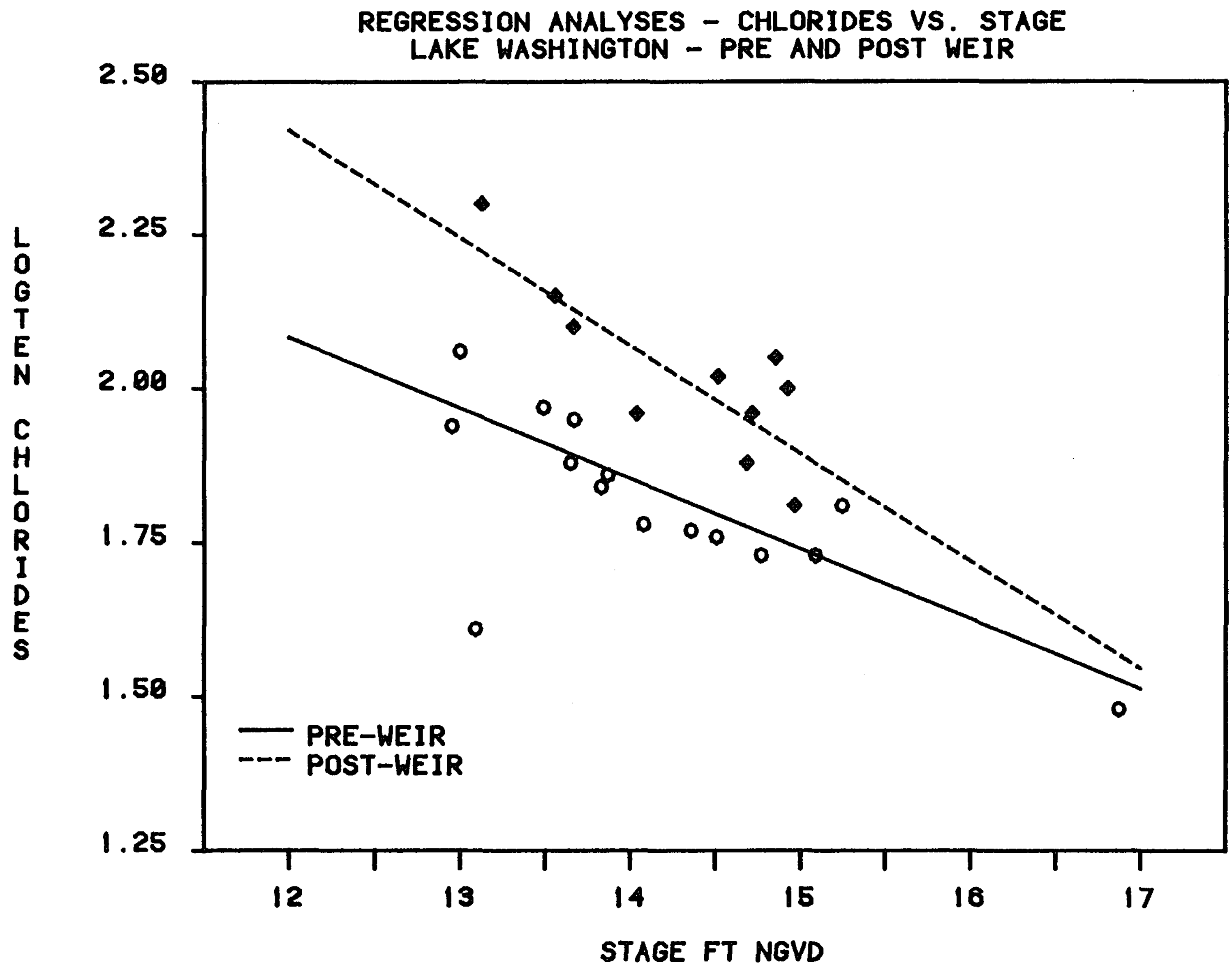

Figure 26. Relationships between annual mean chloride concentrations and annual mean stages in Lake Washington for the pre-weir (1960-1976) and post-weir (1977-1986) periods. Pre-weir regression equation: $\log_{10}$ chlorides (mgl ℓ) = 3.45 - 0.114 (stage in ft. NGVD), $F_{1,15} = 17.67$, $p < 0.005$, $R^2 = 54.1$. Post-weir regression equation: $\log_{10}$ chlorides (mgl ℓ) = 4.52 - 0.175 (stage in ft. NGVD), $F_{1,8} = 16.25$, $p < 0.005$, $R^2 = 67.0$

correlations and prevents the development of new emperical models until the basin's hydrologic regime has stabilized. While we cannot reliably predict future water quality trends or the climatic conditions which will contribute to them, according to District records the occurrence of water quality problems has been limited to 100 year to 200 year droughts. In addition, we are confident that measures taken to improve the hydrologic regime in headwater marshes upstream of Lake Washington (i.e., implementation of the USJRB Project) will decrease the frequency and duration of undesirable water quality conditions.

In establishing minimum flows and levels pursuant to Section 373.042 F.S., consideration shall be given to water quality (Chapter 17-40.08 FAC). In the case of Lake Washington applicable water quality standards include those specified in Section 17-3.091 FAC (Class I Standards; potable water supplies). Of these standards, only those for TDS and chloride appear to be directly affected by variation in water levels. However, in the absence of reliable emperical models, minimum levels appropriate to these parameters cannot be prescribed at this time. Until a minimum level based on these parameters can be prescribed,mineralization of the water column and the water budget of the lake should be primary consideration in regulation and management of the basin.

Transfer of Detrital Materials and Sediments

The existing structural configuration of the Lake Washington weir obstructs the downstream movement of sediments and detrital material. This has increased sedimentation in the river channel immediately upstream of the weir, which if continued, may interfere with navigation and necessitate dredging. Perhaps more importantly, the cessation of sediment movement disrupts downstream detrital foodchains important to the fisheries and subsequent trophic levels.

To alleviate these problems, it is recommended that a permanent weir, if constructed, be designed with moveable gates located near the river bed. These can be opened during periods of high flow to allow the scouring of sediments and detritus off the bottom for transport downstream.

Fish and Wildlife Habitat

The minimum level criteria established for the protection of floodplain soils and vegetation also provide for the maintenance of fish and wildlife habitat. Considering the central role of the soils and vegetation in the implementation of wetland functions, the protection of the floodplain with respect to the timing, frequency and duration of inundation would benefit fish and wildlife populations. There are, however, two areas of special concern: (1) the passage of fish, and (2) the maintenance of adequate water depths to allow for the movement of fish and wildlife and provide refugia during drought conditions. The existing weir configuration prevents downstream discharges at river stages below 13.5 feet NGVD. This prevents the migration of fish. The permanent weir should provide for the movement of fish populations and maintain a downstream flow except during extreme drought (greater than 10 year drought). As a design directive, it is recommended that one day, one-in-five year low stages downstream equal or exceed 9.5 feet NGVD.

To maintain water depths in Lake Washington adequate to protect the fisheries during droughts; one day, one-in-50 years and one day, one-in-100 years minimum surface water levels should equal or exceed 10.0 feet NGVD and 9.5 feet NGVD, respectively. One day, one-in-five year minimum surface water levels should equal or exceed 11.5 ft. NGVD.

Recreation and Navigation

Recreation in the GLWB is inextricably linked to boating and navigation. The lake and river provide outstanding recreational resources and they have historically been heavily used by boaters, a trend that will no doubt continue as the regional population grows.

Presently, the temporary weir is an obstacle to outboard power boats, prohibitng passage except during high flow periods. Provisions for the portage of powerboats should be a major consideration during the design phase of the new weir.

Any new Lake Washington weir should not prohibit the passage of small powerboats (16 to 17 feet in length) during those periods when the water levels are below the weir crest.

Although recreation and navigation are important uses of the resources, maintenance of navigation during extreme droughts is not warranted. Therefore, minimum level criteria for navigation are not prescribed.

Aesthetic and Scenic Attributes

The design, construction and operation of a permanent weir, should, to the extent possible, minimize impacts to the aesthetic and scenic attributes of the river.

DISCUSSION

The ecological character of aquatic systems determines their value for consumptive and non-consumptive uses. Lake Washington is a relatively small component of a large palustrine ecosystem. Its integrity is primarily dependent upon the condition of its floodplain wetlands. Consequently, the primary consideration in prescribing minimum level criteria for the lake is the maintenance of its floodplain wetlands. The following discussion clarifies the overriding importance of the floodplain wetlands.

Hydrology is a primary driving force influencing wetland ecology. Knowledge of the water regime is basic to our understanding, quantification and evaluation of wetland functions and processes (Greenson et. al, 1979; Good et al., 1978; Gopa et al., 1982) and the management of aquatic resource utilization. To protect such systems we must not only prevent their destruction, but also scientifically manage them, particularly with respect to surface water levels and flow rates (Lowe, 1986).

The key functional component of wetlands through which many ecological processes (e.g., primary production, water quality, maintenance of wildlife habitat, etc.) are implemented is the vegetation; and the character of the vegetation is primarily determined by long-term hydrologic trends (Rumberg and Sawyer, 1965; Gosselink and Turner, 1978; Sjoberg and Dannel, 1983; Tallis, 1983). A detailed understanding of the relationship between hydrology and the species composition and community structure of wetland vegetation is, therefore, essential to sound wetland management (Lowe, 1987). Unfortunately, as pointed out by Gosselink and Turner (1978), "solid quantitative information about the hydrodynamic characteristics of different wetlands is surprisingly difficult to find." This fact has hindered the effective management of wetlands. Wetland ecologists have typically inferred hydrology through various means (Lowe, 1987). The ecological information obtained is typically site specific, and not easily applied to the management of other wetlands. In fact, as pointed out by Lowe (1987), "wetland management is often poorly supported by ecological understanding."

In order to improve the District's understanding of the relationship between hydrology and wetland plant community structure, research was conducted in the Blue Cypress Lake floodplain to determine the spatial pattern of the vegetation and its relationship to hydrologic conditions (Lowe, 1983, 1987). The Blue Cypress floodplain was chosen because it is the only large wetland ecosystem in the Upper St. Johns River in which the hydrologic regime and the vegetation have remained relatively undisturbed during the past 40 years (Lowe et al., 1984). Because of this regional uniqueness, it offers researchers the opportunity to study long-term hydrologic/ecological relationships. The ecological insights gained from this research were instrumental in the development of hydrologic criteria (i.e., management objectives) associated with the design and eventual operation of the Upper St. Johns River Basin restoration project (Brooks and Lowe, 1984). The hydrologic criteria were used to evaluate regulation schedules associated with the structural components of that project. The intent of the criteria was to insure that the contemplated alternations of the hydrologic regime did not adversely impact wetland functions and processes. In developing these criteria, it was recognized that the distributions of plant communities in the Blue Cypress Lake Basin were strongly correlated with a hydrologic gradient represented by frequency of inundation. The major components of this gradient which were considered in the development of operation schedules were: 1) mean depth, 2) frequency of inundation, 3) maximum depth, 4) minimum depths, 5) range of fluctuation and 6) timing of fluctuation.

These same hydrologic/ecological criteria have been applied to the GLWB in order to determine the minimum surface water requirements for the basin. The general criteria developed for the Blue Cypress Lake floodplain are directly applicable to the GLWB because: 1) it is located in the same geographical region as Blue Cypress Lake, 2) the soils of the two areas are similar, 3) the plant species composition and community structure are similar, 4) the two basins are hydrologically linked, and 5) they have similar topography.

Using the hydrologic/ecological criteria established for marshlands on histosol soils, the minimum surface water requirements for the Greater Lake Washington Basin have been determined. These requirements were expressed in terms of critical marsh elevations, derived from topographic contour data for the floodplain. It is more appropriate to express these criteria as surface water levels rather than as minimum flows (discharges). This is primarily due to the nature of the floodplain wetlands occurring in the headwaters of the St. Johns River. Here the basin is topographically flat with very small changes in slope occurring over great distances. This results in the vast floodplain wetlands behaving hydrologically like a large continuous lake basin. The wetlands and their associated flora and fauna, therefore, developed along a surface water elevation gradient, becoming dependent upon the timing, intensity and duration of annual inundation, rather than upon the volume of discharges or flow velocities.

The biological health of Lake Washington is largely determined by its interaction with the floodplain wetlands. The wetlands provide a hydrologic buffer for the lake, releasing water to supplement low flow conditions; export nutrients and primary and secondary production required to drive the foodchains of the lacustrine habitats; provide refugia, and feeding and nesting habitats for the lake fauna; and filter pollutants that may enter the basin through surface runoff. Considering the overriding importance of the floodplain marshes to the maintenance of the lacustrine habitat, the protection of the marshlands structural integrity and biotic and abiotic functions and values should be a strategy of any lake management program. It is for this reason that the minimum level criteria for the floodplain vegetation and soils has been the primary emphasis of this study.

This report demonstrates that ecological harm that has occurred in the GLWB as a result of floodplain development, both within and upstream of the basin. Loss of wetland habitat; subsidence of organic soils; shifts in floodplain plant community structure over large areas of the basin; declines in fish and wading bird populations (Cox et. al., 1976; FGFWFC, 1980, 1981); and a general decline in basin water quality through increased mineralization of surface waters (Lowe et al., 1984) are all manifestations of the progressive alterations to the floodplain. It is anticipated that utilization of these minimum surface water criteria will limit further ecological degradation within this basin.

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APPENDIX A

AGREEMENT BETWEEN THE

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

AND THE

SOUTH BREVARD WATER AUTHORITY

THIS AGREEMENT is entered into on the 6th day of May, 1985, by and between the ST. JOHNS RIVER WATER MANAGEMENT DISTRICT, hereinafter referred to as the "District", and the SOUTH BREVARD WATER AUTHORITY, hereinafter referred to as the "Authority".

WHEREAS, the District is requested by Authority and desires to perform an environmental study to aid in the development of a water management plan for Lake Washington; and

WHEREAS, the District has been established and authorized, pursuant to Chapter 373, Florida Statutes, to manage water resources within its geographical boundaries.

NOW, THEREFORE, in consideration of the conveyance of good and valuable consideration as described below, the District and Authority agree to the terms and conditions as set forth herein.

1. The District will conduct a study entitled "Minimum Flow North of Lake Washington" to define the hydrologic criteria required to maintain the ecological integrity of the marshflat flora and fauna, downstream of the Lake Washington weir. The study will be conducted in accordance with the specifications outlined in Exhibit A, attached hereto and incorporated herein. The study report will be finalized on or before December 2, 1985.

2. The Authority agrees to provide to the District services and cash of a total value equal to Thirty-one Thousand Eight Hundred Ten Dollars ($31,810.00) to reduce the District costs associated with the study described in paragraph #1.

3. The services provided by the Authority shall consist of surveying three elevation cross sections lying in Townships 26 and 27 South, Ranges 35 and 36 East, as shown on Exhibit B, attached hereto and incorporated herein. The Authority shall be responsible for contracting for services of a qualified surveyor and providing the total compensation for said surveyor to survey these cross sections, according to the minimum specifications contained in Exhibit

C, attached hereto and incorporated herein, and shall hold the District harmless from any liability or damages arising under or from the survey contract. The Authority shall provide the final survey product to the District on or before July 31, 1985.

4. The Authority shall pay to the District in cash that sum which represents the difference in the contract price between the Authority and the surveyor for the provision of services as described in paragraph #3 and the total financial obligation of the Authority which is Thirty-one Thousand eight hundred ten Dollars ($31,810.00).

(($31,810.00) - (survey contract price) = cash payable to the District). This cash amount shall be paid to the District within ten (10) days of receipt by the Authority of a copy of the final District project report. The District shall not be responsible for any part of the payment for surveying services described in paragraph #3.

IN WITNESS WHEREOF, the parties hereto have duly executed this Agreement on the date and year first above written.

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

BY: ______________________
IDWAL H. OWEN, JR.
CHAIRMAN

(SEAL)

ATTEST:

BY: ______________________
LYNNE C. CAPEHART
SECRETARY

SOUTH BREVARD WATER AUTHORITY

BY: ______________________
C. W. HUDSON
CHAIRMAN

(SEAL)

ATTEST:

BY: ______________________
R. J. MASSARELLI

APPROVED AS TO FORM AND LEGALITY:

BY: ______________________
KATHRYN L. MENNELLA
STAFF ATTORNEY