Technical Memorandum

December 4, 2014

TO:	Resource Evaluation Section Project File Water Resource Bureau File
THROUGH:	Jerry L. Mallams, P.G., Manager, Resource Evaluation Don Ellison, P.G., Resource Evaluation Jason G. Patterson, Hydrogeologist, Resource Evaluation
FROM:	Keith Kolasa, Senior Environmental Scientist, Resource Evaluation

Subject: Reevaluation of Minimum and Guidance Levels for Lake Stemper

Introduction

Minimum and guidance levels for Lake Stemper were approved by the Governing Board in October 1998, and adopted into Water Levels and Rates of Flow, Rule 40D-8.624, Florida Administrative Code (F.A.C) in July 2000. Section 373.0421(3), Florida Statues (F.S.), requires that minimum flows and levels shall be reevaluated periodically and revised as needed. Lake Stemper is one of sixteen lakes in the Northern Tampa Bay (NTB) region that was selected for reevaluation of minimum and guidance levels as part of the NTB Recovery Plan update. These reevaluations are being completed using up-to-date hydrologic data, hydrologic models and peer-reviewed methodologies to determine if any revisions are needed for currently adopted levels. The reevaluation of minimum and guidance levels for Lake Stemper determined no difference between those newly developed to those currently adopted for the lake. The purpose of this memorandum is to provide an overview of the reevaluation methods and results which support maintaining the currently adopted Minimum and Guidance levels for Lake Stemper (Table 1).

Background and Setting

Lake Stemper is in northwest Hillsborough County within the Lutz region (Section 13, Township 27S, Range 18E) (Figure 1). The “Gazetteer of Florida Lakes” (Shafer et al. 1986) lists the lake area as 126 acres. A topographic map of the basin generated in support of minimum levels development indicates Lake Stemper is 192 acres at a stage of 61.2 ft NGVD 29 (Normal Pool elevation) and is a more accurate determination of lake basin size since it includes the extensive area of forested wetlands located on the southeast side of the lake (see Figure 3).

Lake Stemper is part of the Thirteen Mile Run drainage system also known as the Cypress Creek Lake Chain (Figure 2). This system comprises the western part of the much larger Cypress Creek watershed, a sub-watershed of the Hillsborough River basin. At roughly 7400 acres the Thirteen Mile Run comprises roughly one-third of the 21,000-acre Cypress Creek watershed and consists of several interconnected cascading lakes in southwest Pasco County and northwest Hillsborough County with surface water flows generally from north to south. There are no operable structures within the lakes located within the northern portion (Pasco County of Thirteen Mile Run). Flow between the lakes is controlled by numerous culverts with some flow lines occurring through natural channels within cypress strands between lakes. The lakes within the southern portion of the lake chain include Kell, Keene, Hanna, and Stemper, with Lake Hanna and Lake Stemper located at the southern end of the lake chain (Figure 2). A series of five water conservation structures control discharge at high stages between Lakes Keene, Hanna, and Stemper and the outfall conveyance systems leading to Cypress Creek (Figure 2). The structures are operated by the District. Lake Stemper receives flow from Lake Keene and Lake Hanna and discharges to Cypress Creek (Figure 3). Each structure consists of a concrete weir with removable stop logs or boards. Stop logs are typically removed when flood conditions are occurring or expected, and then replaced during times of falling levels for water conservation. Detailed information about the structures and operation is provided by SWFWMD (2009) and Interflow Engineering (2011).

The invert elevation of the outfall structure at Lake Stemper is 60.2 NGVD 29 and with both stop logs installed the elevation is one foot higher at 61.2 (Figure 3). The normal operation of the structure has been to retain both stop logs, with removal occurring during flood alerts (SWFWMD 2009). Because the typical operation of the structure has been to maintain an elevation of 61.2 NGVD 29, this elevation was chosen as the control point elevation during the 1998 evaluation of the Minimum and Guidance levels for Lake Stemper (SWFWMD 1999).

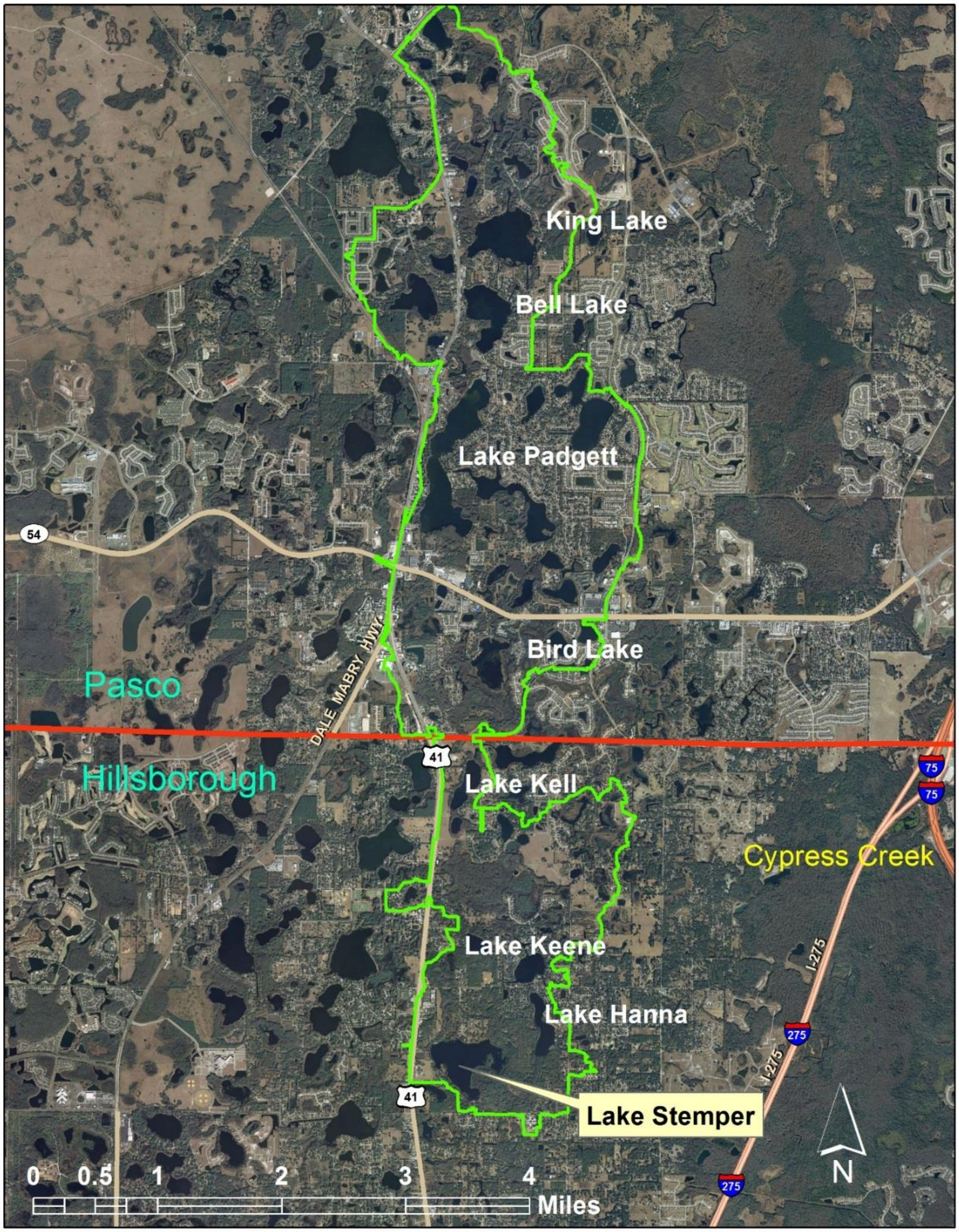

Figure 1. General location of Lake Stemper in relation to the Thirteen Mile Run drainage basin.

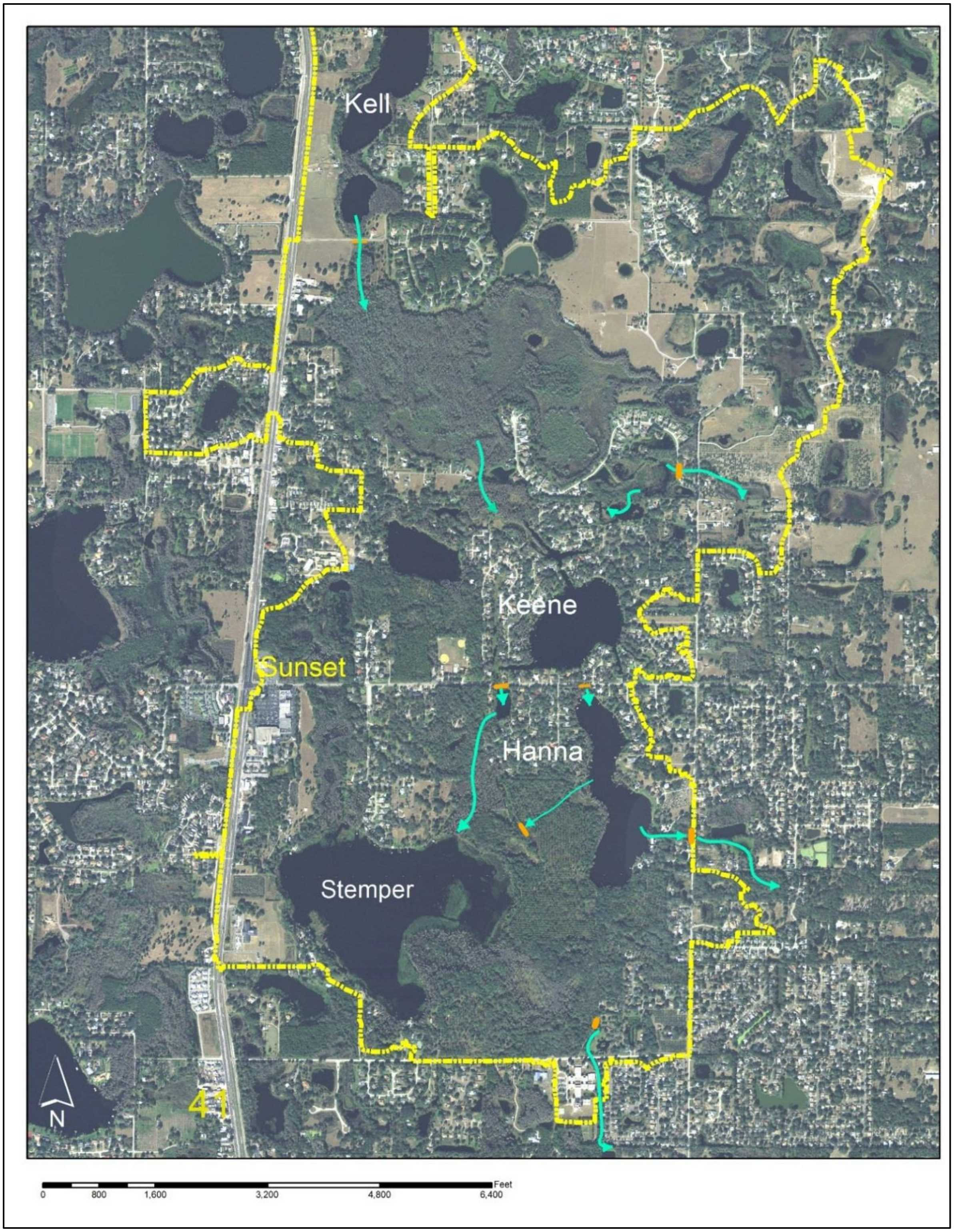

Figure 1. Flow between Lakes Kell, Keene, Hanna, and Stemper within the lower Thirteen Mile Run drainage basin.

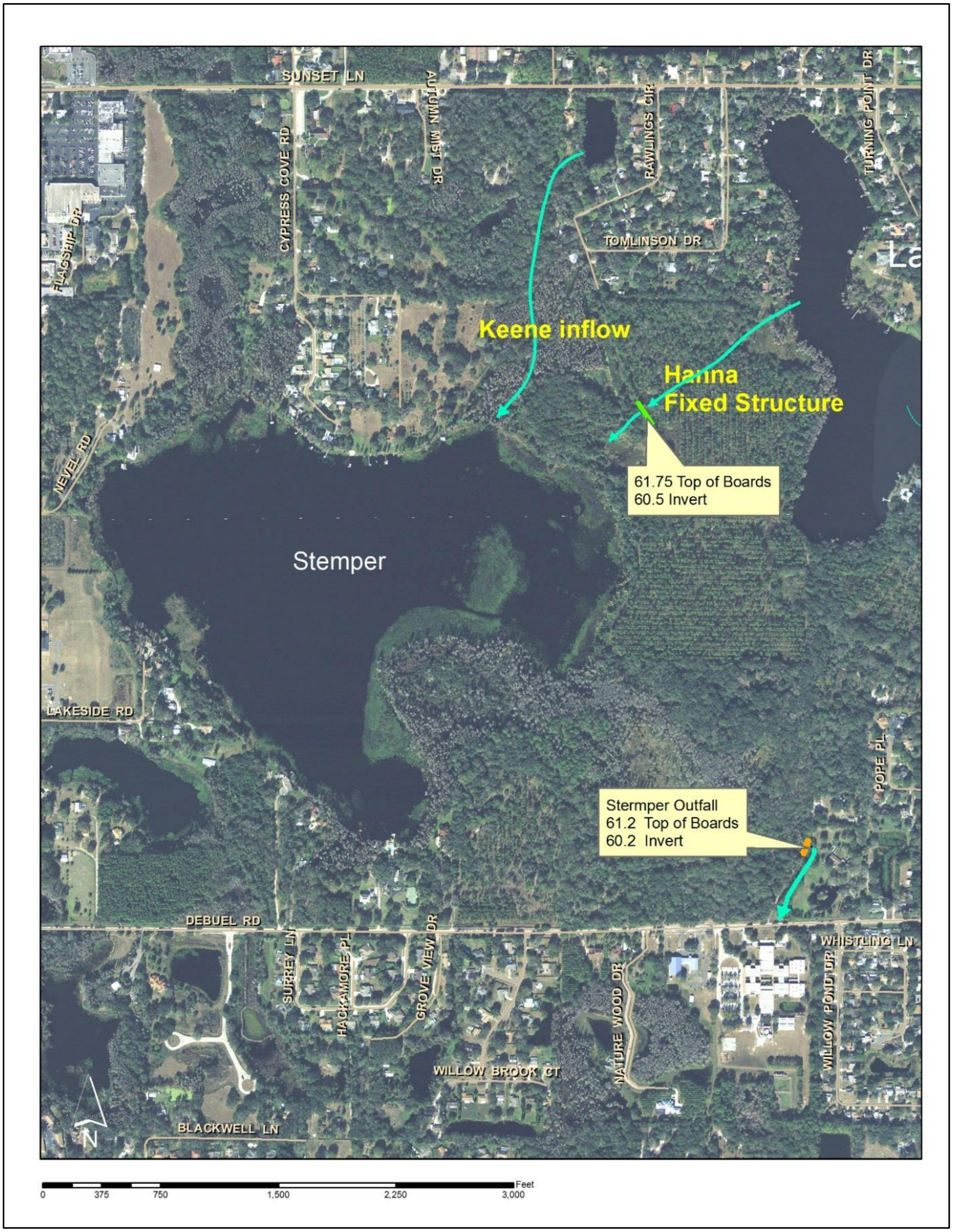

Figure 3. Location of water conservation structure on Lake Stemper and inflows from Lakes Hanna and Keene

Currently Adopted Minimum and Guidance Levels and Lake Classification

The Southwest Florida Water Management District has a long history of water resource protection through the establishment of lake management levels. With the development of the Lake Levels Program in the mid-1970s, the District began an initiative for establishing lake management levels based on hydrologic, biological, physical and cultural aspects of lake ecosystems. By 1996, management levels for nearly 400 lakes had been established.

Based on the approaches for establishing minimum flows and levels developed in the late 1990s and early 2000s. Methods have been developed for establishing minimum levels for systems with fringing cypress-dominated wetlands greater than 0.5 acre in size, and for those without fringing cypress wetlands. Lakes with fringing cypress wetlands where water levels currently rise to an elevation expected to fully maintain the integrity of the wetlands are classified as Category 1 Lakes. Lakes with fringing cypress wetlands that have been structurally altered such that lake water levels do not rise to levels expected to fully maintain the integrity of the wetlands are classified as Category 2 Lake. Lakes with less than 0.5 acre of fringing cypress wetlands are classified as Category 3 Lakes. Lake Stemper is classified as a Category 1 lake.

The Minimum and Guidance Levels adopted for Lake Stemper in October 1998 were developed using the methodology (peer reviewed) for Category 1 Lakes described in Rule 40D-8.624, F.A.C. Specifically, the region-specific Reference Lake Water Regime (RLWR) methods were applied due to the lack of long term Historic lake stage data (SWFWMD 1999). Although Lake Stemper was selected as one of the 22 lakes used to develop the RLWR statistics only data from 1946 to 1962 was considered as Historic data and incorporated to develop the RLWR statistics.

A Ten-Year Flood Guidance Level of 62.6 ft above NGVD that was also adopted for the Lake Stemper in October 1998, but was subsequently removed from Chapter 40D-8, Fla. Admin. Code in 2007, when the Governing Board determined that flood-stage elevations should not be included in the District's Water Levels and Rates of Flow rules.

Ongoing development of methods for establishing minimum flows and levels has led the District to reevaluate the Minimum and Guidance Levels for Lake Stemper. The reevaluation also followed the Category 1 methodology in Rule 40D-8.624; however, for this re-evaluation Historic lake stage data was developed using the most recent methods involving the development of a hydrologic model (Appendix A). The older application of the Reference Lake Water Regime approach utilized in 1998 was therefore replaced with the development of the Historic data. Historic data for Lake Stemper was modeled using a rainfall correlation model (Ellison and Patterson 2014). This model was consistent with rainfall model used to develop the Historic data for Lakes Hanna, Keene, and Kell which are connected to Lake Stemper through the 13 Mile Run surface water conveyance system.

Table 1. Minimum and Guidance Levels adopted in 1998 for Lake Stemper.

Guidance Levels	Elevation in Feet NGVD 29
High Guidance Level	61.2
High Minimum Lake Level	60.8
Minimum Lake Level	59.4
Low Guidance Level	59.1

Data Used for Minimum and Guidance Levels Development

Hydrologic Indicators and Normal Pool

The reevaluation of MFLs for Lake Stemper included revisiting the data collected used to establish the MFLs adopted in 1998 and updating the data as needed. This included collecting hydrologic indicators of water levels (Table 2), dock elevations (see Table 7), reviewing previously surveyed elevations of outfall structures, and those of homes and roadways (see low slab, Table 4). The lake stage data (Figure 4) was updated, analyzed, and used in the development of the rainfall regression model.

Hydrologic indicators of sustained inundation were collected on Oct 9, 2013 for determining the normal pool elevation. The Normal Pool elevation for Lake Stemper was based on inflection points of cypress (*Taxodium sp*.) buttresses. Although a limited number of inflection points were observed (N = 3, Table 2), the elevations were similar to those measured in March 1998 (N = 9) with the median elevation of 61.36 (NGVD 29) measured in 2013 and 61.21 (NGVD 29) recorded in 1998. A supplemental lichen line was also recorded in 2013 at 61.06 and is consistent with the cypress inflection points. Due to the small sample size of the cypress inflection points collected in 2013, it was decided to combine both the 2013 and 1998 data sets to improve the overall sample size. The average of the median elevations of the 2013 and 1998 cypress inflection points (61.36 and 61.2, NGVD 29) was 61.23 NGVD 29 and was used to represent the Normal Pool elevation. This elevation is equivalent to the Normal Pool at 61.2 NGVD 29 determined in 1998 which was based on the average of nine cypress inflection points (Table 2, SWFWMD 1999).

Because the Normal Pool elevation remained the same during the reevaluation, the Cypress Standard was also equivalent. The Cypress Standard is calculated by subtracting 1.8 ft from the Normal Pool elevation (61.2 – 1.8 = 59.4 NGVD 29).

Table 2. Summary statistics for biological indicator measurements (elevations of the buttress inflection points base of lakeshore *Taxodium* sp.) collected in 2013 and 1998 and used for establishing the Normal Pool Elevation for Lake Stemper.

2013 Statistic	**Statistic Value (N) or Elevation (feet above NGVD)**
N	3
Median	61.36
Mean (Standard Deviation)	61.36 (0.1)
1998 Statistic	
N	9
Median	61.10
Mean (Standard Deviation)	61.2 (0.25)
2013 and 1998 Combined	
Average of 2013 and 1998 medians	61.23

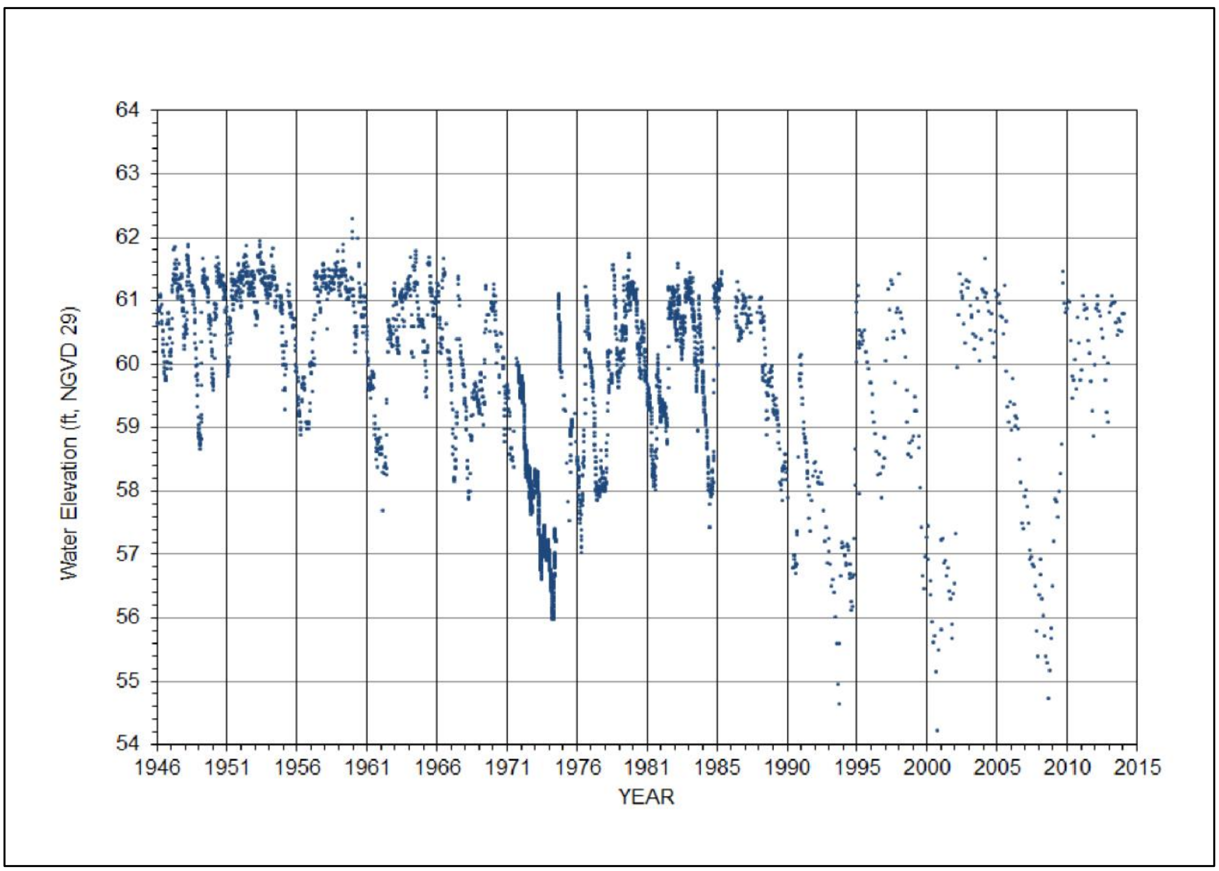

Figure 4. Lake Stemper daily water level for period of record (WMIS ID 19303).

Lake Stage Data and Exceedance Percentiles

For the purpose of establishing Minimum and Guidance levels a 60-year record of Historic lake stage data is needed to develop Historic exceedance percentiles. The two Minimum levels and two Guidance levels are then calculated using the step-by-step procedure outlined in Rule 40D-8.624. Lake stage data are classified as "Historic" for periods when there were no measurable impacts due to water withdrawals, and the lake's structural condition is similar or the same as present day.

Lake stage data, i.e., surface water elevations for Lake Stemper have been recorded for Lake Stemper since January 1946. Although the period of record is fairly long (1946 to 2014, 68 years) only the data prior to 1963 is considered Historic since it pre-dates the start of groundwater withdrawals at the Section 21 and South Pasco wellfield beginning in 1963 and 1973, respectively. Due to the regional increase in water use starting in 1963, Historic data for Lake Stemper was limited to the data prior to 1963, with the data period from 1946 to 1963 too short to develop Historic exceedance percentiles.

The influence of the drainage conveyance and structures appears to have been consistent throughout the period of record as the lake hydrograph (Figure 4) shows similar highs being reached throughout the period of record. This consistency is supported by a review of historical imagery which shows the presence of inflow conveyance ditches from Lake Hanna to Stemper starting in 1938 and an early outfall ditch for Lake Stemper evident in 1957. The present-day conveyance system appears to have been finalized by 1968 as indicated by available historical imagery.

For this reevaluation Historic data was developed by constructing a rainfall-based regression model, a method that was not available in 1998 during the determination of the currently adopted Minimum and Guidance levels (Appendix A). Data from the Historic period (prior to 1963) were used to establish a relationship between rainfall and un-impacted lake stage fluctuation. The procedure uses a linear inverse time weighted rainfall sums to establish the relationship (Ellison 2012). This relationship was then used to extend the available stage record to a full 60 years; which in turn was used to calculate an un-impacted long-term 60-year exceedance percentile that are used to develop the Minimum and Guidance levels. A 60-year period is considered sufficient for incorporating the range of lake stage fluctuations that would be expected based on long-term climatic cycles that have been shown to be associated with changes in regional hydrology (Enfield et al. 2001, Basso and Schultz 2003).

Calibration for the rainfall correlation model was between January 1, 1957 through December 31, 1962 (Ellison and Patterson 2014). Rainfall stations used within the calibration period were St. Leo NWS (SID 18901) and Cosme (SID 19503). These rainfall stations were used until 1966. From 1966 until 2011, a combination of rainfall stations was used. The general rule of using the closest rainfall gauge or NexRad data first was followed for most of the model period.

The coefficient of determination (r^2) of the resulting rainfall model was 0.51. The model predicts historic conditions and was used to develop Historic percentiles to assess the minimum level being set. A graph of the modeled historic water level is shown in Figure 5. The observed lake stage data is also shown to illustrate the model fit. The long-term Historic percentiles developed from modeled lake stage include the Historic P10, P50, and P90. These are defined as the elevation the lake water surface equaled or exceeded ten, fifty, and ninety percent of the time during the historic period. The Historic lake stage exceedance percentiles (P10, P50, and P90) developed from the modeled lake stage were 61.3, 60.2, and 59.1 NGVD 29 (Table 3).

Table 3. Historic exceedance percentiles estimated using the Lake Stemper rainfall model

Exceedance Percentile	Horse Lake (ft NGVD29)
P10	61.3
P50	60.2
P90	59.1

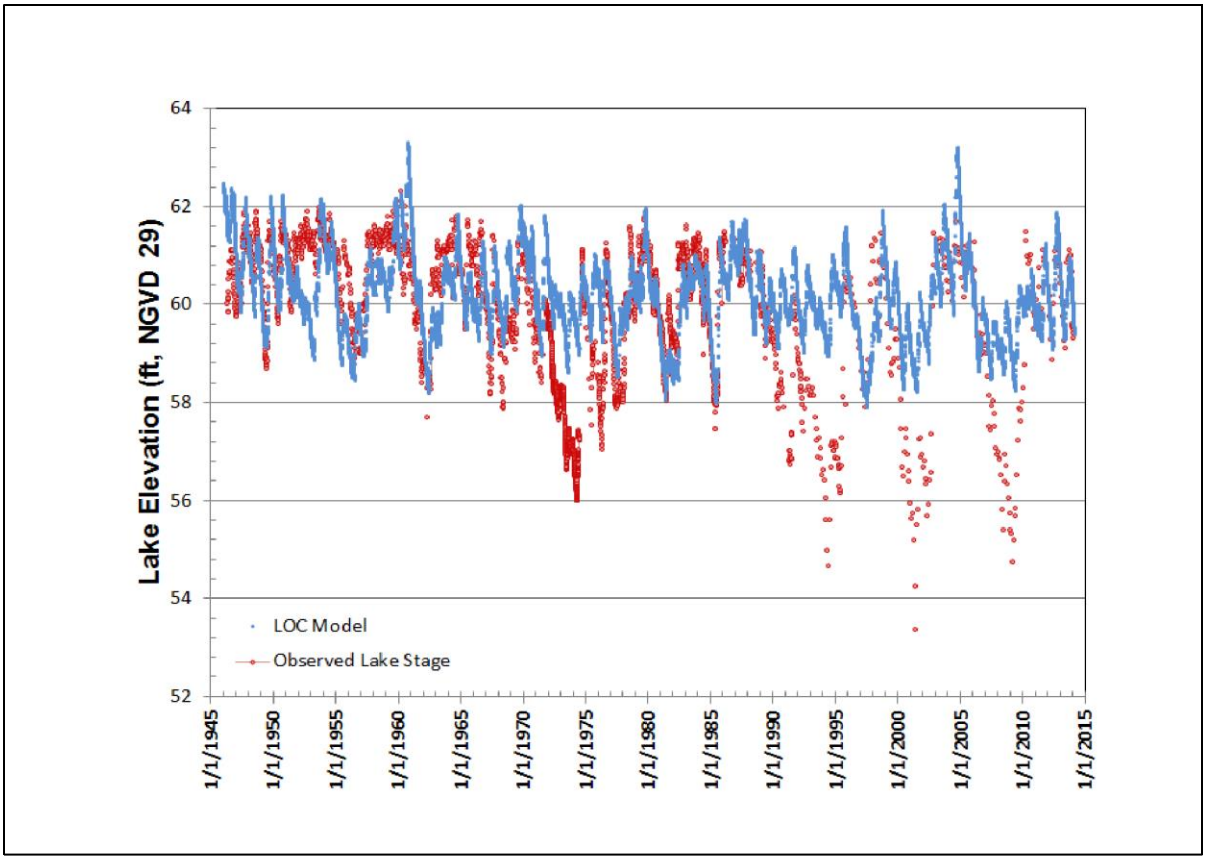

Figure 5. Modeled long term Historic lake stage (as daily, see blue line) from 1946 to 2014 and observed lake stage (as daily, see red points) for Lake Stemper.

Comparison of the original adopted and reevaluated Minimum and Guidance Levels

The critical elevations evaluated in the development of MFLs for lakes with fringing cypress wetlands (greater than 0.5 acres) are the normal pool and the Historic P50. The normal pool elevation assessed during the reevaluation was equivalent to the original normal pool (Table 4).

The Historic P50 assessed in development of the currently adopted MFLs in 1998 was determined by subtracting the RLWR50 (1 ft) from the elevation of control point elevation of the outfall structure (61.2 NGVD 29, Table 4), using the RLWR option in Rule 40D-8.624 (SWFWMD 1999). The model derived Historic P50 during this reevaluation matches the Historic P50 calculated in 1998 using the RLWR offset approach (both 60.2 NGVD 29). Following the methods outlined for Category 1 Lakes, the Minimum Level was established at the Cypress Standard (1.8 ft below the Normal Pool). For Lake Stemper, the Historic P50 (60.2 NGVD 29) is approximately 0.8 ft greater than the Cypress Standard (59.4), indicating that the structural alterations do not prevent the lake from raising to elevation at or above the 1.8-foot offset below the Normal Pool elevation. The Minimum Lake Level established at the Cypress Standard is expected to provide protection of the cypress wetlands occurring within the basin.

The High Minimum Level and Low Guidance Level determined for this reevaluation were also equivalent to the same levels adopted in 1998 (Table 5). The Low Guidance Level established at the Historic P90 was equivalent to that established in 1998 using the RLWR calculation (NP minus the RLWR P90 statistic of 2.1 ft). The High Minimum Level was calculated was calculated in the same manner (NP – 0.4 ft) for both the RLWR and Historic data methods and was established at 60.8 ft (Table 5).

There was a one tenth (0.1) foot difference between the High Guidance Level developed at the Historic P10 using the modeled Historic data approach of the reevaluation and that assessed at the NP elevation in 1998 (61.3 vs 61.2 Table 5). The difference of 1/10 foot is not considered significant enough to recommend changing the High Guidance Level for Lake Stemper. In addition, no difference in the Normal Pool elevation was determined for Lake Stemper, indicating that a High Guidance level determined from the Normal Pool would yield the same elevation.

Overall there was strong consistency between the Historic P50 and Minimum and Guidance Levels developed by the RLWR methods in 1998 and Historic data method utilized in the reevaluation. The Historic condition predicted by the rainfall model indicates that Lake Stemper historically had a natural range in fluctuation very similar to the median range of fluctuation developed from the 22 reference lakes (SWFWMD 1999). Lake Stemper was selected as one of the 22 reference lakes in which Historic data was used to develop the median range statistics used in the RLWR method of calculating Minimum and Guidance Levels. Stage data from Lake Stemper from 1946 to 1962 time period was selected since this period pre-dates ground water withdrawals impacts in this region.

Table 4. Summary of Elevation Data (ft, NGVD 29)

	Elevation	**1998 Calculations**	**2014 Reevaluation**
Control Point (CP)	61.2	Surveyed Elevation	Used previous survey elevations of 1998 and 2009*
Low Floor Slab	63.7	Surveyed Elevation	New Survey**
Normal Pool (NP)	61.2	Avg. of nine cypress inflections	Avg. of 1998 and 2013 Cypress inflections combined

* - SWFWMD 2009
** - Cumbey and Fair 2014

Table 5. Comparison of the Historic P50, Minimum and Guidance Levels, and method of calculation for Lake Stemper used in 1998 and during the 2014 reevaluation.

	1998	1998 Calculations using RLWR	2014	2014 Reevaluation Calculations using modeled Historic
Historic P50 (HP50)	60.2	CP - 1.0 ft (RLWR50)	60.2	Median of Modeled Historic 60-year Record
High Guidance Level	61.2	NP	61.3	Historic P10
High Minimum Level	60.8	NP - 0.4 ft	60.8	NP - 0.4 ft
Minimum Level	59.4	NP - 1.8 ft (Cypress Standard)	59.4	NP - 1.8 ft (Cypress Standard)
Low Guidance Level	59.1	NP - 2.1 ft (RLWR90)	59.1	Historic P90

Note: 61.2 (NP) – 1.0 ft (RLWR50) = 60.2 (HP 50)
60.2 (HP50) – 0.8 ft (Wetland Offset) = 59.4 (Cypress Standard)

Comparison to Category 3 Lake Change Standards

When developing minimum levels, the District evaluates categorical significant change standards and other available information to identify criteria that are sensitive to long-term changes in hydrology and represent significant harm thresholds. For Category 1 or 2 Lakes, a significant change standard is established 1.8 feet below the Normal Pool elevation. This standard identifies a desired median lake stage that if achieved, may be expected to preserve the ecological integrity of lake-fringing wetlands. Although not identified by name in the District's Minimum Flows and Levels rule, the elevation 1.8 feet below normal pool is typically referred to as the Cypress Standard in District documents pertaining to minimum levels development. For Lake Stemper, the Cypress Standard was established at 59.4 NGVD. Based on the modeled Historic water level record, the Cypress Standard was equaled or exceeded eighty-two percent of the time, *i.e.*, the standard elevation corresponds to the Historic P82. Based on the observed water level the Cypress Standard was equaled or exceeded sixty-one percent of the time.

The Minimum levels for Lake Stemper established at the Cypress Standard is protective of all relevant environmental values identified for consideration in the Water Resource Implementation Rule when establishing minimum flows and levels (see Rule 62-40.473, F. A. C.). This includes fish and wildlife habitats and the passage of fish, transfer of detrital material, aesthetic and scenic attributes, filtration and absorption of nutrients and other pollutants, sediment loads and water quality.

Although Lake Stemper is a Category 1 Lake, Category 3 Lake standards were developed for comparative purposes (Table 6). For Category 3 lakes, six significant change standards, including a Dock-Use Standard, a Basin Connectivity Standard, an Aesthetics Standard, a Recreation/Ski Standard, a Species Richness Standard, and a Lake Mixing Standard are developed. These standards identify desired median lake stages that if achieved, are intended to preserve various natural system and human-use lake values.

The Ski Standard calculated for the lake was 61.4 NGVD and was higher than the structure outfall elevation of 61.2 and the HP 10 of 61.3. The Ski Standard elevation is not appropriate for development of a minimum level since it is well above a median lake stage elevation and above the 10th exceedance percentile. The Dock Use standard was 60.1 NGVD and was 0.1ft lower than the Historic P50. Dock elevation data was collected in October 2013 (Table 7). This standard would be acceptable for the establishment of a minimum level given Lake Stemper was classified as a Category 3 lake resulting in a higher Minimum Level. The Wetland Offset calculated by subtracting 0.8 ft from the Historic P50 was equivalent to the Cypress Standard. The Aesthetics Standard, Species Richness Standard, and Lake Mixing Standard were all lower than the Cypress Standard indicating that the establishment of the Minimum Level at the Cypress Standard achieves protection of environmental values associated with these category 3 lake standards. The use of the Basin Connectivity standard was not appropriate for Lake Stemper since the lake maintains one continuous basin throughout its observed range in fluctuation.

Table 6. Cypress Standard, Category 3 Change Standards, and adopted Minimum and Guidance Levels.

Significant Change Standards	**Elevation (feet above NGVD)**	**Lake Area (acres)**
Recreation/Ski Standard	61.4	194.7
Dock-Use Standard	60.1	161.6
Cypress Standard	59.4	120.2
Wetland Offset	59.4	120.2
Aesthetics Standard	59.1	117.8
Species Richness Standard	58.0	110.7
Lake Mixing Standard	56.5	95.3
Basin Connectivity Standard	NA	NA
Minimum and Guidance Levels		
High Guidance Level	61.3	193.3
High Minimum Lake Level	60.8	195.1
Minimum Lake Level	59.4	120.2
Low Guidance Level	59.1	120.2

Table 7. Summary statistics and elevations associated with 14 docks in Lake Stemper as based on measurements collected on October 9, 2013.

Summary Statistics for 14 docks	Elevation (ft NGVD 29) of Sediments at Waterward End of Docks	Elevation (ft NGVD 29) of Dock Platforms
Mean	55.7	62.5
10th Percentile (P90)	55.2	62.3
50th Percentile	55.8	62.7
90th Percentile (P10)	57.0	63.1
Maximum	57.2	63.3
Minimum	53.2	61.4

Summary

The reevaluation of the Minimum and Guidance levels for Lake Stemper indicates that no revisions to the currently adopted levels are needed. The Minimum Level, High Minimum Level, and Low Guidance level were equivalent. The elevation of the High Guidance Level determined for the reevaluation through modeling was 0.1 ft greater (61.3 vs 61.2 NGVD) than the currently adopted High Guidance Level that was based on the Normal Pool Elevation. This difference is considered insignificant and does not warrant amending the currently adopted Minimum and Guidance Levels (see Table 1 and Figure 6). The Minimum Level established at Category 1 Cypress Standard.

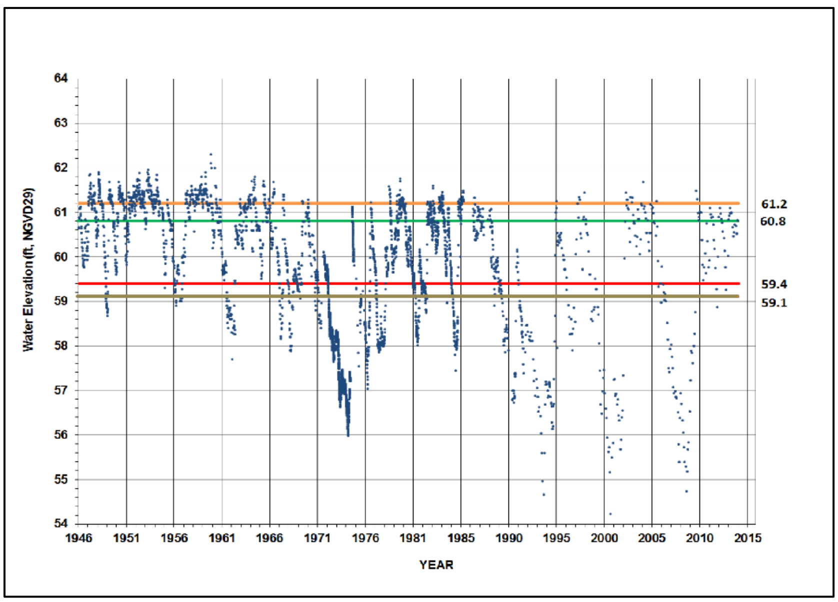

Figure 6. Period of record daily lake stage for Lake Stemper and Minimum and Guidance Levels shown as horizontal lines. Lines are color coded with orange representing the High Guidance Level (HGL), green as the High Minimum Level, red as the Minimum Level, and brown as the Low Guidance Level.

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Southwest Florida Water Management District. 2009. Stemper Structure Profile. Brooksville, Florida.

APPENDIX A

Technical Memorandum

December 10, 2014

TO: Keith Kolasa, Senior Environmental Scientist, Water Resources Bureau

THROUGH: Jerry L. Mallams, P.G., Manager, Water Resources Bureau

FROM: Donald L. Ellison, P.G., Senior Hydrogeologist, Water Resources Bureau
Jason Patterson, Hydrogeologist, Water Resources Bureau

Subject: Lake Stemper Hydrogeology, Rainfall Correlation Model, Historic Percentile Estimations, and Assessment of Minimum Lake Level Status

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A. Introduction

A rainfall correlation model was developed to assist the Southwest Florida Water Management District (District) in the reevaluation of the Minimum Lake Level (MLL) for Lake Stemper located in northwest Hillsborough County (Figure 1). This document will discuss the model approach used to calculate historic percentiles and an evaluation of the lake MLL status.

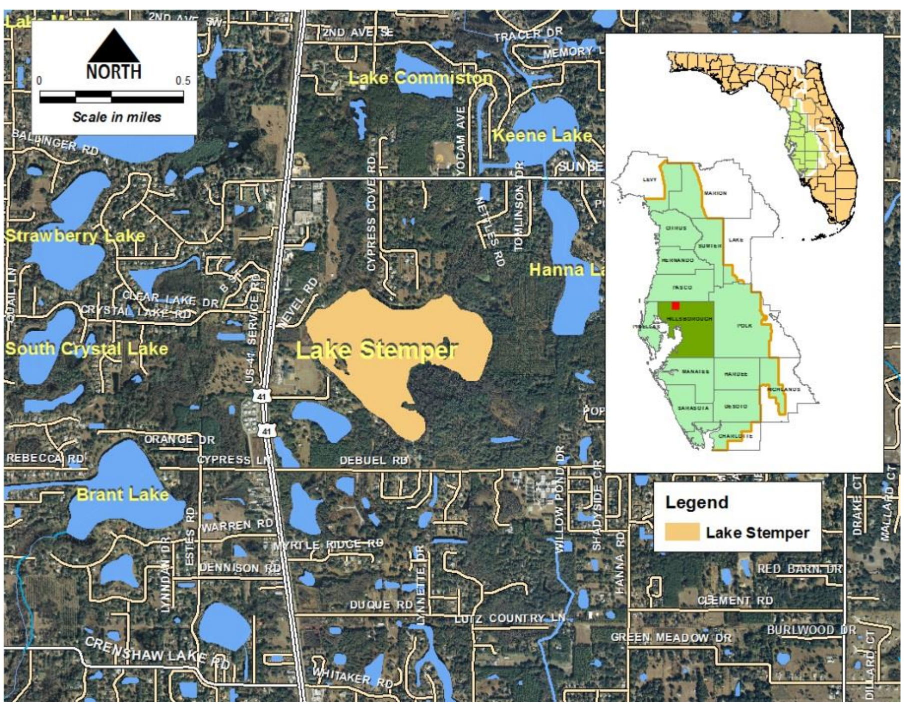

Figure 1. Location of Lake Stemper in Hillsborough County, Florida

B. Background and Setting

Lake Stemper is in northwest Hillsborough County, approximately 2.4 miles south of the northern Hillsborough County line (Figure 1). The lake is in the Lake Hanna Outlet Basin which lies within the larger Hillsborough River watershed (Figure 2). White (1970) classified the physiographic area as the Northern Gulf Coastal Lowlands bordered to the east by the Western Valley. The area surrounding the lake is categorized as the Land-O-Lakes subdivision of the Tampa Plain in the Ocala Uplift Physiographic District (Brooks, 1981), a region of many lakes on a moderately thick plain of silty sand overlying limestone (Figure 3). The topography is very flat, and drainage into the lake is a combination of overland flow and flow through drainage swales and minor flow systems.

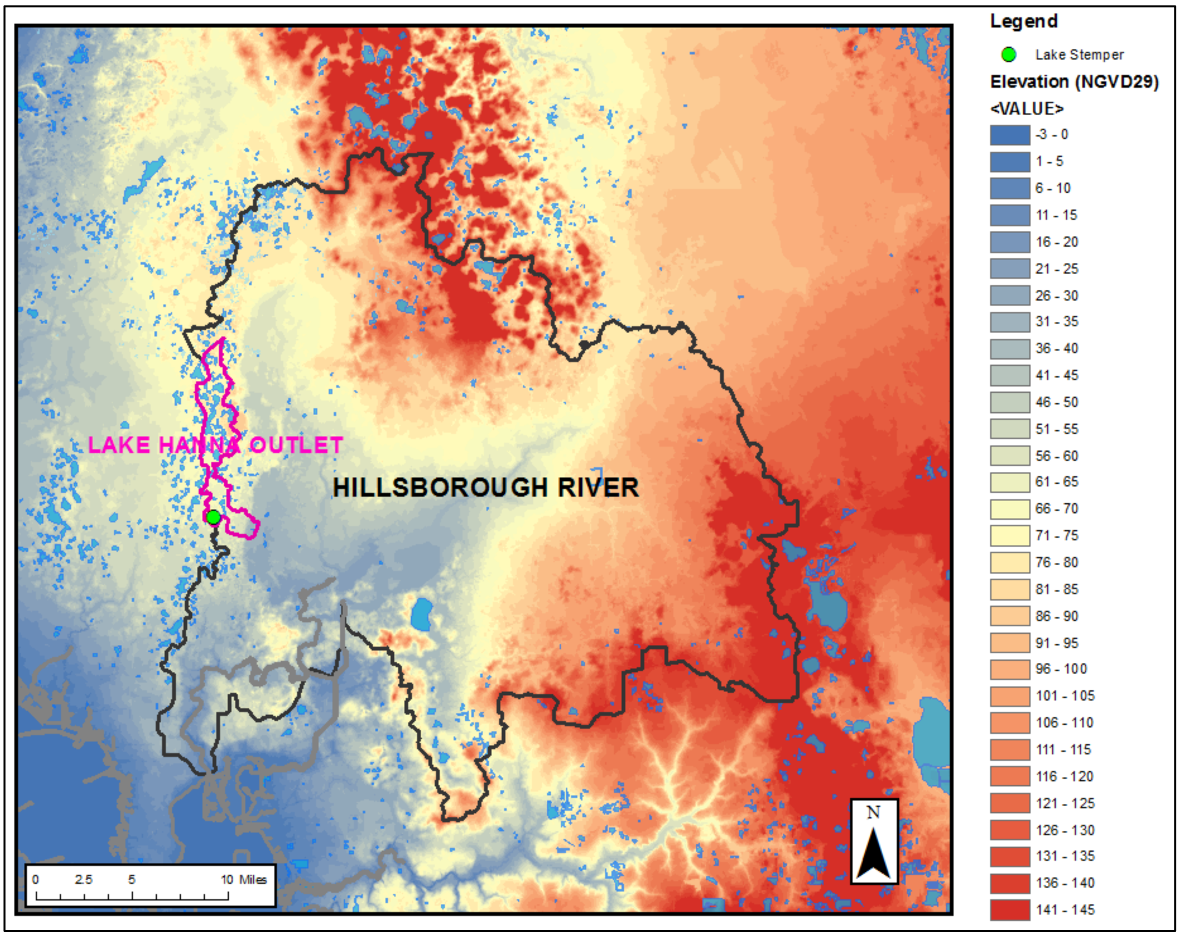

Figure 2. Location of Lake Stemper in the Lake Hanna Outlet drainage basin.

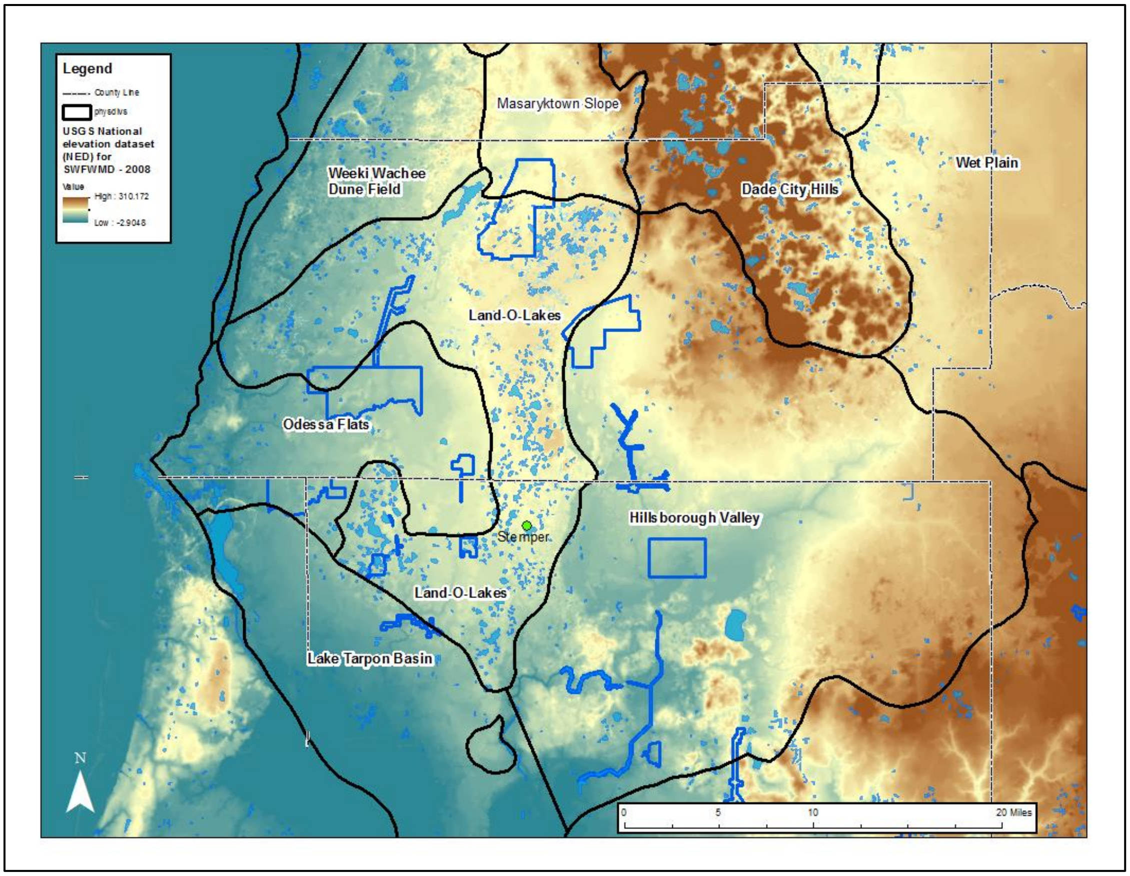

Figure 3. Physiographic Provinces (Brooks, 1981)

The hydrogeology of the area includes a sand surficial aquifer; a discontinuous, intermediate clay confining unit; and the thick carbonate Upper Floridan aquifer. In general, the surficial aquifer in the study area is in good hydraulic connection with the underlying Upper Floridan aquifer because the clay confining unit is generally thin, discontinuous, and breeched by numerous karst features. The surficial aquifer is generally ten to thirty feet thick and overlies the limestone of the Upper Floridan aquifer that averages nearly one thousand feet thick in the area (Miller, 1986). In between these two aquifers is the Hawthorn Group clay that varies between a few feet to as much as 25 feet thick. Because the clay unit is breached by buried karst features and has previously been exposed to erosional processes, preferential pathways locally connect the overlying surficial aquifer to the Upper Floridan aquifer resulting in moderate-to-high leakage to the Upper Floridan aquifer (Hancock and Basso, 1996).

C. Drainage and Structures

Lake Stemper receives flow from Lake Keene and Lake Hanna and discharges to Cypress Creek (Figure 4). Each structure consists of a concrete weir with removable stop logs or boards. Stop logs are typically removed when flood conditions are occurring or expected, and then replaced during times of falling levels for water conservation. Detailed information about the structures and operation is provided by SWFWMD (2009) and Interflow Engineering (2011).

The invert elevation of the outfall structure at Lake Stemper is 60.2 NGVD 29 and with both stop logs installed the elevation is one foot higher at 61.2 (Figure 4). The normal operation of the structure has been to retain both stop logs, with removal occurring during flood alerts (SWFWMD 2009). Because the typical operation of the structure has been to maintain an elevation of 61.2 NGVD 29, this elevation was chosen as the control point elevation during the 1998 evaluation of the Minimum and Guidance levels for Lake Stemper (SWFWMD 1999).

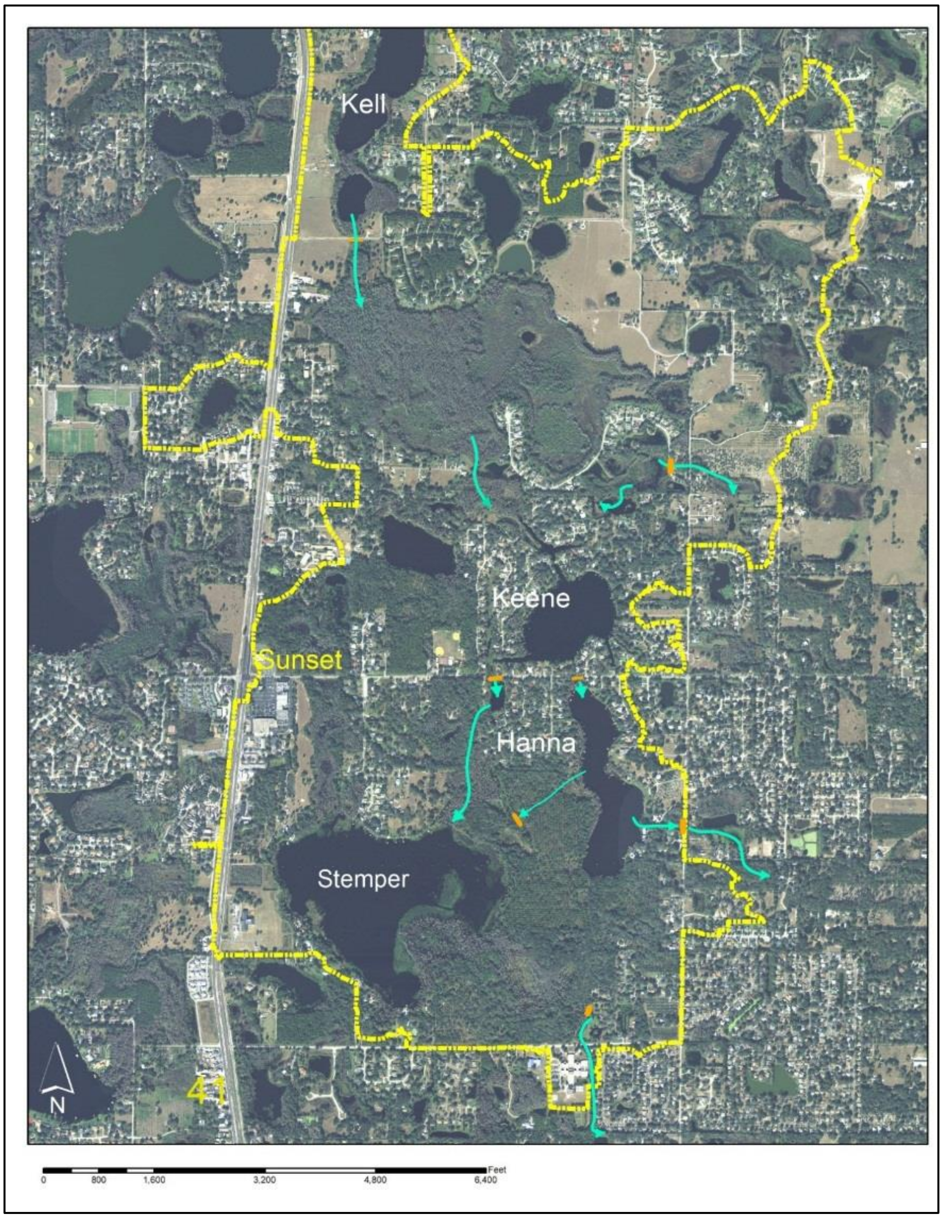

Figure 4. Lake Stemper Drainage

D. Water Use

Lake Stemper is located approximately 4 miles southeast of the South Pasco wellfield, and less than 2.7 miles northeast of the Section 21 wellfield, two of eleven regional water supply wellfields operated by Tampa Bay Water (Figure 5). Groundwater withdrawals began at the Section 21 wellfield in 1963 and steadily climbed to approximately 20 mgd in 1967 (Figure 4). With the development of the South Pasco wellfield in 1973, withdrawal rates at the Section 21 wellfield were reduced to approximately 10 mgd, while withdrawal rates at the South Pasco wellfield quickly rose to 16 to 20 mgd, for a combined withdrawal rate ranging from 20 to 30 mgd in the mid to late 1970s (Figure 6). Combined withdrawal rates since 2005 have ranged from zero to nearly 20 mgd, with several extended periods when one wellfield or the other was shut down completely.

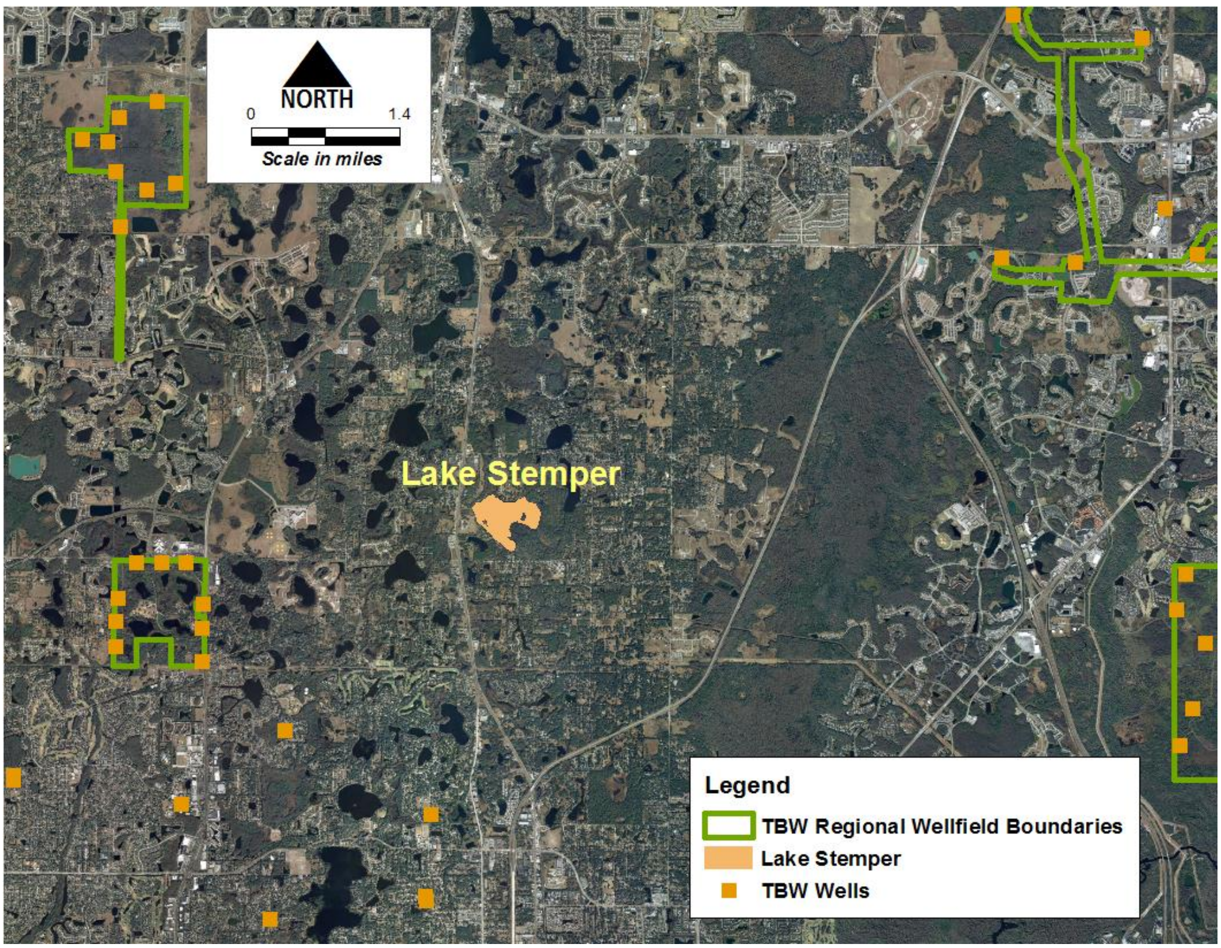

Figure 5. Location of Lake Stemper and the Section 21 and South Pasco wellfields

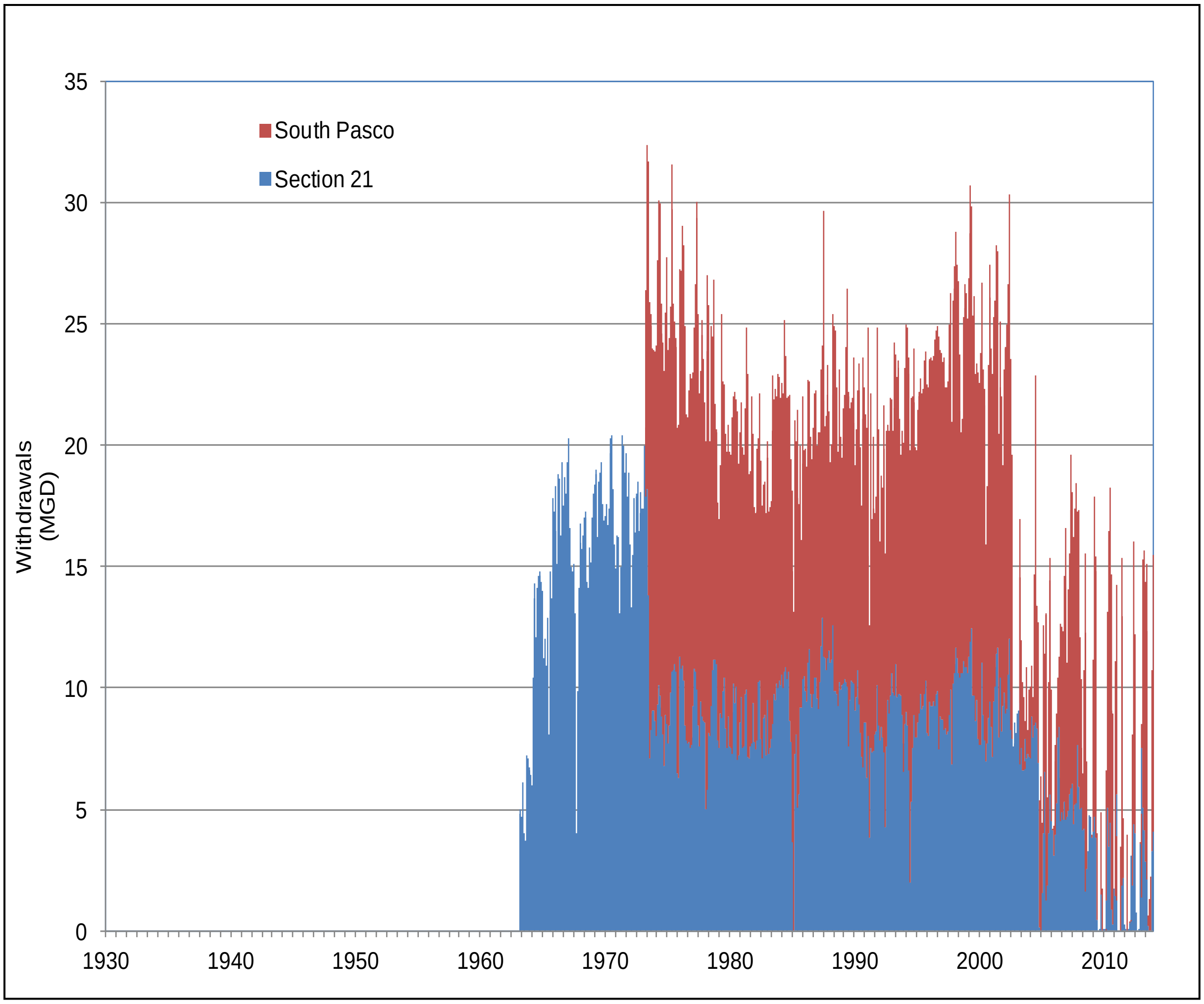

Figure 6. Section 21 and South Pasco wellfield withdrawals

E. Rainfall Regression Long-Term Historic Lake Percentile Estimation

The procedure to establish lake Minimum Levels (ML) uses long-term lake stage percentiles in the calculation of the both the High Minimum Level (HMLL) and the Minimum Level (ML). A rainfall-based regression model was constructed and used to model lake stage fluctuations. One of the first steps in the rainfall regression model process is the delineation of “Historic” and “Current” time periods. Historic time period is a period of time when there are little to no groundwater withdrawal impacts on the lake, and the lake’s structural condition is similar or the same as present day. Data from the Historic period are used to establish a relationship with rainfall. This relationship is then used to extend the available stage record to a full 60 years; which in turn can be used to calculate a long-term 60 year median and P10 for the lake. The rainfall model can then be used to evaluate whether the lake is fluctuating consistently with climate, primarily rainfall. To determine the Historic and Current time periods an evaluation of hydrologic changes in the lake's vicinity is necessary to determine if the water body has been significantly impacted by groundwater withdrawals or structural modifications.

The regression between rainfall and lake stage uses the line of Organic Correlation (LOC). The LOC is a linear fitting procedure that minimizes errors in both the x and y directions and defines the best-fit straight line as the line that minimizes the sum of the areas of right triangles formed by horizontal and vertical lines extending from observations to the fitted line (Helsel and Hirsch, 1997). LOC is preferable for this application since it produces a result that best retains the variance (and therefore best retains the "character") of the original data.

Rainfall is correlated to lake water level data by applying a linear inverse weighted sum to the rainfall. The weighted sum gives higher weight to more recent rainfall and less weight to rainfall in the past. In this application, weighted sums varying from 6 months to 10 years are separately used, and the results are compared, with the correlation with the highest correlation coefficient (R^2) chosen as the best model.

E.1 Delineation of Historic Period for Calibration

Water level data for Lake Stemper dates back to May 23, 1946 pre-dating the start of withdrawal in 1963 at the Section 21 wellfield and pre-dating the start of withdrawals in 1973 at South Pasco. Lake Stemper is part of the 13-mile drainage run and is considered a structurally altered lake. Dates and details of past alterations of structures and drainage conveyances are poorly documented, but review of the lake hydrograph shows highs slightly lower by a tenth or two of the highs reached in the early years, indicating that the structure elevation range on the lake has been operated within a relatively consistent range over the years. The early data from 1957 to 1963 is considered Historic data and was used to establish a rainfall correlation model to predict lake stage. Available data prior to 1957 was not used in the calibration period because the highs are slightly higher than the current highs, suggesting the structure was operated at a slightly higher elevation. The current invert elevation of the outfall structure at Lake Stemper is 60.2 NGVD 29 and with both stop logs installed the elevation is one foot higher at 61.2. The normal operation of the structure has been to retain both stop logs, with removal occurring during flood alerts (SWFWMD 2009).

E.2 Rain Gauge Data

Available rain data was inventoried and sorted by distance and period of record to locate the closest rain data to the lake. Consideration was also given to the location of the data site within the drainage basin with preference given to those sources within the drainage basin above Lake Stemper. Table 1 list presents the progression of gauges used and Figure 7 shows the location of the gages.

Table 1: Rain gauges used in the rainfall regression model.

Rain Gauges for Lake Stemper Rainfall Regression Model		
Start Date	**End Date**	**Gauge Description**
8/1/2004	Present	Hanna
7/1/1975	6/1/1988	Whalen
11/1/1963	6/30/1975	Lutz
1/1/1935	12/31/62	(St. Leo)

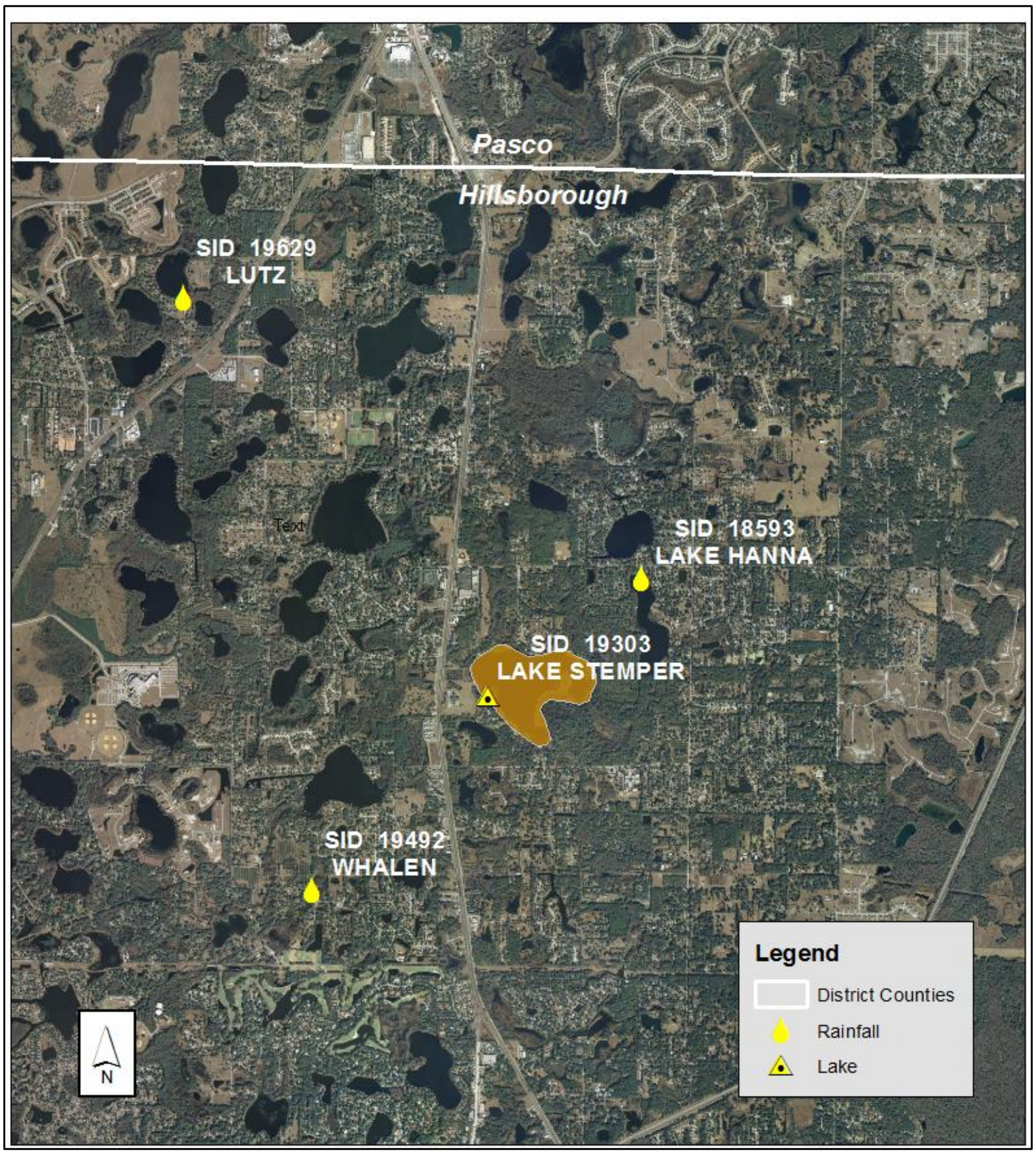

Figure 7. Rain gauge locations used in the Lake Stemper rainfall correlation model.

E.3 Lake Stemper Rainfall Correlation Model

The rainfall correlation model was calibrated using lake stage data and rainfall data from the period starting January 1, 1957 and ending on December 31, 1962. The resulting model (Figure 8) used a 2-year decay period and had a correlation coefficient (R^2) of 0.51. A comparison between percentiles for the calibration period based on the actual data and modeled data are presented in Table 2. The long-term percentiles are presented in Table 3. The model derived percentiles for the calibration period were 0.4', higher, 0.5' lower and 0.4' higher than the data derived P10, P50, and P90 respectively. Comparison of the predicted to the observed show periods of several feet of impact on the lake mostly during drought periods.

Historic normal pool is a vertical datum established to standardize measured water levels and facilitate comparison among wetlands and lakes. The historic normal pool elevation is commonly used in the design of wetland storm water treatment systems (Southwest Florida Water Management District, 1988). This level can be consistently identified in cypress swamps or cypress-ringed lakes based on similar vertical locations of several indicators of inundation (Hull, et al, 1989; Biological Research Associates, 1996). Historic normal pools have been used as an estimate of the P10 in a natural wetland, based on observation of many control sites in the northern Tampa Bay area. Historic normal pool was determined for Lake Stemper based on inflection points of remaining cypress trees. The historic normal pool for Lake Stemper was determined to be 61.2 feet NGVD. A comparison of the long-term P10 of 61.3 is reasonably close to Lake Stemper's normal pool of 61.2 ft. indicating Lake Stemper can achieve long-term lake levels that established the fringing wetlands.

Table 2. Comparison of Lake Stemper Calibration Period Percentiles

Calibration 1957 through 1962		
Percentiles	**Observed**	**Model**
P10	61.5	61.9
P50	61.0	60.5
P90	58.8	59.2

Table 3. Lake Stemper Long-term Historic Percentiles

Stemper Long-term Historic Percentiles (1946 to 2014)	
Percentiles	
P10	61.3
P50	60.2
P90	59.1

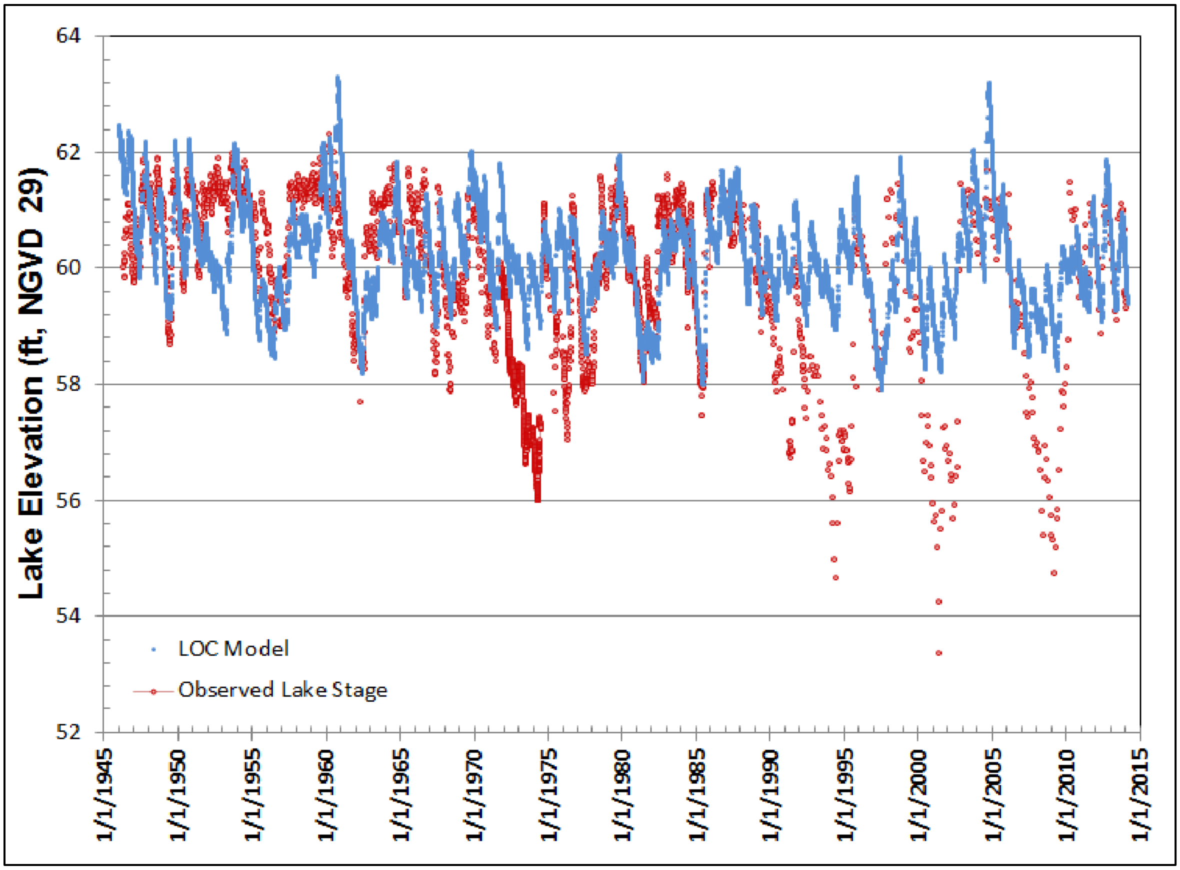

Figure 8. Lake Stemper rainfall regression model results.

F. Assessment of Lake Stemper MLL and HMLL Status

Section 373.0421, F.S. requires that a recovery or prevention strategy be developed for all water bodies that are found to be below their minimum flows or levels or are projected to fall below the minimum flows or levels within 20 years. In the case of Lake Stemper and other water bodies with established minimum flows or levels in the northern Tampa Bay area, an applicable regional recovery strategy, referred to as the “Comprehensive Plan”, has been developed and adopted into District rules (Rule 40D-80.073, F.A.C.). One of the goals of the Comprehensive Plan is to achieve recovery of minimum flow and level water bodies that are in the area affected by the Consolidated Permit wellfields (i.e., the Central System Facilities) operated by Tampa Bay Water. This section provides information and analyses to be considered for evaluating the status (i.e., compliance) of the revised minimum levels proposed for Lake Stemper and any recovery that may be necessary for the lake.

Re-evaluation of Lake Stemper resulted in the same MLL’s originally adopted and no changes are proposed. Minimum levels for Lake Stemper are presented in Table 4 and the MLL re-valuation is discussed in more detail by Kolasa and others (2014). Minimum levels represent long-term conditions that if achieved, are expected to protect water resources and the ecology of the area from significant harm that may result from water withdrawals. The Minimum Lake Level is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis. The High Minimum Lake Level is the elevation that a lake's water levels are required to equal or exceed ten percent of the time on a long-term basis. The Minimum Lake Level therefore represents the required 50th percentile (P50) of long-term water levels, while the High Minimum Lake Level represents the required 10^{th} percentile (P10) of long-term water levels. To determine the status of minimum levels for Lake Stemper or minimum flows and levels for any other water body, long-term data or model results must be used.

Table 4. Adopted Minimum and Guidance Levels for Lake Stemper (no change).

Guidance Levels	Elevation in Feet NGVD 29	
	Original MFLs	**Re-evaluated MFLs**
High Guidance Level	61.2	61.2
High Minimum Lake Level	60.8	60.8
Minimum Lake Level	59.4	59.4
Low Guidance Level	59.1	59.1

The overall goal of the MLL assessment evaluation is to determine if lake levels are fluctuating relative to the adopted MLLs in an appropriate manner. In addition to the using rainfall regression model, the process includes a comparison of long-term levels with adopted levels, review of periodic groundwater modeling updates, and investigation of other potential factors that could explain lake level fluctuations.

One of the MLL assessment methods uses prediction intervals based on the calibration window predicted and observed monthly average lake levels. The LOC and the prediction intervals are then shifted down by the difference between the MLL and the Historic P50 (Figure 9). These shifted lines now represent range of lake elevations due to climate around the new MLL.

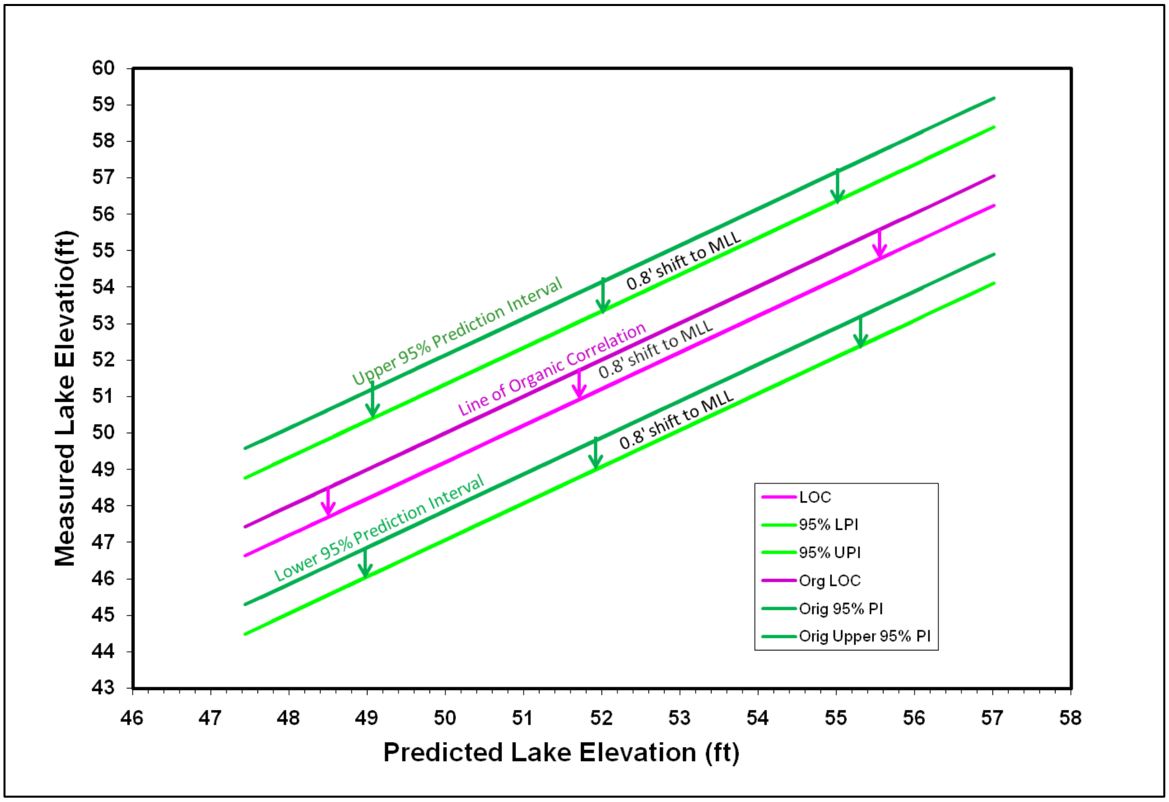

Figure 9. Example of the shifts to the prediction interval and LOC lines to reflect the MLL.

Prediction intervals were calculated for alpha equal to 0.025 (single tail) using the following equation (Helsel and Hirsch, 1992).

$$\left(\hat{y} - ts\sqrt{1 - \frac{1}{n} + \frac{(x_0 \ - \bar{x})^2}{SS_x}}\ ,\ \hat{y} + ts\sqrt{1 - \frac{1}{n} + \frac{(x_0 \ - \bar{x})^2}{SS_x}}\right)$$

$\hat{y_i} = b_0 + b_i x_i$ *the estimate of y given x_i*

$t = \frac{\bar{y} - \mu_0}{s/\sqrt{n}}$ *students t distribution*

$s = \sqrt{s^2}$ *standard error of the regression*

$\bar{x} = \sum_{i=1}^{n} \frac{x_i}{n}$ *mean x*

$SS_x = \sum_{i=1}^{n}(x_i - \bar{x}_i) = \sum_{i=1}^{n} {x_i}^2 - n(\bar{x})^2$ *sums of squares*

Updates to the LOC model will be used to update the predicted daily lake levels which are then plotted on the assessment graph (i.e. shifted LOC and prediction intervals) to determine if the number points plot below the lower 95% prediction interval are high. By definition of a 95% prediction interval it is expected that 2.5% of the points will lie below the lower prediction interval. However, such a strict interpretation may not be reasonable due to the variability in rainfall and the complexities in representing the area total with point measurement taken at a gauge. Because of this and other factors such as limitations imposed on calibration to short time periods that may not include the entire range of levels (extreme highs and record lows) the MLL assessment is doubling the theoretical number to 5%. A large number of points plotting below the lower prediction interval would suggest the lake is lower than rainfall alone can account for, and possible changes may be resulting from groundwater withdrawals or some other factor(s).

Plotted regression model results versus observed levels for Stemper (Figure 10) since January 2010, lie within the two prediction intervals indicating that the lake is behaving in accordance with the rainfall regression model which was calibrated to pre-pumping conditions. Because Lake Stemper's MLL (59.4') is 0.8 ft. below the Historic P50, the prediction intervals and LOC lines were shifted 0.8 ft. down.

Use of actual observed lake data provides a direct method of assessing the lakes levels in relation to the MLL and HMLL. The MLL and HMLL represent long-term (60 plus years) period 50th and 10th percentiles respectively, so full assessment of the levels with actual corresponding percentiles requires a long period of data. In the case of Lake Stemper the long-term period during the last 60 years includes periods of withdrawals that are greater than the current withdrawal cutbacks as part of the NTB recovery effort. Assessment of the levels using the record starting in 1963 evaluates the lake relative to the history of withdrawals in the area which have been variable through time. The cumulative median starts at a high elevation of 61.1' dips to a low of 58.3' and oscillates slightly above the MLL of 59.4'. The P10 follows a similar pattern and stabilizes at approximately 61.1' which is 0.3' higher than the HML of 60.8'.

When withdrawals in the area are cutback the question of interest is what improvement will occur under the new reduced withdrawals. Assessment of the MLL with a median based on data periods shorter than the long-term 60-year period can provide some insight on the lakes condition. The reliability of the evaluation increases with longer time periods of data and wide swings in the median early in the cumulative median calculation are normal. As the length of the data used in the median calculation increase the swings in the median that result from wet and dry cycles decrease and start to center on the long-term median more providing an early indication of the long term median.

Withdrawals from the two wellfields started reduction of production in August 2002 (Figure 12). South Pasco reduced from approximately 15 mgd to less than 10 mgd with periods as low as 2 mgd. Section 21 gradually reduce production from approximately

10 mgd down to 2 mgd in 2010. The sum of the two wellfields shows a reduction in 2002 and another one in 2010. Production was increased in 2008 with a peak of 17 mgd reached. Review of the total production from all water use permits out to a six-mile radius shows less than 3 mgd peak use within the first two miles of the lake. At three miles water use increases primarily from the inclusion of Section 21 wellfield. At 5 and six-mile radius water use increases again primarily from inclusion of South Pasco wellfield.

The cumulative 10th and 50th percentiles starting with the reduction of production in 2002 (Figure 13) are both above the respective levels. The cumulative P50 is 1.2' higher than the minimum level. The cumulative P10 is 0.4' higher than the HMLL for most the period but drops to just 0.1' higher from 2014 on from operation of the structure at a lower elevation.

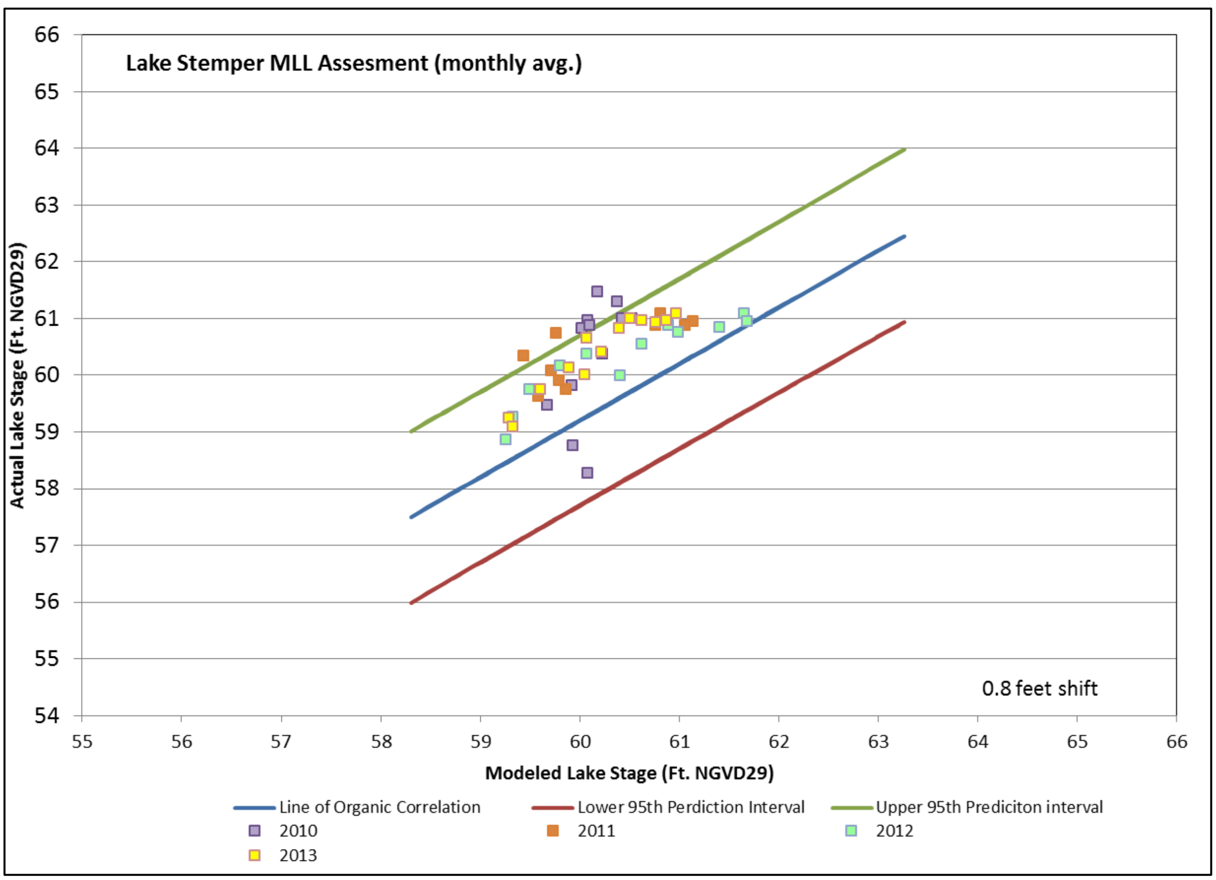

Figure 10. Lake Stemper MLL assessment prediction intervals and model versus observed data since 2010.

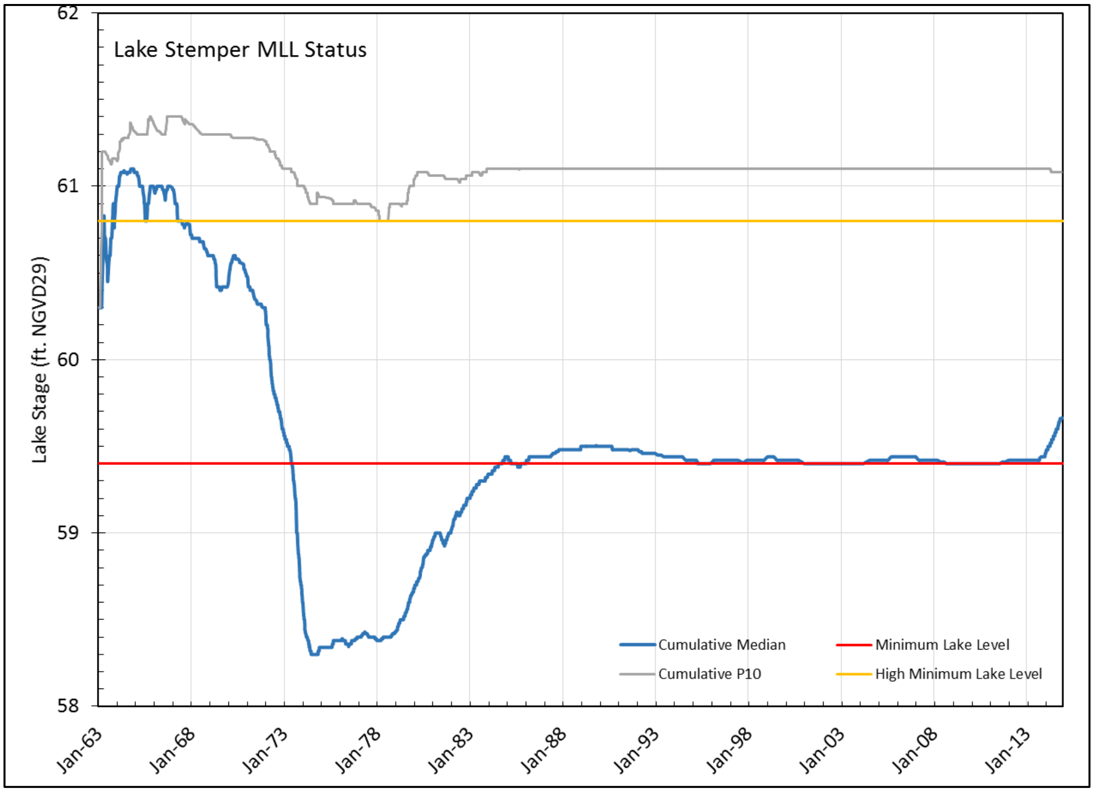

Figure 11. Lake Stemper MLL assessment prediction intervals and model versus observed data since 2010.

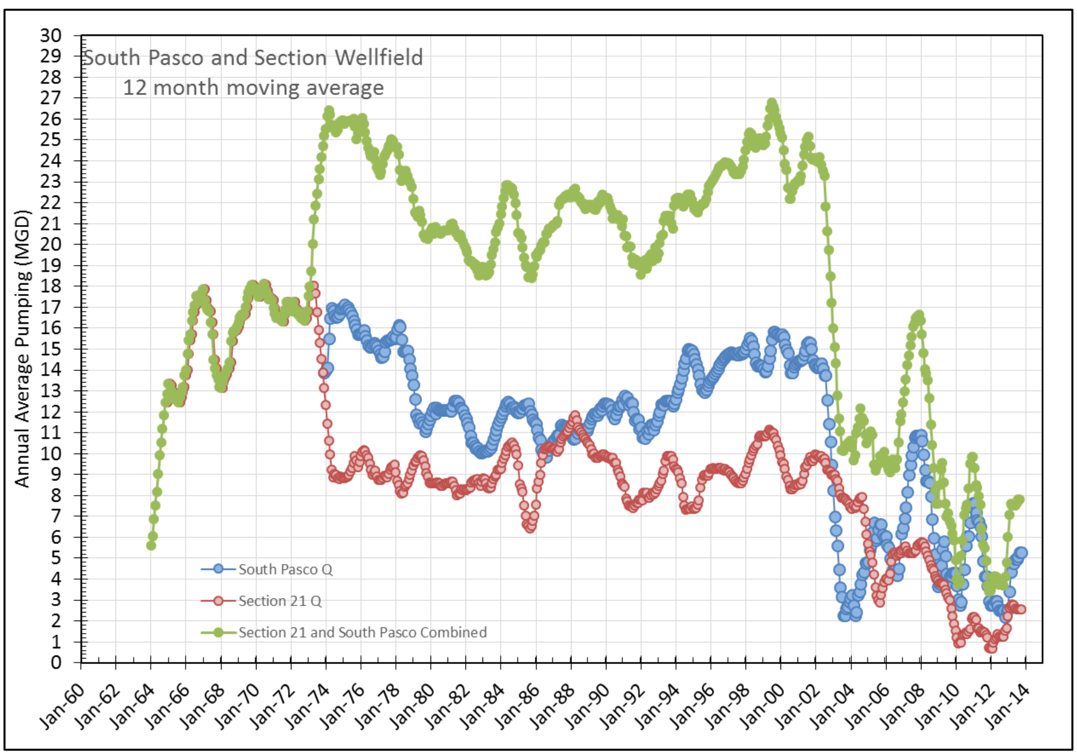

Figure 12. A 12 Month moving average of Section 21, South Pasco and the two combined.

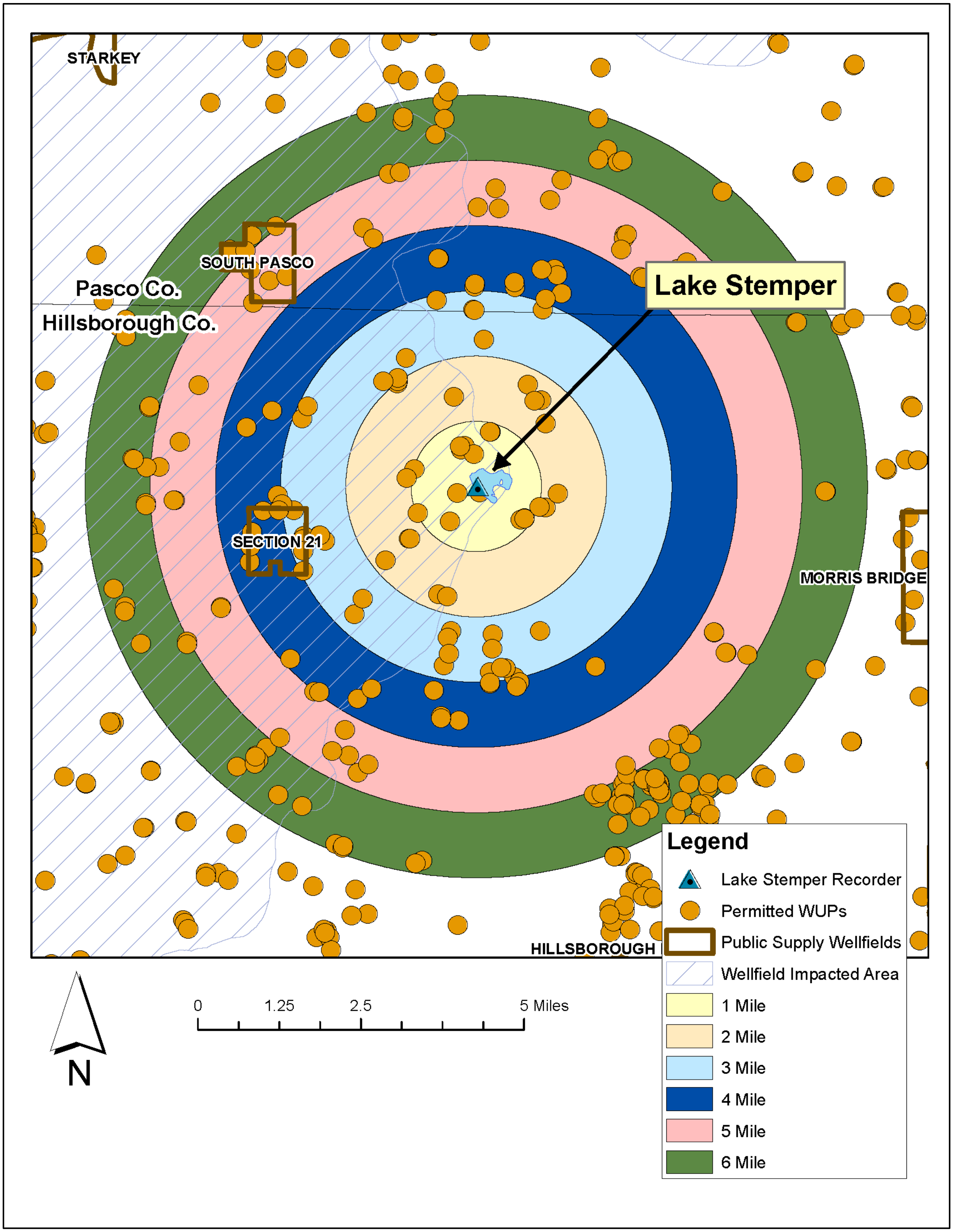

Figure 13. Location of permitted withdrawals.

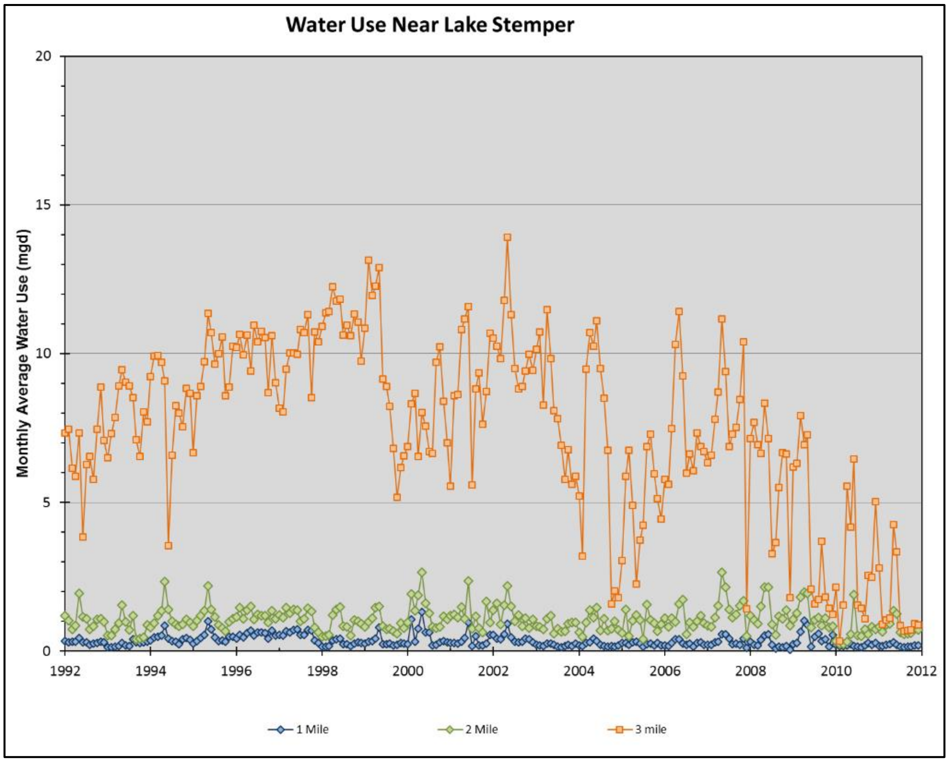

Figure 14. Combined monthly average withdrawals from all water use permits within 1, 2, and 3 miles of Lake Stemper.

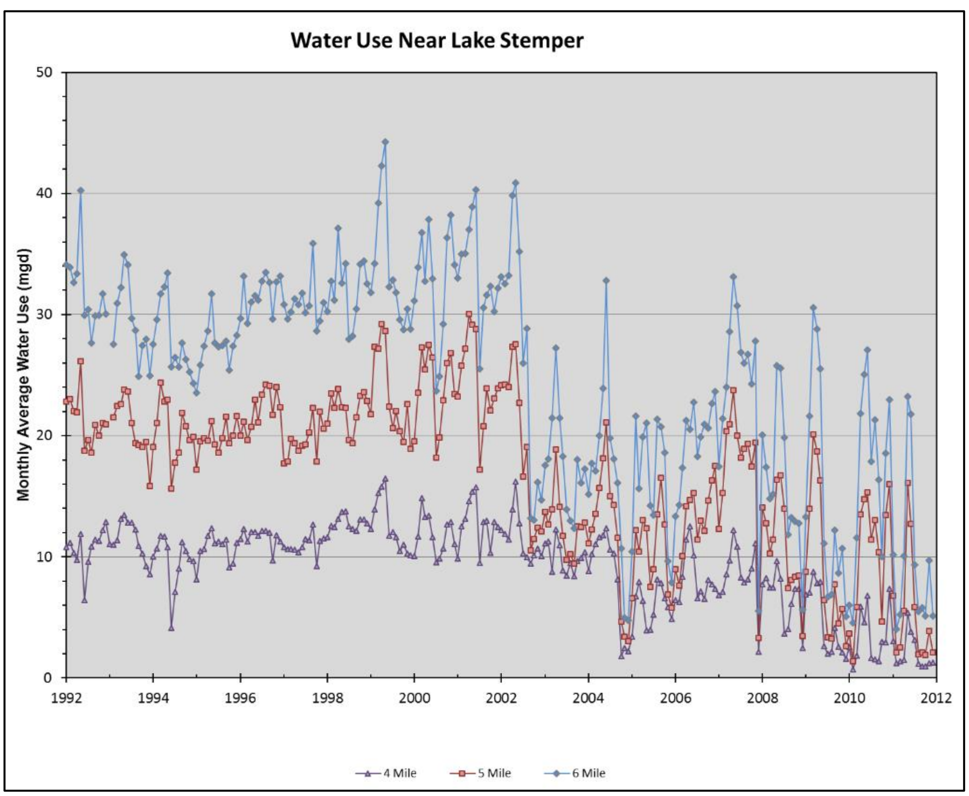

Figure 15. Combined monthly average withdrawals from all water use permits within 4, 5, and 6 miles of Lake Stemper.

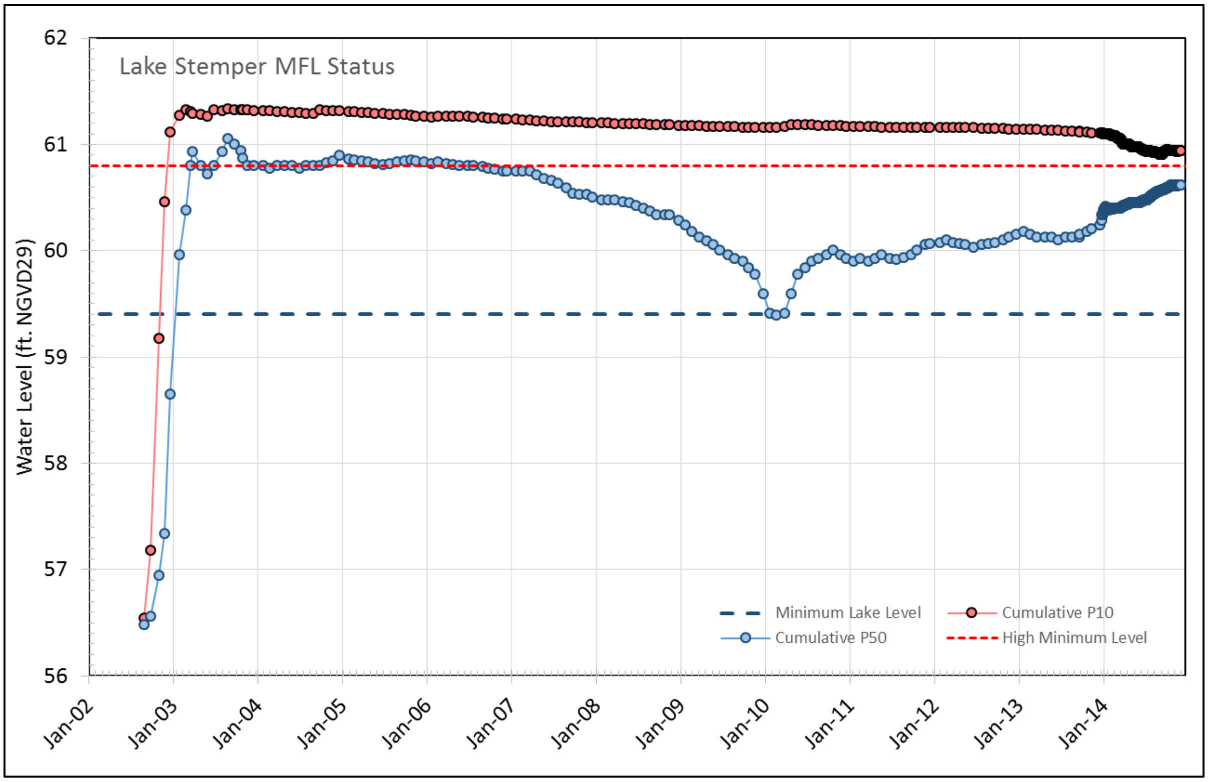

Figure 16. Lake Stemper observed data cumulative median starting in 2002 compared to the proposed HMLL and MLL.

G. Conclusions

Long-term historic lake stage fluctuations for Lake Stemper were developed using a rainfall correlation model. Lake Stemper has data pre-dating withdrawals at the nearest wellfield (Section 21) located 2.7 mile to the west. This early data (1957 through 1962) was used to calibrate a rainfall correlation model which was then used to predict lake stage fluctuations back to 1946 and forward to 2014. The resulting prediction represents an estimation of the un-impacted lake stage fluctuations. The model was then used to calculate the long-term historic lake stage percentiles consisting of the P10, P50 and P90. The long-term historic P10, P50 and P90 were 61.3', 60.2' and 59.1' respectively. The Long-term Historic P50 is above the MLL (59.4') for Lake Stemper which was calculated by subtracting significant change standard of 1.8' from normal pool (61.2'). Evaluation of the status of the levels indicates that the lake is above the MLL and HMLL for both data from periods starting in 1973 and 2002. Significant reductions in wellfield withdrawals occurred in 2002 and evaluation of the levels since then indicates improved lake levels that exceed the MLL by 1.2 ft and the HMLL by 0.2'. The period since the wellfield reductions took place in 2002 is short limiting the conclusions that can be made, but the data does suggest improvement in lake levels since the reductions in withdrawals.

Based on the information presented in this memorandum, it is concluded that Lake Stemper water levels are currently above the Minimum Lake Level and High Minimum Lake Level. These conclusions are supported by comparison of long-term observed lake stage exceedance percentiles with the proposed minimum levels.

Minimum flow and level status assessments are completed on an annual basis by the District and on a five-year basis as part of the regional water supply planning process. In addition, Lake Stemper is included in the Comprehensive Environmental Resources Recovery Plan for the Northern Tampa Bay Water Use Caution Area (40D-80.073, F.A.C). Therefore, the analyses outlined in this document for Lake Stemper will be reassessed by the District and Tampa Bay Water as part of this plan, and as part of Tampa Bay Water's Permit Recovery Assessment Plan (required by Chapter 40D-80, F.A.C. and the Consolidated Permit (20011771.001)). Other lakes in the area are not meeting their levels and will Tampa Bay Water, in cooperation with the District will assess the specific needs for recovery in other lakes and other water bodies in the area affected by groundwater withdrawals from the regional wellfields. Lake Stemper is expected to continue to meet its levels as other efforts to address the impacted lakes in the area should be a neutral or positive effect on Lake Stemper. The draft results of the Permit Recovery Assessment Plan are due to the District by December 31, 2018.

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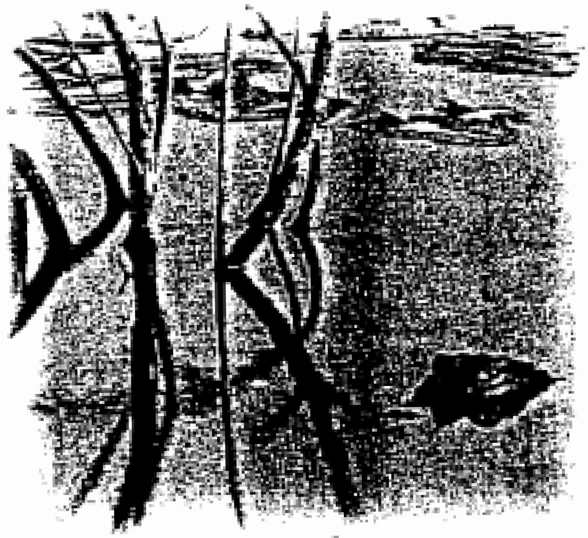
Southwest Florida Water Management District

Northern Tampa Bay
Minimum Flows & Levels White Papers



White Papers Supporting The Establishment of Minimum Flows and Levels For:

- Isolated Cypress Wetlands
- Category 1 and 2 Lakes
- Seawater Intrusion
- Environmental Aquifer Levels, and
- Tampa Bypass Canal

PEER REVIEW FINAL DRAFT
March 19, 1999

Northern Tampa Bay
Minimum Flows and Levels
Overview

The Northern Tampa Bay area is comprised of the counties of Pinellas, Pasco and the northern portion of Hillsborough. These counties are located in southwest Florida and surround the northern half of Tampa Bay. Pinellas County is almost entirely urbanized, as are much of northwest Hillsborough County and southwestern Pasco County. Inland areas of Pasco are rapidly becoming urbanized also. Potable water supplies for these counties and municipalities within these counties are principally from eleven regional wellfields located in Hillsborough and Pasco counties drawing from the Upper Floridan aquifer.

The first of the regional wellfields began operating in the early 1930's. The eleventh wellfield began operating in 1992. In addition to other sources, wellfields continue to be brought on-line in the area to meet the potable water supply needs of the Northern Tampa Bay area.

The surface water environment within the Northern Tampa Bay area is highly interconnected with the ground water system. Because of the karst geology that characterizes the area, a discontinuous and leaky confining layer provides a relatively good hydraulic connection between the surficial aquifer and the underlying Upper Floridan aquifer. Although localized areas of good confinement exist, overall the Upper Floridan aquifer is described as poorly to moderately confined within the Northern Tampa Bay area. As a result, water levels in the aquifers are linked, and fluctuate similarly.

Without ground water withdrawals, recharge from rainfall to the surficial aquifer and discharge by evapotranspiration and flow from the surficial aquifer are the only significant driving forces of these fluctuations. Very little ground water is contributed to the area from lateral inflow. The variable head in the surficial aquifer in turn largely regulates the recharge to the Upper Floridan aquifer through the leaky semi-confining unit. Therefore, the fluctuations in the surficial aquifer affect the fluctuations in the Upper Floridan aquifer.

An additional stress is introduced to this process when ground water withdrawals from the Upper Floridan aquifer are added. Ground water withdrawals lower the potentiometric surface of the Upper Floridan aquifer, which in turn increase leakage from the surficial aquifer to the Upper Floridan aquifer. This additional recharge is referred to as induced recharge. The result is a lowering of the water table. Assessments have shown that in leaky areas of the Northern Tampa Bay area, most of the water withdrawn from the Upper Floridan aquifer by pumping is derived by vertical leakage downward from the surficial aquifer (Liu and Polmann, 1996). Thus, Upper Floridan aquifer water level fluctuations caused by ground water withdrawals affect surficial aquifer water level fluctuations, as well as the water levels of lakes and wetlands that are connected to the surficial aquifer.

Waters and wetlands account for approximately 23 percent of the land area within the Northern Tampa Bay area.

In the mid 1980's, the District declared the northwest Hillsborough County area and limited portions of Pinellas and Pasco Counties, within which several of the wellfields are located, to be an "area of special concern" regarding the condition of local water resources.

In 1987, the District undertook a water resource assessment project ("WRAP") to examine the water resources within the area of special concern. In 1989, based on preliminary information from the WRAP, the District declared an area as the "Northern Tampa Bay Water Use Caution Area" in recognition of environmental stress identified by the District.

In 1992, the WRAP study area was expanded and became identified as the "Northern Tampa Bay Water Resource Assessment Project" ("NTBWRAP"). The NTBWRAP is the District's most recent attempt at determining the condition of the water resources in the area of the regional wellfields. (The NTBWRAP is among the materials provided with the White Papers).

Due to environmental stress to the water resources in the Northern Tampa Bay area, Section 373.02 Florida Statutes (F.S.), as amended by the Florida Legislature in 1996, directed the District to establish minimum flows and levels for the region before October 1, 1997.

Section 373.042, F.S. defines the minimum flow to a surface water course to be the flow below which additional withdrawals would cause significant harm to the water resources or ecology of the area. Section 373.042, F.S. defines the minimum level of an aquifer or surface water body to be the level below which additional withdrawals would cause significant harm to the water resources of the area. The 1996 amendments to the statute required the District to adopt minimum flows and levels in Hillsborough, Pasco, and Pinellas County for priority waters that are experiencing or may be expected to experience adverse impacts. In response to this legislative direction, the District established 41 minimum wetland levels, minimum levels for 15 lakes, sea water intrusion aquifer levels, narrative aquifer levels and a minimum flow for the Tampa Bypass Canal. Work is ongoing to establish minimum flows and levels in the future for additional water bodies.

Section 373.042, F.S. requires the District to use the best data available to set minimum flows and levels. The legislative requirement to set the levels by October 1, 1997 was absolute, that is, there was a limited time to collect additional information. Because of the time deadline, and the associated requirement to use the best information available, the District was constrained to use existing data complete with any associated limitations of that data.

The process to develop the methods for determination of minimum flows and levels was an open public process with all interested parties invited to participate in the development of methodologies for determining the limit at which significant harm occurs to the lakes, wetlands, surface water courses and aquifers for which levels must be established. Many lay and technical representatives of the interested local governments, environmental groups and individuals did participate in the rule development process through months of meetings, public workshops, and public hearings.

Following this public process the District staff finalized methodologies and minimum levels and flows for approval by the Governing Board. However, effective July 1, 1997, subparagraph 373.042(l)(a), F.S. was added. That paragraph directs the District to consider changes and structural alterations to watersheds, surface waters, and aquifers and the effects such changes and alterations have had when establishing minimum flows and levels. Therefore, at the Board's direction, staff reviewed the previous work, additional data as appropriate, continued meetings and workshops with affected parties and held public workshops with the Governing Board to ensure that the changes to the statute had been assimilated into the methodologies.

On October 28, 1998, the Governing Board approved the subject minimum flows and levels.

As permitted under subsection 373.042(4), F.S., five parties requested Scientific Peer Review of the scientific and technical data and methodologies used to determine the flows and levels. The purpose of this series of reports is to document for the Scientific Peer Review Panel scientific and technical data and methodologies used to determine the flows and levels for priority waters in the Northern Tampa Bay area.

The reports are organized in the following sections. This first section provides a general explanation of the area, hydrogeology, the Legislature's direction to the District and the processes and constraints for the District's establishment of minimum flows and levels. The next four sections describe the specific methods developed for determination of minimum levels in certain wetlands, certain lakes, and in the Upper Floridan aquifer, respectively. The last section describes the methods used to develop the minimum flow for the Tampa Bypass Canal.

March 1999

Establishment of Minimum Levels for Category 1 and Category 2 Lakes

Prepared by the
Resource Conservation and Development Department
Southwest Florida Water Management District

printed on recycled paper

PROFESSIONAL GEOLOGIST

The geological evaluation and interpretations contained in the report Establishment of Minimum Levels for Category 1 and Category 2 Lakes (March 1999) were prepared by, or reviewed by, a Certified Professional Geologist in the State of Florida.

DONALD L. ELLISON
LICENSE
No. 1670
STATE OF
FLORIDA
PROFESSIONAL GEOLOGIST

Donald L. Ellison

March 18, 1999
Date

License No. 0001670

Ronald J. Basso, Jr.

March 18, 1999
Date

License No. 0001325

PROFESSIONAL ENGINEER

The engineering contained in the report Establishment of Minimum Levels for Category 1 and Category 2 Lakes (March 1999) consisting of characterization of structural alterations on specific lakes and identification of related control points was prepared by, or reviewed by, a Registered Professional Engineer in the State of Florida.

Gordon L. McClung, P.E.

March 19, 1999
Date

License No.: 43351

Table of Contents

Page No.

Chapter 1- Introduction 1
Report Format 1
Acknowledgments 2

Chapter 2 - Lake Level Data Collection 4
Hydrologic Data 4
Historic Data 4
Current Data 5
Hydrologic Indicators 5
Determination of Structural Alteration and Control Point 6

Chapter 3 - Establishment of a Reference Lake Water Regime For the Northwest Hillsborough Area 7
Introduction 7
Selection of Reference Lakes 9
Calculation of the RLWR 22
Conclusions 22

Chapter 4 - Establishment of Guidance and Minimum Levels 25
Introduction 25
Establishment of the High Guidance Level (HGL) 25
Calculation of the Historic P50 29
Calculation of the High Minimum and Minimum Level 30
Calculation of the Low Guidance Level (LGL) 32

References Cited 34

APPENDICES

APPENDIX A. Lake Level Sub-Committee Meeting Minutes.
APPENDIX B. Reference Lake Hydrographs.
APPENDIX C. Application of Minimum Lake Level Method to 15 Lakes.
APPENDIX D. Summary Statistics for 88 Lakes Reviewed.
APPENDIX E. Comparison of Lake Thomas to 14 Other Lakes Located in the Land O' Lakes Region.

LIST OF FIGURES

Figure No.		Page No.
FIGURE 1	Location of Minimum Level Lakes in Northern Tampa Bay	3
FIGURE 2	Data Limitations encountered that require use of the reference lake water regime to define lake fluctuation absent withdrawal impacts	8
FIGURE 3	Example of percentiles	10
FIGURE 4	Location of well nests referenced in Figure 5	11
FIGURE 5	Hydrographs of six nested wells within the Northern Tampa Bay WRAP Area	13
FIGURE 6	Zones of similar subregional hydrogeology within the Northern Tampa Bay WRAP (Modified from Ryder, 1985 and Parker, 1992)	14
FIGURE 7	Location of Reference Lakes Used in Reference Regime	15
FIGURE 8	Graph depicting wellfield pumpage	17
FIGURE 9	Predicted Floridan aquifer drawdown from South Pasco wellfield at selected reference lakes	19
FIGURE 10	Hydrograph comparison of Lake Thomas with Camp Lake	20
FIGURE 11	Hydrograph comparison of Lake Thomas with Lake Linda	21
FIGURE 12	Water level trend at the Bexley monitor well	23
FIGURE 13	Method for calculation of the High Guidance Level (HGL)	26
FIGURE 14	Method for calculation of the Historic P50	30
FIGURE 15	Method for calculation of high minimum and minimum lake levels	31
FIGURE 16	Method for calculation of the low guidance level (LGL)	33

LIST OF TABLES

Table No. — Page No.

Table 1 — Background lake information on augmentation, structural alteration, and direct withdrawals....16

Table 2 — Statistical summary of reference lakes in the study area.... 24

Table 3 — Comparison of the reference wetland normal pool elevations to the P10....27

Table 4 — Comparison of a P10 representing a stable period of current structural alterations on each reference lake to the control point elevation in place during this period....28

Chapter 1
Introduction

The District assembled a Technical Advisory Committee (TAC) consisting of District staff, representatives of local governments and interested citizens to develop methods for determining the MFLs. The TAC was subsequently divided into subcommittees with a goal of reaching a consensus on methods to set minimum levels for lakes, wetlands and aquifers no later than March 1, 1997.

The Lake Level Subcommittee (LLS) was made up of District staff as well as local government and water supply representatives (staff and or their consultants) including: Hillsborough County; Tampa Bay Water (formerly West Coast Regional Water Supply Authority); Pinellas County; the City of St. Petersburg; the City of Tampa; and Pasco County. The LLS agreed that establishment of the Minimum Levels should rely more on stage duration and biological data than on cultural indicators such as docks, and that several hydrologic indicators of high water levels exist which could be used. The minutes from each LLS meeting are contained in Appendix A.

The method resulting from the work of the LLS was used to establish levels for nine lakes in Northwest Hillsborough by October 1, 1997. The Northwest Hillsborough area is depicted on Figure 1. However, at this public hearing, the Governing Board requested that staff reevaluate the method and the Minimum Levels used. Subsequently, District staff reviewed additional data, met with affected parties and held public workshops with the Governing Board and lake shore homeowners. Following these meetings, the District further revised the October 1, 1997 MFL lake method. This revision incorporated some of the concepts from the previous LLS method, but it also included some changes that the District felt were necessary. This revised method for establishing Minimum Levels for lakes was used to propose Minimum Levels for 15 lakes which were approved by the Governing Board on October 28, 1998.

Report Format

This report describes the method used by District staff to establish the High Guidance level, the High Minimum Level, and Minimum Level for the 15 lakes which were approved by the Governing Board on October 28, 1998. The lakes are: Alice, Bird, Brant, Camp, Crystal, Deer, Dosson, Sunshine, Juanita, Little Moon, Rainbow, Merrywater, Sapphire, Stemper and Sunset.

Chapter 2 describes the data used to set the levels and the data collection methods. Chapter 3 describes the method for calculating a Reference Lake Water Regime (RLWR), which was used to establish levels in the absence of historic lake level stage data. Chapter 4, Establishment of Guidance and Minimum Levels, describes how the data were analyzed and the method was applied to determine the levels. Appendix B contains hydrographs of the reference lakes used to develop the Reference Lake Water Regime. Appendix C discusses application of the method to determine Guidance and Minimum Lake Levels for fifteen (15) lakes in the Northern Tampa Bay Area (Figure 1).

Acknowledgments

Establishment of Minimum Lake Levels was a team effort that began with the formation of the Minimum Flows and Levels Advisory Committees in 1997. Preparation of this report was a joint effort of the Resource Conservation and Development Department and the Resource Management Department under the direction of D.L. Moore. K.L. Garcia managed and coordinated field data collection and many of the activities involving input from outside parties such as Hillsborough County and Hillsborough County Environmental Protection Commission. H.C. Hull was instrumental in adapting the wetland minimum level to the lakes, establishing normal pools, and determining the wetland status on each lake. K.L. Garcia and D.L. Ellison complied lake data and calculated the minimum levels. R.J. Basso and D.L. Ellison analyzed water level data, developed the Reference Lake Water Regime, and developed the assumptions and supporting analysis for the determination of the High Guidance Levels. R.D. Gant provided historical knowledge of the lakes, gained access to the lakes for field data collection, and assisted in field data collection. D.C. Richardson, under the direction of G.L. McClung, was responsible for analyzing structural alterations on the lakes and identifying control points. The SWFWMD Survey Section verified elevations of the control points for the lakes. In addition to the named, staff from the Environmental and Engineering Sections of the Resource Management Department and from the Hydrologic Data section of the Resource Data Department participated in the collection of field data. Aerial and GIS maps were provided by the GIS/Mapping Section of the SWFWMD. Graphics support was provided by the SWFWMD Graphics Department.

Location of Minimum Level Lakes In Northern Tampa Bay

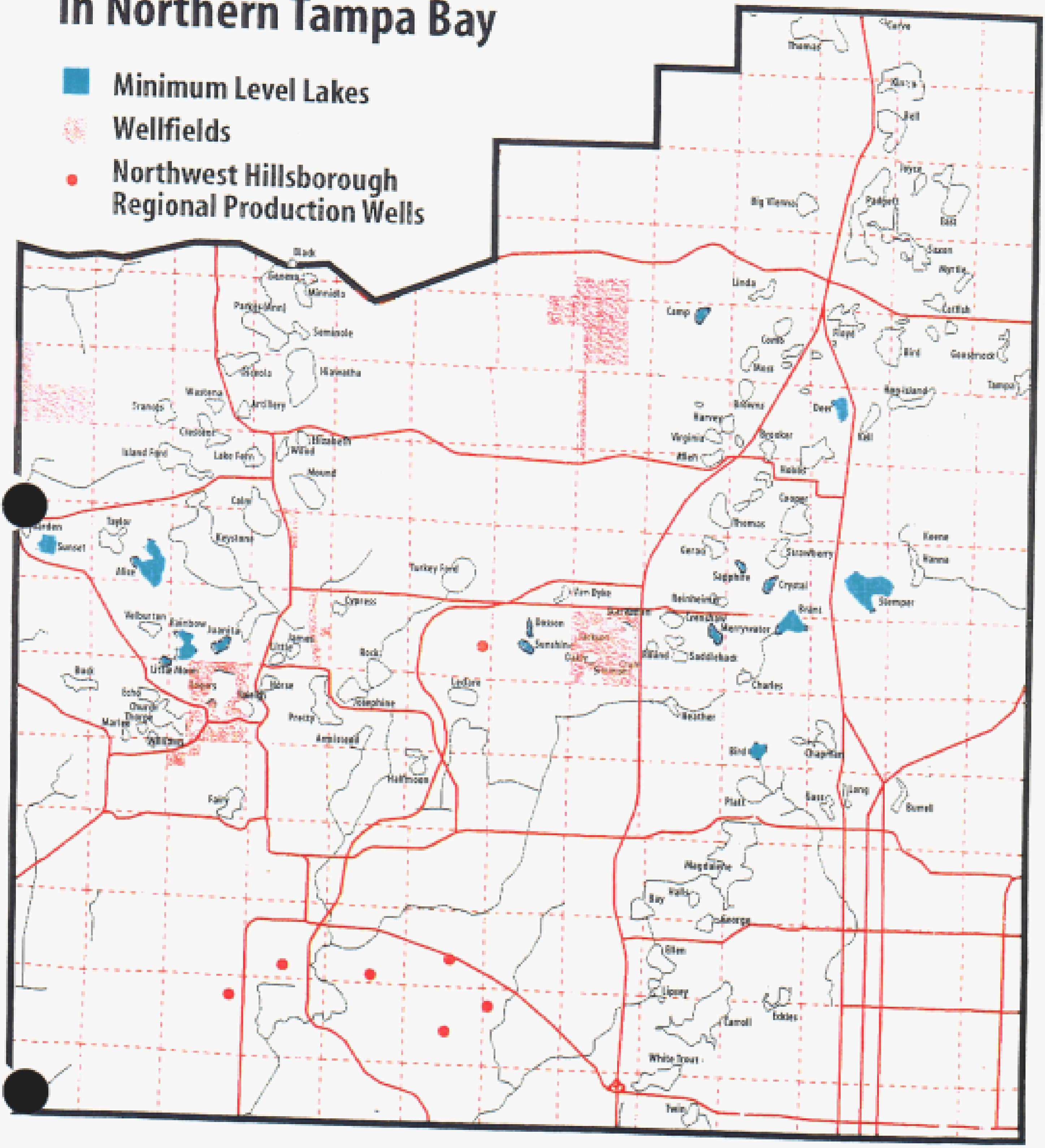


Figure 1

Chapter 2
Lake Level Data Collection

Hydrologic Data

Hydrologic data refers to lake level measurements, in feet National Geodetic Vertical Datum of 1929 (NGVD), recorded in the Water Management District Database. The Resource Data Department of the SWFWMD is responsible for maintaining the Water Management District Database and for quality control of the data prior to uploading raw data to the Database. Data collected by and/or recorded by the District is handled in accordance with standard operating procedures and quality control and quality assurance procedures (SWFWMD, 1994; SWFWMD, 1999a). Once information is entered into the Database, the data can be downloaded to various programs for analysis and preparation of hydrographs.

Historic Data

In establishing lake levels, "Historic" means a long-term period when there are no measurable impacts due to withdrawals, and impacts due to structural alterations are similar to current conditions.

Historic lake level data refers to lake level data that covers a period when there were no measurable impacts due to water withdrawals, and impacts due to structural alterations were the same as current conditions. Therefore, to qualify as historic lake level data, the data must meet two tests: 1) the data must predate the beginning of water withdrawals from known wellfields or wells, or impacts due to water withdrawals must not be measurable; and 2) configuration of the surface water conveyance system and the control point elevation of the surface water conveyance system for the lake, must have been the same as currently exists.

If, based on reasonable scientific judgement, a period was found that did not appear to be impacted by withdrawals, then water level data from this period potentially was eligible to qualify as historic data. However, the configuration of the surface water conveyance system and the control point elevation of the surface water conveyance system must be determined to be similar to that which currently exists. The configuration of the surface water conveyance system and the control point elevation of the surface water conveyance system were assumed to be the same as the current condition unless:

1. There was documentation that a change had been made to the surface water conveyance system between the beginning of the record and present; or

2. District staff had knowledge that the operation schedule or level of an operable structure had been changed; or

3. District staff determined, using best scientific judgement, from review of the hydrograph, that a change had been made to the structural conveyance system.

If a period of data was found that met the criteria for Historic Data, then elevations equal to the tenth, fiftieth and ninetieth percentile (P10, P50 and P90) were calculated using monthly average lake level data. These elevations were recorded as the Historic P10, Historic P50 and Historic P90.

If a period of data was not found that met the criteria for Historic Data, then the data was identified as Current Data. Therefore, the elevations recorded as the Historic P10, Historic P50 and Historic P90 had to be estimated using control point or hydrologic indicators discussed below, or P10 elevations calculated from current data (if available) and the Reference Lake Water Regime. The method for estimating these historic elevations is discussed in the Establishment of Guidance and Minimum Levels Chapter. Calculation of the Reference Lake Water Regime is discussed in the Reference Lake Water Regime Chapter.

Current Data

As used in this paper, "Current" means a recent long-term period during which structural alterations and hydrologic stresses are stable.

Current lake level data refer to lake level data from a period when there were measurable impacts due to water withdrawals and these were stable during the period. Also, the configuration of the control point and surface water conveyance system must have been stable during the period.

If a period of data was found that met the criteria for current data, then elevations equal to the tenth, fiftieth and ninetieth percentile were calculated using monthly average lake level data. These elevations were recorded as the Current P10, Current P50 and Current P90.

The current data are used to calculate the lake specific difference between the Current P10 and Current P50. This value is compared to the RLWR50 to determine which value to use in calculating the Minimum Level. The Current P10 may also be used to establish the High Guidance Level. This will be more fully discussed in the Reference Lake Water Regime Chapter and in the Establishment of Guidance and Minimum Levels Chapter.

Hydrologic Indicators

As used in this paper, "Hydrologic Indicators" means those biological and physical features, which are representative of previous water levels as listed in Section 373.4211(20), Florida Statutes. For cypress-wetland fringed lakes in the Northern Tampa Bay Area, hydrologic indicator refers to indicators of normal pool in the cypress wetland of the lake. This level can be consistently identified in cypress swamps based on similar vertical indicators of inundation (Hull et al., 1989). Five indicators of normal pool elevations are listed in the `report entitled "Establishment of Minimum Levels in Wetlands" (SWFWMD, 1999b). Some hydrologic indicators such as the buttress of cypress trees and the outermost cypress tree, may be used as relict indicators of normal pool since they remain, even though declining water levels may have caused the downward migration of other wetland species.

However, for the lakes in the Northern Tampa Bay Area the presence of these indicators was very limited. This may have been due to impacts associated with prolonged low water levels. Normal pool elevation data is included in the individual lake discussions found in Appendix C.

Two to ten replicate measurements of normal pool were performed per lake depending on presence of indicators and access to cypress-fringing wetlands. All lakes had staff gages referenced to NGVD. Normal pool elevations were determined by measuring the distance above a known water level elevation. The average normal pool elevation was used to calculate the Guidance and Minimum Levels.

Determination of Structural Alteration and Control Point

Methods for establishment of Guidance and Minimum Levels are dependant on the presence or absence of structural alterations. As used in this paper "Structural Alteration" means man's physical alteration of the control point of a lake or wetland that affects water levels. "Structurally Altered" means a lake or wetland where the control point has been physically altered by man such that water levels are affected. As used in this paper, "Control Point Elevation" means the elevation of the highest stable point along the outlet profile of a surface water conveyance system that principally controls lake water level fluctuations.

The control point elevation is determined by conducting a field inspection of the lake and determining the presence of surface water conveyance systems and structural alterations. Surface water conveyance systems may include open ditches or channels, closed pipes or any combination of features and structures which function to convey water out of the lake. Establishment and documentation of the control point elevation was performed by a registered survey. Potential outlets are located by reviewing maps of the lake system. Potential outlets are field verified and high points along the outlet bottom are identified. Elevation of high points are measured using accepted survey practices. The elevation of the highest stable point along the outlet profile is recorded as the control point elevation used in establishing Guidance and Minimum Levels.

Control point and normal pool elevations are compared to determine whether the lake is or is not structurally altered. A lake is considered to be structurally altered if the control point elevation is below the normal pool elevation. If the control point elevation is above the normal pool elevation or there is no outlet for the lake, then the lake is not considered to be structurally altered.

Chapter 3
Establishment of a Reference Lake Water Regime For the Northwest Hillsborough Area

Introduction

The establishment of minimum levels requires information on the natural fluctuation of the lake under the influence of current structural alterations but absent impacts from groundwater withdrawals. While many of the lakes in the Northwest Hillsborough area have several decades of stage measurements, few pre-date the early start of groundwater withdrawals for municipal supply. These withdrawals began as early as the 1930's at the Cosme wellfield and gradually increased with the addition of the Section 21 wellfield in 1963 and the South Pasco wellfield in 1973. The impacts from these withdrawals have led to decreased stages and increased fluctuations in many of the lakes in the area (SWFWMD, 1996). As a result of the early pumpage, there are very few lakes in the area which have data pre-dating the potential influence of withdrawals or are located in an area which is not impacted by withdrawals. As a result, determination of what a lake's fluctuation would be without withdrawal impacts, becomes a task complicated by the limited availability of the necessary data.

The District has identified two types of lake stage data based on the potential influence of groundwater withdrawals on the lake water levels. The two data types are referred to as historic and current. In the simplest terms, the difference between historic and current data is the absence of influences of groundwater withdrawals during the historic period. Everything else is the same or assumed to be the same between the two data periods. This includes structural changes and long-term climatic conditions. As an example, Figure 2 illustrates some of the different lake stage data conditions encountered in the Northwest Hillsborough area. All but case 1 requires an alternative method to approximate the historic lake stage fluctuations. Case 1 illustrates the most straightforward situation where a period of historic data and current data exists. Because the structural alterations are similar between the two periods, the pre-withdrawal lake stage data would be used directly to quantify the natural lake fluctuation that would occur absent any withdrawal impacts. The second situation depicts a condition where only current data exists and historic data is absent. Even though there are lake stage data prior to withdrawal impacts, because a structural alteration was made to a lake during the current period, historic data don't exist. In the third and most common situation, data pre-dating withdrawals is simply absent because long-term data was not collected prior to potential groundwater withdrawal impacts on the lake.

In order to expand the set of lakes for minimum level adoption, a method to calculate the natural fluctuation of the lake was needed when all the data for the lake are potentially affected by withdrawals. The District developed an approach which estimates the natural fluctuation based on a group of typical lakes in the area which have little or no impacts from withdrawals. These lakes are referred to as reference lakes. The natural range of fluctuation is statistically defined by calculating the elevation of the lake stage which would be exceeded ten percent of the time (the 10^{th} percentile or P10), the P50 or median elevation (one-half of lake stage

Figure 2. Data limitations encountered that required use of the reference lake water regime to define lake fluctuation absent withdrawal impacts.

measurements above or below this value), and the elevation exceeded ninety percent of the time or more (P90). Figure 3 is an example of the three percentile elevations. Using the calculated percentiles in each reference lake, the difference between the P10 and P50, and the difference between the P10 and P90 for each lake were calculated. Using the two differences calculated for each of the 22 lakes, the median P10-P50 difference and the median P10-P90 difference using the total population of lakes was calculated. These median values were then used to establish the "Reference Lake Water Regime" (RLWR). The difference between the P10 and P50 is referred to as the RLWR50 and the difference between the P10 and P90 is referred to as the RLWR90. These two values were then subtracted from an indicator of the historic P10 of a lake which can be reasonably approximated for most lakes. It is important to note that the RLWR only describes the typical fluctuation range of a lake. In order to apply this data to a lake to represent the actual elevations of the lake fluctuation, a known reference point such as the historic P10 is needed on each lake. The method of determining this reference point is presented in Chapter 4, *Determination of the High Guidance Level.*

Selection of Reference Lakes

As part of the reference lake selection process, an area of similar hydrogeology to the lakes chosen for Minimum Level adoption was first delineated. Lakes with long term data pre-dating groundwater withdrawals were then identified. Finally, lakes which didn't have data that pre-dated withdrawal impacts but are far enough away from major groundwater withdrawals so that their stage fluctuation would approximate pre-withdrawal conditions, were selected. This final selection process was based on several analyses presented below.

The lakes region in west-central Florida generally encompasses northwest Hillsborough, northeast Pinellas, and south-central Pasco counties. In this area, there are numerous lakes and isolated cypress wetlands associated with the Lakes Terrace physiographic region (Hutchinson, 1985). The geology of the area is dominated by karst features such as sinkholes and solution conduits which greatly enhance the degree of hydraulic connection between the surficial aquifer and the Floridan aquifer. These karst connections tend to be localized, causing confinement between the surficial and Upper Floridan aquifer to be highly variable.

To the north of the Lakes Terrace region is another area of lakes located in central Hernando and eastern Pasco Counties in a physiographic region termed the Brooksville Ridge. While it would have been advantageous to develop a reference lake regime from these lakes, the area is geologically dissimilar to the Lakes Terrace region. On the Brooksville Ridge, lakes tend to be "perched" or hydraulically isolated from the underlying Floridan aquifer with head differences between the lake and aquifer of 50 feet or more. There is also a notable decrease in the presence of isolated cypress wetlands and an increase in marsh type wetland systems. Lake level fluctuations from lakes on the Brooksville Ridge also tend to be larger than the Northwest Hillsborough region.

Variability in hydrogeology (mainly variability in confinement) is demonstrated by inspection of Floridan aquifer and surficial aquifer paired hydrographs along a north-south transect (Figure 4). Figure 4 also depicts the study area of the Northern Tampa Bay Water Resources Assessment Project (SWFWMD, 1996). The hydrographs show a decrease in the head difference between

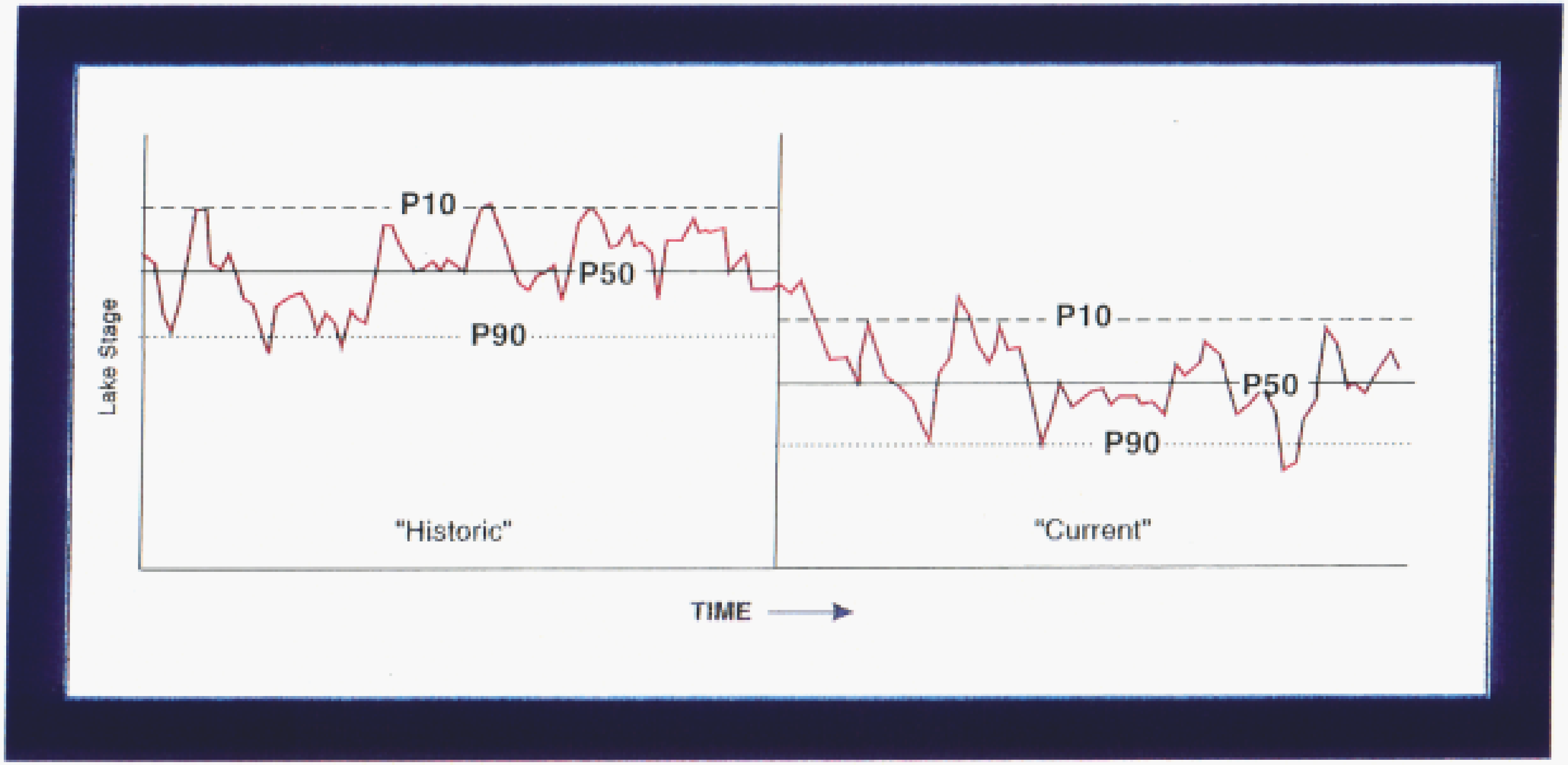


Figure 3. Example of percentiles.

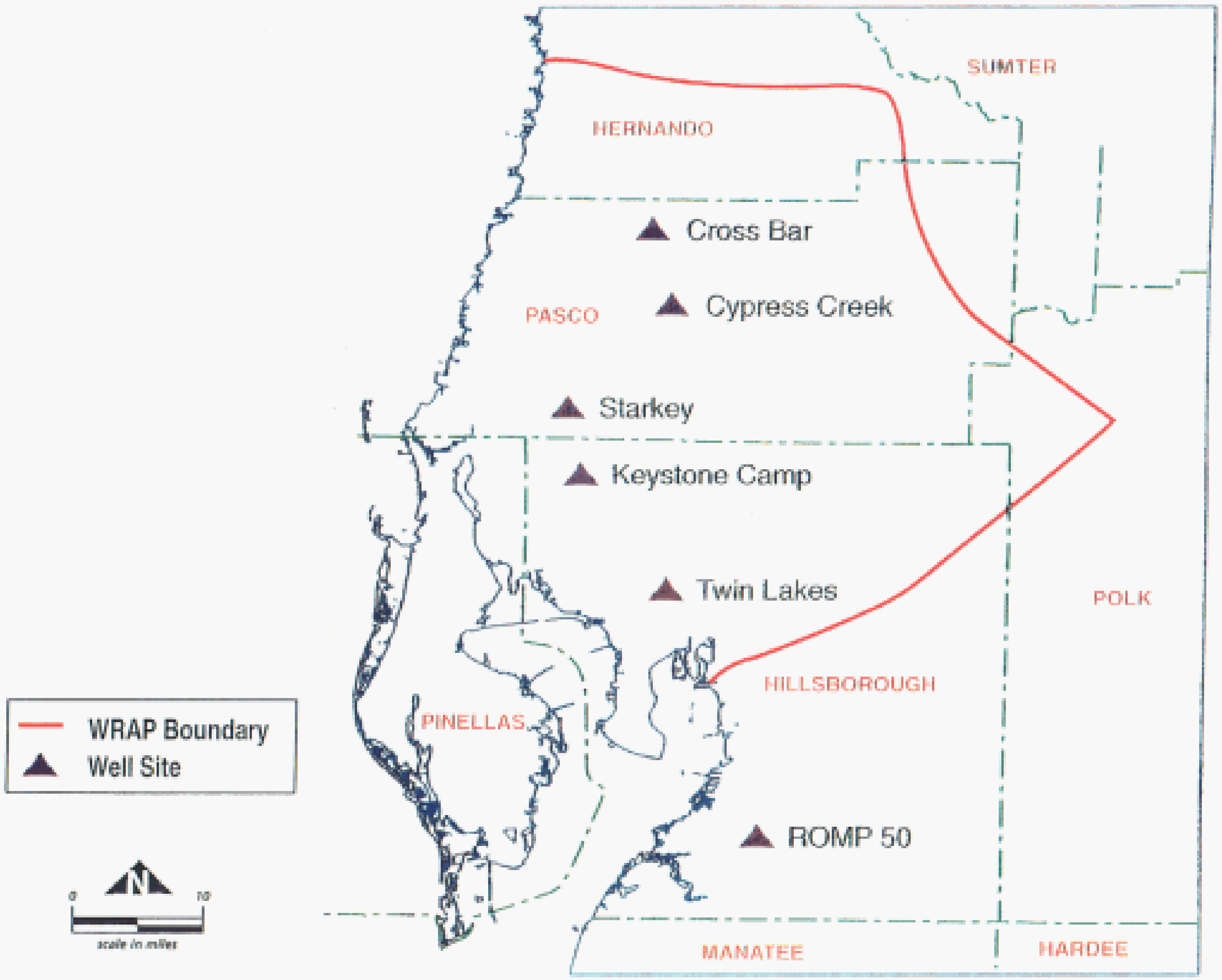


Figure 4. Location of well nests referenced in Figure 5.

the surficial aquifer and Floridan aquifer in the north compared to the south, indicating an increase in hydraulic connection between the surficial and Floridan aquifers toward the north (Figure 5). Based on the review of hydrologic information summarized above, region two was delineated as an area considered to be hydrologically similar to the lakes chosen for adoption in Hillsborough and Pasco counties (Figure 6).

Figure 7 shows the location of the reference lakes and the Minimum Level Lakes. In order for a lake to be used for the purpose of establishing the RLWR, it would either had to have data that pre-dates groundwater withdrawal impacts, or it would have to be located in an area where groundwater withdrawals have little to no impact on lake levels. In both cases, if any structural alterations had been made to the lake, a "long-term" stable period representing the change would also be required.

As a first step in the process of developing a RLWR, the period of record stage information for 88 lakes in the region was examined to determine if any lake had data that pre-dated any groundwater withdrawals (Appendix D). Because the Cosme-Odessa Wellfield was brought on line in 1930, there are very few lakes in the western portion of the area to serve as reference lakes with data that pre-dates pumpage. Additionally, Eldridge-Wilde Wellfield started pumpage in 1956 and was followed by Section 21 Wellfield in 1963, South Pasco Wellfield in 1973, and finally Northwest Hillsborough Wellfield in 1977. Figure 8 is a graph depicting wellfield pumpage initiation and past withdrawal rates. The search for lakes with wellfield pre-pumping data took into consideration the chronological order and relative area influenced by the cumulative withdrawals.

After initial review of all 88 lakes in the region, there were 22 lakes that had data which could be used to establish a RLWR. Of the 22 lakes, six lakes had at least ten years of record pre-dating wellfield groundwater withdrawals. The other 16 lakes were deemed far enough away from wellfield groundwater withdrawals while still in an area with similar hydrogeology (region 2) to serve as reference lakes. Of the 16 remaining, 12 are located immediately north of Land O' Lakes in Pasco County and are at least three to five miles east-northeast of South Pasco wellfield. Another three lakes, Parker, Minniola, and Seminole, are located on the extreme north end of the Cosme-Odessa chain about three to five miles from the Eldridge-Wilde and Cosme-Odessa wellfields. The remaining reference lake, Moon Lake, is located furthest away in southwest Pasco County. Table 1 lists the 22 lakes included in the reference lake regime along with information on the physical setting and type of data available. Appendix B contains hydrographs for each of the 22 lakes.

After the lakes were selected that met the lake stage data requirements, available information on structural alterations, direct withdrawals, and augmentation was reviewed to determine if any of these activities had an appreciable enough magnitude or duration to interfere with the value of the lake as a reference lake. Three lakes (Bird, Cooper and Hobbs) have been augmented for a short period in the past; however, the exact periods and quantities are not documented. It is believed that for Bird and Cooper, augmentation occurred sometime after 1973 as a response to the impacts caused by groundwater withdrawals in the area that began at this time. The date that augmentation was terminated is unknown. Augmentation on Lake Hobbs is also poorly documented. The District is assuming that augmentation would have been

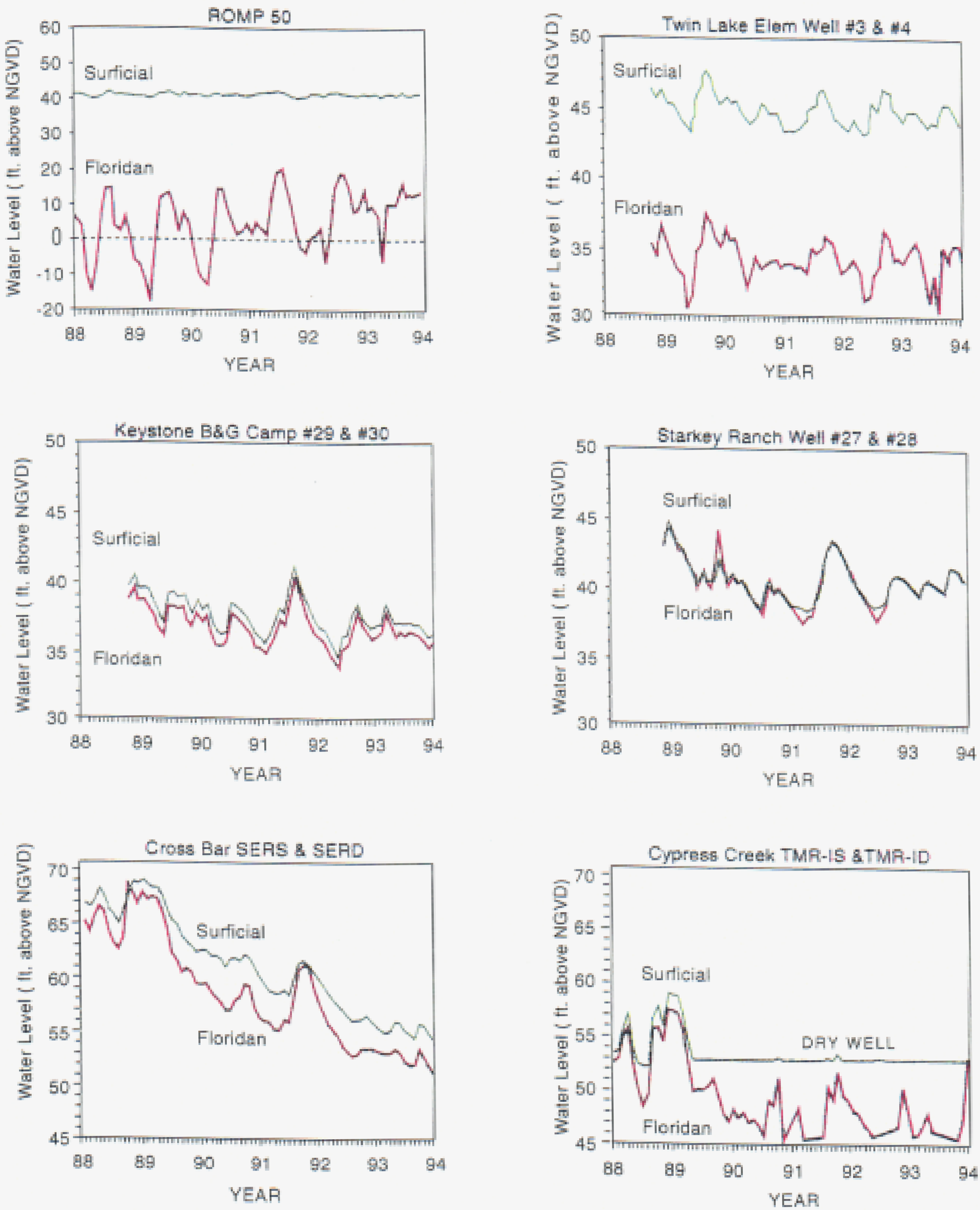


Figure 5. Hydrographs of six nested wells within the Northern Tampa Bay WRAP area.

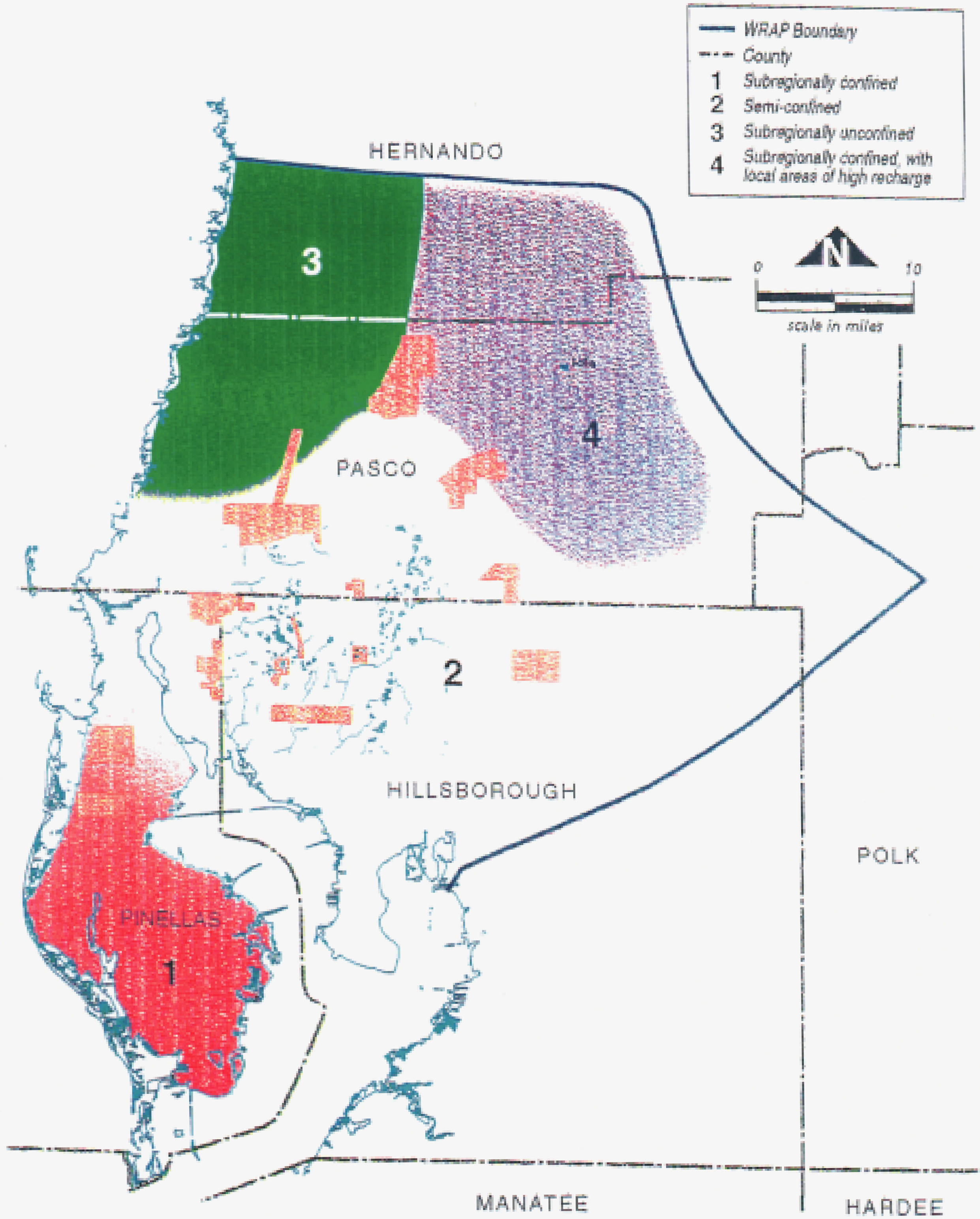
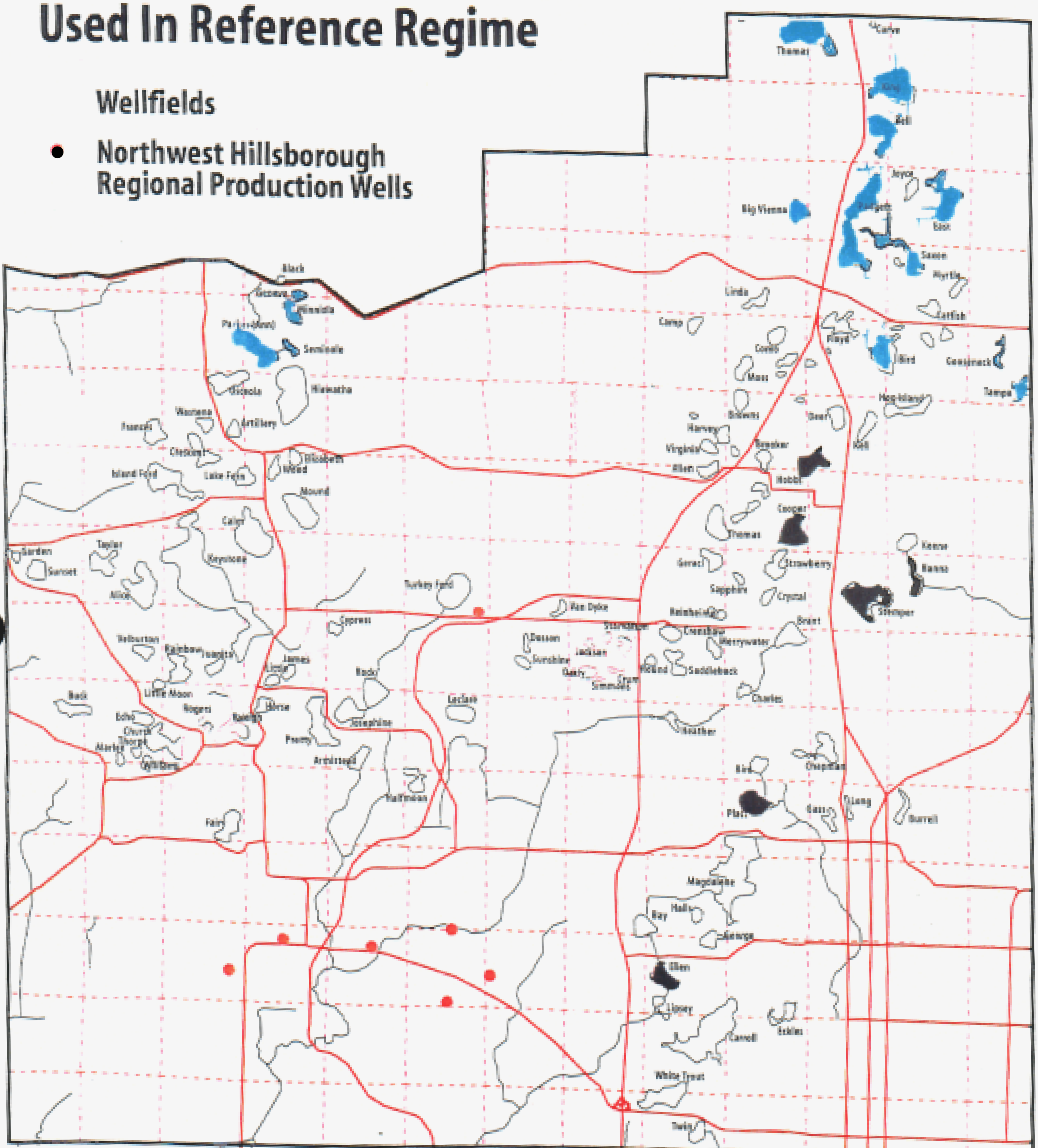


Figure 6. Zones of similar subregional hydrogeology within the Northern Tampa Bay WRAP (modified from Ryder, 1985 and Parker, 1992).

Location of Reference Lakes Used In Reference Regime

Wellfields

• Northwest Hillsborough Regional Production Wells



Reference Lakes

Data prior to 1963 (prior to Section 21 withdrawals)

Period-of-record data

Note: Includes Moon Lake (not pictured)

Figure 7

Table 1. Background lake information on augmentation, structural alteration, and direct withdrawals.

Lake	Augmented	Altered Structurally	WUP Withdrawal	Outlet Data
Bell	NO	YES	NO	4 culverts, invert 70.1'
Big Lake Vienna	NO	YES	NO	culvert (DU) , invert 68.4'
Bird Lake	YES	YES	NO	4 culverts; invert 64.1'
Cooper	YES	YES	NO	culvert (DU); invert 59.5'
Cow (East)	NO	YES	NO	4 culverts; invert 77.5'
Curve	NO	NO	NO	
Ellen	NO	YES	NO	operable structure
Geneva (Mud)	NO	YES	NO	see lake Minniola
Gooseneck	NO	YES	NO	culvert (DU); invert 72.6'
Hanna	NO	YES	NO	operable structure
Hobbs	YES	YES	NO	culvert (DU); invert 65.5'
King	NO	YES	NO	culvert (DU); invert 71.0'
Minniola	NO	YES	NO	culvert (DU); structure
Moon	NO	YES	NO	culvert (DU); invert (na)
Padgett	NO	YES	NO	9 culverts (DU); invert 68.8'
Parker	NO	YES	NO	operable structure
Platt	NO	YES	NO	culvert (DU); invert 47.9'
Saxon	NO	YES	NO	60" diam.culvert; invert 67.2'
Seminole	NO	YES	NO	culvert (DU); invert (na)
Stemper	NO	YES	NO	operable structure
Tampa (Turtle)	NO	YES	NO	culvert (DU); invert 61.1'
Thomas	NO	YES	NO	culvert (DU), invert 73.8'

Note: All elevations referenced to FT NGVD.
(DU) = Diameter Unavailable
(na) = not available

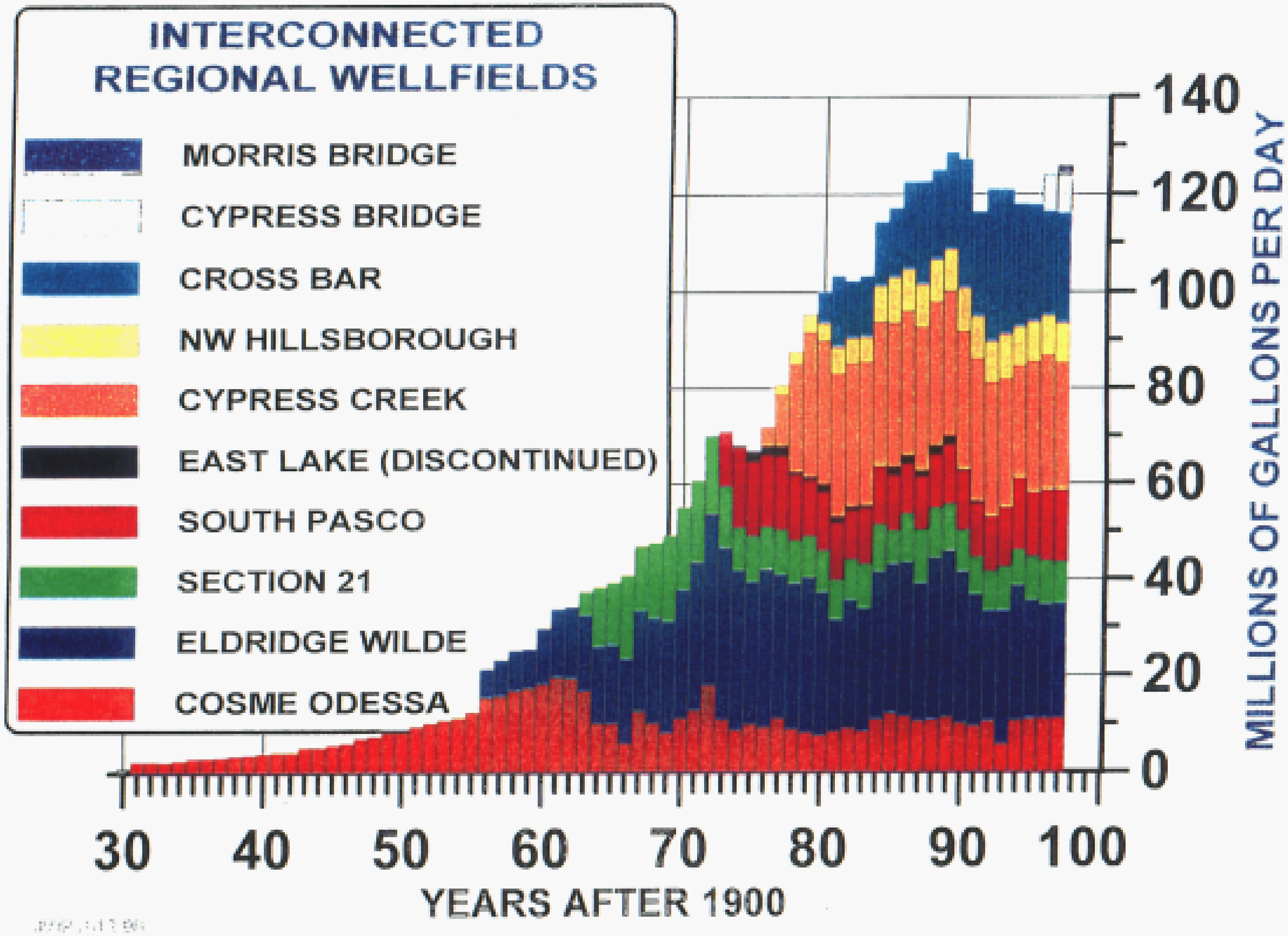


Figure 8. Graph depicting wellfield pumpage.

in response to impacts resulting from groundwater withdrawals similar to the situation found at lakes Bird, Cooper and Hobbs. Since the period of record used in the RLWR calculation pre-dated wellfield withdrawals in the area (1940's-1950's), there would probably be no need for augmentation, and thus it is assumed to be non-existent during this period.

Four lakes (Ellen, Hanna, Parker, and Stemper) have operable structures that could possibly influence lake fluctuation if the structures were in place and operated during the reference period. While there is limited information on the date of installation and on the operation schedules of these structures during the period used in the RLWR analysis, the majority of the operable structures in the District were assumed to have been installed after 1960 following the severe flooding that occurred from Hurricane Donna. In some cases, these new operable structures replaced fixed crest structures in an attempt to provide flood relief. Of the four lakes with operable structures, Lake Parker was the only lake where all of the lake stage data was collected after 1960. Visual inspection of the high stage elevations on the Lake Parker hydrograph shows that there are no noticeable changes in the hydrograph, thus it was assumed that any structure operation that may have occurred had limited influence on the lake.

Several methods were used to confirm that the selected reference lakes in the Land O' Lakes area had little to no impact by groundwater withdrawals. The first method was to review the numerical simulation of predicted drawdown from the South Pasco wellfield using the Northern Tampa Bay Groundwater Flow Model (SWFWMD, 1993). Drawdowns in the Floridan aquifer from a one year run using average recharge conditions indicates that the majority of the lakes were outside the one-foot drawdown contour in the vicinity of Land O' Lakes (Figure 9). Three lakes were located between the one foot and two foot Floridan aquifer drawdown contour lines. The resulting drawdown in the surficial aquifer from the Floridan aquifer drawdown would probably be less due to the confinement between the Floridan and surficial aquifer. However, because this confinement is variable and it is possible that some lakes could be well connected to the Floridan aquifer, a second analysis was performed to check for impacts from groundwater withdrawals.

This second analysis consisted of a comparison of distance-drawdown relationships between Lake Thomas and other lakes located in the Land O' Lakes region (Appendix E). An example of the analysis is presented on Figures 10 and 11. Assuming Lake Thomas is a background lake (not impacted by groundwater-withdrawals), a comparison was made with Camp Lake located one mile east of the South Pasco wellfield , and Lake Linda located about two miles east of the wellfield. Lake Thomas is located about four miles northeast of the South Pasco wellfield. Review of the stage hydrographs shows that Lake Thomas and Linda hydrographs are almost identical while significant deviation occurs between Lake Camp and Lake Thomas water levels. In both cases, about four to five years of pre-withdrawal stage measurements were available to match the two lake hydrographs prior to South Pasco wellfield withdrawals. Results from the distance-drawdown analysis based on lake hydrographs, indicates that drawdown effects do not appear to propagate past Lake Linda. In addition, Lake Thomas was compared to 14 reference lakes. Similar to Lake Linda, all 14 lakes show little separation from Lake Thomas.

As one more additional check, empirical Floridan aquifer water level data was reviewed to determine if there is any discernable drawdown in the area.

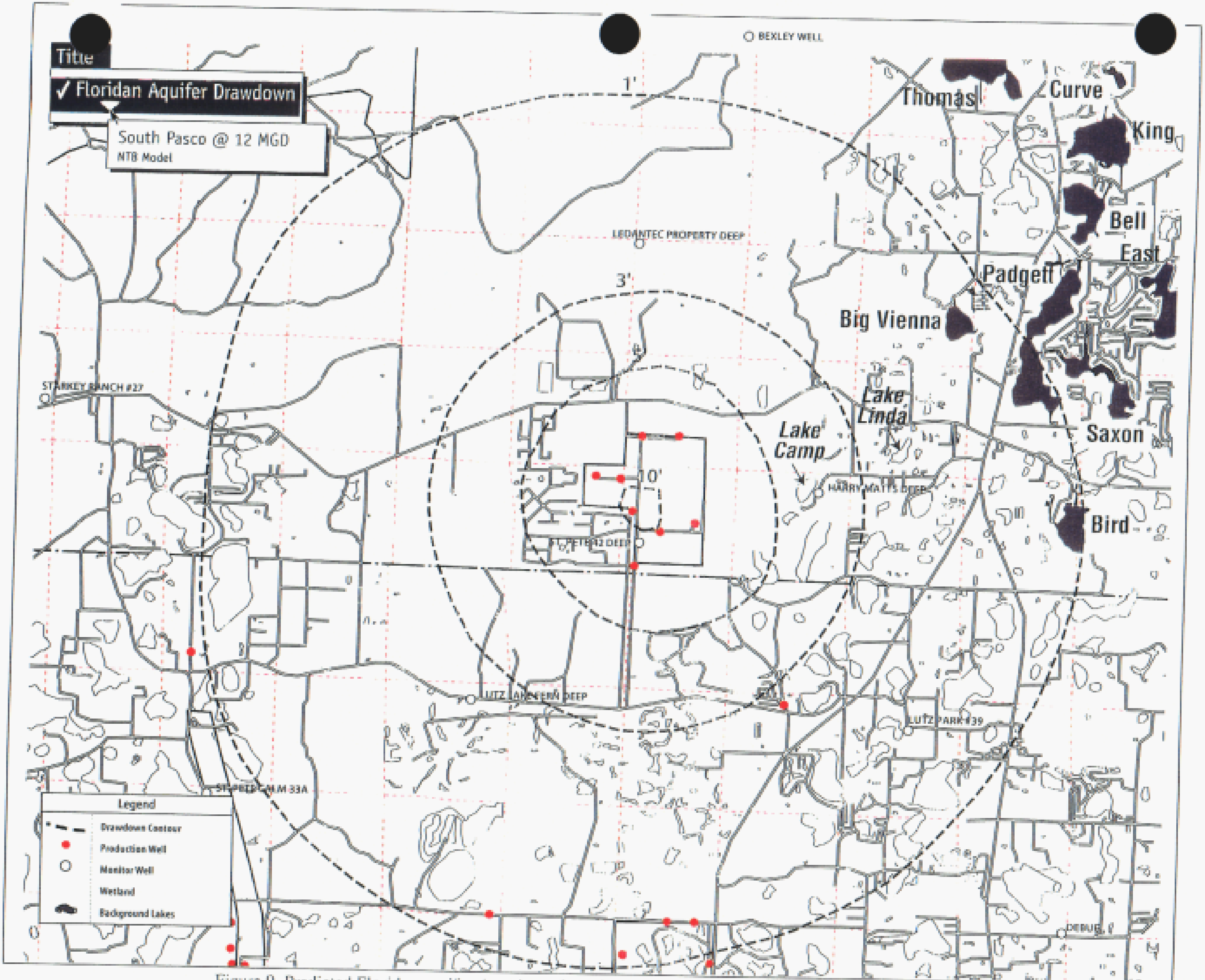


Figure 9. Predicted Floridan aquifer drawdown from South Pasco wellfield at selected reference lakes.

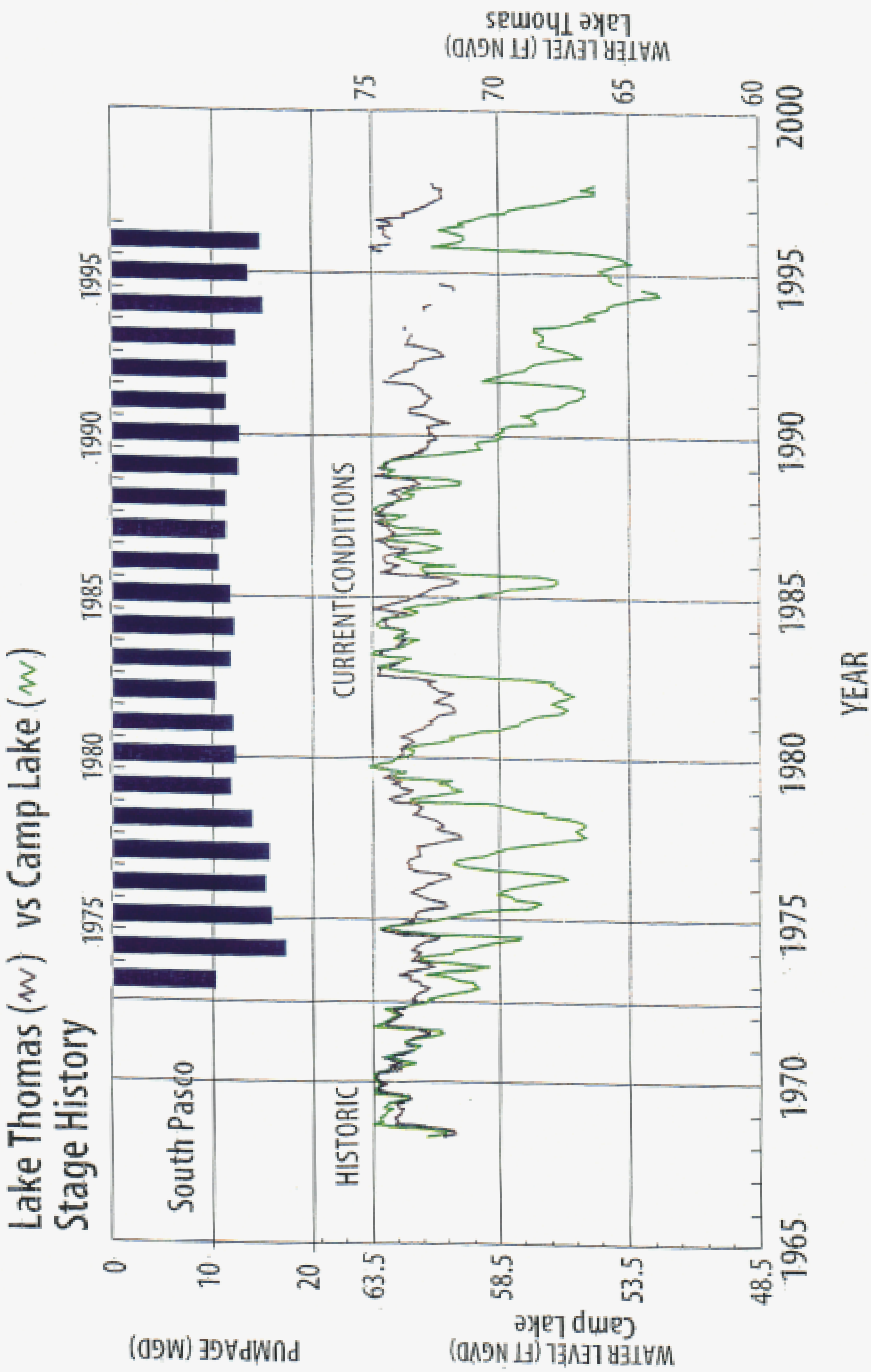


Figure 10. Hydrograph comparison of Lake Thomas with Camp Lake.

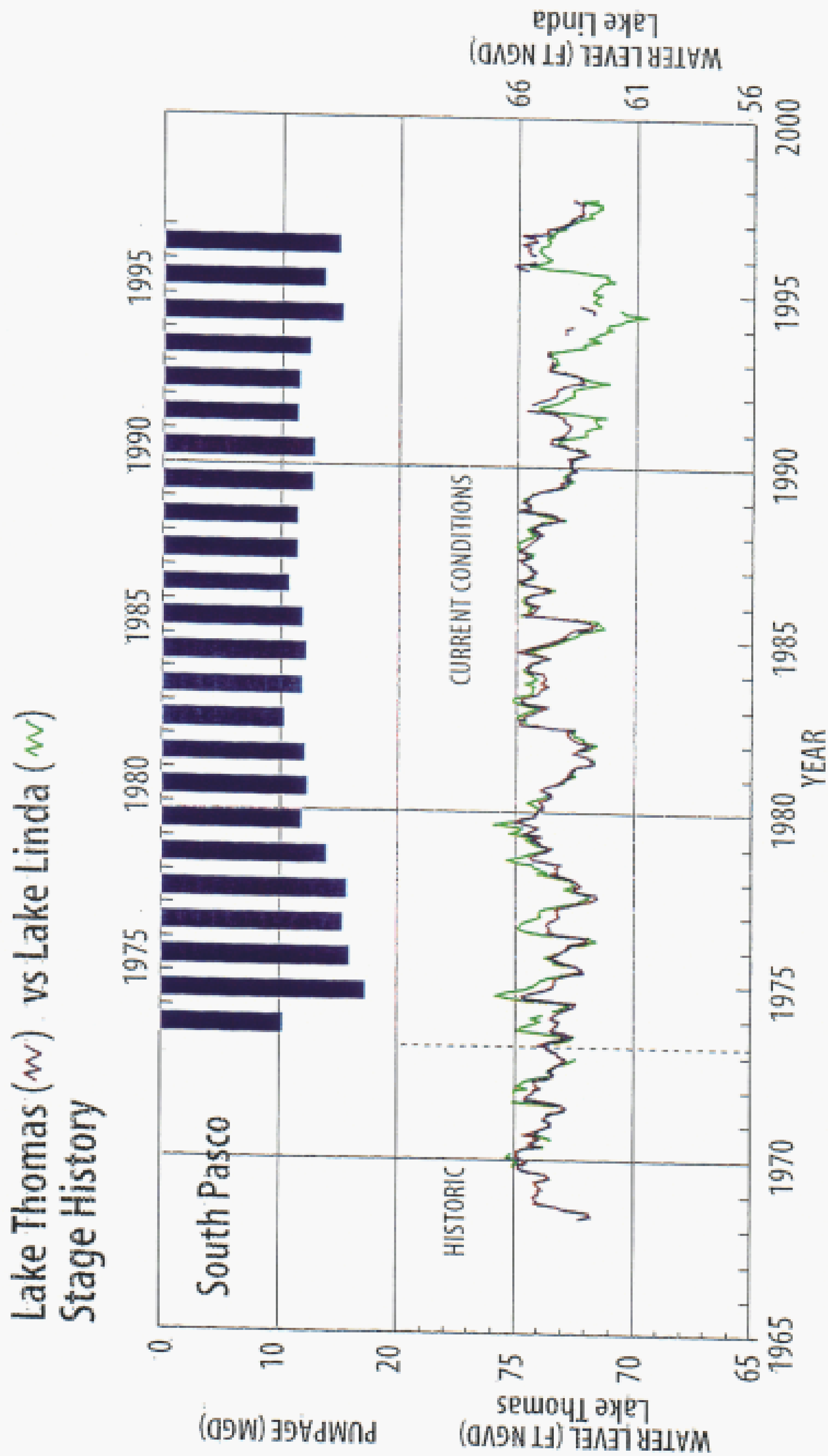


Figure 11. Hydrograph comparison of Lake Thomas with Lake Linda.

The closest long-term Floridan aquifer well that pre-dates wellfield withdrawals, is the Bexley well located about two miles west of Lake Thomas. Based on a linear regression of the water levels since 1970, there is no significant statistical trend in the water levels. Figure 12 is a hydrograph of the Begley well.

Based on the absence of measurable Floridan aquifer water level decline in the Bexley well, combined with the distance-drawdown relationship to the east of the South Pasco wellfield, the hydrograph comparison between Lake Thomas and 15 other reference lakes, as well as the numerical model results; it was determined that the chosen reference lakes in the area of Land O' Lakes are minimally affected by groundwater withdrawals while still being located in the same hydrogeologic and climatic regime as the Minimum Level lakes.

Calculation of the RLWR

Percentile calculations were performed for the P10, P50, and P90 for each of the 22 RLWR lakes. Because data collection frequency varied for each lake, monthly averages were used in the calculation and in the creation of the hydrographs for each lake. Percentile calculations were limited to the period of record that corresponded to long-term stable periods of similar structural alterations, and periods pre-dating ground water withdrawal impacts as identified in the analysis described above. The results of the calculations for each lake are presented in Table 2. The difference between the P10 and P50, and the difference between the P10 and P90 for each lake are also presented. Using the two differences calculated for each of the 22 lakes, the median P10-P50 difference and the median P10-P90 difference using the total population of lakes was calculated. The median values were used as opposed to the averages to minimize leveraging that may result from the minimums and maximums. The median P10-P50 difference equals 1.0 foot, and the median P10-P90 difference equals 2.1 feet. The range of the P10-P50 difference was 2.0 feet. The smallest P10-P50 value is 0.4 feet (Lake Cow) and the largest value is 2.4 feet (Lake Gooseneck). The range of the P10-P90 difference was 3.2 feet. The smallest P10-P90 value is 1.2 feet (Lake Cow) and the largest is 4.4 feet (Lake Gooseneck).

Conclusions

Twenty-two lakes exist within Pasco County and portions of Northwest Hillsborough County that were identified as reference lakes in the determination of the expected typical range of lake stage fluctuations over a "long-term" period. Results of this analysis yielded a P10-P50 Reference Lake Water Regime (RLWR50) value of 1.0 foot, and a P10-P90 Reference Lake Water Regime (RLRR90) of 2.1 feet.

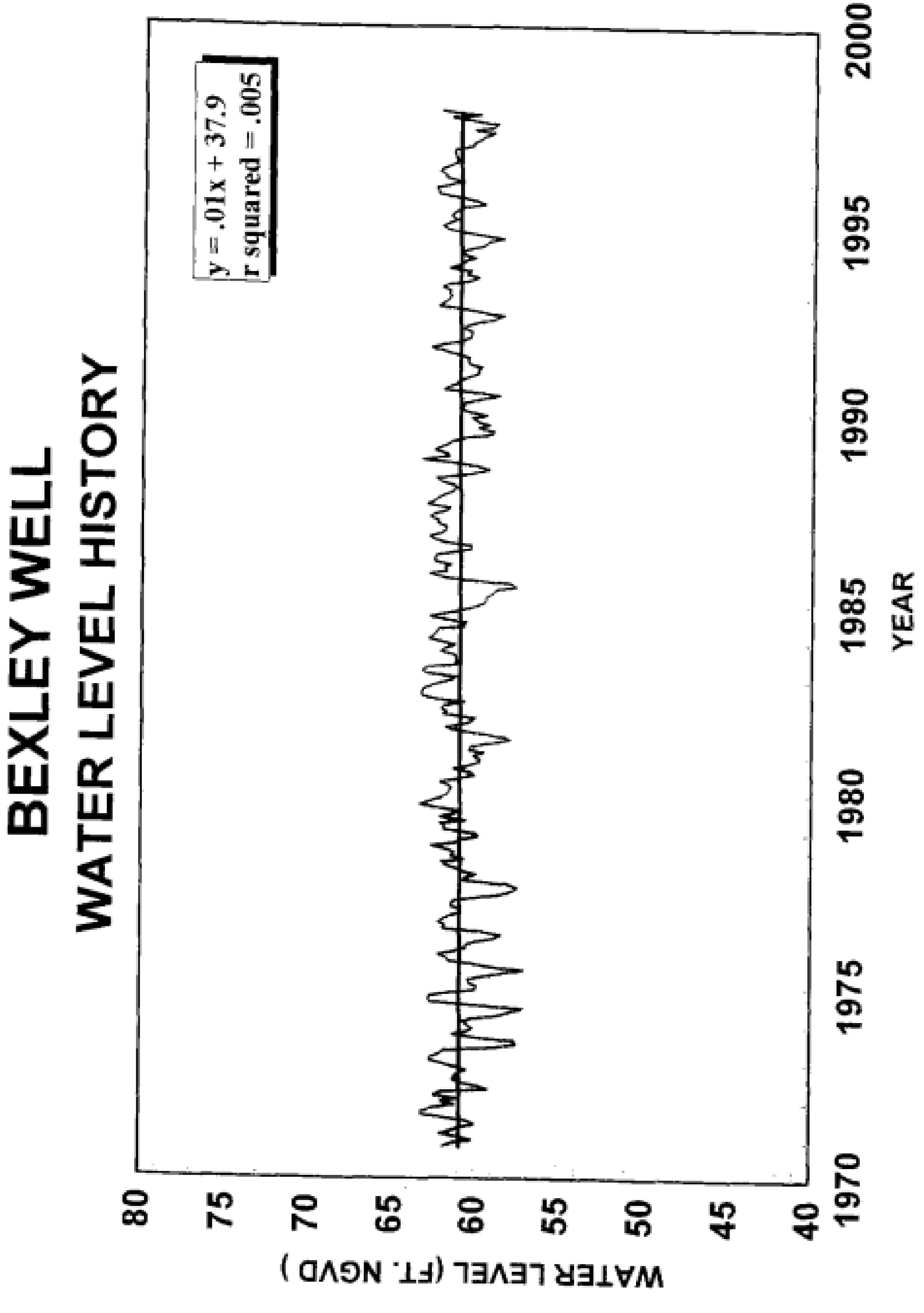


Figure 12. Water level trend at the Bexley monitor well.

Table 2. Statistical summary of reference lakes in the study area.

No.	Lake	P10	P50	P90	P10-P50 Difference	P10-P90 Difference	P.O.R.
1	Bell	71.6	70.5	69.5	1.1	2.1	1977-97
2	Big Lake Vienna	68.8	67.6	66.7	1.2	2.1	1986-97
3	Bird	66.8	65.4	64.4	1.4	2.4	1978-97
4	Cooper	61.6	61	60.2	0.6	1.4	1946-56
5	Cow (East)	78	77.6	76.8	0.4	1.2	1976-97
6	Curve	76.6	75.4	74	1.2	2.6	1976-97
7	Ellen	40.6	39.9	38.9	0.7	1.7	1946-56
8	Geneva (Mud)	49.8	49.2	48.2	0.6	1.6	1981-97
9	Gooseneck	72.8	70.4	68.4	2.4	4.4	1978-97
10	Hanna	61.7	61.2	59.9	0.5	1.8	1946-55
11	Hobbs	67	65.9	63.8	1.1	3.2	1947-62
12	King	72.6	71.7	70.4	0.9	2.2	1970-97
13	Minniola	49.8	49.3	48.2	0.5	1.6	1981-97
14	Moon	39.9	38.6	36.6	1.3	3.3	1965-97
15	Padgett	70.5	69.6	68.6	0.9	1.9	1965-97
16	Parker (Ann)	48	46.8	45.6	1.2	2.4	1969-97
17	Platt	49.8	48.9	47.8	0.9	2.0	1946-56
18	Saxon	70.5	69.6	68.5	0.9	2.0	1983-97
19	Seminole (Pasco)	48.2	46.9	45.9	1.3	2.3	1969-97
20	Stemper	61.5	61	59.4	0.5	2.1	1946-62
21	Tampa	64.3	62.8	60.9	1.5	3.4	1978-97
22	Thomas	74.6	73.6	72.4	1	2.2	1968-97
				MEAN:	**1.0**	**2.3**	
				MEDIAN:	**1.0**	**2.1**	

Note: Percentile Values in Ft. NGVD
P.O.R. = Period of Record

Chapter 4
Establishment of Guidance and Minimum Levels

Introduction

Prior to establishing Guidance and Minimum levels, normal pool and control point elevations are measured and all available water level data are compiled from the Water Management District Database. Chapter 2 describes methods for measuring normal pool and control point elevations, and for determining whether water level data are historic or current. Chapter 3 describes the methods for calculating the RLWR50 and RLWR90 which are used to estimate the Historic P50 and Historic P90 for lakes without historic data, but with current data which are measurably impacted by ground water withdrawals and for lakes without current or historic data. This Chapter describes the process used to establish Guidance and Minimum Levels once the data were collected and the RLWRs have been calculated.

Establishment of the High Guidance Level (HGL)

The High Guidance Level is provided as an advisory guideline for local governments and lakeshore property owners to aid in the proper siting of lakeshore development and water dependent structures such as docks and seawalls. The District also may use the High Guidance Level for the operation of water management structures. The HGL is the expected Historic P10 of the lake, in the absence of water withdrawals, but with the current structural alterations in place.

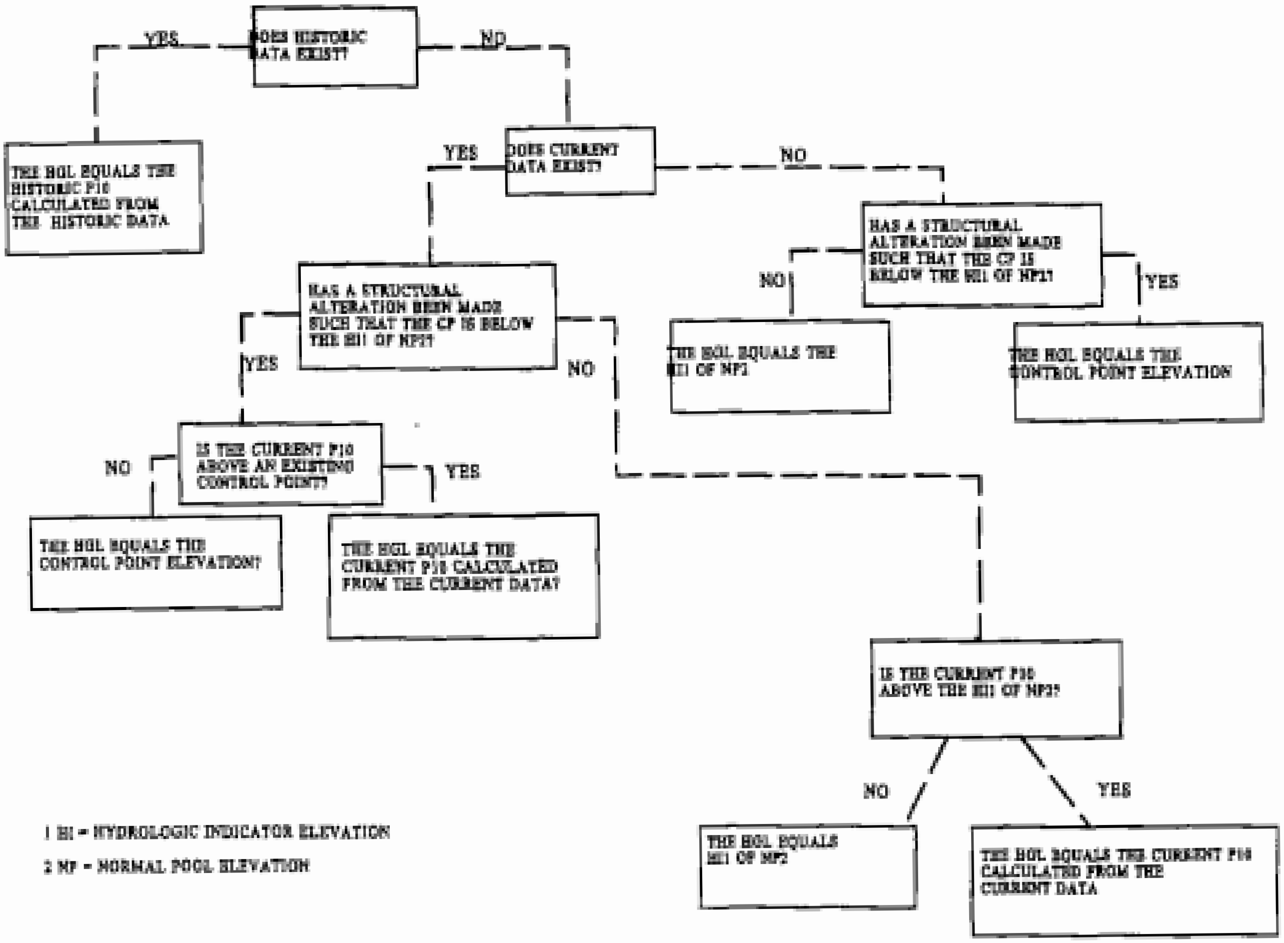
Figure 13 shows a flow diagram of the method used to establish the HGL. If historic data are available, then the HGL is calculated from the data because these data are representative of the existing structural alterations (if present) and do not reflect measurable impacts due to water withdrawals. Therefore, the HGL is equal to the P10 calculated from the historic data.

If no historic data are available, then the HGL will be established using best available information including current data and normal pool or control point elevations, depending upon the presence or absence of structural alterations.

For lakes with current data that are not structurally altered, the current P10 elevation is calculated and compared to the normal pool elevation which is assumed to be approximately equal to the historic P10 in this situation. This assumption is based on a comparison of the P10 elevation observed in reference wetland sites (refer SWFWMD, 1999) and their normal pool elevations. The results of this analysis (Table 3) shows the median value of the difference between the normal pool minus the P10 is 0.2 feet. If the Current P10 elevation is equal to or above the normal pool elevation, then the HGL is equal to the Current P10 elevation. If the Current P10 is below the normal pool elevation, then the HGL is equal to the normal pool elevation.

For lakes with current data that are structurally altered, the Current P10 elevation is calculated and compared to the control point elevation. If the Current P10 elevation is equal to or above the control point elevation, then the HGL is equal to the Current P10 elevation. Otherwise, the HGL is equal to the control point elevation.

Figure 13 : METHOD FOR CALCULATION OF THE HIGH GUIDANCE LEVEL (HGL)



The HGL is established as the higher of the Current P10 and control point elevation for a structurally altered lake, or the higher of the Current P10 and normal pool elevation for a non-structurally altered lake. The reasons for this are described below.

By definition, current data coincides with a period of water withdrawals, therefore a P10 calculated from the current data may reflect impacts due to water withdrawals. For a structurally altered lake, it is assumed that most lakes would reach the control point elevation on an approximate frequency equal to or greater than the P10 in the absence of water withdrawals. This is based on an analysis comparing a P10 representing a stable period of current structural alterations on each reference lake to the control point elevation in place during this period. The results of this analysis (Table 4) show that the median value of the difference between the P10 minus the control point elevation is 0.6 feet. Based on this analysis, if the lake does not reach or exceed the control point elevation more than ten percent of the time, the lake may be measurably impacted by water withdrawals. Under this situation, the use of a current P10 elevation lower than the control point elevation as the HGL could grandfather impacts due to water withdrawals. In the case of a structurally altered lake, the normal pool elevation is not used as the HGL since, even in the absence of water withdrawals, the structural alteration may prevent water levels from reaching the normal pool elevation on a frequency equal to the P10. Therefore, the higher of the current P10 elevation or the control point elevation is chosen as the HGL.

Table 3. Comparison of the reference wetland normal pool elevations to the P10.

SITE NAME	REFERENCE POR*	POR	NORMAL POOL (FT) NGVD	P10 (FT) NGVD	DIFFERENCE NP- P10 (FT)	P50 (FT NGVD)	DIFFERENCE P10-P50 (FT)
S68	**10/88-9/95**		43.9	43.7	0.2	43	0.7
MB96	**10/88-9/95**		35.4	35	0.37	34.3	0.7
S70	**10/88-9/95**		44.7	44.1	0.56	43.5	0.6
G1	10/88-9/95	**5/79-4/98**	100.5	100.3	0.2	99.9	0.4
G2	10/88-9/95	**5/79-4/98**	100.5	100.3	0.2	99.2	1.1
G3	10/88-9/95	**5/79-4/98**	102.7	102.6	0.1	101.8	0.8
G4	10/88-9/95	**5/79-4/98**	102.7	102.8	-00.1	101.6	1.2
G5	10/88-9/95	**6/79-4/98**	98.9	98.8	0.1	97.3	1.5
G6	10/88-9/95	**6/79-4/98**	97.7	97.7	0	96.8	0.9
S75	**10/88-9/95**		47.2	47.1	0.08	46.1	1
NW 125	**10/88-9/95**		35.7	35.6	0.1	34.7	0.9
S. E. REC	**10/88-9/95**		46.4	46	0.37	45.2	0.8
EW11	**5/89-9/95**		38.5	37.8	0.69	36.2	1.6
STK N	**10/88-9/95**		46.9	46.8	0.11	46.4	0.4
STK M	**10/88-9/95**		44.8	44.6	0.16	44	0.6
S97	**10/88-9/95**		44.2	44	0.21	43.2	0.8
142817	**10/88-8/95**		15.7	15.4	0.3	14.4	1
WC342718	**10/88-8/95**		54.8	54.4	0.37	54.2	0.2
NW115/MB89	**10/88-9/95**		42.4	42.8	-0.36	42	0.8
NW61	**10/88-8/95**		34.2	34.5	-0.33	33.2	1.3
				MEDIAN	**0.2**		**0.8**
				AVG	**0.2**		**0.9**

*= Bolded is the Period-of-Record used in the analysis

Table 4 **Comparing a P10 representing a stable period of current structural alterations on each reference lake to the control point elevation in place during this period.**

Lake Name	Period of Record for P10	Elevation P10 (NGVD)	Control Point Elevation (NGVD)	Distance P10 is Above (+) or Below (-) the Control Point (FT)
BELL	1977-97	71.6	70.1	1.50
BIRD	1986-97	66.8	66.1	0.70
BIG LK VIENNA	1978-97	68.8	68.4	0.40
COOPER	1980-97	61.6	59.5	2.10
COW (EAST)	1976-97	78	77.5	0.50
CURVE	1976-97	76.6	na	
ELLEN	1974-97	40.6	41	-0.40
GENEVA	1981-97	49.8	na	
GOOSENECK	1978-97	72.8	72.6	0.20
HANNA	1974-97	61.3	61.3	0.00
HOBBS	1974-97	65.4	65.5	-0.10
KING	1970-97	72.6	71	1.60
MINNIOLA	1981-97	49.8	na	
MOON	1965-97	39.9	40.8	-0.90
PADGETT	1965-97	70.5	69.4	1.10
PARKER (ANN)	1969-97	48	48.2	-0.20
PLATT	1974-97	49.8	47.9	1.90
SAXON	1983-97	70.5	67.2	3.30
SEMINOLE	1969-97	48.2	na	
STEMPER	1974-97	61.1	61.2	-0.10
TAMPA	1978-97	64.3	61.1	3.20
THOMAS	1968-97	74.6	73.8	0.80
			MEAN	**0.87**
			MEDIAN	**0.60**
			STANDARD DEV.	**1.19**
			RANGE	**4.20**
			MINIMUM	**-0.90**
			MAXIMUM	**3.30**

na = not available

A lake that is not structurally altered and not influenced by water withdrawals should reach the normal pool elevation on a frequency equal to about the P10. If the lake does not reach the normal pool elevation at a P10 frequency, then the lake may be measurably impacted by water withdrawals. In this case, the normal pool elevation would be the best estimate of the Historic P10, and would be used as the HGL.

For lakes without historic or current data, the HGL must be estimated from best available information. For lakes that are not structurally altered, the HGL is set at the normal pool elevation. For lakes that are structurally altered, the HGL is set at the control point elevation.

Calculation of the Historic P50

A flow chart for calculating the Historic P50 is shown in Figure 14. This flow chart and the discussion below assume that the presence or absence of structural alterations has been determined and that the HGL has been calculated.

If there are historic data, the Historic P50 is calculated from the data.

For lakes without historic data, the Historic P50 is estimated using best available information, including current data, the normal pool or control point elevations and application of the Reference Lake Water Regime. (The normal pool and control point elevations are used in the determination of the HGL.)

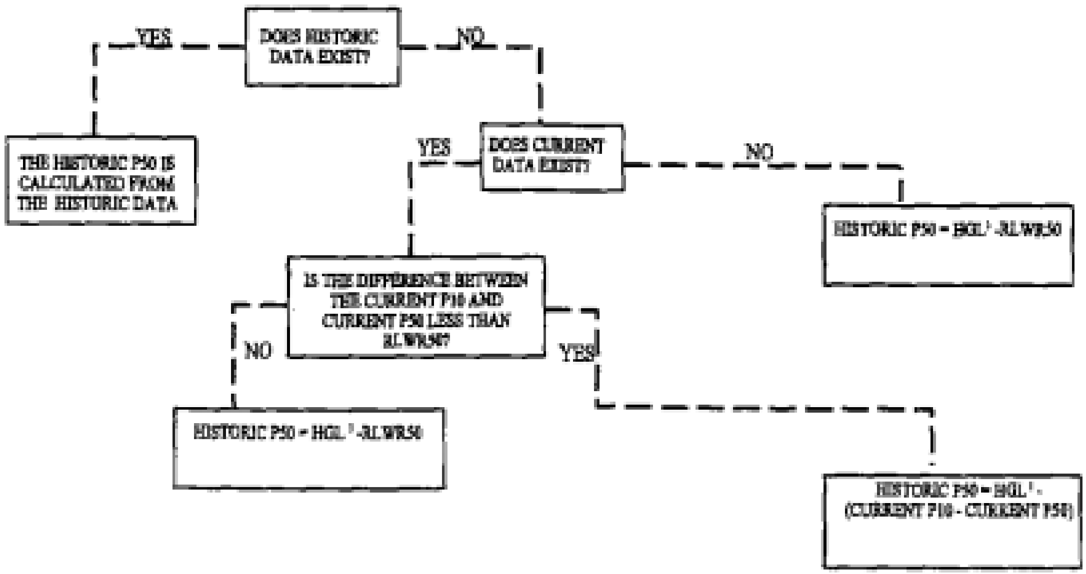
The RLWR is used to estimate the natural fluctuation range of a lake in the absence of water withdrawals. The RLWR50 and RLWR 90, respectively, are used to estimate the Historic P50 and P90 elevations. Calculation of the RLWRs for Northwest Hillsborough lakes is described in the RLWR Chapter.

By definition in Chapter 40D-8, FAR, the RLWR50 is the median value of the difference between the P10 and P50 lake stage for all lakes with historic data with similar hydrogeologic conditions as the lake of concern. The RLWR50 reflects the median fluctuation between the P10 and P50 for a set of reference lakes in the Northwest Hillsborough region that are not measurably impacted by withdrawals. The RLWR50 calculated from these reference lakes is 1.0' and this value is used for the lakes discussed in Appendix C.

To determine the Historic P50 for lakes with current data, the difference between the Current P10 and Current P50 is calculated. This difference is compared to the RLWR50 of 1.0'. If the difference between the Current P10 and Current P50 is less than the RLWR50 value of 1.0', then the P50 calculated from the current data is used as the Historic P50. If the difference between the Current P10 and Current P50 is greater than 1.0', it is assumed the lake is impacted by water withdrawals, and the Historic P50 is equal to the HGL minus the RLWR50 of 1.0'.

For lakes without historic or current data, the Historic P50 must be estimated from the RLWR50 and the HGL. The Historic P50 is equal to the HGL minus the RLWR50 of 1.0'.

Figure 14 : METHOD FOR CALCULATION OF THE HISTORIC P50



[1] SEE FIGURE 4-1 FOR METHOD FOR CALCULATION OF HIGH GUIDANCE LEVEL (HGL)

Calculation of the High Minimum and Minimum Level

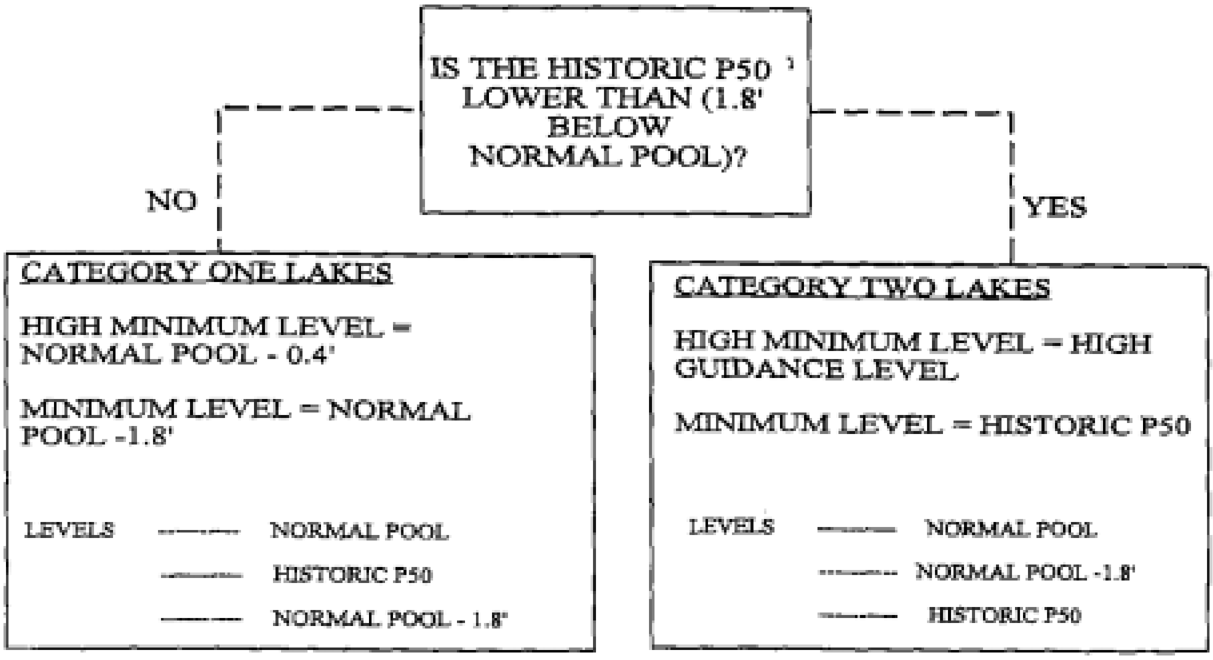
The High Minimum Lake Level is the elevation that a lake's water levels are required to equal or exceed ten percent (P10) of the time on a long-term basis. This High Minimum Lake Level is established to ensure that a lake reaches higher levels on a periodic basis. The Minimum Lake Level is the elevation that the lake's water levels are required to equal or exceed fifty percent (P50) of the time on a long-term basis.

The Minimum Lake Level for cypress-wetland fringed lakes is set taking structural alterations into account and a level will not be set above the level the lake could reach given the structural alteration. Therefore, the structural alteration status of the lake must be determined and the Historic P50 must be calculated before the Minimum Lake Level can be set. (A flow chart for calculating the Historic P50 is shown in Figure 14.) The Historic P50 elevation is then compared to the significant change elevation described below.

For cypress-wetland fringed lakes, the Minimum Lake Level is calculated using the method developed for cypress wetlands, which is described in the report "Establishment of Minimum Levels in Wetlands" (SWFWMD, 1999). In summary, a cypress wetland was determined to be significantly changed when the P50 level of the wetland was lower than the normal pool minus 1.8 feet. Therefore, the Minimum Lake Level for cypress-fringed wetland lakes is the elevation equal to 1.8' below the normal pool elevation or NP - 1.8'.

The Historic P50 elevation is compared to the significant change elevation (NP-1.8') to determine which Category a lake is in and subsequently which methods will be used to calculate the High Minimum Lake and Minimum Lake Levels. A flow chart showing the method to calculate the High Minimum and Minimum Level is shown in Figure 15. A similar analysis was performed

Figure 15 : METHOD FOR CALCULATION OF HIGH MINIMUM AND MINIMUM LAKE LEVELS



[1] SEE FIGURE 4-2 FOR CALCULATING HISTORIC P50

on the P10 wetland data. Results of the analysis indicate that a cypress wetland would be significantly changed when the P10 level of the wetland was lower than the normal pool minus 0.4 feet based on the wetland methodology.

A Category 1 Lake is a cypress-wetland fringed lake where structural alterations do not prevent the Historic P50 elevation from equaling or rising above an elevation that is equal to the normal pool elevation minus 1.8'. (Historic P50 > Normal Pool - 1.8')

High Minimum Lake Level = Normal Pool elevation -0.4'
Minimum Lake Level = Normal Pool elevation - 1.8'

A Category 2 Lake is a cypress-wetland fringed lake where structural alterations prevent the Historic P50 from equaling or rising above an elevation that is equal to the normal pool minus 1.8', but the lake-fringing cypress swamp(s) remain viable and perform functions beneficial to the lake. (Historic P50 < Normal Pool - 1.8')

High Minimum Lake Level = High Guidance Level
Minimum Lake Level = Historic P50

Calculation of the Low Guidance Level (LGL)

The Low Guidance Level is provided as an advisory guideline for local governments and lakeshore property owners to aid in the proper siting of water dependent structures such as docks and seawalls, and to educate the residents about "normal" lake level fluctuations. The District also may use the Low Guidance Level for the operation of water management structures. The Low Guidance Level is the expected historic P90 of the lake, in the absence of water withdrawals, but with the current structural alterations in place.

A flow chart for calculating the Low Guidance Level is shown as Figure 16. This flow chart and the discussion below assume that the presence or absence of structural alterations has been determined and that the HGL has been calculated.

If there are historic data, the Low Guidance Level is equal to the Historic P90 calculated from the data.

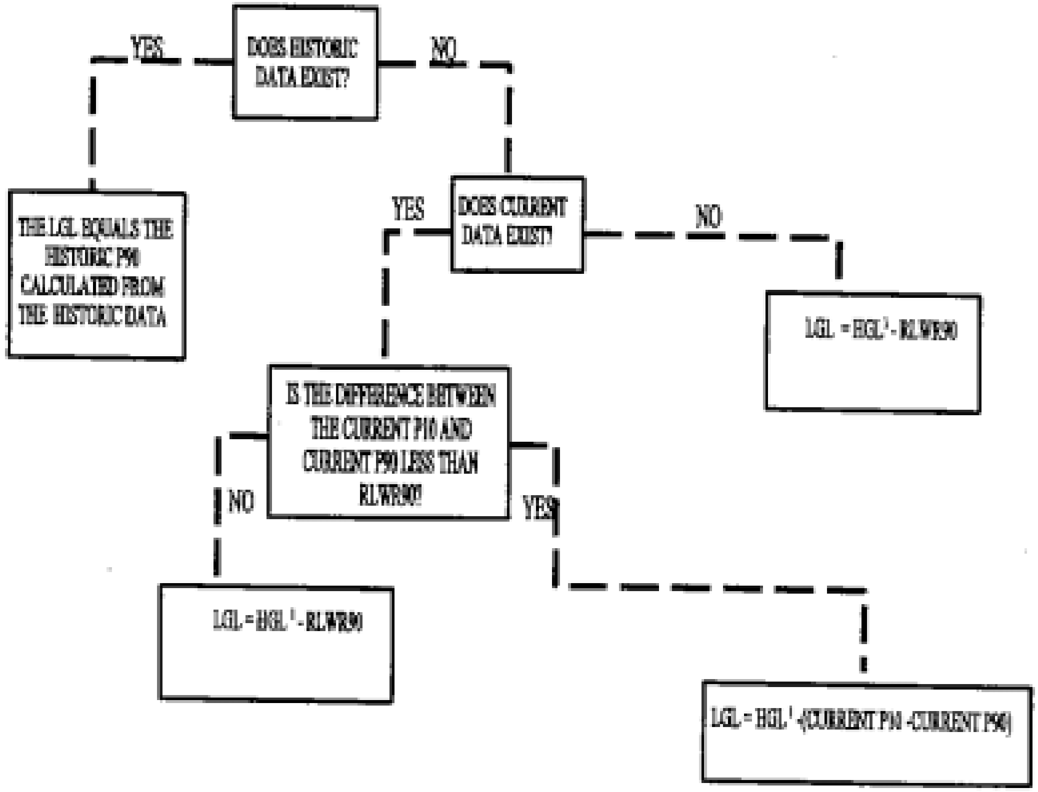
For lakes without historic data, the Low Guidance Level is estimated using best available information, including current data, normal pool and control point elevations and application of the Reference Lake Water Regime. (The normal pool and control point elevations are used in the determination of the HGL.)

As described previously, the RLWR is used to estimate the natural fluctuation range of a lake in the absence of water withdrawals. By definition in Chapter 40D-8, FAR, the RLWR90 is the median value of the difference between the P10 and P90 lake stage for all lakes with historic data with similar hydrogeologic conditions as the lake of concern. The RLWR90 reflects the median fluctuation between the P10 and P90 for a set of reference lakes in the Northwest Hillsborough region that are not measurably impacted by withdrawals. The RLWR90 calculated from the reference lakes and applied here is equal to 2.1'.

To determine the LGL, for lakes with current data, the difference between the Current P10 and Current P90 is calculated and compared to the RLWR90. If the difference between the Current P10 and Current P90 is less than the RLWR90 value of 2.1', then the P90 calculated from the current data is set as the Low Guidance Level. If the difference between the Current P10 and Current P90 is greater than 2.1', it is assumed the lake is impacted by water withdrawals, and the LGL is equal to the HGL minus the RLWR90 of 2.1'.

For lakes without historic or current data, the Low Guidance Level must be estimated from the RLWR90 and the HGL. In this case, the Low Guidance Level is equal to the HGL minus the RLWR90 of 2.1'.

Figure 16 : METHOD FOR CALCULATION OF THE LOW GUIDANCE LEVEL (LGL)



¹ SEE FIGURE 4-1 FOR METHOD FOR CALCULATION OF HIGH GUIDANCE LEVEL (HGL)

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APPENDIX A
Lake Level Sub-Committee Meeting Minutes

LAKE LEVELS SUBCOMMITTEE MEETING
March 6, 1997

1. The meeting began with a discussion of the last paragraph of Section II B. concerning the determination of the post-modification minimum flood level. Cathleen Beaudoin felt the current wording of that paragraph did not allow flexibility for setting a minimum flood level somewhere between the historic and post-modified level. She agreed to draft a revised version to clarify this point for the group's review.
2. The remainder of the meeting involved a discussion of the field work and other tasks before the subcommittee necessary to set proposed management levels for the NW Hillsborough lakes by May 1. These tasks and the personnel assigned to them are as follows:
   a. Determination of 10-year Flood Level and details of methodology for the Lake Levels SOP Manual. District Engineering Section is responsible for this.
   b. Bathymetric measurements will be performed by Richard Gant and Lizanne Garcia. This task will be combined with the vegetation transect task (below). The number of transects conducted will be determined in the field.
   c. Vegetation transects will be performed by Jim Bays, Doug Durbin, Chuck Courtney, Ross McWilliams and/or Scott Emery. These transects will be matched up, as much as possible, with the bathymetric transects. The number of transects will be determined in the field.
   d. Survey work has been completed by the District Survey Section.
   e. Shoreline survey of cultural features (or other notable features) will be conducted by the bathymetric and vegetation teams.
   f. Lake hydrology including development of stage duration curves, nearby well locations etc. will be performed by Mark Barcelo. Dave Wiley and Cathleen Beaudoin, because of budget constraints by their clients, will be used sparingly.
   g. Determination of Reference Lakes to use for the NW Hillsborough lakes will be conducted by the hydrology team based on a list of lakes prepared by Lizanne Garcia and Richard Gant. The suggested reference lakes will be evaluated by the whole subcommittee before proposing management levels. This team will determine minimum data requirements and appropriate period(s) of interest.
   h. A literature search for scientific information relating to the effect of lake level changes and physical, chemical or biological components of a lake system will be the responsibility of Ken Romie.
   i. GIS plots of lake bathymetry will be coordinated by Ken Romie.
   j. Any water quality data available for the lakes in question will be assembled by Ken Romie.
3. Finally, every Thursday for the next two months has been set aside by the team members to conduct field work while every Friday has been designated for subcommittee meetings to discuss the field results and continue to fine tune the methodology.

The next meeting of the Subcommittee will be at 8:30 AM, Friday March 14, 1997 at the Tampa Service Office.

LAKE LEVELS SUBCOMMITTEE MEETING
February 24, 1997

The entire meeting was devoted to reviewing the most recent draft of the Lake Level Methodology as well as preparing for the Governing Board presentation on February 24th. Several issues that remained from the February 18th meeting as well as several that were raised during the Lake Levels presentation to the Minimum Flows Committee on February 19th were discussed including:

1. It was decided to change the name of the reference lake coefficient from Regional Adjustment Factor (RAF) to Reference Lake Water Regime (RLWR). This change was incorporated into the current draft methodology.

2. It was decided to combine lakes with and without anthropogenic hydrologic modifications into a single group but to determine the various levels for both historic and post-modification periods. This change was incorporated into the current draft.

3. It was decided to define the Period of Record (for stage data) as the entire period for which stage data may exist. Period of Interest was defined as some portion of the Period of Record. This change was not explicitly incorporated into the current draft.

4. Mark Barcelo presented another definition of Minimum Level-Significant Change that excludes the use of standard deviations and, instead, relies on a range of change between the P80 and P90 points on a stage duration curve. After extended discussions Doug Durbin suggested a definition that was incorporated into the current draft. This definition will be considered an interim definition until further field work is completed on the eight lakes for which levels must be established by October 1.

The next meeting of the Lake Levels Subcommittee will be at 1:30 PM on Thursday March 6, 1997 at the Tampa Service Office.

LAKE LEVEL SUBCOMMITTEE MEETING
February 13, 1997

1. Craig Dye proposed that the "minimum level" of "significant harm" be one that would be superimposed upon the existing four levels the District currently adopts. The existing methodology for determining the four levels would be modified to address the comments and changes the subcommittee has suggested and a separate method would be employed to determine the "minimum level of significant harm". Mark Barcelo indicated that, as has been previously discussed, this level could be taken from various points on a stage duration curve. Craig reminded the group that most of the lakes for which levels will be adopted in the future will have little or no stage data. Ross McWilliams expressed some concerns about how permits would be affected by setting levels in this way.

2. Discussions ensued concerning what period of record (POR) to use for determining the stage duration curves. Cathleen Beaudoin and Jim Bays felt that the last 20 years would be most appropriate while Marty Kelly felt the first 20 years or the umimpacted POR would be best for determining historical levels.

3. Ken Romie presented the GIS plots of bathymetry for lake Rogers and tables of absolute and percent changes in lake area, volume and littoral zone based on various drawdown scenarios for lakes Padgett, Mound and Rogers.

4. Discussions began on how to define "significant harm" based on some reduction of lake area or volume. It was decided that District staff would develop a "straw man" proposal to present to the subcommittee at the next meeting on the methodology and definition of "significant harm".

Next meeting is Tuesday February 18, 1997 in the Tampa Service Office

MINIMUM LEVELS: LAKE SUBCOMMITTEE
MEETING SUMMARY
FEBRUARY 10, 1997

1. Mark Barcelo presented descriptive statistics and annual-frequency of occurrence graphs (stage duration) for lakes Dosson, Mound, Padgett and Rogers. Descriptive statistics were also provided for lakes Calm, Island Ford, Platt and Stemper. The descriptive statistics were a summary of daily lake levels for each year (e.g. minimum, maximum, median, tenth percentile and 90th percentile.

2. Most of the meeting discussion was about correlating recorded elevations of vegetation indicators to frequencies of occurrence for each lake. The purpose for this was to establish the historical range of lake level fluctuations. It was determined that, the elevation of the base of the lowest cypress tree at each lake was approximately equal to the mean of the tenth percentile of lake levels for each year (the lake level that was equaled or exceeded 90 percent of the time during each year) and the mean of the median lake levels for each year less one standard deviation.

3. The next meeting was scheduled for Thursday, February 13, 1997 at 1 pm.

LAKE LEVELS SUBCOMMITTEE MEETING
February 6, 1997

1. The meeting began with Mark Barcelo and Jim Bays providing a summary of the meeting of the large MFL committee that met the previous day as well as recapping some aspects of our last meeting on February 4, 1997. This included discussions of how a lake's bathymetry would affect the setting of levels. Doug Durbin also noted that there are many models linking biological effects with lake levels, but that they tend to be very complex and would be difficult to include in the methodology the committee has been charged with developing. A number of people felt that a matrix of biological effects vs. changes in depth will be needed at some point for the methodology.

2. Tom Champeau from the Florida Game and Freshwater Fish Commission made a presentation on the impact to lake fisheries with lake level fluctuations. Tom emphasized that fish production was very much dependent on the littoral zone of a lake as well as lake size (surface area, volume). How much littoral zone is available was particularly important. Clark Hull asked whether fish production would be affected by reduced inundation of the cypress fringe of a lake. Tom suggested there would be a negative effect but that there was no data or studies to support this. Jim Bays asked whether there was a lower limit that may have a "significantly" negative effect on fisheries. Tom indicated that there were to many variables to consider to answer that question unequivocally. Tom provided an example of what could happen to fish in a very shallow lake that was subjected to a cold snap during the spawning period of a selected game fish. Because there would be little thermal protection for the fish spawn in such a shallow lake the particular year class would be significantly impacted. Tom also indicated that the concept of a lake reestablishing itself at a lower level from historic elevations (because of long term low water) as a mirror image in terms of quantity and quality of fisheries was, in his opinion, false. Jim Bays asked how Tom would define significant harm in terms of fisheries. Tom indicated that, at least qualitatively, the fishing success of anglers is how the GFC evaluates impacts. Jim then asked how the GFC would define significant harm quantitatively and Tom indicated that a fishery survey, including creel census and other quantitative methods (e.g. seining, block nets, electrofishing) would have to be employed. Tom was asked what predictors he would use to estimate the quality of a fishery. He suggested several ideas including population balance (i.e. forage vs. predacious fish), fish biomass vs. trophic state indices, as well as population size structures. Jim asked how Tom would quantify the <u>loss</u> of fishery and Tom responded that he would measure the loss of functional littoral zone. Jim also asked if Tom knew what effects lake augmentation (either surface or ground water) might have on a fishery. Tom did not have any specific information on augmentation although he did say that flow- through lakes and phosphate pits often supported productive fisheries. Mark Barcelo asked how long a lake would have to reach its high levels and Tom responded that for fisheries that lakes should reach highs over a long term and not necessarily on a seasonal basis. Jim asked if the GFC had any reference lakes for fishery success. Tom said that they had several such as Okeechobee and Kissimmee, but none in our area. Craig suggested that the NW Lakes Augmentation Project the District was undertaking to evaluate the biological effects of

augmenting lakes has a fishery component and that these lakes may serve as reference lakes in the future.

3. The final topic of the day was the beginning of discussions concerning how to scientifically define "significant harm" for lakes. All participants agreed to evaluate the statistical significance of water level change. At this point it was decided to perform a detailed evaluation of bathymetric, vegetational and hydrologic data for the following test lakes to determine if we could arrive at a statistically significant relationship for evaluating harm : Dosson, Mound, Padgett, and Rogers. These data and analyses will be evaluated at the next meeting.

Next meeting is scheduled for Monday, February 10, 1997 at the Tampa Service Office

MINIMUM LEVELS LAKE SUBCOMMITTEE
SUMMARY OF MEETING ON JANUARY 30, 1997

MORNING

1. Craig Dye emphasized that the committee needs to conclude its analysis as soon as possible and determine where we have consensus and where we do not. Writing assignments have to be made so that the committee's findings and conclusions can be documented.

2. The next two meetings were scheduled for the Tampa Service office as follows:
   - February 4, 1997, 11 am to 2 pm - continued analysis and discussion of committee business.
   - February 6, 1997, 8:30 am to 5 pm - discussion with Tom Champeau of the FFWFGC and continued analysis and discussion of committee business.
   - February 10, 1997, 8:30 am to 5 pm - continued analysis and discussion of committee business.
   - February 14, 1997, 8:30 am to 5 pm - continued analysis and discussion of committee business.

3. Jim Bays presented an approach for determining minimum lake levels. He suggested using this to estimate a historical seasonal-low level. The example he presented consisted of a plot of stage duration (cumulative frequency) curves for all the lakes that were visited by the committee with the exception of Big Fish Lake.
   - Elevations of the lake water surface in the stage duration curves were reported as depth to water from the elevation of the saw palmetto line. This line represents the seasonal high water level.
   - The curves for each lake need to be constructed for the same period of record. The period used in Jim's analysis was from 1985 to 1996 and coincided with the period for which wetlands data are most abundant. It was discussed that the period should represent a period prior to anthropogenic impacts as much as possible.
   - Elevations of biological occurrences, vegetation indicators and construction of structural features need to be overlaid on the curves.

4. Observations that were made from the stage duration curves included:
   - Though the starting elevations were different, the curves for several lakes had very similar slopes. Horse and Rogers were the notable exceptions to this observation.
   - There appeared to be a difference in the curves for flow-through versus closed lake basins. Flow-through lakes were clumped together at the top of the graph. Isolated lake basins generally had steeper slopes and a lower starting point.

5. There was consensus that the saw palmetto line can be used as an indicator of the historical seasonal-high water elevation.

6. Jim Bays suggested that there may be a series of lakes that define the normal range of expected fluctuations and that other lakes will fall outside this range.

7. Marty Kelly noted that Jim's presentation applies to setting levels to protect wetlands adjacent to lakes but does not address harm in the lake itself.

8. Physical features (e.g. ditches, structures) affecting the ability of a lake to achieve historical seasonal-high water levels were discussed. Clark Hull noted that construction of physical features, such as a culverts, that cause lake level lowering implies a decision was made regarding the ability of the lake community to withstand lower levels.

9. There was consensus that the elevation of physical features affecting the ability of a lake to reach its historical seasonal high water level may be used to reflect the "new" seasonal high-water level.

AFTERNOON

1. Summary of Jim Bay's presentation:
    - Lake level fluctuations yield certain types of shoreline habitat. The approach looks at relating these occurrences, along with physical features that have affected the lake, to the stage-duration (cumulative frequency) curve. The goal is to set an expected seasonal-high level and a normal range of fluctuation.
    - Concerns that were expressed were that:
        - the method sets a level to maintain cypress fringe or adjacent wetlands.
        - the method does not yield seasonal fluctuations for lakes.
        - the level set in an adjacent wetland should protect the lake volume.
        - the methodology can be used but there may be disagreement over the starting point (new seasonal-high level over the historical seasonal-high level)

2. The relic upland edge may be used as the seasonal-high level in lakes where seasonal high levels declined several years ago.

3. Can we re-establish seasonal high water marks because of physical alterations of the system?

    It was generally concluded that the seasonal-high water marks could be re-established where physical alterations have occurred.
    - Physical features affecting lake levels include: culverts, structures, drainage ditches, sinkholes and alterations of the watershed affecting the contributing area.
    - Cultural features affecting lake levels include: septic tanks, house pads, seawalls, docks (visible), water intakes for irrigation, wells, roads, landuses (landscapes, satellite dishes), and recreation.

4. What if seasonal-high levels are changed by a physical alteration of the system but the high level could be re-established (e.g., Lake Armistead)?
   - Physical features affecting the seasonal-high level should be used to re-establish this level.
   - Decisions to structurally restore seasonal-high levels should be made by the Governing Board.

5. It was agreed that the method provides a mechanism for establishing a starting point. The serenoa fringe was one suggestion for use as a starting point. It was also agreed that it was acceptable to adjust the starting point due to physical alterations that affect the ability of the lake to achieve historical levels.

6. Lake basin morphometry and drainage basin characteristics may affect the shape of the stage-duration curves.

7. If current District methodology is used would updated data be used to set new levels or stage/duration curves?
   - Lakes would be reset and, it is not time specific as to when this would be done.

8. The District's lake levels program was discussed. Craig Dye emphasized that the District does not use a single criterion to set a particular level but rather the preponderance of evidence, both quantitative and qualitative.
   - 10 year flood level
     - this level is an advisory level and a tool for developmental interests.
     - control structures on lakes are opened before this elevation is reached.
     - cultural impacts should not affect this level.
   - Minimum flood level - this level is the peak elevation on lakes with structures and approximates the seasonal high level. This level equates well with the palmetto line discussed in Jim Bay's approach.
     - the elevation that is equaled or exceeded 7 percent of the time.
     - vegetation indicators include elevation of the palmetto and wax myrtle line, lichens line, and 2/3 of the cypress buttress. Problems affecting the 2/3 cypress buttress measurement are soil erosion and soil subsidence.
     - the toe of the escarpment was suggested as an indicator of this level.
   - Minimum low management level - approximates the seasonal low level. Surface water withdrawals are limited by this elevation.
     - the elevation that is equaled or exceeded 87 percent of the time.
     - the elevation that is 3.5 feet below representative docks and seawalls on a lake.
     - the lowest elevation residents desire.
     - the elevation coinciding with the year long flooding of contiguous emergent zones. The lake emergent vegetation is on the landward side of this line.
     - why is typhaa and bullrush excluded?

LAKE LEVELS SUBCOMMITTEE MEETING
January 27, 1997

1. The purpose of this meeting was to review all the data collected during the three field trips to the "test case lakes" in NW Hillsborough and Pasco Co. The committee broke up into the four field teams and evaluated and discussed their particular data sets among their teams. These data will be further analyzed before the next meeting.

2. Ken Romie and Marty Kelly discussed their findings with the subcommittee since they had little data with which to work (i.e. historical biological data). They concluded that the biological data available for our test lakes was extremely sparse. These data consisted primarily of the District's semi-quantitative vegetation mapping that was performed during the earlier lake levels work when levels were originally set, as well as vegetation transects performed by Jim Bays. However, they will attempt to compare historic depth of the edge of emergent aquatic plants with current data.

3. The meeting continued with discussions of a variety of subjects including:

   a. How or if it would be possible to partition the effects of drawdown and development on lake levels;

   b. The vegetational indicators of high and low water. Palmetto and cypress may be good indicators of high water conditions, but that vegetational indicators of low water were poor.

   c. The need to develop a bathymetric model for determination of littoral zone reduction vs. lake drawdown using actual lake data. Ken Romie is working with the District GIS section to accomplish this.

   d. How to apply value judgements to determine a biological definition of "significant harm".

The next meeting will be at the Tampa Service Office on January 30, 1997.

LAKES SUBCOMMITTEE
January 7, 1997

1. The purpose of this meeting was to discuss the logistics and tasks to be completed during the field evaluation of the 15 "Test Lakes" that the Committee will visit in the next two weeks. The primary tasks are:
    a. Determine width and depth of littoral zone
    b. Determine slope of littoral zone
    c. Identify aquatic and wetland vegetation
    d. Determine setting of lakes and relationship to surrounding features
    e. Compare and contrast available historic biological, hydrologic and morphometric data with current conditions

2. Jim Bays, Doug Durbin and Richard Gant will be doing some preliminary littoral zone transects for a few selected lakes on January 14.

3. Ken Romie briefly reviewed the available biological data that included plankton, benthic invertebrate and vegetation data. He also produced a table of available water quality data for the 15 "Test Lakes".

4. Mark Barcelo presented the hydrographs and stage duration curves for the "Test Lakes" within Hillsborough County. He will have similar plots for the remaining lakes (i.e. those in Pasco County). Cathleen Beaudoin noted that although there was a considerable amount of water level data available for Lake Dosson, the District had not already set levels for this lake. Richard Gant explained that when levels were being established for lakes in this area that only lakes 20 acres or greater were considered. Lake Dosson is only 11 acres in size.

5. Craig Dye made the group aware of the tight time lines associated with accomplishing our tasks. By March 1, 1997 the methodology for setting lake levels must be completed with proposed levels established by mid-April. This time line needs to be adhered to so the District can meet it's statuatory obligation of setting levels by October 1, 1997.

6. A discussion ensued about the Committee's responsibility for establishing a methodology for setting lake levels based on factors other than a scientific evaluation of physical and biological conditions, specifically recreational and aesthetic properties of a lake. It was decided, unanimously, that the Committee's primary focus would be on scientific issues and that the recreational and aesthetic considerations were a policy and/or management issue that was generally outside our group's responsibility. However, the Committee may make some recommendations related to these issues in their final report.

LAKES SUB-COMMITTEE
January 3, 1997

1. The purpose of the meeting was to review and discuss the criteria for selecting test lakes and to narrow the list of lakes. Accessibility was discussed as an important criteria for determining which lakes to include as test cases.

2. Richard Gant reviewed a table summarizing selected information on lakes in the NTB area.

3. Ken Romie presented a summary of available literature that discusses biological data collected on lakes in the NTB area.

4. A preliminary list of lakes was discussed as follows:

   Hillsborough County:
   Alice, Allen, Calm, Carroll, Chapman, Church, Crenshaw, Crescent, Deer, Dosson, Fairy, Hiawatha, Hobbs, Horse, Island Ford, Keene, Keystone, Mound, Osceola, Platt, Pretty, Rainbow, Raleigh, Rogers, Saddleback, Starvation, Stemper, and Turkey Ford

   Pasco County
   Bell, Big Fish, Crews, Hancock, Padgett, and Pierce

5. A second list was developed that focused principally on lakes that had biological information. The attached Table 1 summarizes the discussion that took place regarding the list.

6. A final list of lakes for which site visits will be conducted was determined and organized according to geographical area. The list is as follows (**bold names indicate that lake levels are currently low**):

   Keystone Area
   Mound, Calm, Keystone or Island Ford, **Rogers**, and **Horse**.

   Lutz Area
   Dosson, **Starvation**, Carroll, Platt, and Stemper.

   Pasco County
   Hancock, Padgett, Pierce, and **Big Fish**.

7. Scheduled field days for site visits to these lakes are January 16, 17 and 24, 1997.

LAKES SUB-COMMITTEE
December 19, 1996

1. Marty Kelly described a simple spreadsheet model for lake drawdown that would calculate loss of volume, lake surface area and littoral zone. The spreadsheet calculations are based on the volume of a cone and elliptic sinusoid of varying dimensions. Discussion ensued concerning what the real change in littoral zone area might be under various drawdown and lake morphometric scenarios. Other comments were made concerning the potential changes in water quality and fish populations under various drawdown scenarios.

2. An attempt was made to associate a level of usefulness (high, medium and low) to the various criteria we will be evaluating to select 12 - 15 "Test Lakes" that will be used to evaluate lake level methodology. These criteria were selected at our December 16, 1996 meeting and are as follows (with degree of usefulness):

   a. Lake level data - **high**
   b. Monitor well data - shallow well - **high**, deep (Floridan) well - **medium**
   c. Lake and watershed morphology - all categories - **high**
   d. Lake uses - **high**
   e. Geotechnical information - **medium**
   f. Water quality data - **medium**
   g. Biological studies - littoral vegetation studies - **high**, plankton studies - **low**, wildlife studies - **medium**
   h. Aerial photography - **high**
   I. Survey information - **high**

3. Doug Durbin prepared a draft table of ecological impacts associated with lake level reductions that included the type of impact, potential indicators information requirements, limitations and values. Although we discussed some of the categories it was decided that the committee members would review the table and offer comments at the next meeting.

4. Richard Gant made a presentation on how the District currently evaluates and adopts lake levels into District rules.

Next meeting is at 1:30 PM, Friday, January 3, 1997 at the Tampa Service Office.

LAKES SUB-COMMITTEE
December 16, 1996

1. Ken Romie reviewed all the data bases available for water quality which consisted of STORET. Florida LAKEWATCH, and the District's Ambient Monitoring Program. He also provided a list of biological studies performed on lakes within the NTBWRAP area. Doug Durbin of BRA, Jim Bays of CH2M and Dave Bracciano of West Coast provided, or will provide. other biological studies of which they were aware.

2. Richard Gant reviewed the lake level data that resides in the District's Hydrologic Data Base for lakes within the NTBWRAP. In the next draft of this list he will include any lakes that are to be adopted by October 1. 1997 and were inadvertently left off the first draft.

3. Dave Bracciano questioned whether Round Lake was on the priority list of lakes to be adopted by October 1. 1997 or was it added after that list was approved by the Governor and Cabinet. Craig Dye will determine this before the next subcommittee meeting.

4. The majority of the meeting was devoted to determining a list of criteria that will be used to select a group of 12 -15 "Test Lakes". The "Test Lakes" will be used to evaluate the hydrologic and biologic characteristics on which to base functional relationships and to evaluate the current Lake Level Methodology. The criteria selected by the group is as follows:

   a. Lake level data (period of record as long as possible)
   b. Availability of data from shallow and deep monitoring wells in vicinity of lakes
   c. Morphology of lake basin and watershed to include: bathymetry; inflow/outflow type (i.e. seepage, flow through systems, surface inflow only); surface drainage alterations (i.e. ditching and culverts); associated wetlands; lake size; contributing watershed size and land use (%developed shoreline)
   d. Lake uses (WUP's etc.)
   e. Geotechnical information available (seismic or GPR data)
   f. Water quality data
   g. Biological studies available
   h. Aerial photography with contouring available (e.g. 1-2000 IR, 1-200 B&W)
   i. Survey information (mostly adopted lakes)

Next meeting is at 1:30 PM, Friday, January 3, 1997 at Tampa Service Office

Lake Sub-Committee

December 6, 1996

I. Goal

1. Define measurable functional relationships between ecological/limnological parameters and lake levels.

2. Determine methodology for minimum lake levels and evaluate existing methods.

II. Objectives

1. Identify ecological and hydrologic data available to consider in the development of functional relationships.

2. Develop usable consistent database.

3. Identify and develop test cases on approximately 15 lakes.

III. Data Inventory

1. Water Levels

2. Water Quality

3. Biological

4. Morphologic Data

IV. Schedule

1. Data base update (District will compile) 12/18/96

2. Identify criteria for test case selection for 12/18/96 (selection in January)

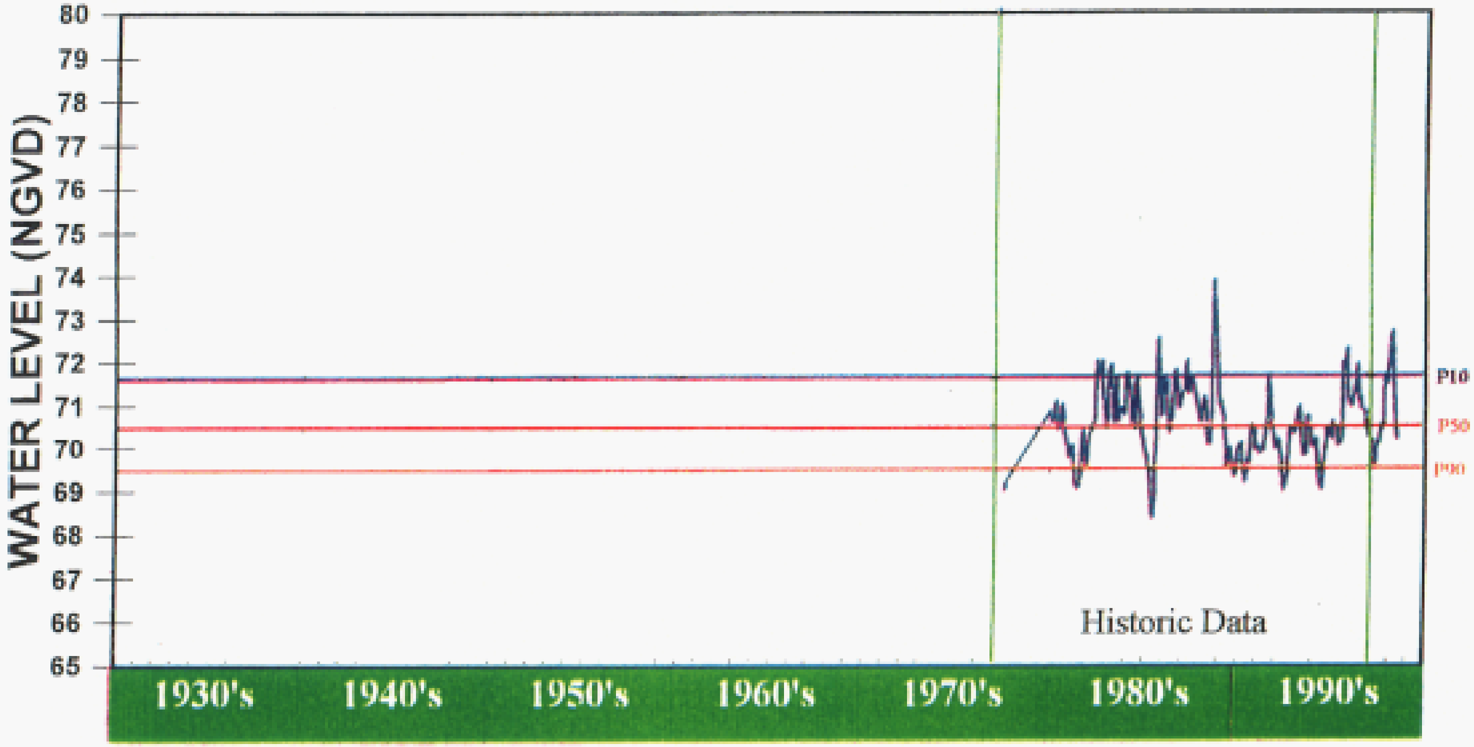
3. Progress report to be determined

4. Final product - Technical Memo

Next Meeting: Monday, December 16, 1996 at 8:00 a.m.

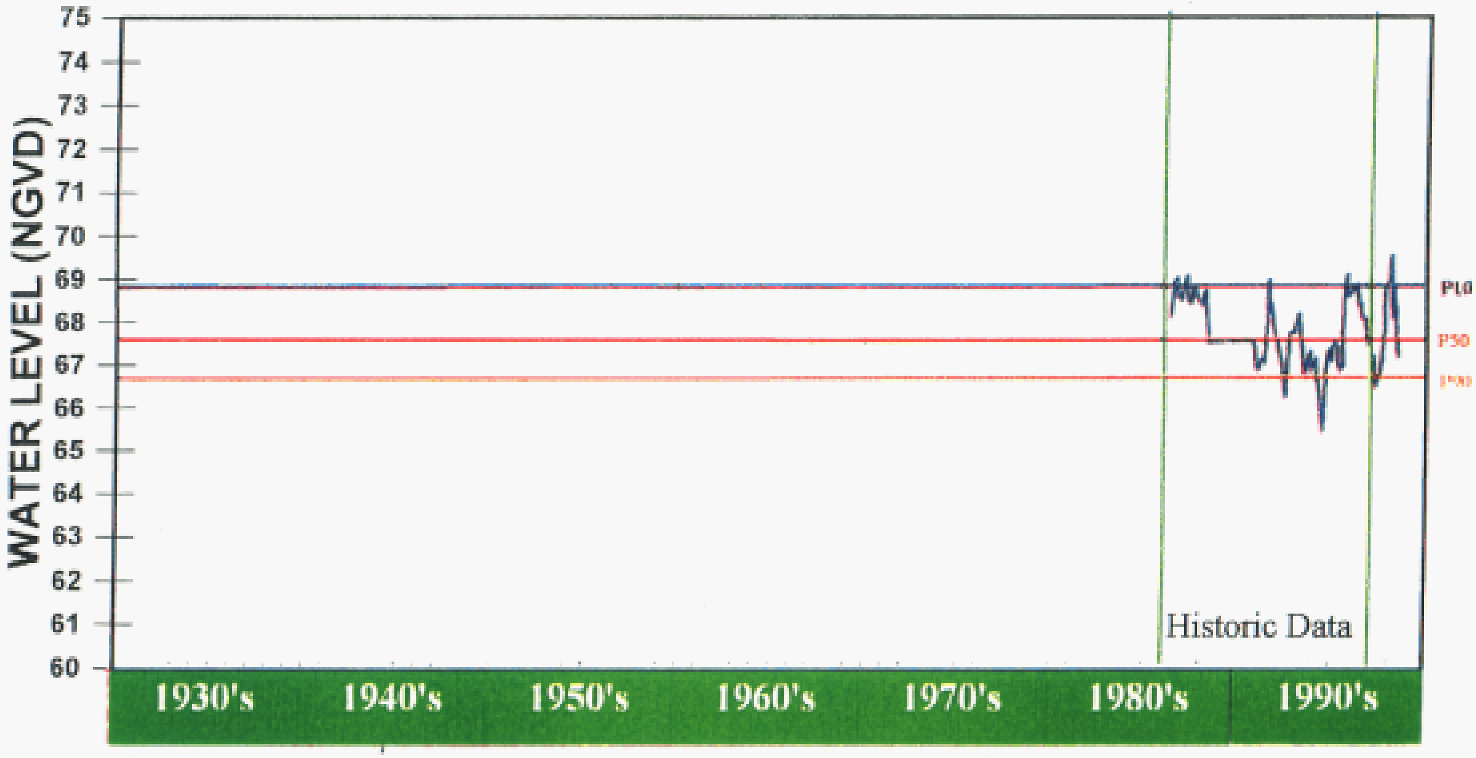
APPENDIX B
Reference Lake Hydrographs

Lake Bell



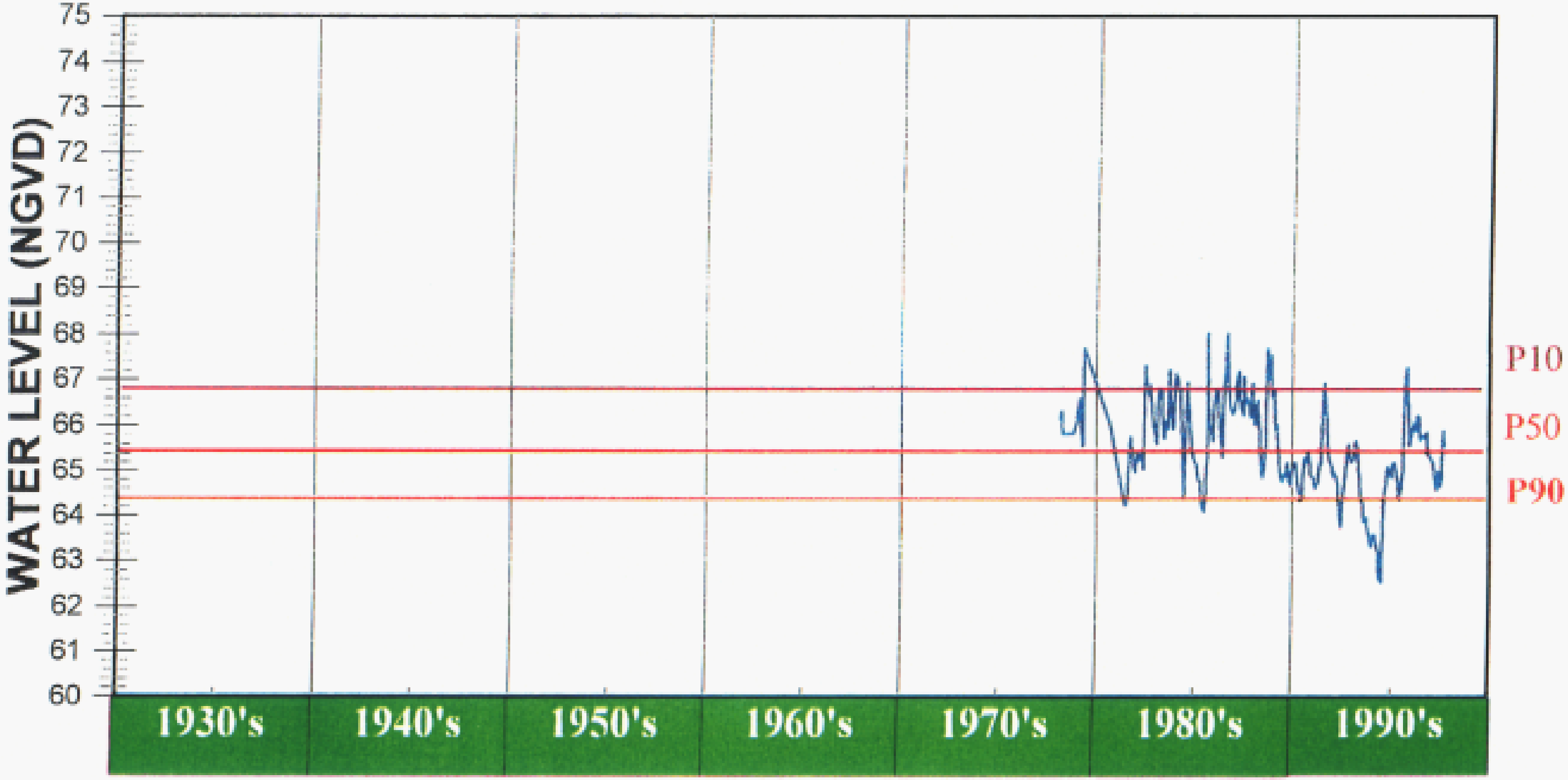
All Water Levels are Monthly Averages

Big Lake Vienna



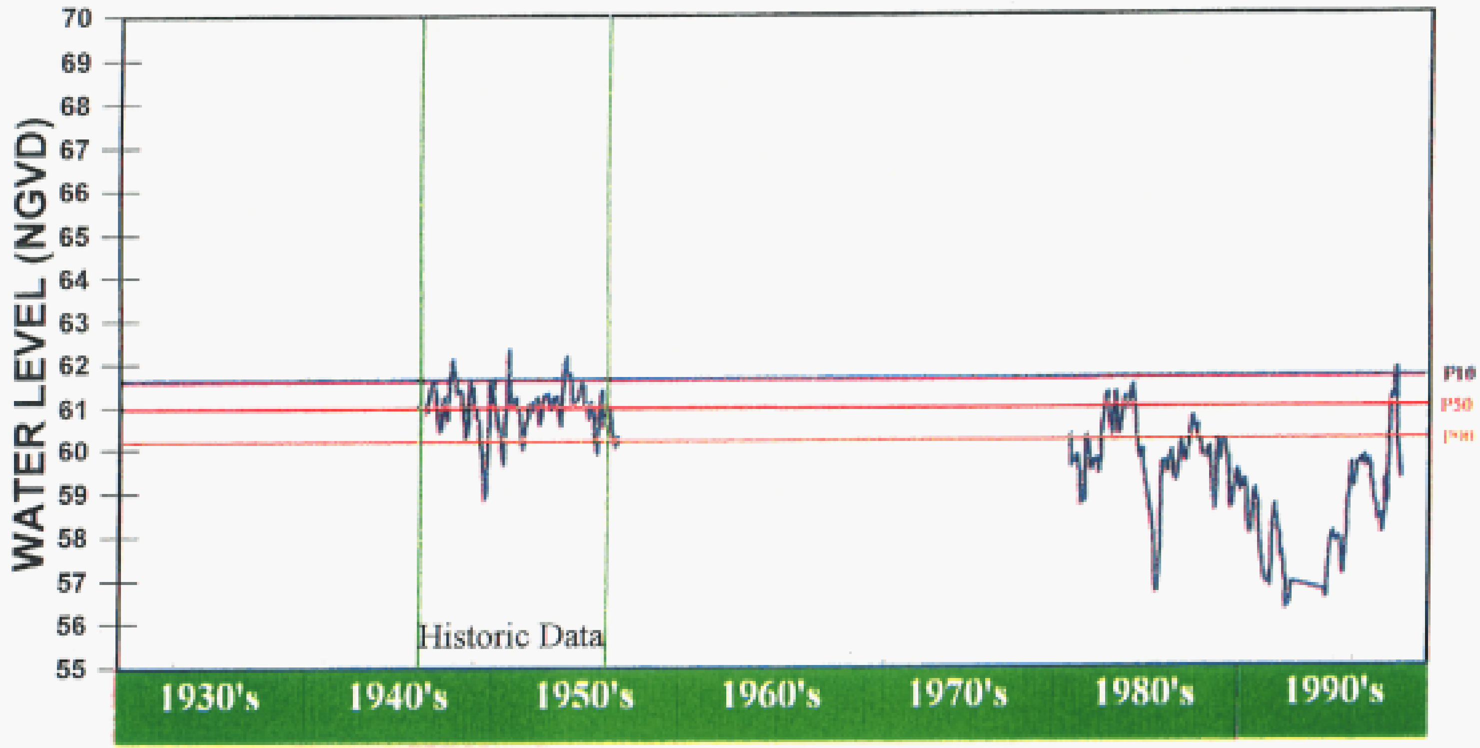
All Water Levels are Monthly Averages

Lake Bird - Pasco County



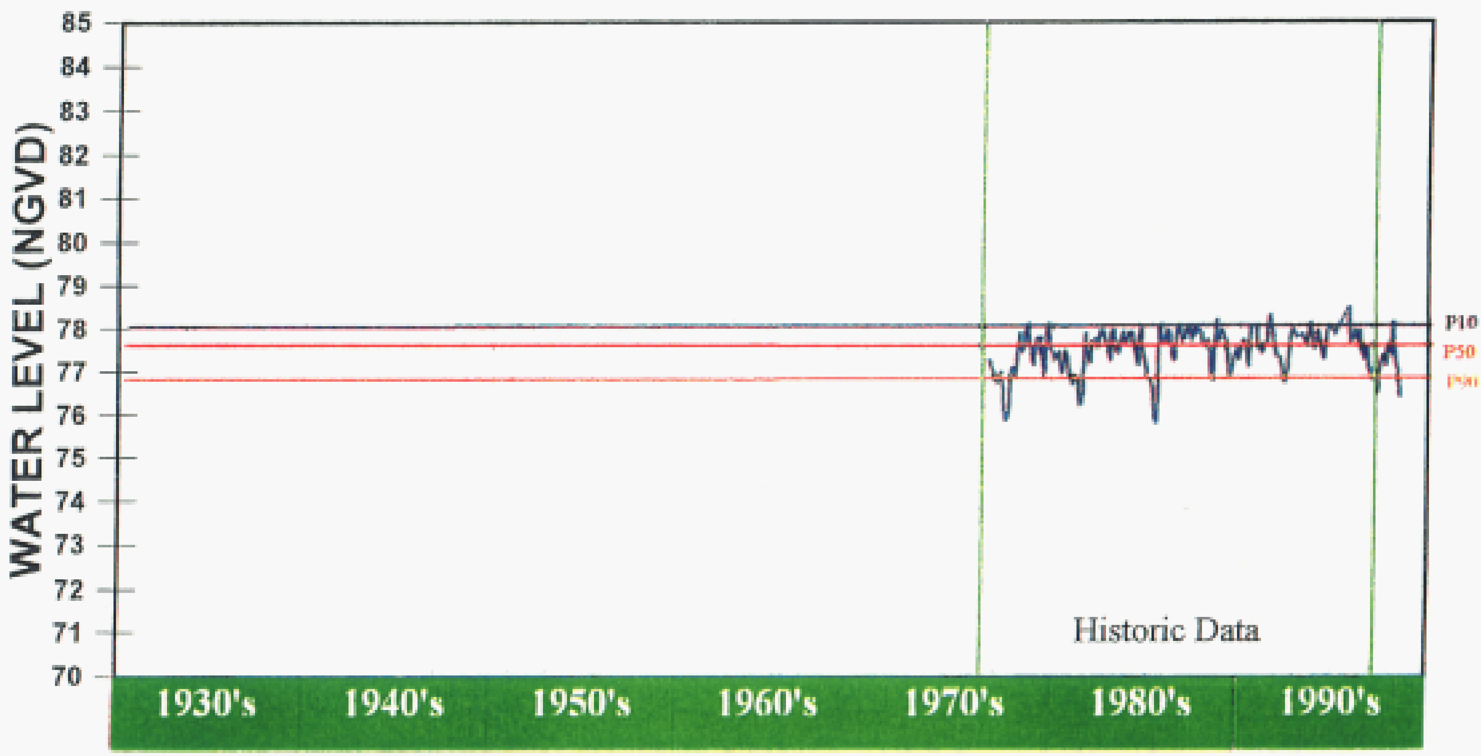
All Water Levels Are
Monthly Averages

Lake Cooper



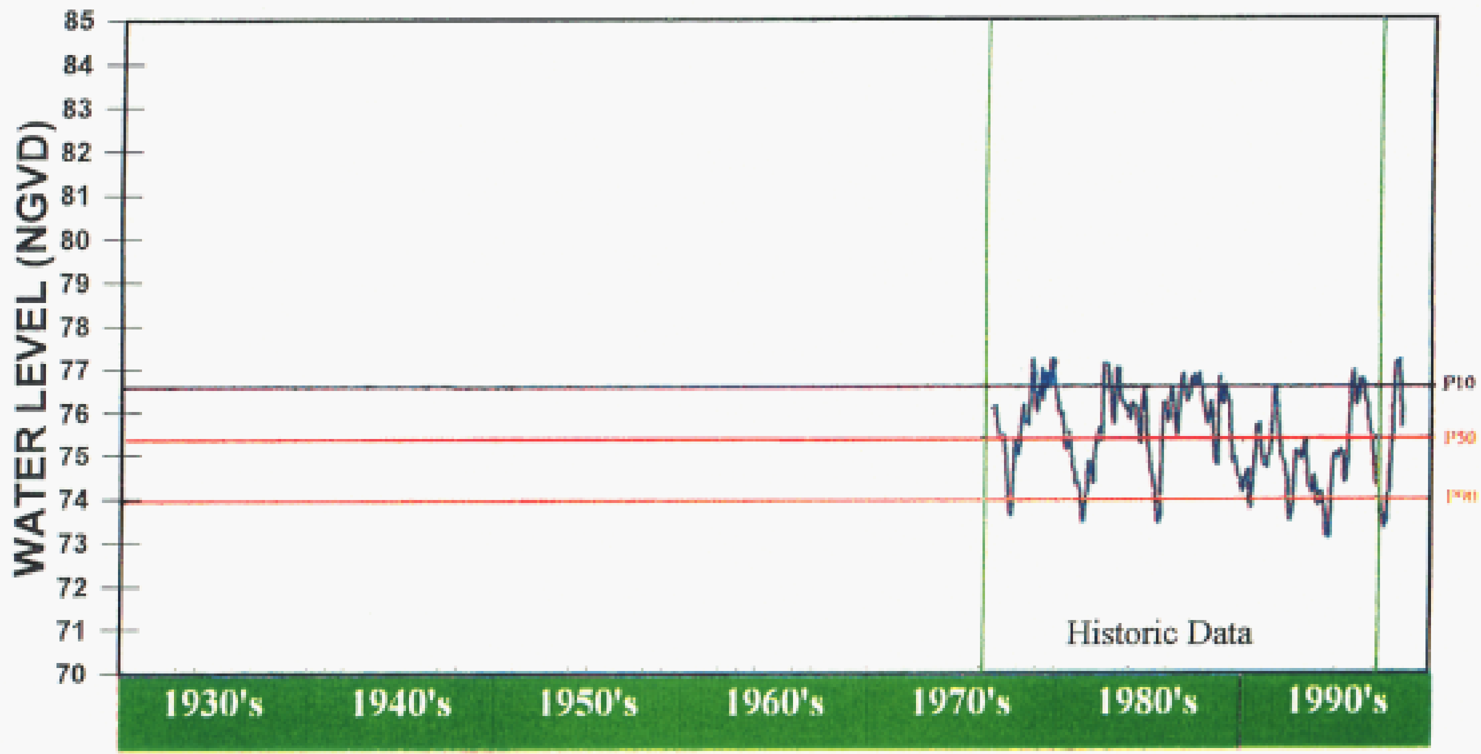
All Water Levels are Monthly Averages

Lake Cow East



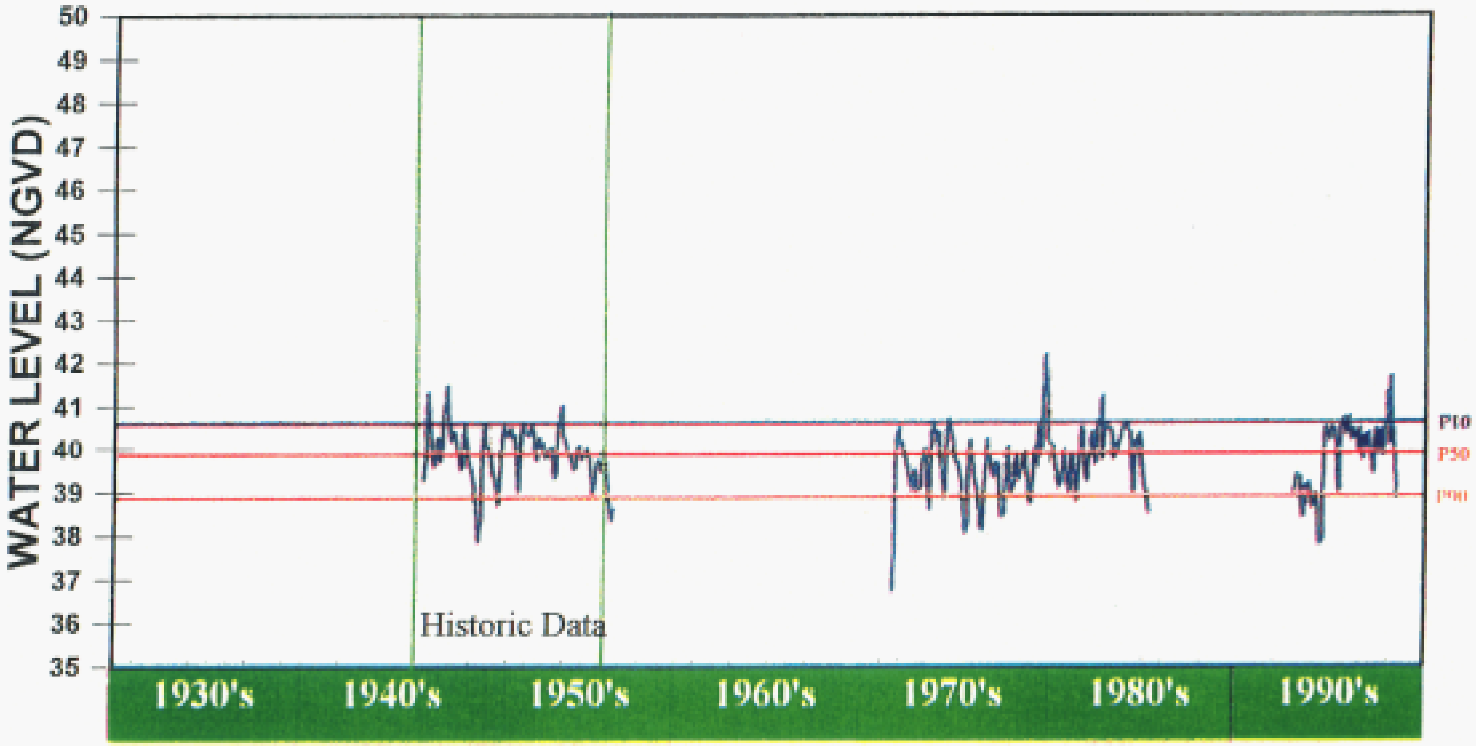
All Water Levels are Monthly Averages

Lake Curve



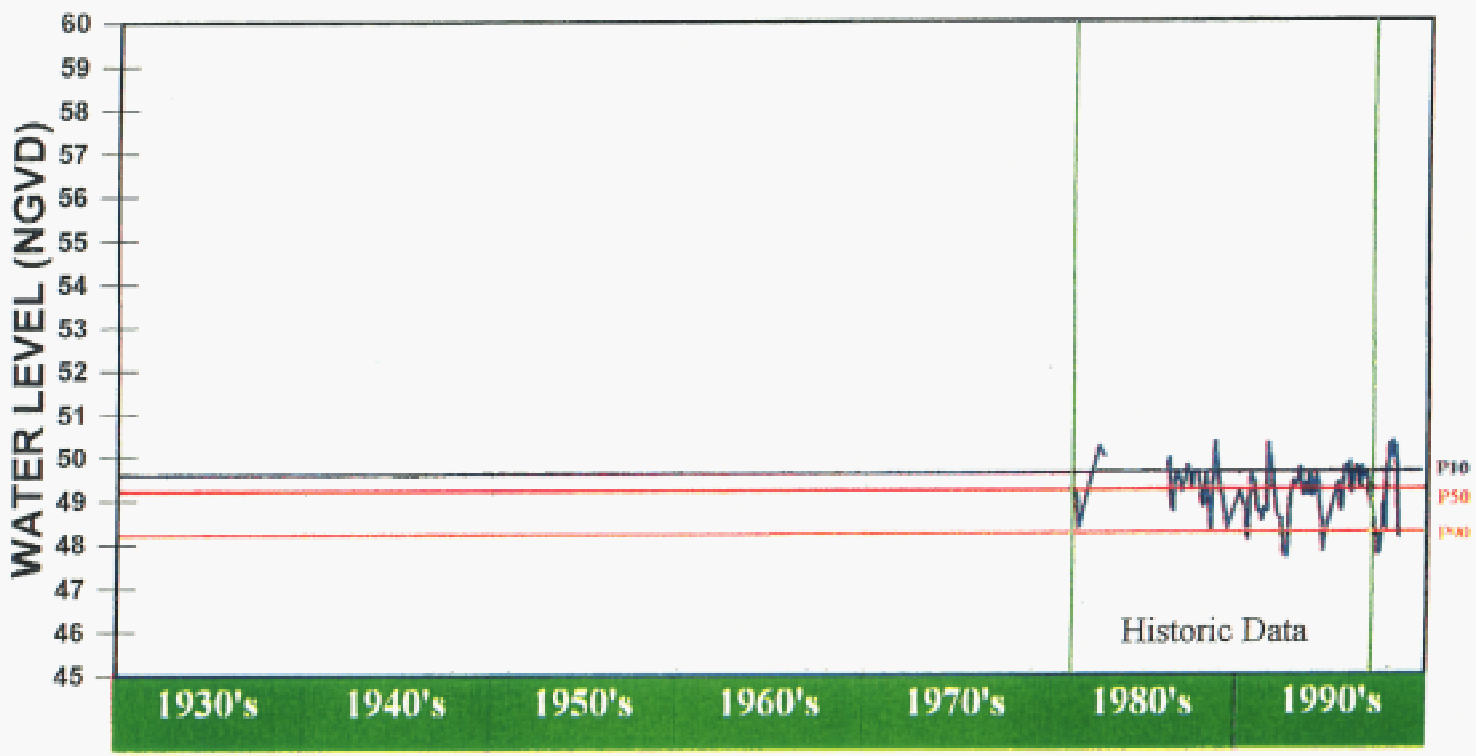
All Water Levels are Monthly Averages

Lake Ellen



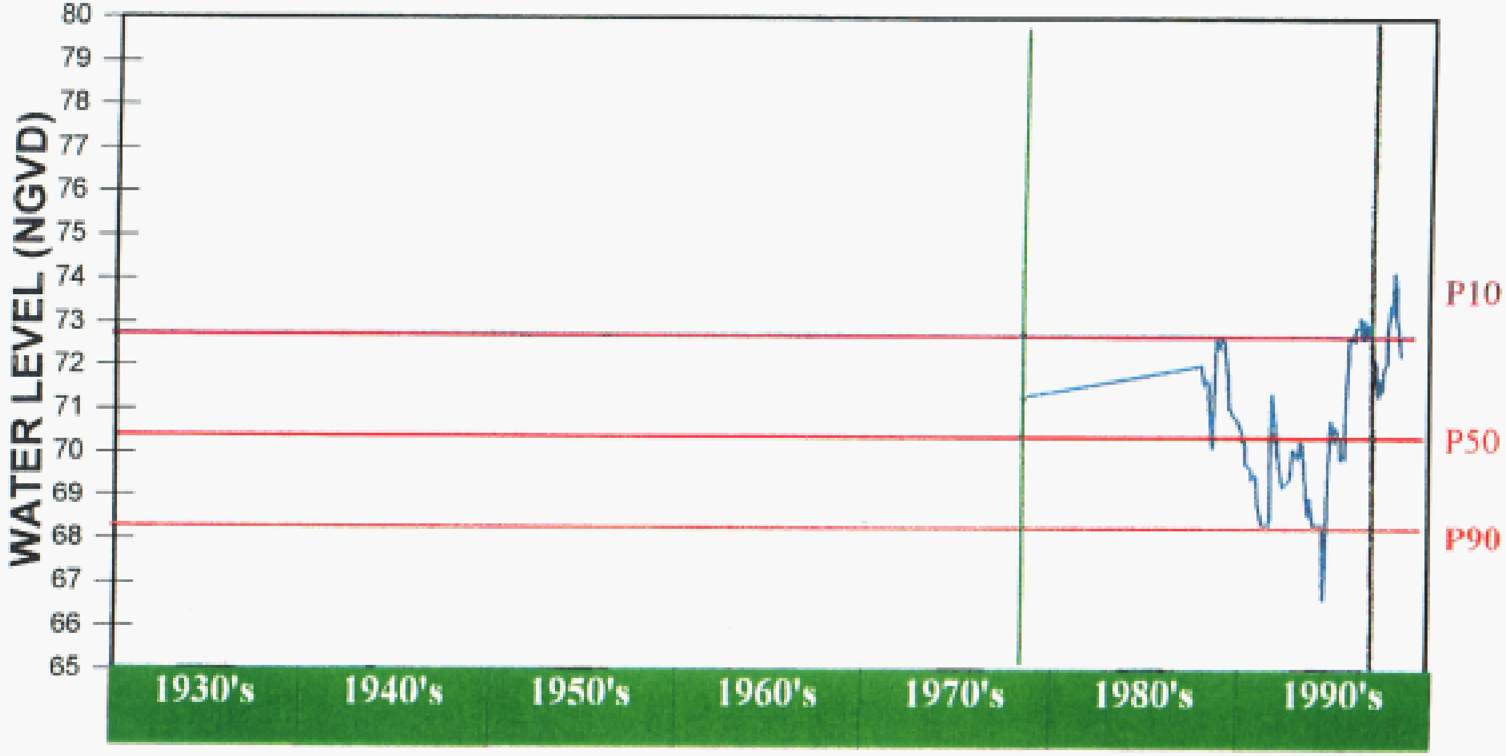
All Water Levels are Monthly Averages

Lake Geneva (Mud)



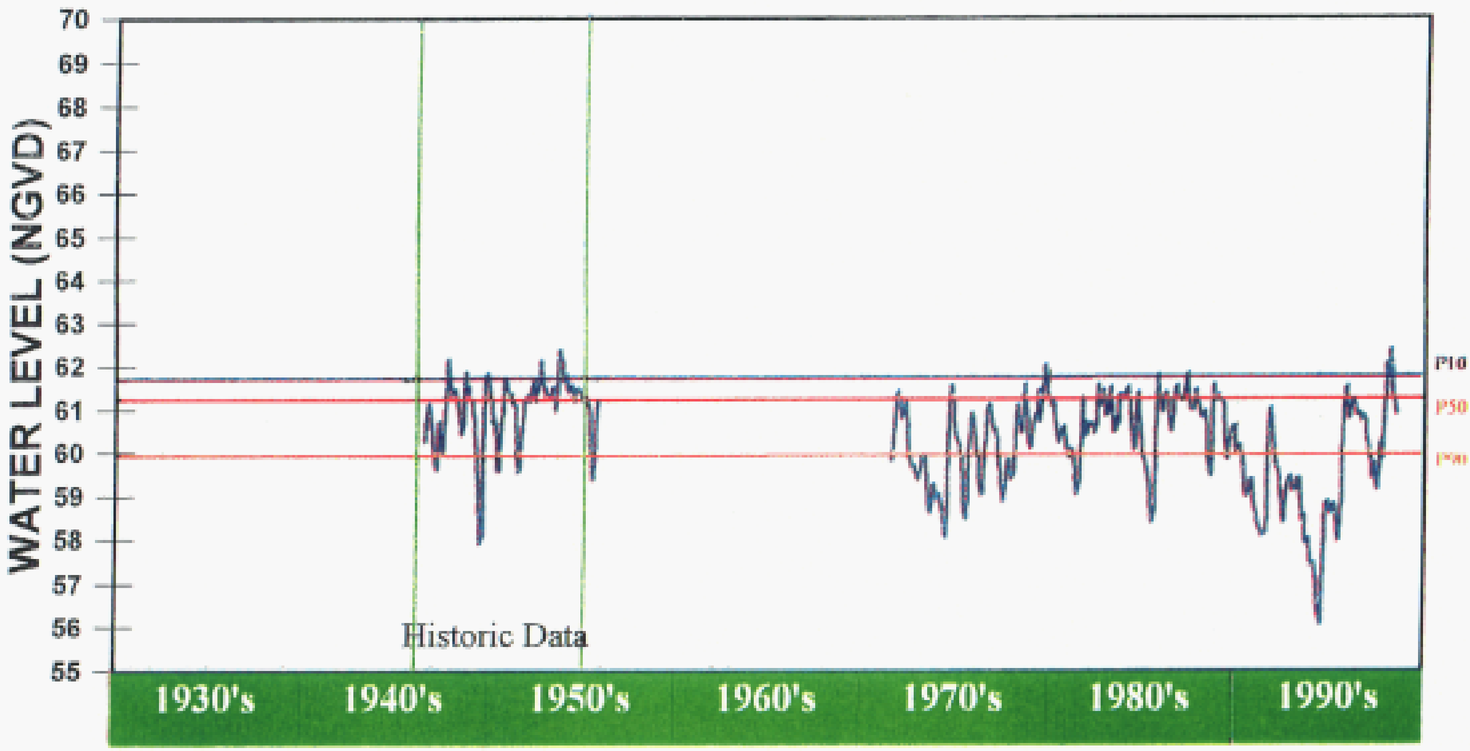
All Water Levels are Monthly Averages

Gooseneck



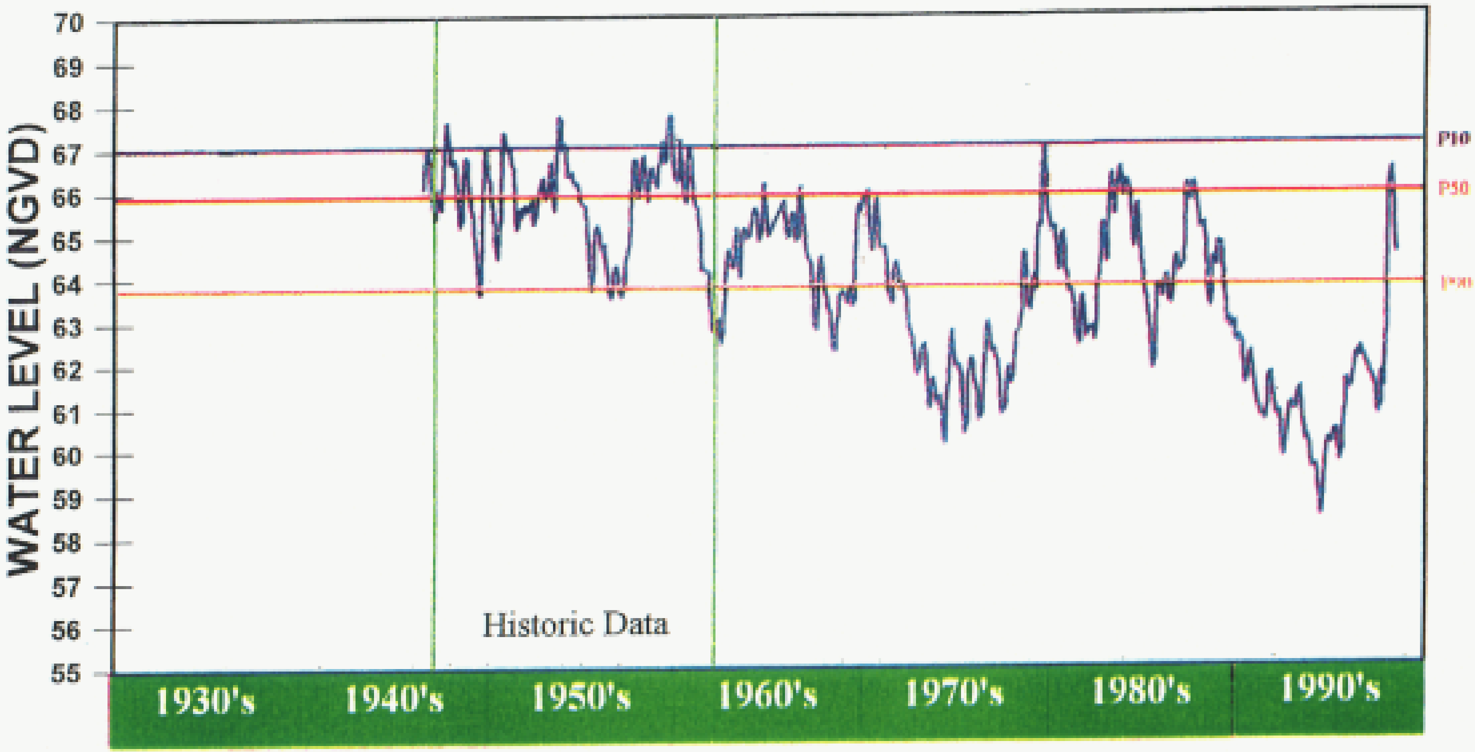
All Water Levels Are
Monthly Averages

Lake Hanna



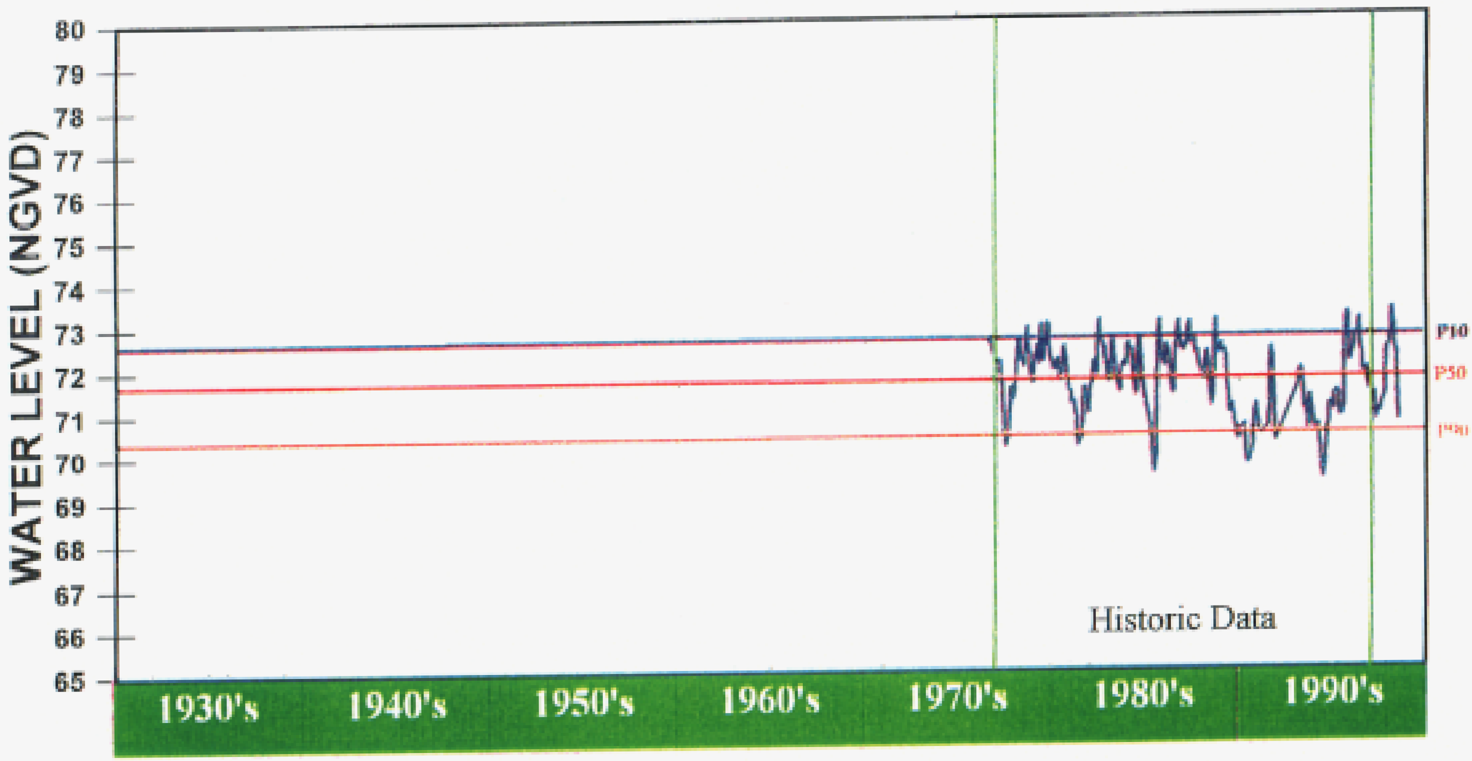
All Water Levels are Monthly Averages

Lake Hobbs



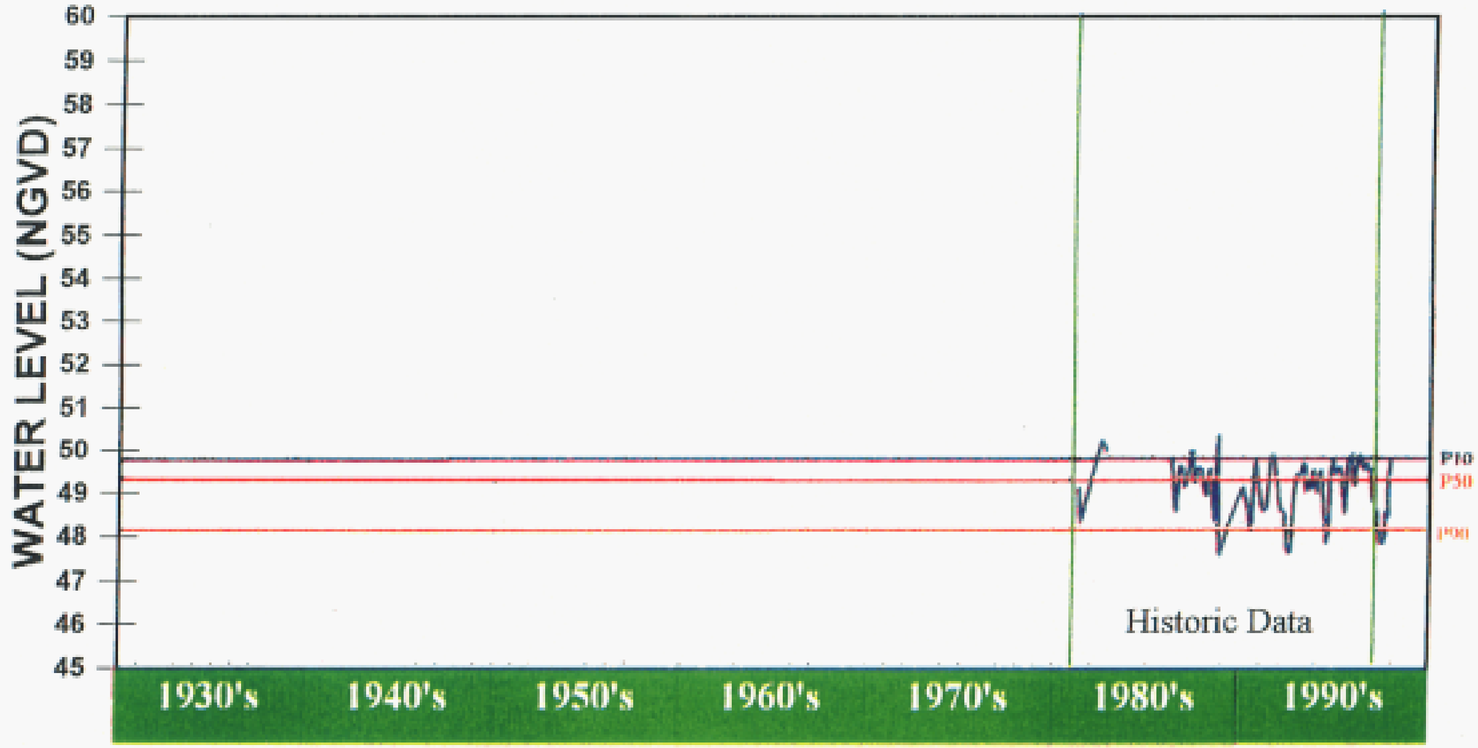
All Water Levels are Monthly Averages

Lake King At Drexel



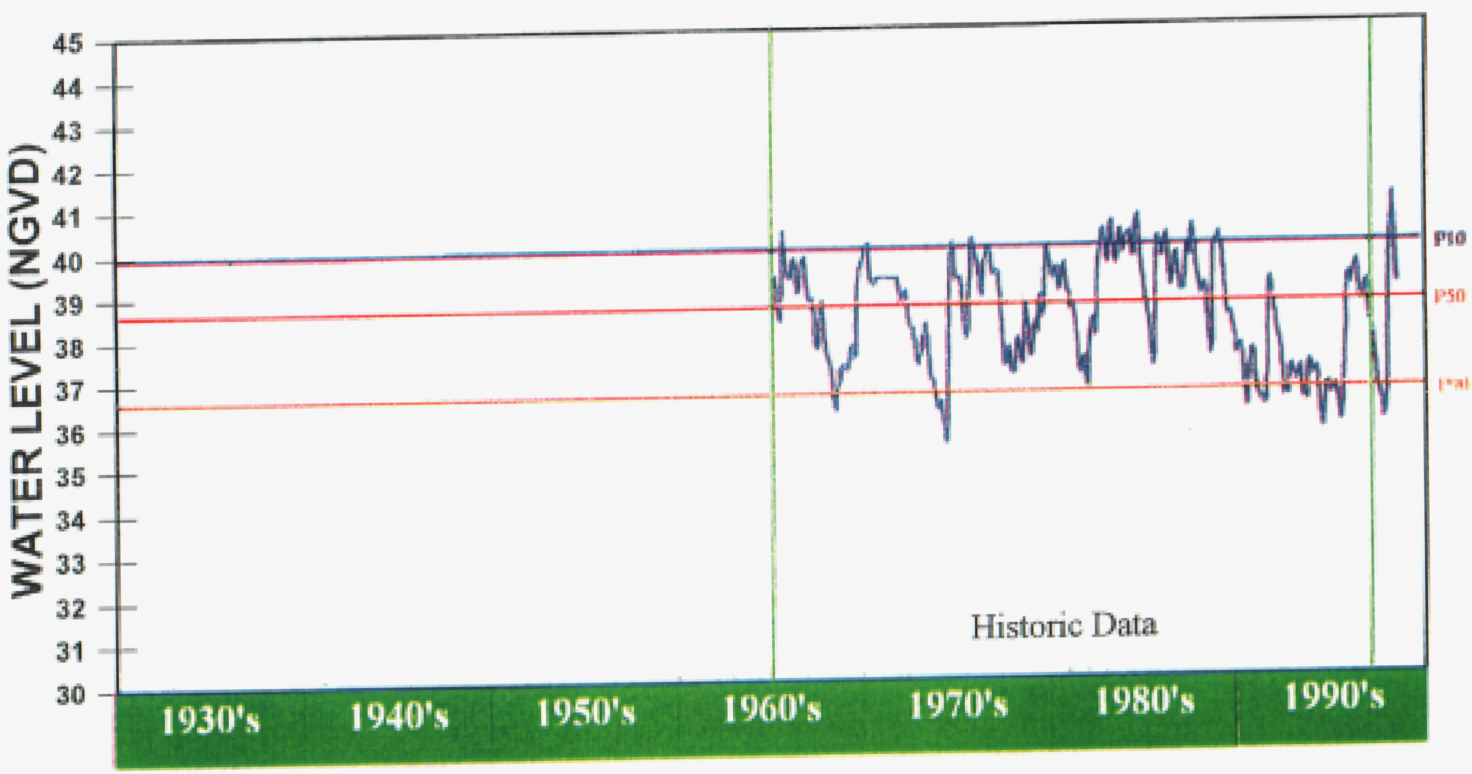
All Water Levels are Monthly Averages

Lake Minniola



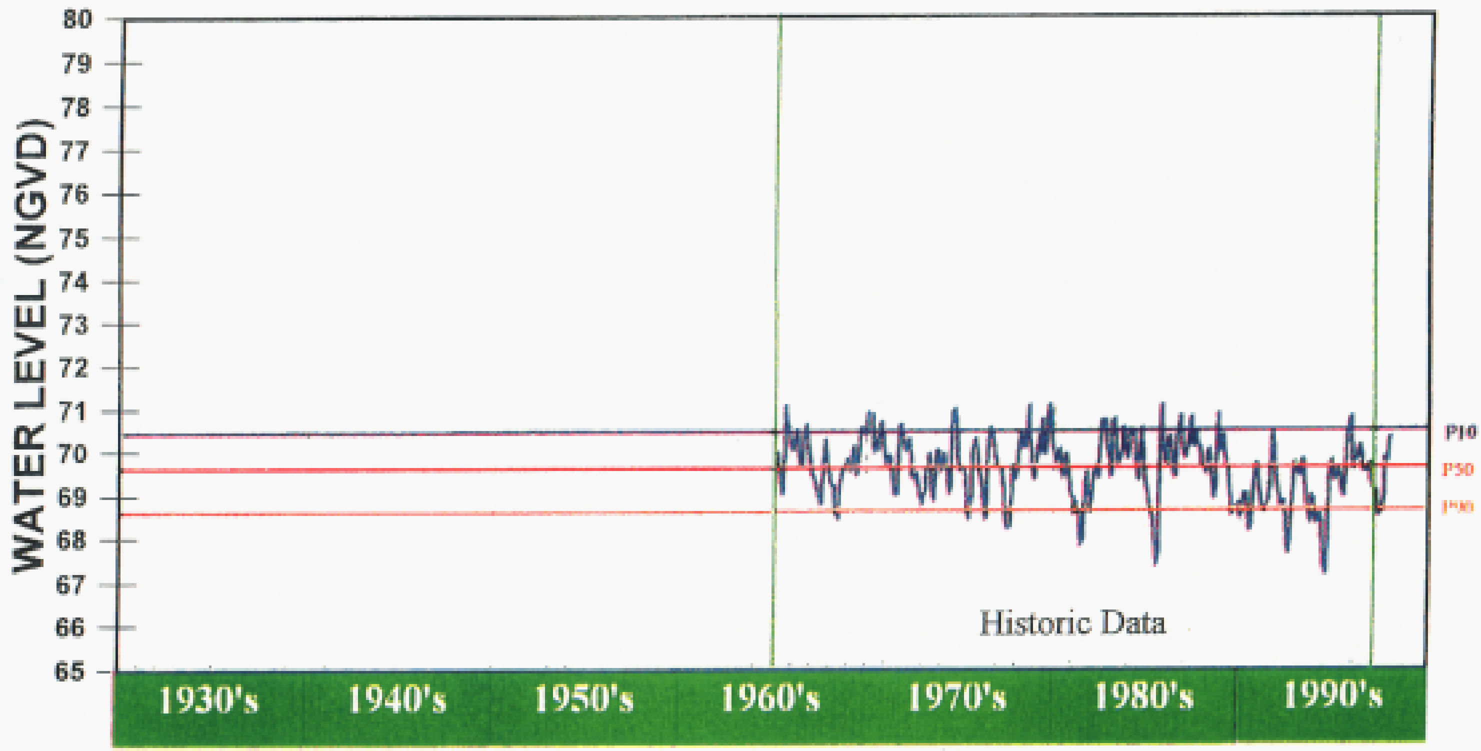
All Water Levels are Monthly Averages

Lake Moon



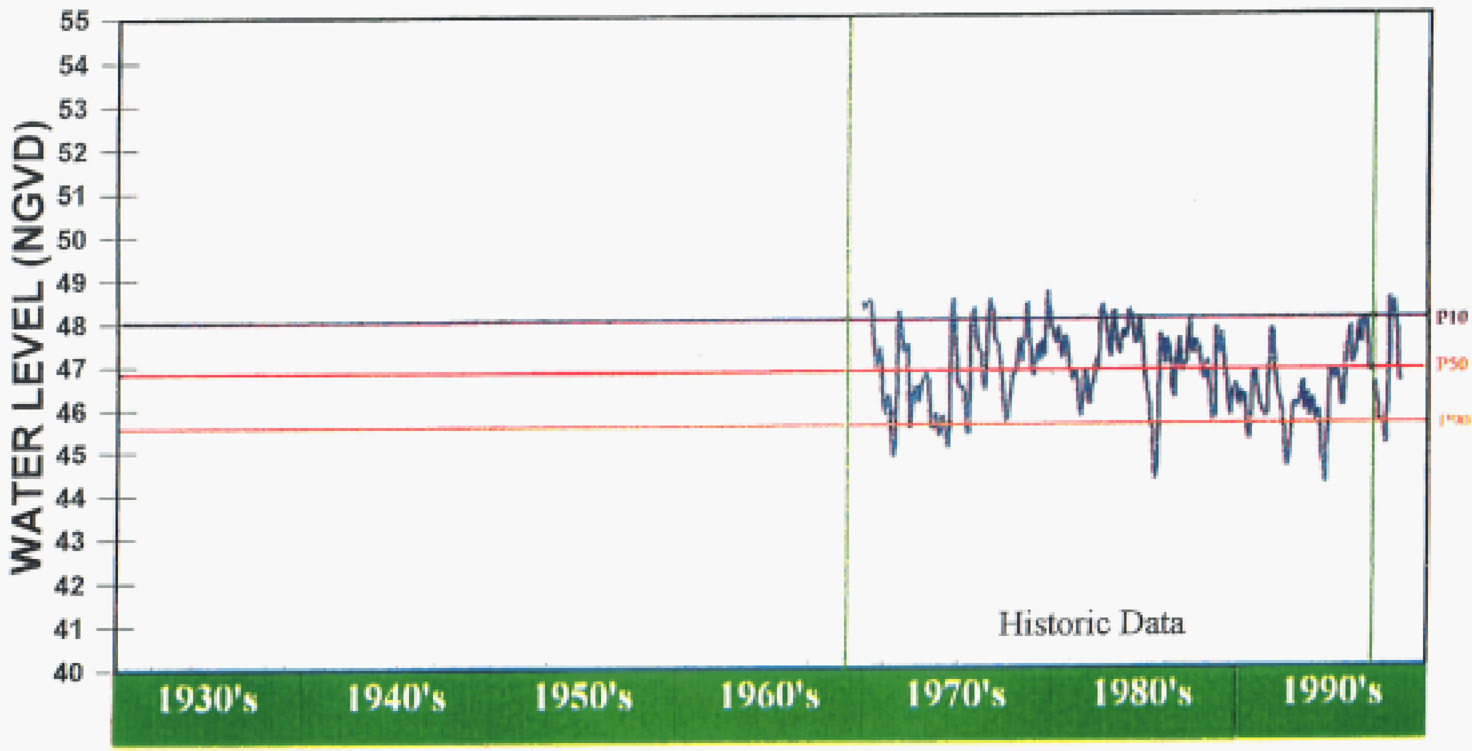
All Water Levels are Monthly Averages

Lake Padgett



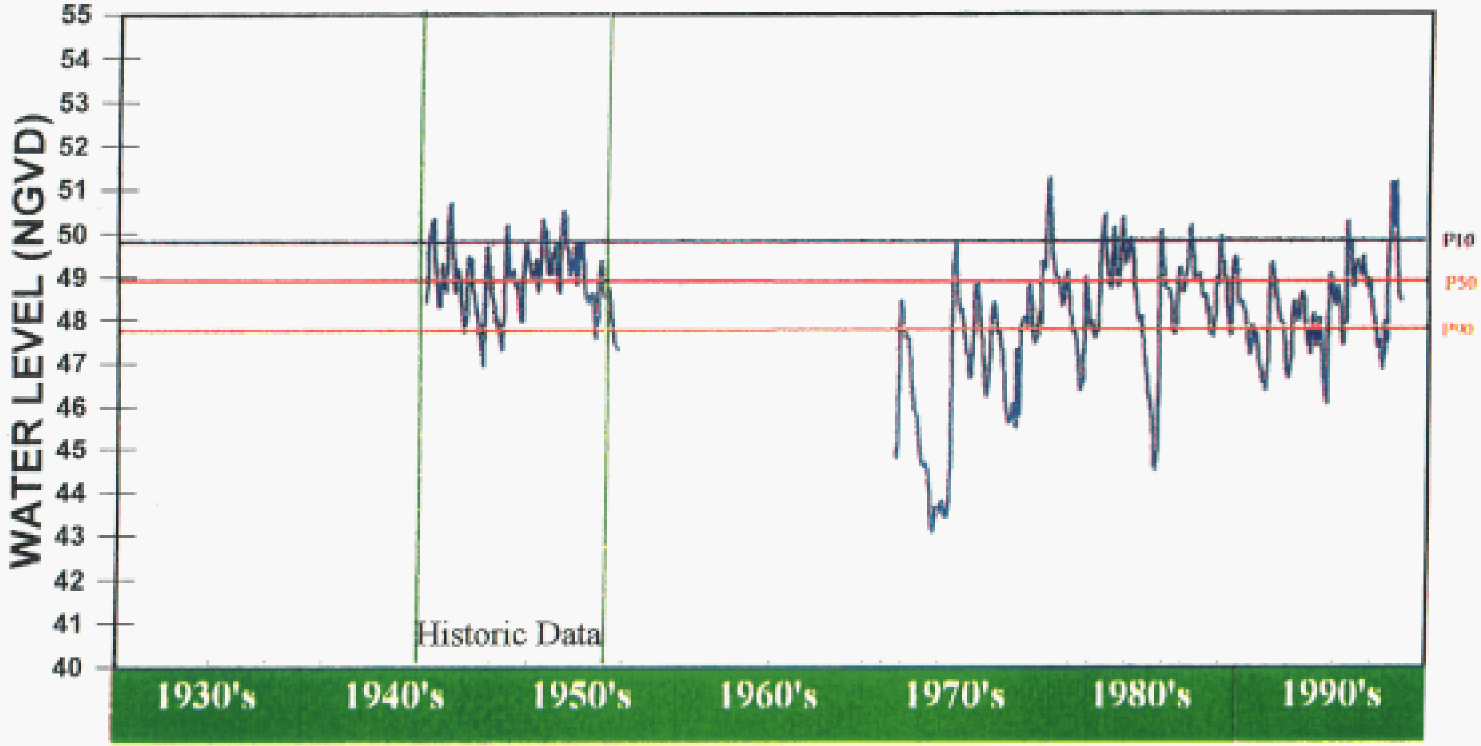
All Water Levels are Monthly Averages

Lake Parker



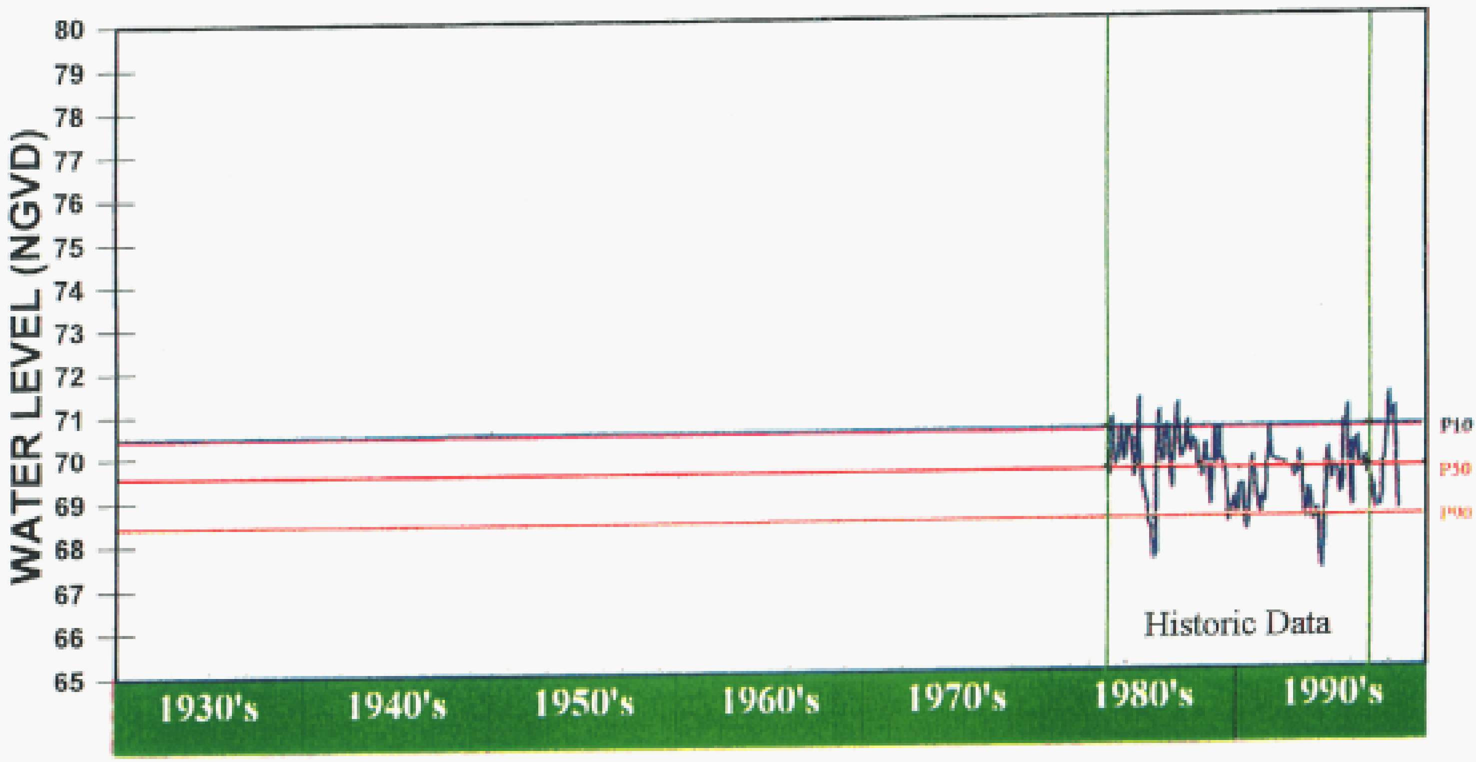
All Water Levels are Monthly Averages

Lake Platt



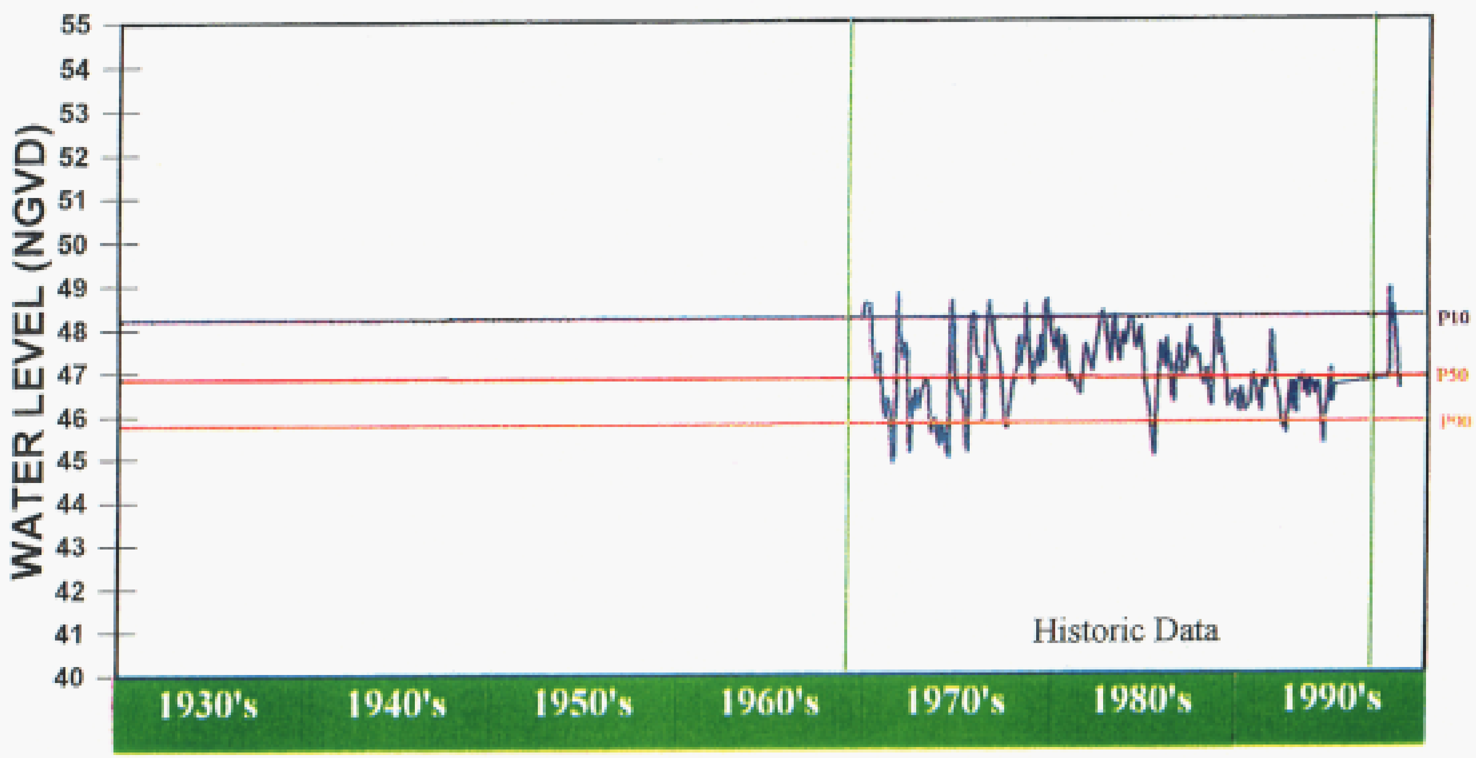
All Water Levels are Monthly Averages

Lake Saxon



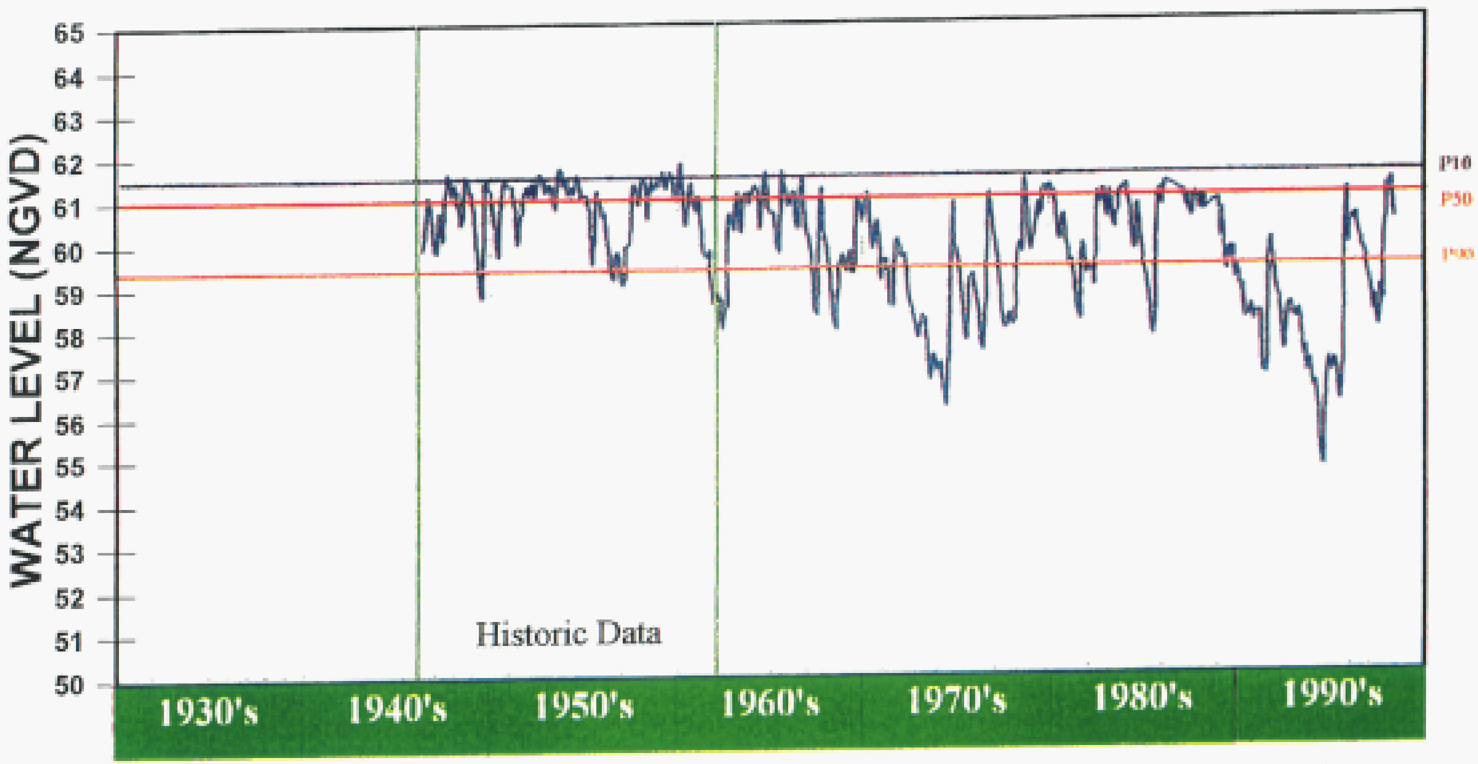
All Water Levels are Monthly Averages

Lake Seminole



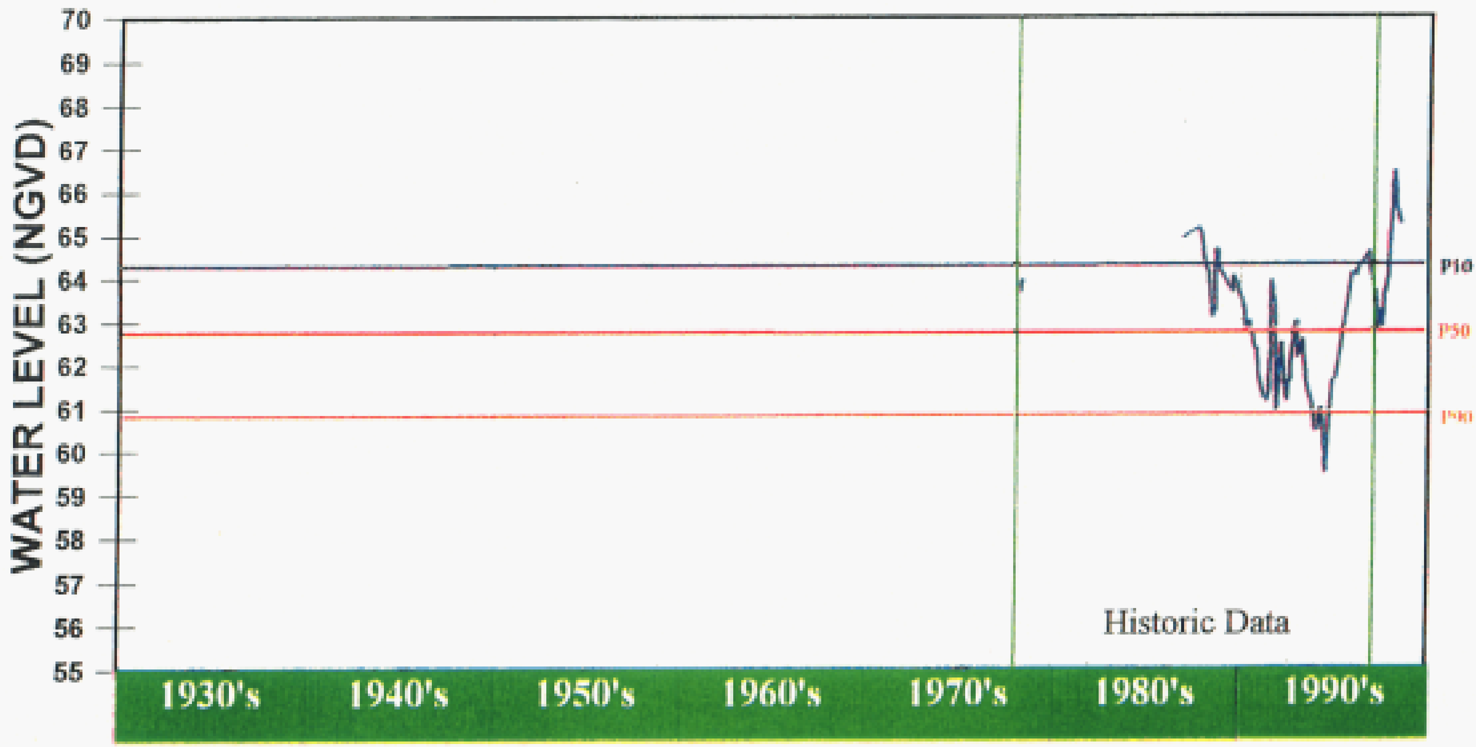
All Water Levels are Monthly Averages

Lake Stemper



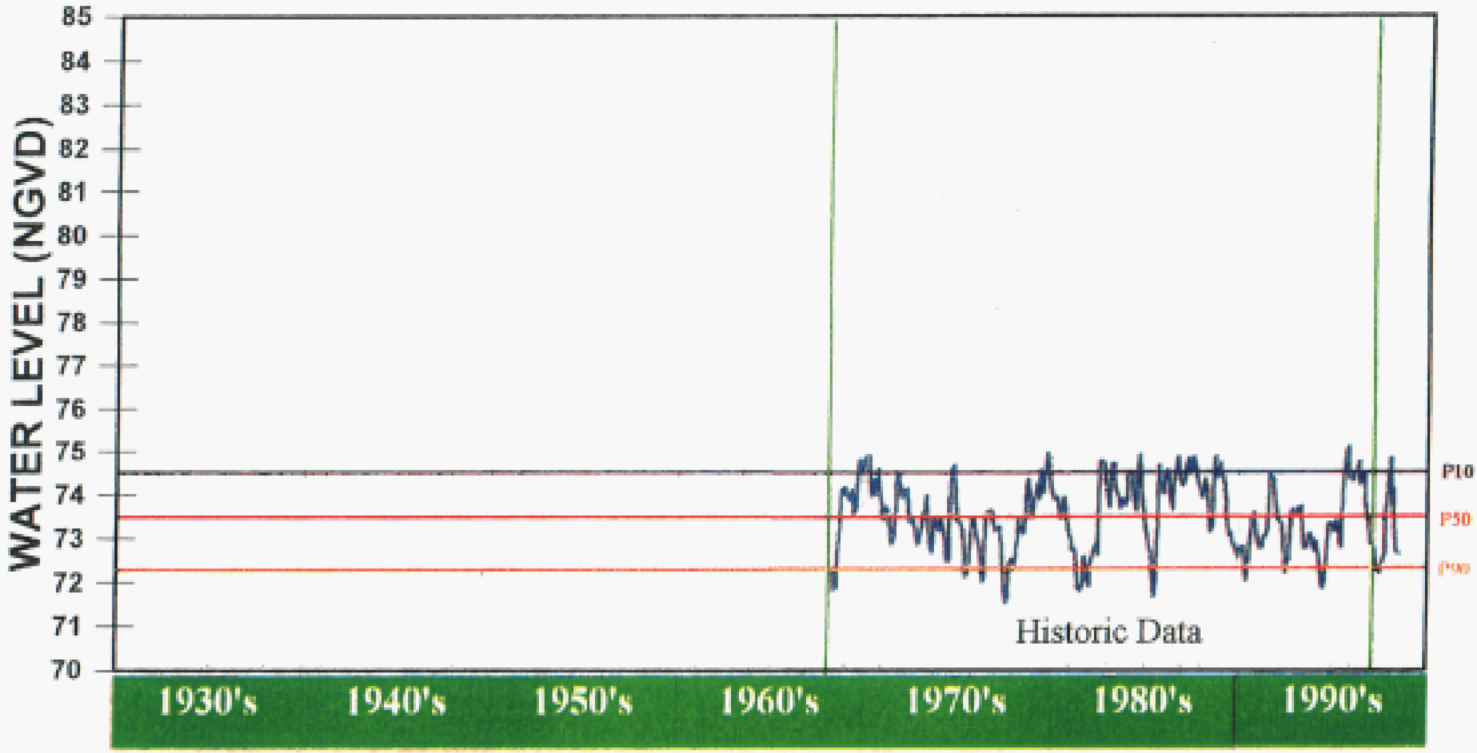
All Water Levels are Monthly Averages

Lake Tampa



All Water Levels are Monthly
Averages

Lake Thomas



All Water Levels are Monthly Averages

March 1999

APPENDIX C

Application of Minimum Lake Level Method to 15 Lakes

Abbreviations

Has Wetlands:	A minimum of ½ acre of viable cypress fringe wetlands occur on the lake.
Category 1	Lakes have cypress wetlands and there are no structural alterations or the elevation of the structural alteration has not caused the Historic P50 to be lower than 1.8' below the normal pool elevation.
Category 2	Lakes have cypress wetlands and the structural alteration has caused the Historic P50 to be lower than 1.8' below the normal pool elevation, but the cypress wetland remains viable.
10yr:	Ten Year Flood Guidance Elevation
CP:	Control Point elevation of the lake
LFS:	Lowest Floor Slab elevation of a residential dwelling
NP:	Normal pool elevation, which is the level that can be consistently identified in cypress swamps based on similar vertical indicators of inundation.
Sig. Change:	Significant Change - The elevation equal to the normal pool elevation minus 1.8'.
P10:	Tenth percentile
$P10_{hist}$	Tenth percentile calculated from historic data or estimated from the normal pool elevation, the control point elevation or current data using reasonable scientific judgement
$P10_{cur}$	Tenth percentile calculated from current data
P50:	Fiftieth percentile
$P50_{hist}$	Fiftieth percentile calculated from historic data or estimated, using reasonable scientific judgement, from the $P10_{hist}$ minus the RLWR50
$P50_{cur}$	Fiftieth percentile calculated from current data
P90:	Ninetieth percentile
$P90_{hist}$	Ninetieth percentile calculated from historic data or estimated, using reasonable scientific judgement, from the $P10_{hist}$ minus the RLWR90
$P90_{cur}$	Ninetieth percentile calculated from current data
HGL:	High Guidance Level
HML:	High Minimum Level
ML:	Minimum Level
LGL:	Low Guidance Level
RLWR:	Reference Lake Water Regime
RLWR50	The median value of the difference between the P10 and P50 lake stage for reference lakes with historic data with similar hydrogeologic conditions as the lake of concern.
RLWR90	The median value of the difference between the P10 and P90 lake stage for reference lakes with historic data with similar hydrogeologic conditions as the lake of concern.
HI:	Hydrologic Indicator
WL:	Water Level

Lake Alice

Lake Alice has wetlands and is structurally altered. The magnitude of the structural alteration places this lake in Category 2 for purposes of calculating the High Minimum and Minimum Levels. There are no historic data. Current data for the period from June 1971 to September 1997 were used to calculate the Current P10 and P50 elevations. The Historic P50 was calculated from the control point elevation minus the RLWR50.

Summary of Elevation Data (ft, NGVD)		Proposed Levels (ft, NGVD)	
LFS	43.8	10-yr	42.4
NP	43.0	HGL	40.9 *(CP)*
Sig. change	41.2	HML	40.9
CP	40.9	ML	39.9
P10cur	40.0	LGL	38.8
P50hist	39.9 *(CP-RLWR50)*		
P50cur	37.9		

Hydrologic Indicators of Normal Pool

Hydrologic Indicators of normal pool were measured along the western shoreline of the lake from a parcel located on Oakley Scott Lane. Cypress buttresses were measured for six cypress trees located in standing water adjacent to a weekend cottage which extended over the water. Some fill may have been pumped onto the shore landward of the cypress trees measured for normal pool. There were some leaning and falling cypress in this area. A second wetland area, located on the northern end of the lake was also investigated. This wetland was relatively undisturbed and contained healthy specimens of *Gordonia sp., Persea sp.* and *Taxodium sp.* Water Management District staff did not measure normal pool elevations in this wetland.

Hydrologic indicator elevations for Lake Alice on 3/30/98, water level: 41.2 ft, NGVD

HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	1.6	42.8
Cypress buttress	1.8	43.0
Cypress buttress	1.7	42.9
Cypress buttress	1.8	43.0
Cypress buttress	1.9	43.1
Cypress buttress	1.9	43.1
Average hydrologic indicator elevation (ft, NGVD)		43.0
Standard deviation (σxn-1)		0.1

Structural Alteration/Control Point

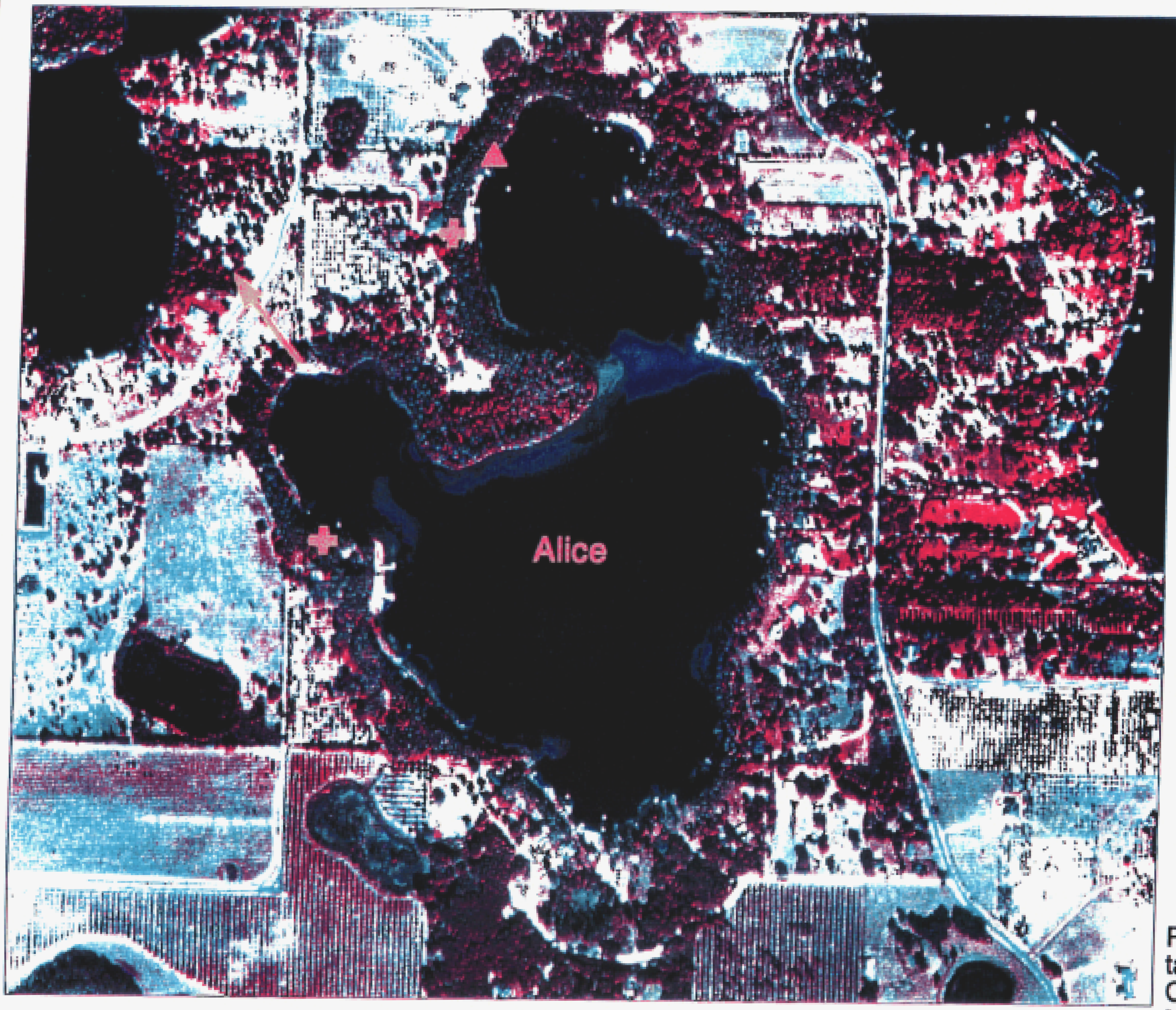
Numbers identify points on the figure showing the outlet conveyance system of the lake.

#1: Ditch extending from the lake shoreline through the lake's natural escarpment

#2: Control point - a 48 inch diameter corrugated metal pipe with invert of 40.9' NGVD

#3: Storm gutter inlet and junction box

#4: Reinforced Concrete Pipe to Taylor Lake



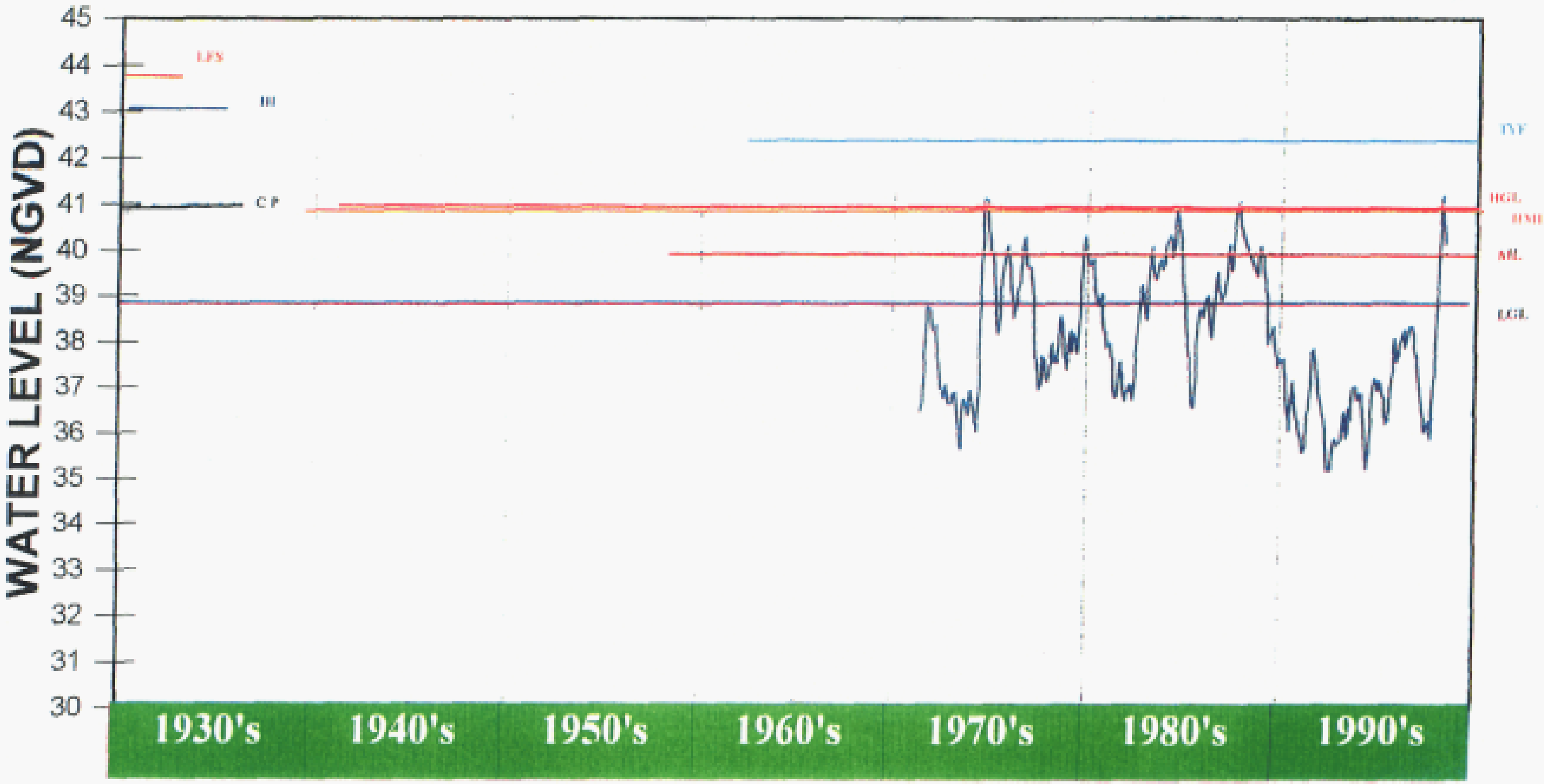
Hydrologic Indicator Location

SWFWMD Lake Gauge Site

Outlet

Photography taken between Oct 1994 and Mar 1995

Lake Alice - Hillsborough County



GUIDANCE AND MINIMUM LEVELS

TYF = Ten Year Flood = 42.4

HGL = High Guidance Level = 40.9

HML = High Minimum Level = 40.9

ML = Minimum Level = 39.9

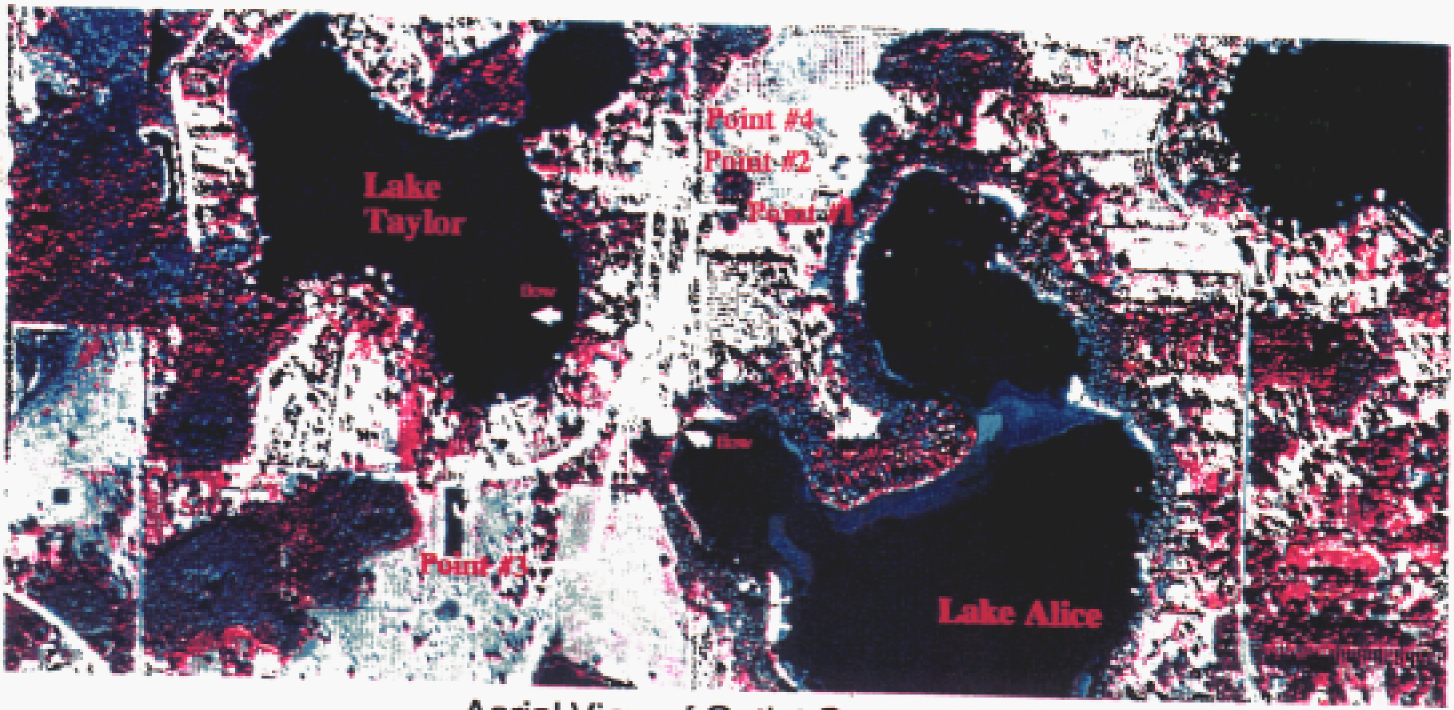
LGL = Low Guidance Level = 38.8

LAKE FEATURES

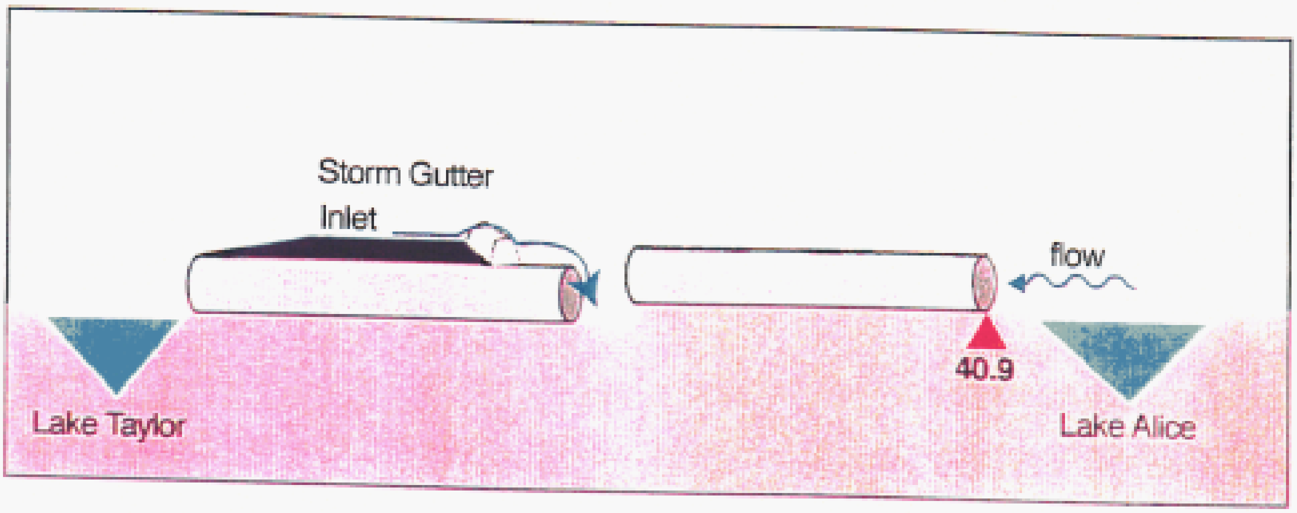
CP = Control Point Invert = 40.9

HI = Hydrologic Indicators = 43.0

LFS = Lowest Floor Slab = 43.8



Aerial View of Outlet Conveyance System



Profile of Outlet Conveyance System

Point #2 - 48 inch CMP

Bird Lake

Bird Lake has wetlands and is structurally altered. The magnitude of the structural alteration places this lake in Category 2 for purposes of calculating the High Minimum and Minimum Levels. There are no historic data. Current data for the period from February 1978 to September 1997 were used to calculate the Current P10 and P50 elevations.. The Historic P50 was calculated from the Current P10 minus the RLWR50.

Summary of Elevation Data (ft, NGVD)		Proposed Levels (ft, NGVD)	
LFS	51.9	10-yr	53.0
NP	51.3	HGL	49.6 *(P10cur)*
P10cur	49.6	HML	49.6
Sig. change	49.5	ML	48.6
P50hist	48.6 *(P10cur-RLWR50)*	LGL	47.5
P50cur	47.7		
CP	47.1		

Hydrologic Indicators of Normal Pool

Hydrologic indicators of normal pool were measured along the northern shore of the lake off Shagbark Place and Lake Bird Drive.

Hydrologic indicator elevations for Bird Lake on 4/21/98, water level: 49.7 ft, NGVD

HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	1.6	51.3
Cypress buttress	1.6	51.3
Cypress buttress	1.5	51.2
Average hydrologic indicator elevation (ft, NGVD)		51.3
Standard deviation (σxn-1)		0.1

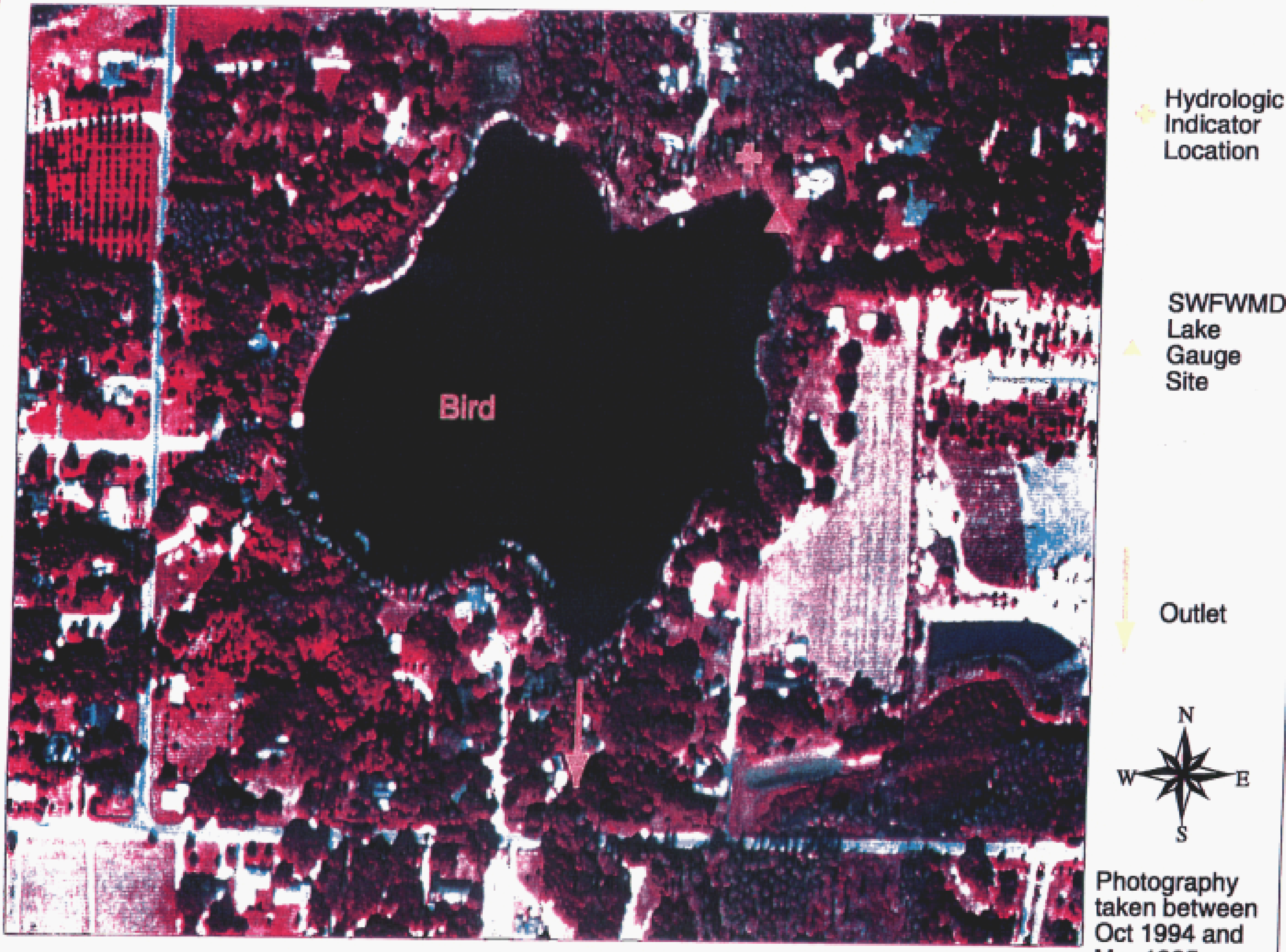
Structural Alteration/Control Point

Numbers identify points on the figure showing the outlet conveyance system of the lake.

#1: 450' foot trench extending from the shoreline of Bird Lake through a wetland to Lake Magdalene Boulevard

#2: Control point - two 4' x 8' box culverts, approximately 26' long, under Lake Magdalene Boulevard with inverts of 47.14' and 45.57' at the north and south ends, respectively

#3: Ditch, extending approximately 1175' feet in length to Platt Lake


Bird
Hydrologic Indicator Location
SWFWMD Lake Gauge Site
Outlet
N
W
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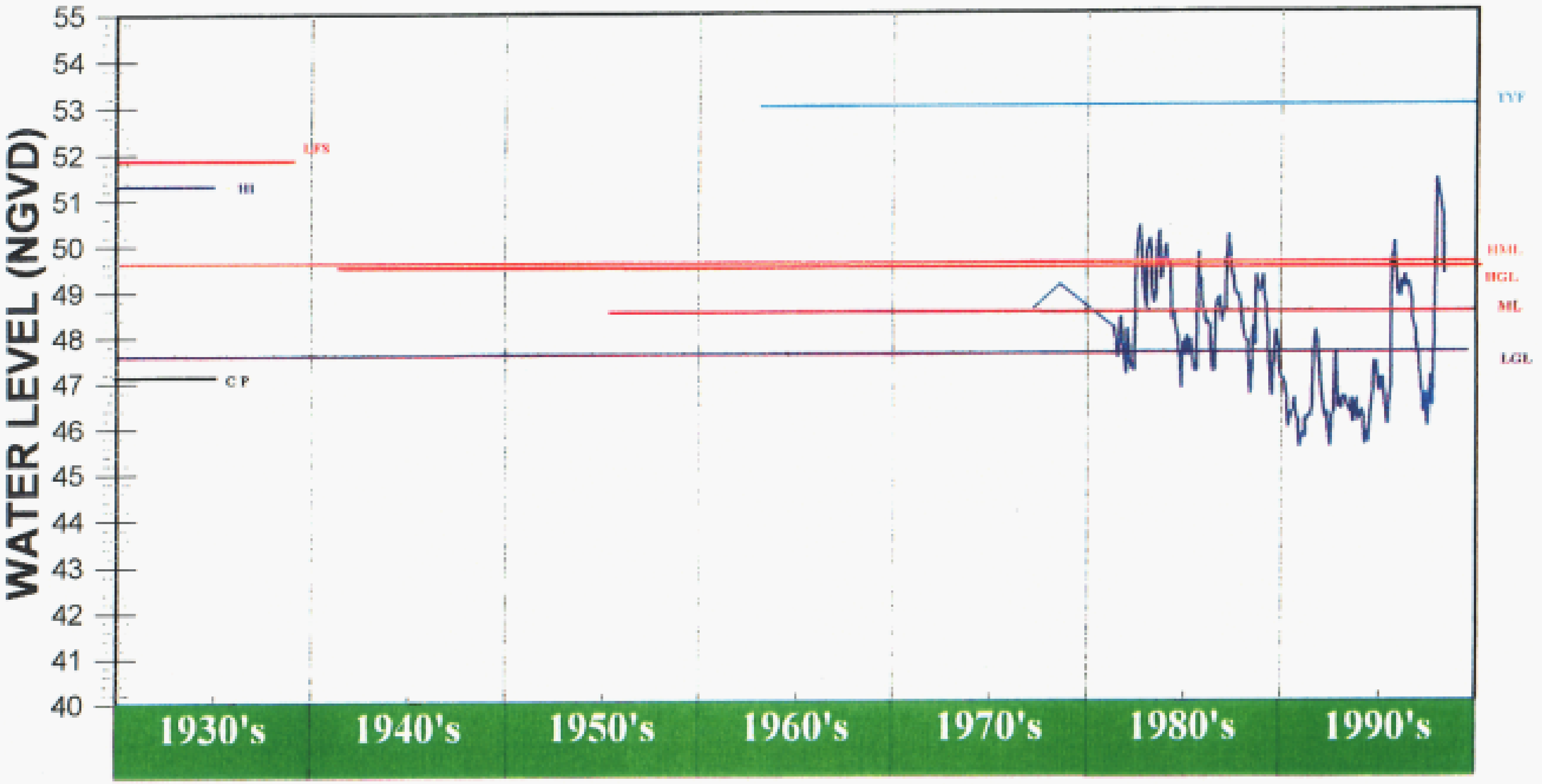
S
Photography taken between Oct 1994 and Mar 1995

Lake Bird - Hillsborough County



GUIDANCE AND MINIMUM LEVELS

TYF = Ten Year Flood = 53.0

HGL = High Guidance Level = 49.6

HML = High Minimum Level = 49.6

ML = Minimum Level = 48.6

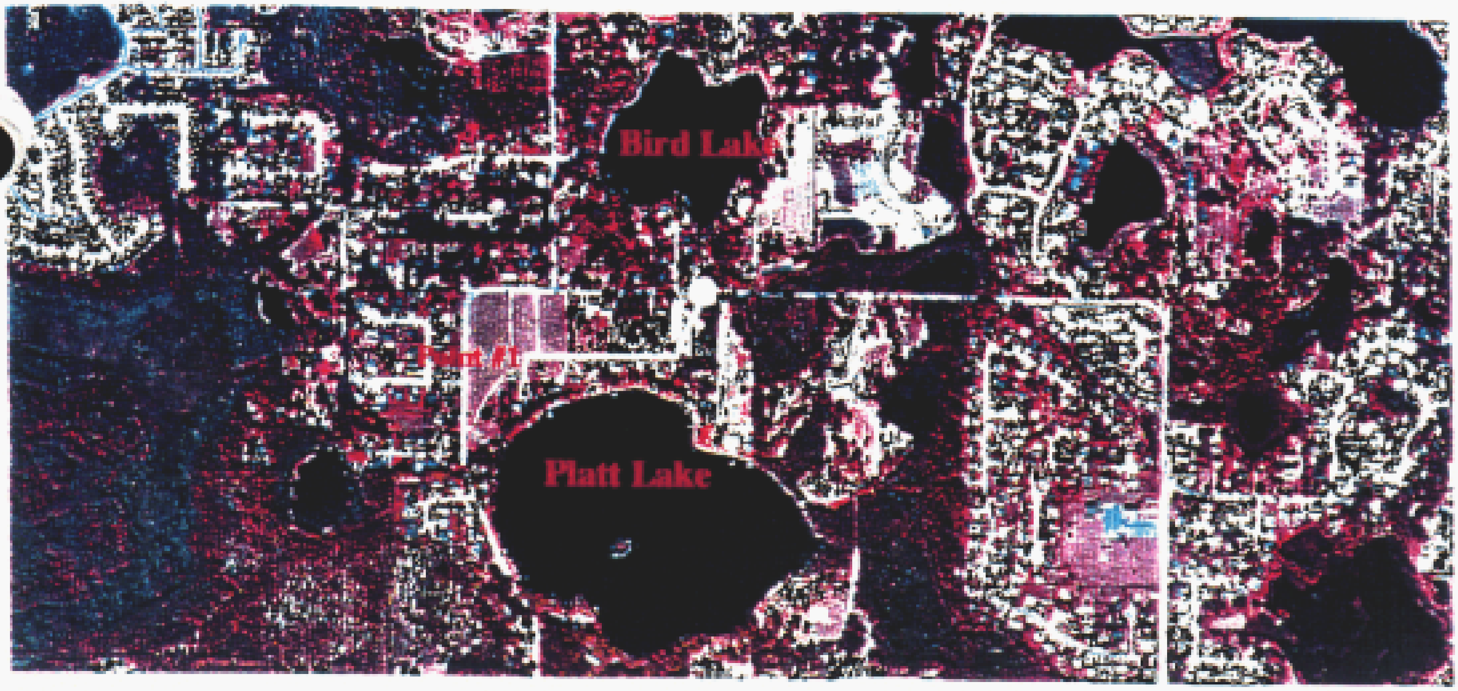
LGL = Low Guidance Level = 47.5

LAKE FEATURES

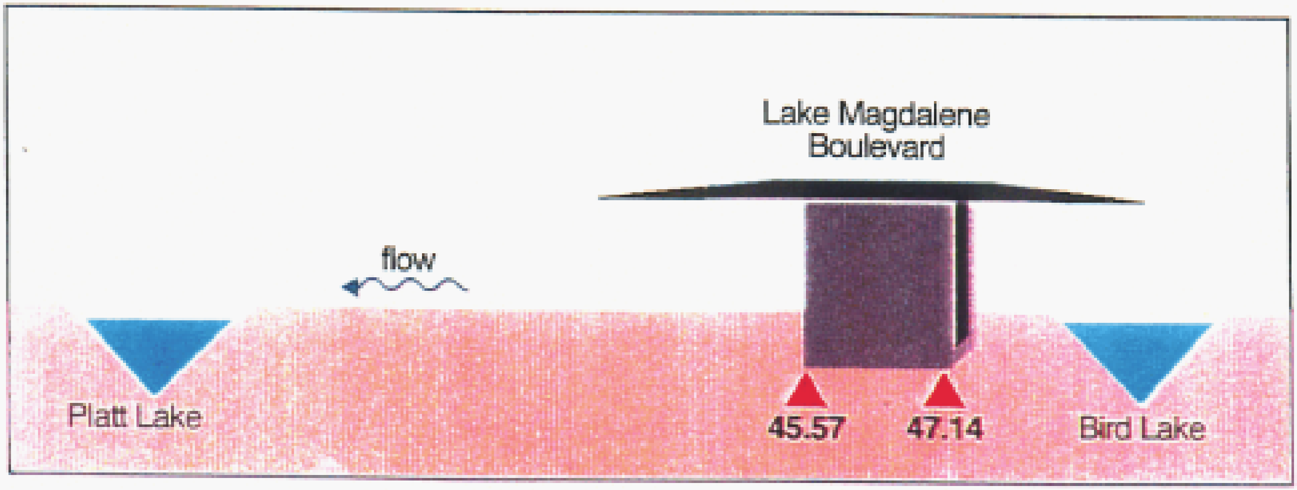
CP = Control Point Invert = 47.1

HI = Hydrologic Indicators = 51.3

LFS = Lowest Floor Slab = 51.9



Aerial View of Outlet Conveyance System



Profile of Outlet Conveyance System

Point #1 - North Side of Lake Magdalene Blvd

Brant Lake

Brant Lake has wetlands and is structurally altered. The magnitude of the structural alteration places this lake in Category 2 for purposes of calculating the High Minimum and Minimum Levels. There are no historic data. Current data for the period from January 1974 to September 1997 was used to calculate the Current P10 and P50 elevations. The Historic P50 was calculated from the Current P10 elevation minus the RLWR50.

Summary of Elevation Data (ft, NGVD)		Proposed Levels (ft, NGVD)	
NP	58.9	10-yr	60.5
P10cur	58.0	HGL	58.0 *(P10cur)*
CP	57.7	HML	58.0
Sig. change	57.1	ML	57.0
P50hist	57.0 *(P10cur-RLWR50)*	LGL	55.9
P50cur	55.8		

Hydrologic Indicators of Normal Pool

Hydrologic indicators of normal pool were measured in a wetland on the east side of the lake adjacent to Estes Road.

Hydrologic indicators for Brant Lake on 3/30/98, water level: 58.3 ft, NGVD

HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	0.7	59.0
Cypress buttress	0.4	58.7
Cypress buttress	0.6	58.9
Cypress buttress	0.7	59.0
Cypress buttress	0.6	58.9
Average hydrologic indicator elevation (ft, NGVD)		58.9
Standard deviation (σxn-1)		0.1

Structural Alteration/Control Point

Numbers identify points on the figure showing the outlet conveyance system of the lake.

#1: Control Point- Path through wetlands at 57.7' NGVD

#2: North-south aligned corrugated metal pipe driveway crossing

#3: North-south aligned ditch, 450' in length, with 1:1 side slopes.

#4: 10 acre cypress wetland

#5: Control point - 36" corrugated metal pipe under Crenshaw Lake Road.


Brandt
Hydrologic Indicator Location
SWFWMD Lake Gauge Site
Outlet
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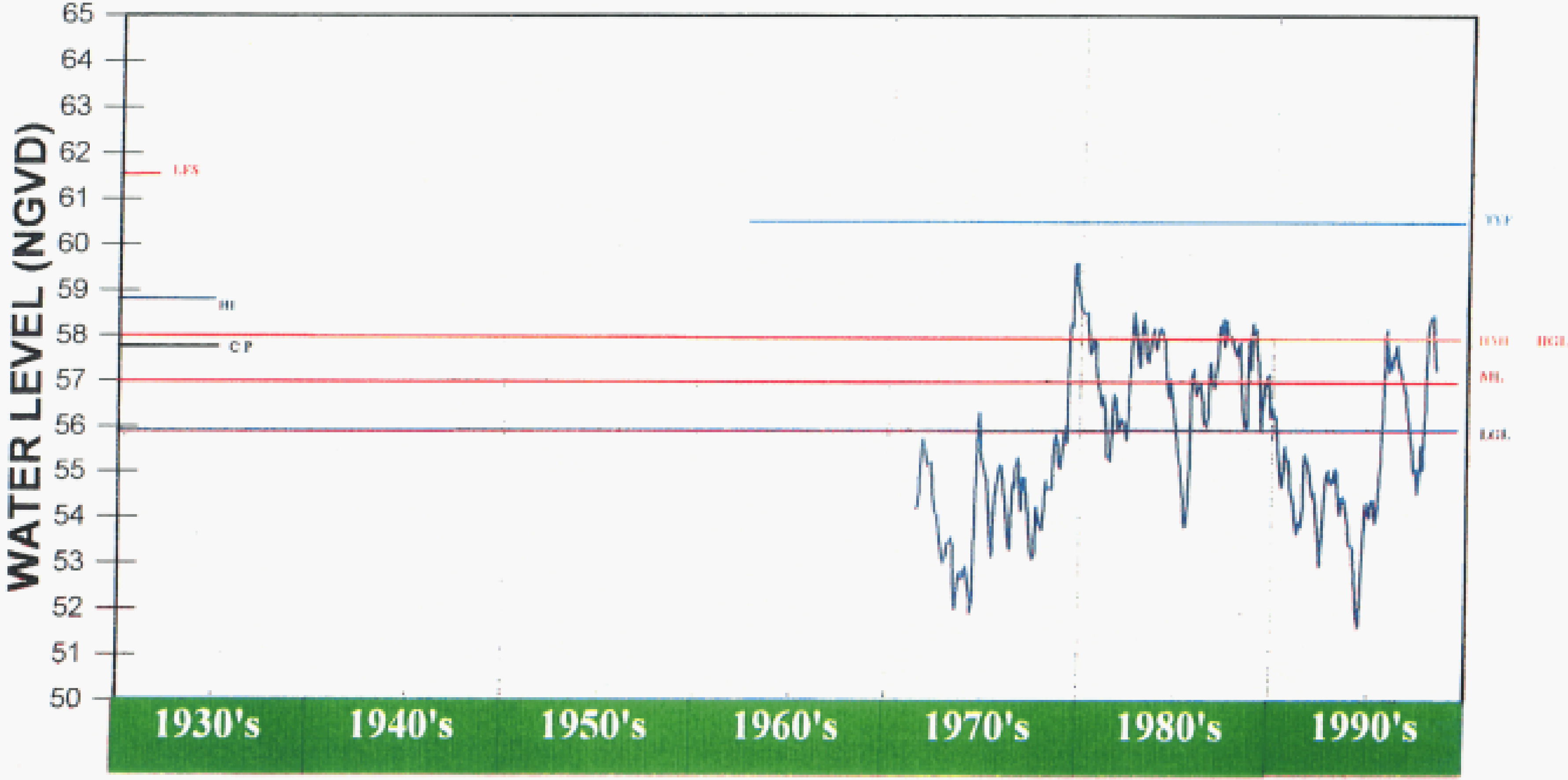
S
Photography taken between Oct 1994 and Mar 1995

Lake Brant - Hillsborough County



GUIDANCE AND MINIMUM LEVELS

TYF = Ten Year Flood = 60.5

HGL = High Guidance Level = 58.0

HML = High Minimum Level = 58.0

ML = Minimum Level = 57.0

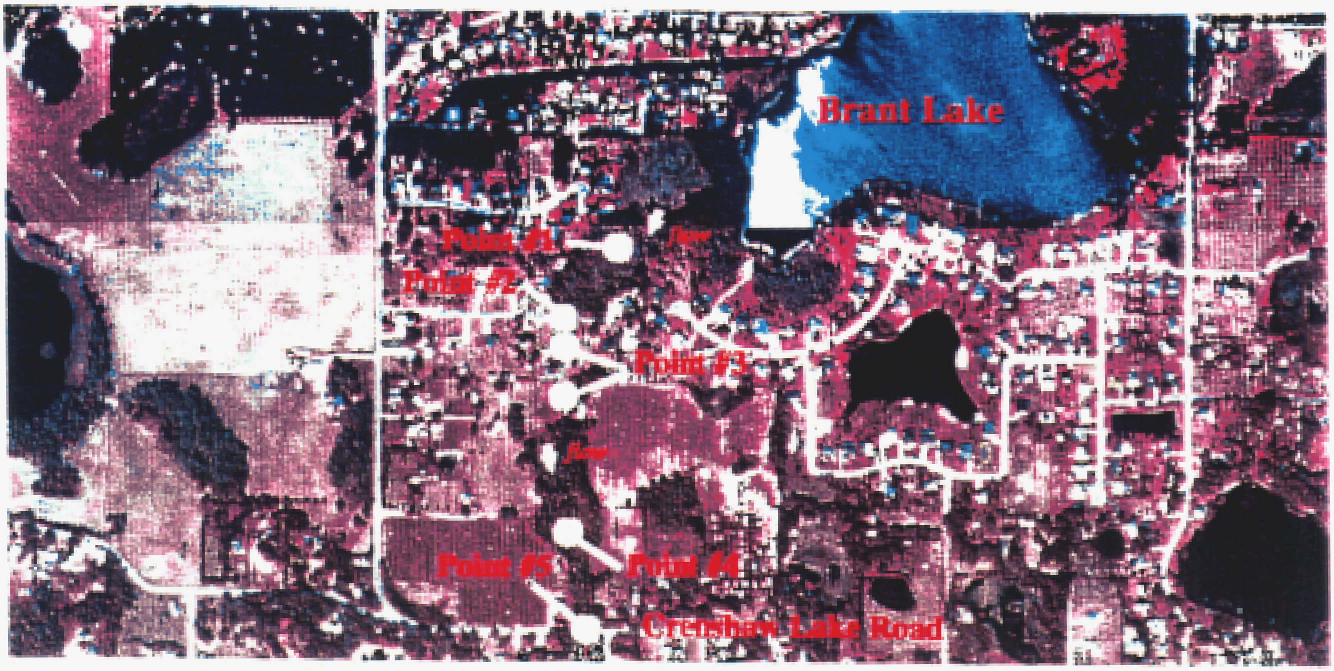
LGL = Low Guidance Level = 55.9

LAKE FEATURES

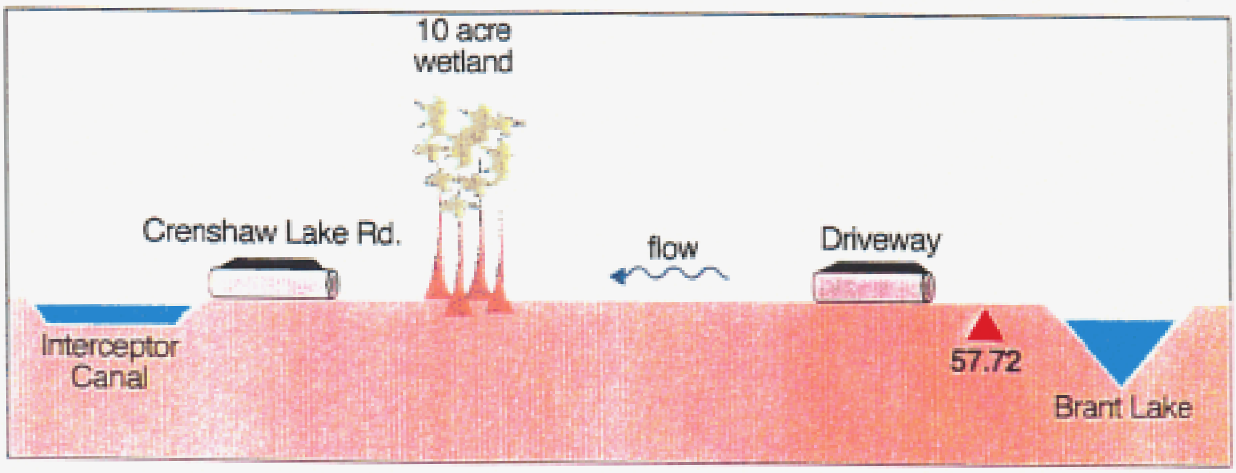
CP = Control Point Invert = 57.8

HI = Hydrologic Indicators = 58.9

LFS = Lowest Floor Slab = 61.5



Aerial View of Outlet Location



Profile of Outlet Conveyance System

Point #1: Path Through Wetland

Point #3: 450' Ditch

Camp Lake

Camp Lake has wetlands and is not structurally altered. This lake is a Category 1 lake for purposes of calculating the High Minimum and Minimum Levels. There are no historic data. Current data for the period from March 1973 to September 1997 were used to calculate the Current P10 and P50 elevations. The Historic P50 was calculated from the normal pool elevation minus the RLWR50.

Summary of Elevation Data (ft, NGVD)		Proposed Levels (ft, NGVD)	
CP	high outlet	10-yr	64.3
LFS	none	HGL	63.8 *(NP)*
NP	63.8	HML	63.4
P50hist	62.8 *(NP-RLWR50)*	ML	62.0
P10cur	62.7	LGL	61.3
Sig. change	62.0		
P50cur	59.1		

Hydrologic Indicators of Normal Pool

Hydrologic indicators of normal pool were measured in a wetland on the northeast side of the lake.

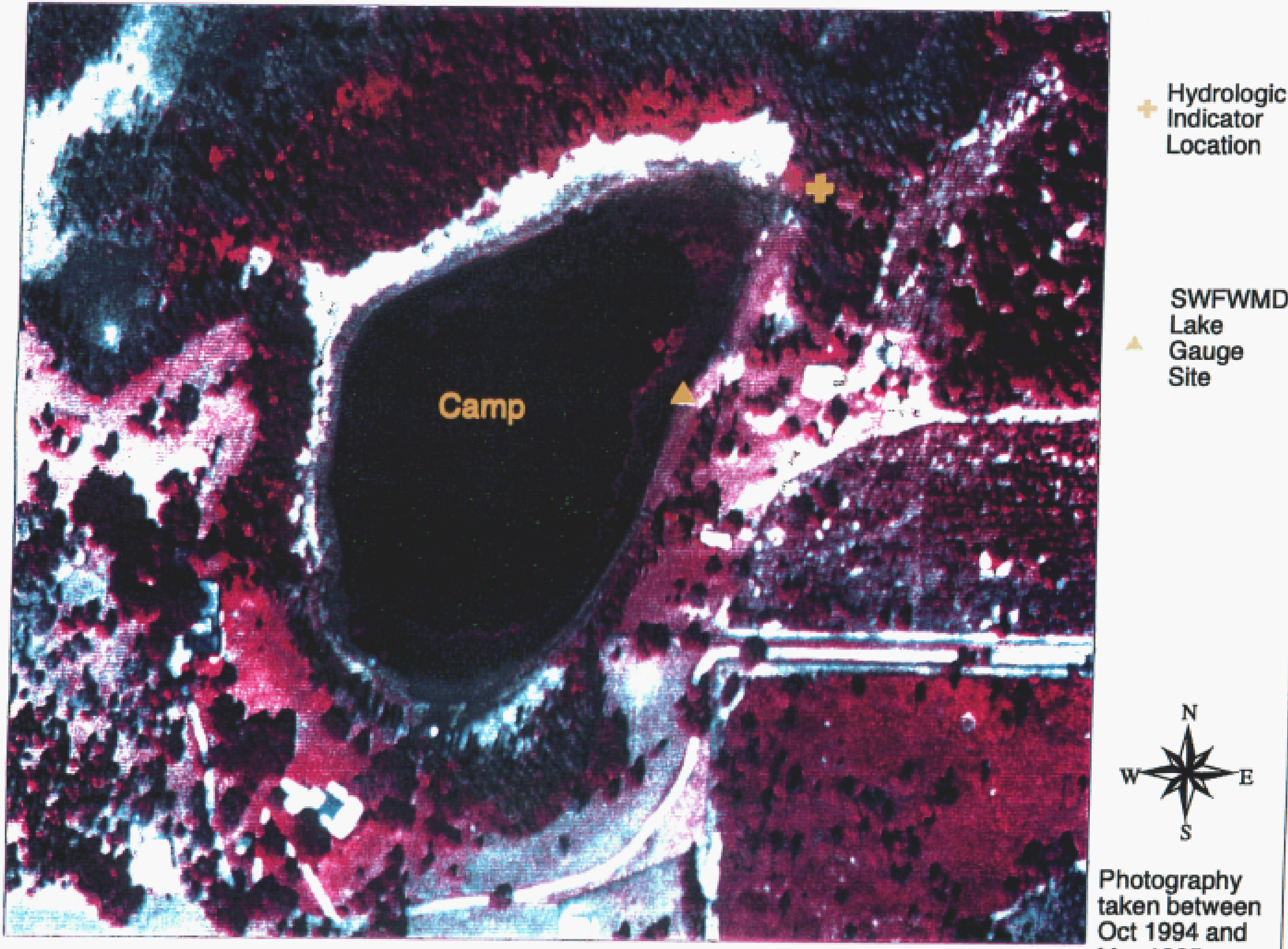
Hydrologic indicators for Camp Lake on 4/21/98, water level: 62.4 ft, NGVD

HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	1.3	63.7
Cypress buttress	1.3	63.8
Cypress buttress	1.6	64.0
Cypress buttress	1.4	63.9
Cypress buttress	1.3	63.8
Average hydrologic indicator elevation (ft, NGVD)		63.8
Standard deviation (σxn-1)		0.1

Structural Alteration/Control Point

Numbers identify points on the figure showing the outlet conveyance system of the lake.

#1: District Topographic Aerials (1"=200') indicate a natural topographically low feature located approximately 1150' from the shoreline, 300' wide, with a spot elevation of 63.2' NGVD. Overflow is into the South Pasco Wellfield which is part of the Anclote River Watershed.


Camp
Hydrologic Indicator Location
SWFWMD Lake Gauge Site
N
W
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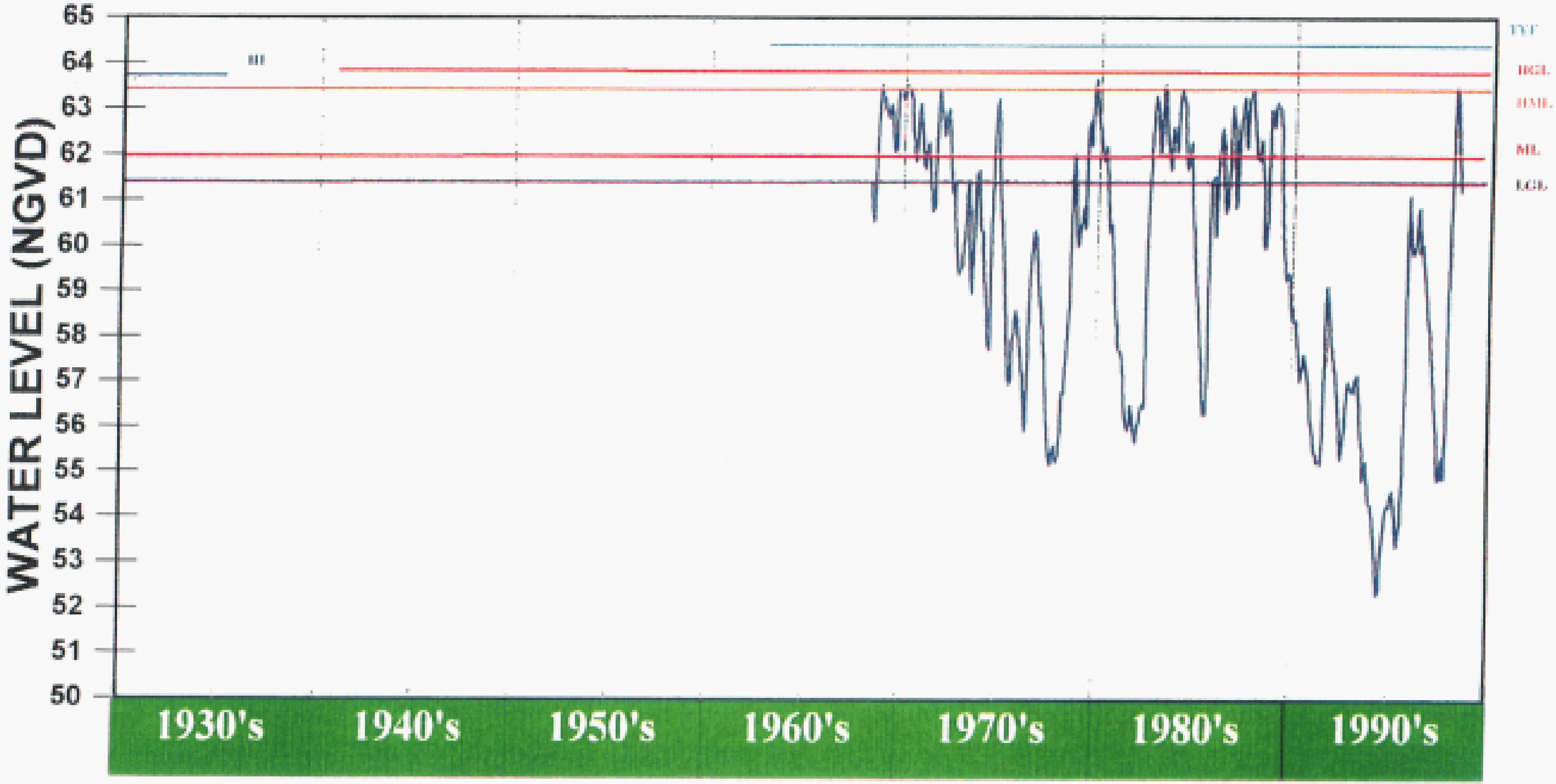
S
Photography taken between Oct 1994 and Mar 1995

Lake Camp - Pasco



GUIDANCE AND MINIMUM LEVELS

TYF = Ten Year Flood = 64.3

HGL = High Guidance Level = 63.8

HML = High Minimum Level = 63.4

ML = Minimum Level = 62.0

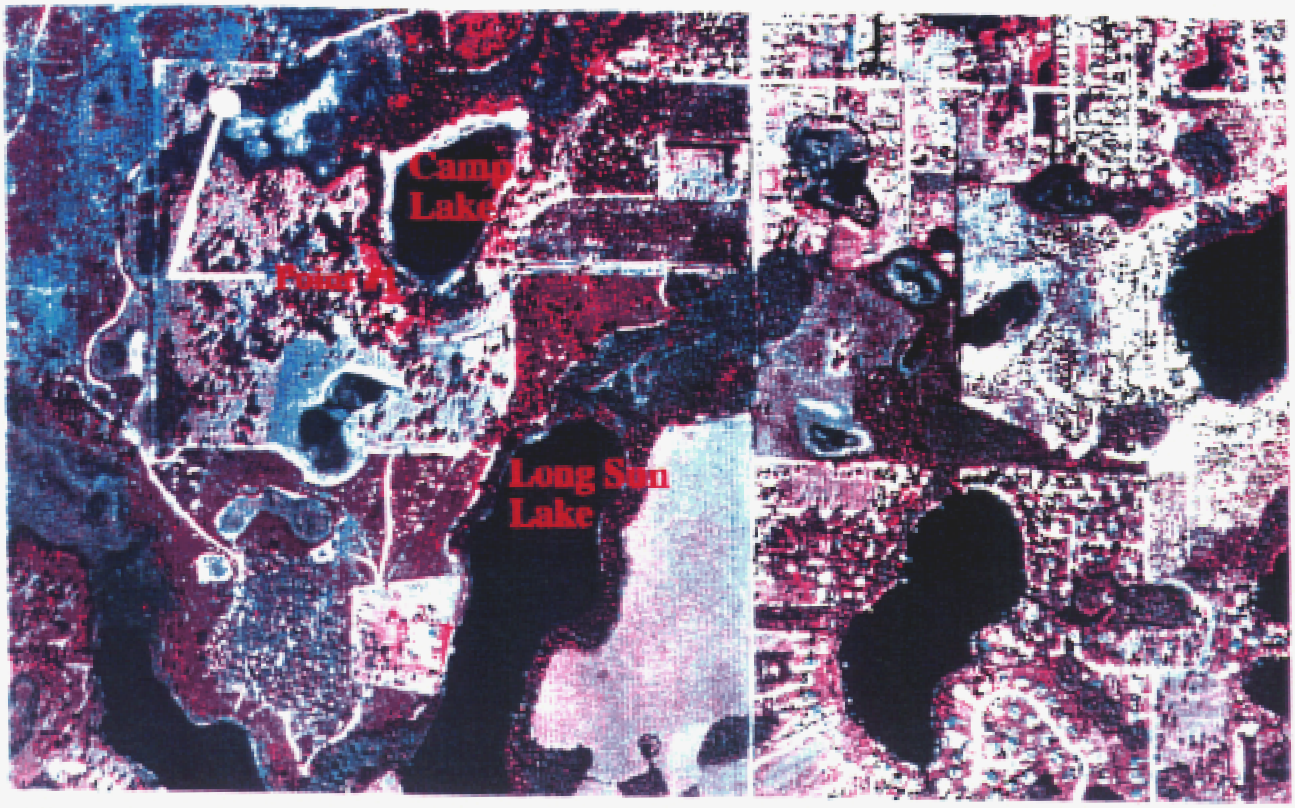
LGL = Low Guidance Level = 61.3

LAKE FEATURES

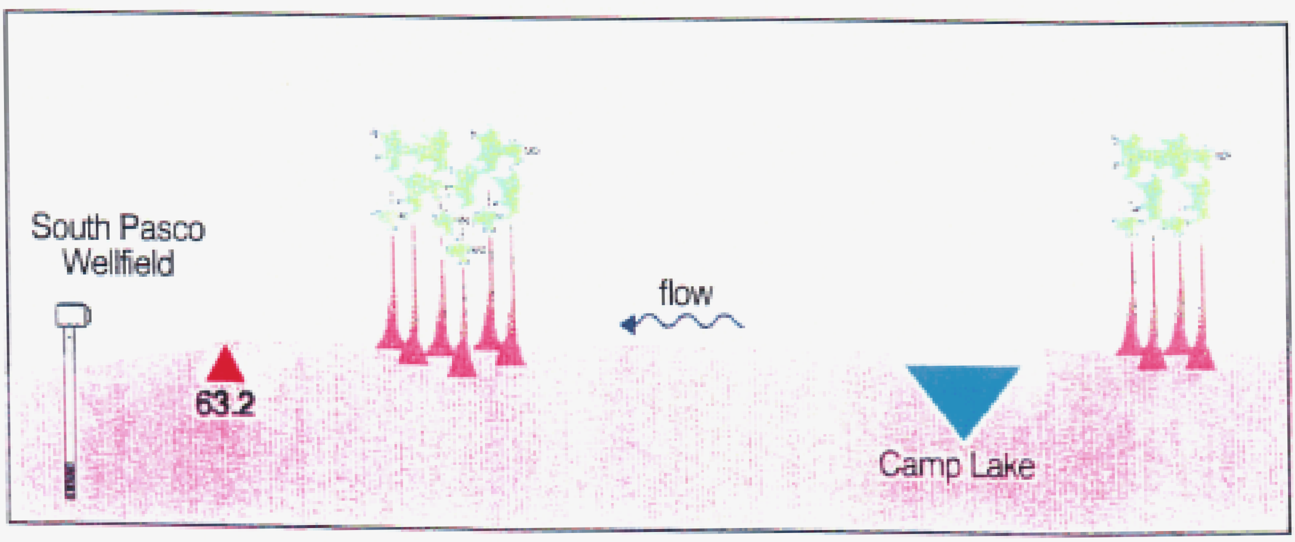
CP = Control Point Invert = High Outlet

HI = Hydrologic Indicators = 63.8

LFS = Lowest Floor Slab = none



Aerial View of Outlet Conveyance System



Profile of Outlet Conveyance System

Crystal Lake

Crystal Lake (also known as South Crystal Lake) has wetlands and is structurally altered. The magnitude of the structural alteration places this lake in Category 2 for purposes of calculating the High Minimum and Minimum Levels. There are no historic data. Current data for the period from January 1985 to August 1997 were used to calculate the Current P10 and P50 elevations. The Historic P50 was calculated from the Current P10 minus the RLWR50.

Summary of Elevation Data (ft, NGVD)		Proposed Levels (ft, NGVD)	
LFS	64.7	10-yr	62.1
NP	62.6	HGL	59.8 *($P10_{cur}$)*
Sig. change	60.8	HML	59.8
P10cur	59.8	ML	58.8
CP	59.8	LGL	57.7
P50hist	58.8 *(P10cur-RLWR50)*		
P50cur	57.7		

Hydrologic Indicators of Normal Pool

Hydrologic indicators of normal pool were measured in a wetland on the southeastern shore of the lake.

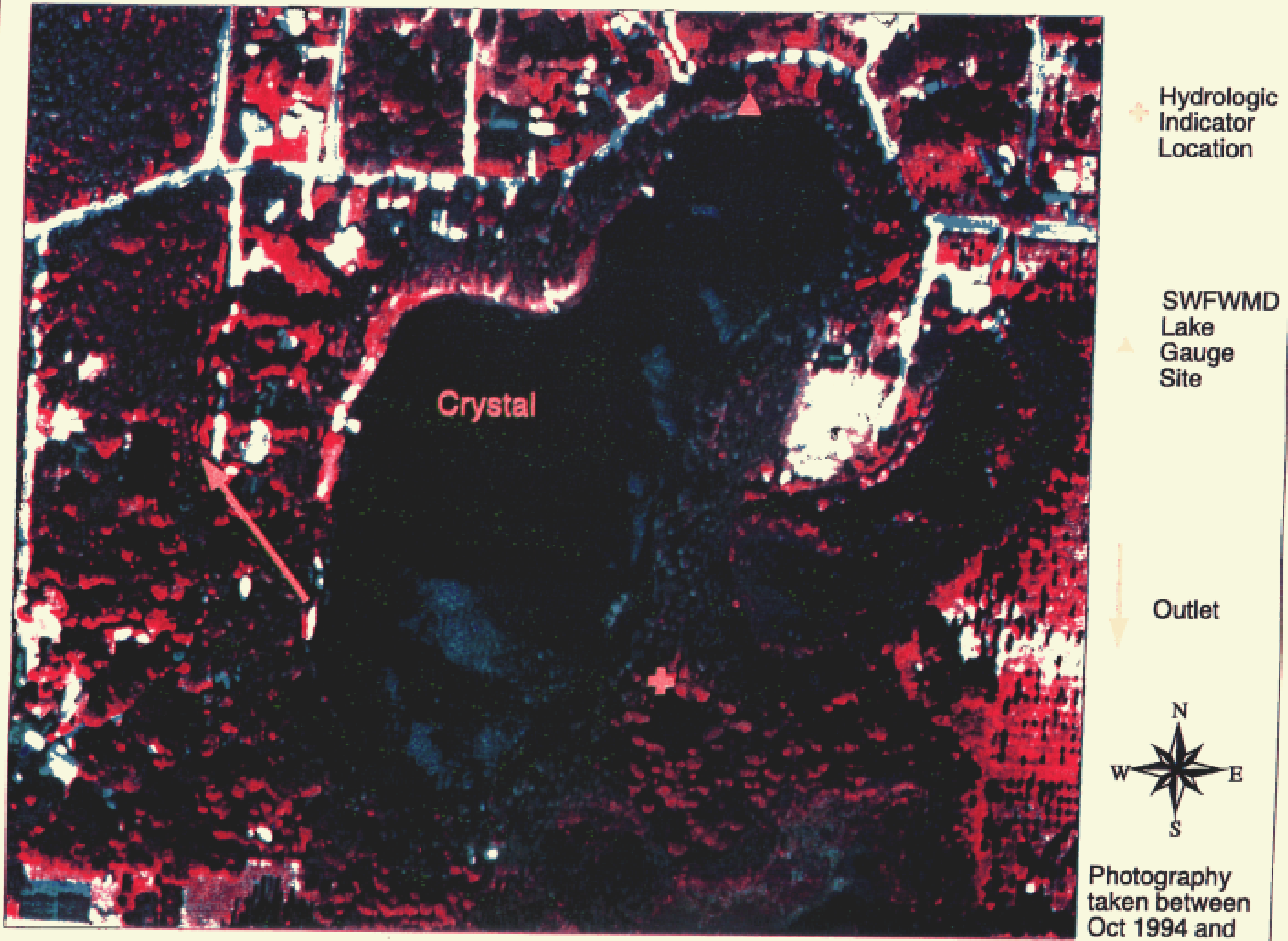
Hydrologic indicators for Crystal Lake on 3/17/98, water level: 61.1 ft, NGVD

HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	1.5	62.6
Cypress buttress	1.5	62.6
Average hydrologic indicator elevation (ft, NGVD)		62.6
Standard deviation (σxn-1)		0

Structural Alteration/Control Point

Numbers identify points on the figure showing the outlet conveyance system of the lake.

#1: Control point - Poorly maintained "homemade" weir with sill elevation of 59.80' NGVD


Crystal
Hydrologic Indicator Location
SWFWMD Lake Gauge Site
Outlet
N
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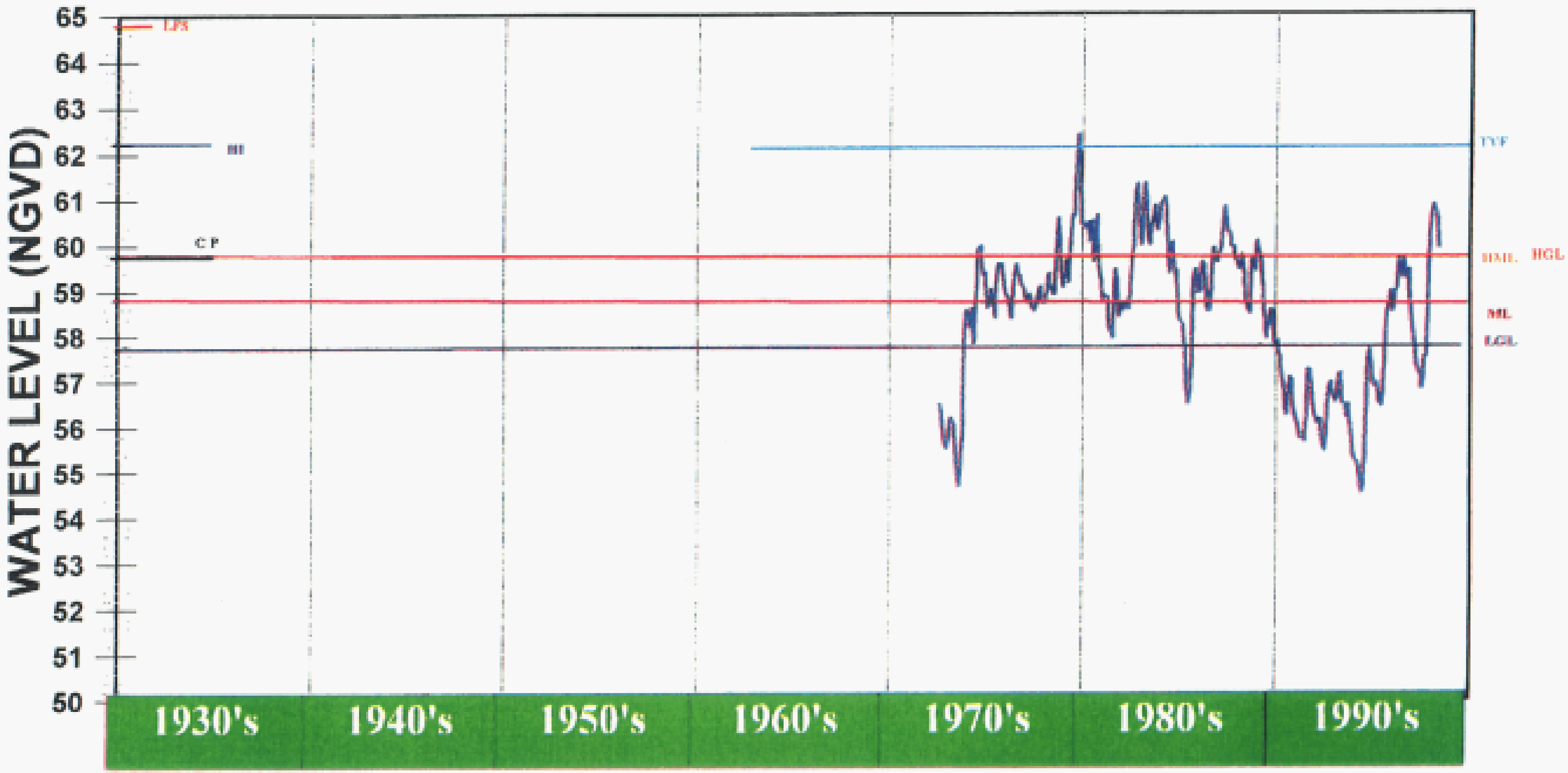
S
Photography taken between Oct 1994 and Mar 1995

Lake Crystal - Hillsborough County



GUIDANCE AND MINIMUM LEVELS

TYF = Ten Year Flood = 62.1

HGL = High Guidance Level = 59.8

HML = High Minimum Level = 59.8

ML = Minimum Level = 58.8

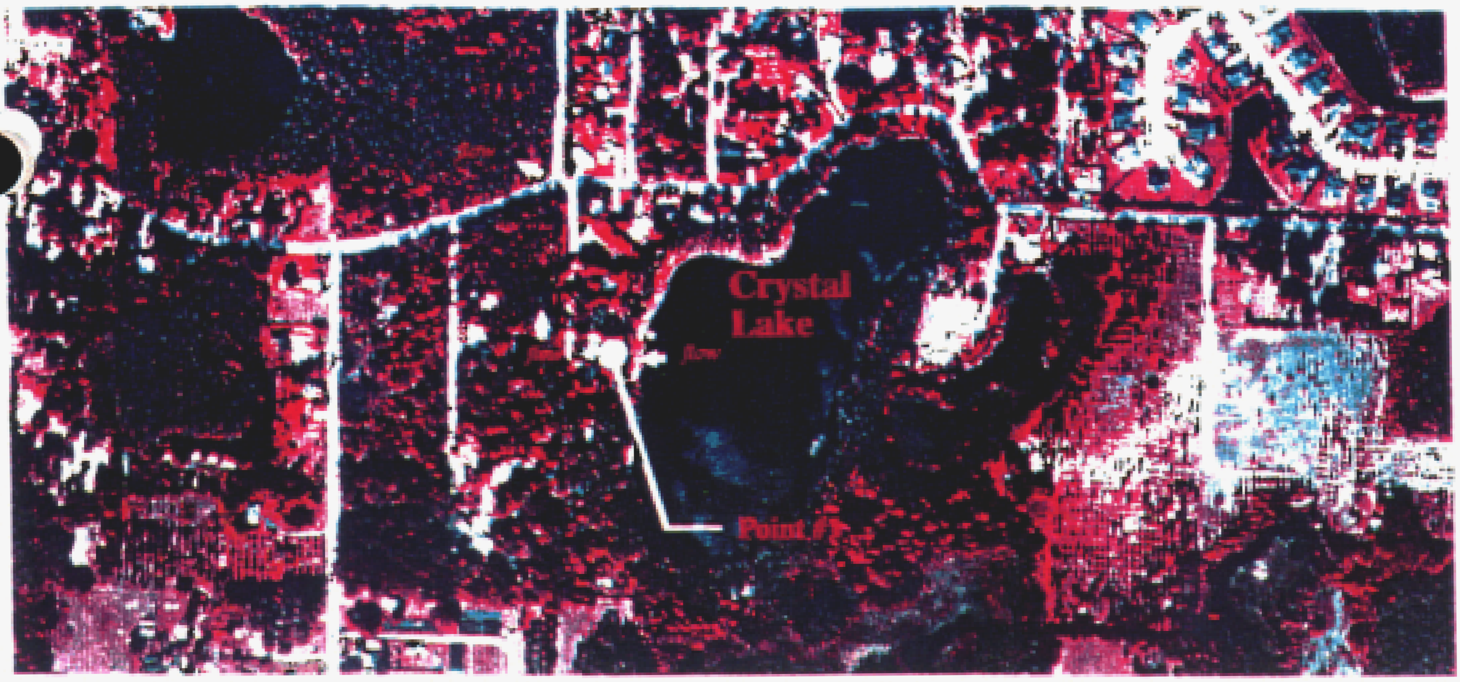
LGL = Low Guidance Level = 57.7

LAKE FEATURES

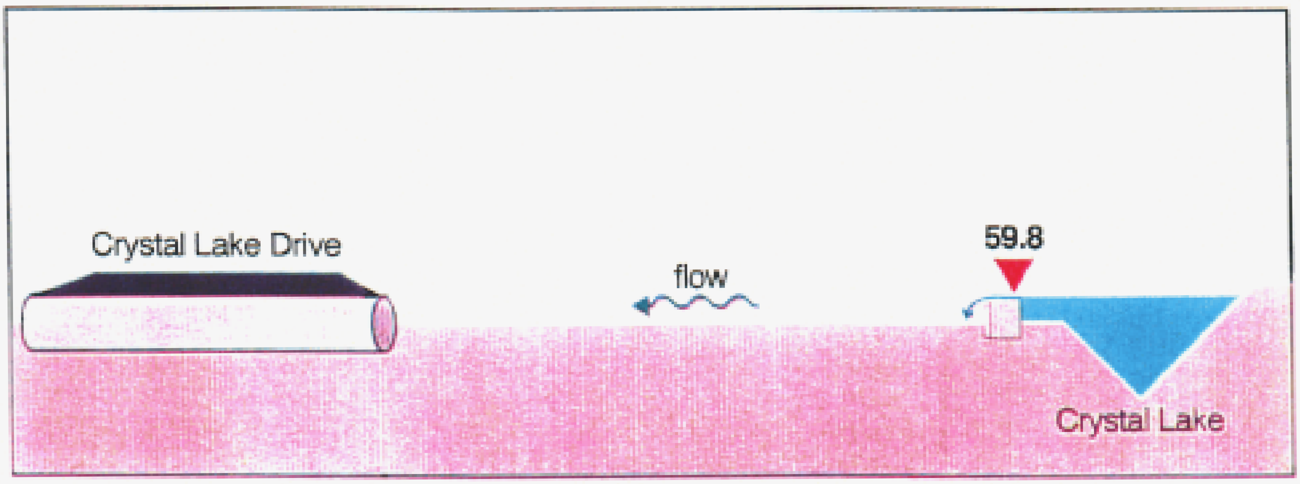
CP = Control Point Invert = 59.8

HI = Hydrologic Indicators = 62.2

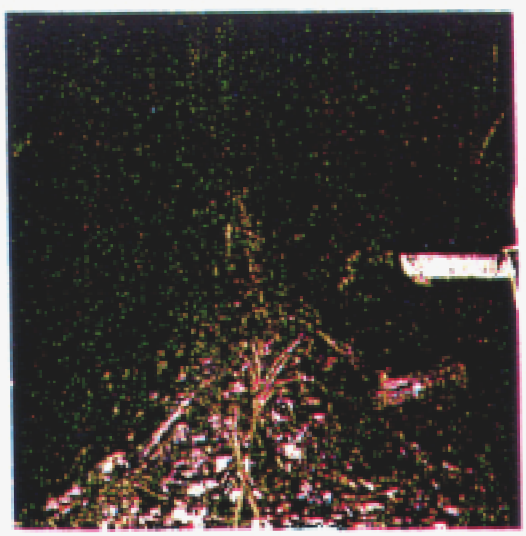
LFS = Lowest Floor Slab = 64.7



Aerial View of Outlet Conveyance System



Profile of Outlet Conveyance System



Point #1 - Weir (View Obscured by Debris)

Deer Lake

Deer Lake has wetlands and is structurally altered. The magnitude of the structural alteration places this lake in Category 2 for purposes of calculating the High Minimum and Minimum Level. There are no historic data. Current data for the period from August 1977 to September 1997 were used to calculate the Current P10 and P50 elevations. The Historic P50 was calculated from the Current P10 minus the RLWR50.

Summary of Elevation Data (ft, NGVD)		Proposed Levels (ft, NGVD)	
LFS	68.5	10-yr	70.0
NP	68.0	HGL	66.5 *($P10_{cur}$)*
P10cur	66.5	HML	66.5
Sig. change	66.2	ML	65.5
P50hist	65.5 *(P10cur-RLWR50)*	LGL	64.4
CP	65.2		
P50cur	64.6		

Hydrologic Indicators of Normal Pool

Hydrologic indicators of normal pool were measured in the wetland at the south end of the lake. This wetland is between Deer and Hobbes Lakes.

Hydrologic indicators for Deer Lake on 3/17/98, water level: 66.8 ft, NGVD

HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	1.3	68.1
Cypress buttress	1.2	67.9
Cypress buttress	1.3	68.0
Cypress buttress	1.1	67.9
Cypress buttress	1.3	68.0
Average hydrologic indicator elevation (ft, NGVD)		68.0
Standard deviation (σxn-1)		0.1

Structural Alteration/Control Point

Numbers identify points on the figure showing the outlet conveyance system of the lake.

#1: Control point - outlet control point of Lakes Deer, Little Deer, and Hobbs at 65.19' NGVD.

Deer
Hydrologic Indicator Location
SWFWMD Lake Gauge Site
Outlet
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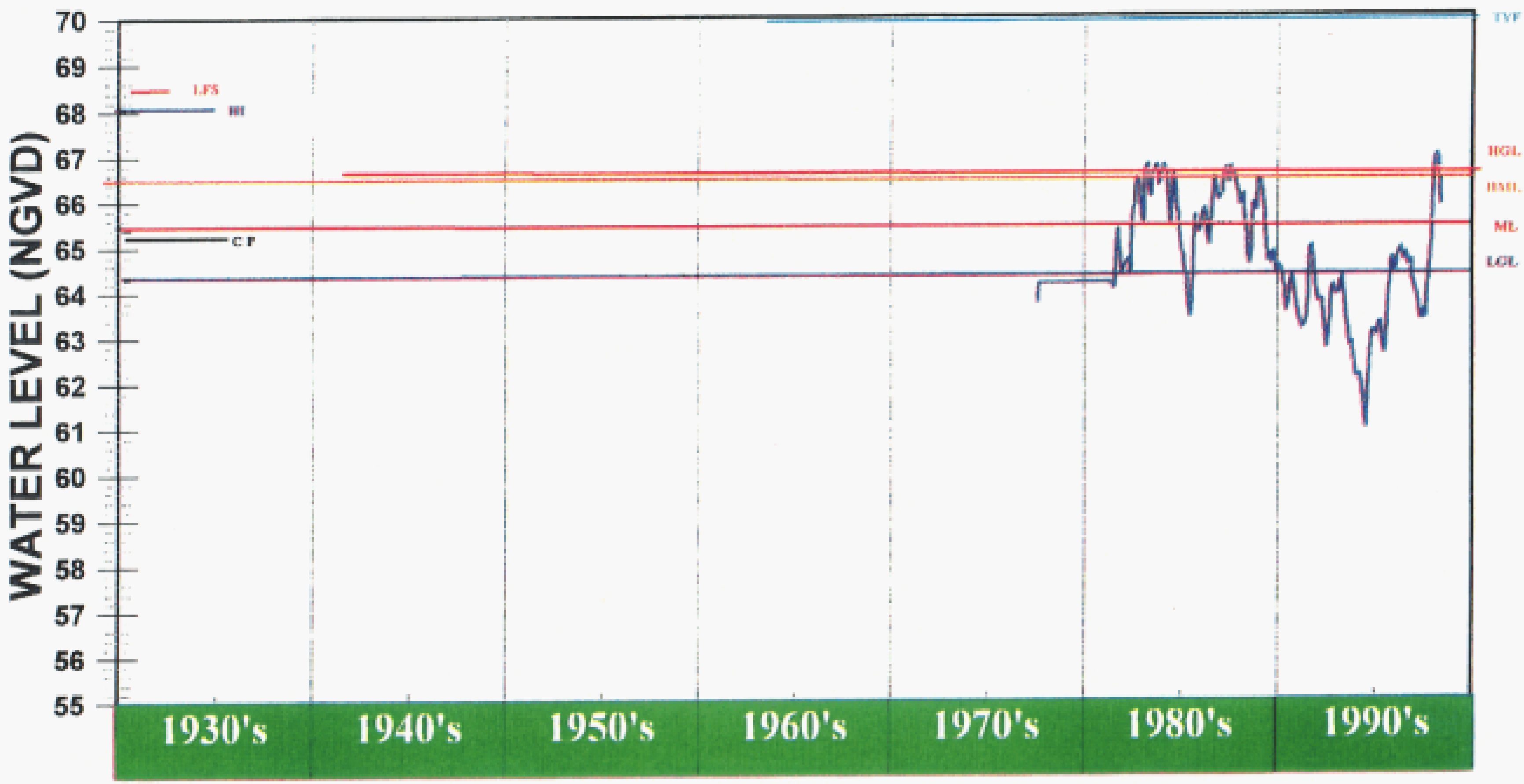
S
Photography taken between Oct 1994 and Mar 1995

Lake Deer - Hillsborough County



GUIDANCE AND MINIMUM LEVELS

TYF = Ten Year Flood = 70.0

HGL = High Guidance Level = 66.5

HML = High Minimum Level = 66.5

ML = Minimum Level = 65.5

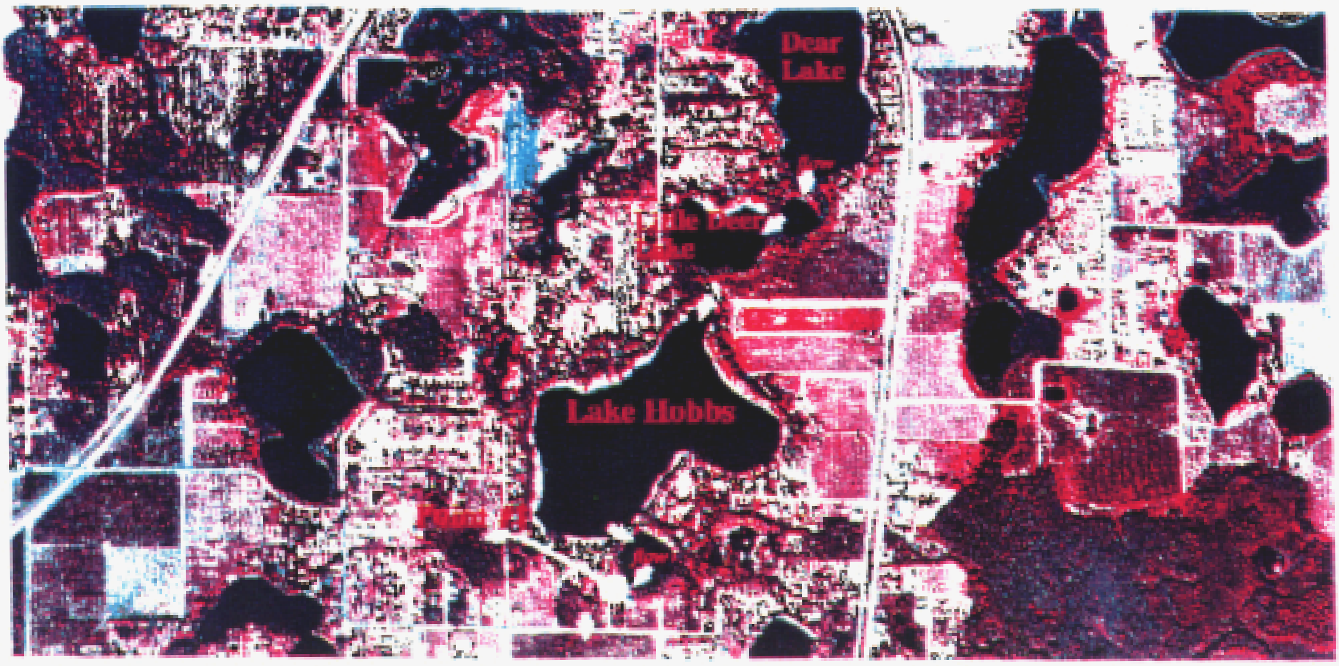
LGL = Low Guidance Level = 64.4

LAKE FEATURES

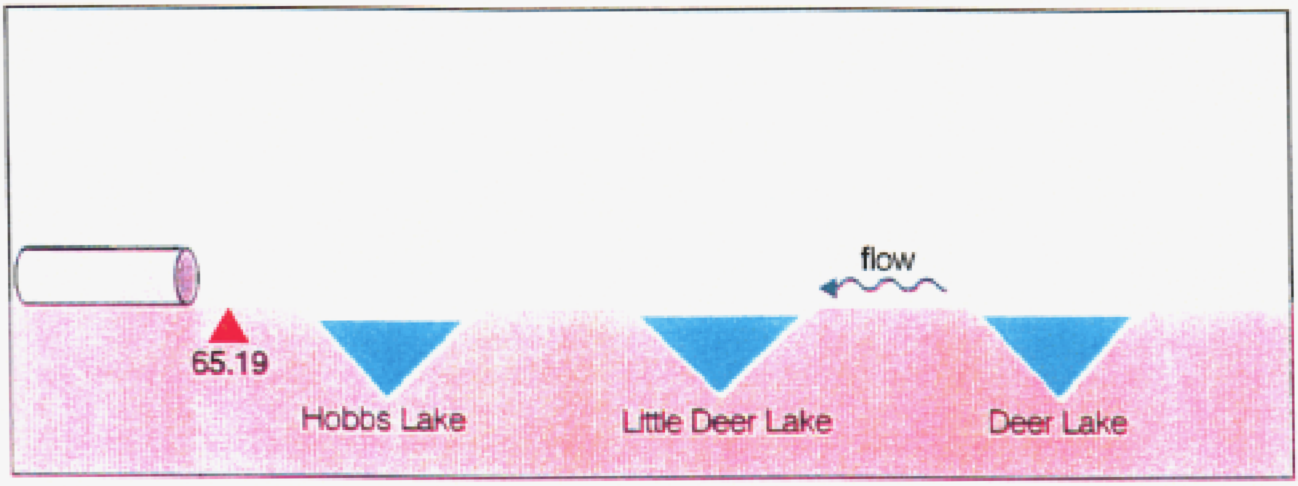
CP = Control Point Invert = 65.2

HI = Hydrologic Indicators = 68.0

LFS = Lowest Floor Slab = 68.5



Aerial View of Outlet Conveyance System



Profile of Outlet Conveyance System

Point #1 - High Point in Conveyance System

Dosson/Sunshine Lakes

Dosson and Sunshine lakes are connected by a cypress wetland. This lake system has been structurally altered and the magnitude of the structural alteration places these lakes in Category 2 for purposes of calculating the High Minimum and Minimum Level. There are no historic data. Current data for the period from January 1974 to September 1997 were used to calculate the Current P10 and P50 elevations. The Historic P50 was calculated from the Current P10 minus the RLWR50.

Summary of Elevation Data (ft, NGVD)		Proposed Levels (ft, NGVD)	
LFS	56.3	10-yr	55.1
NP	54.6	HGL	53.4 *($P10_{cur}$)*
P10cur	53.4	HML	53.4
Sig. change	52.8	ML	52.4
CP	52.8	LGL	51.3
P50hist	52.4 *(P10cur-RLWR50)*		
P50cur	52.2		

Hydrologic Indicators of Normal Pool

Hydrologic indicators of normal pool for Lakes Dosson and Sunshine were measured in the cypress wetland on the southeast side of the Lake Dosson.

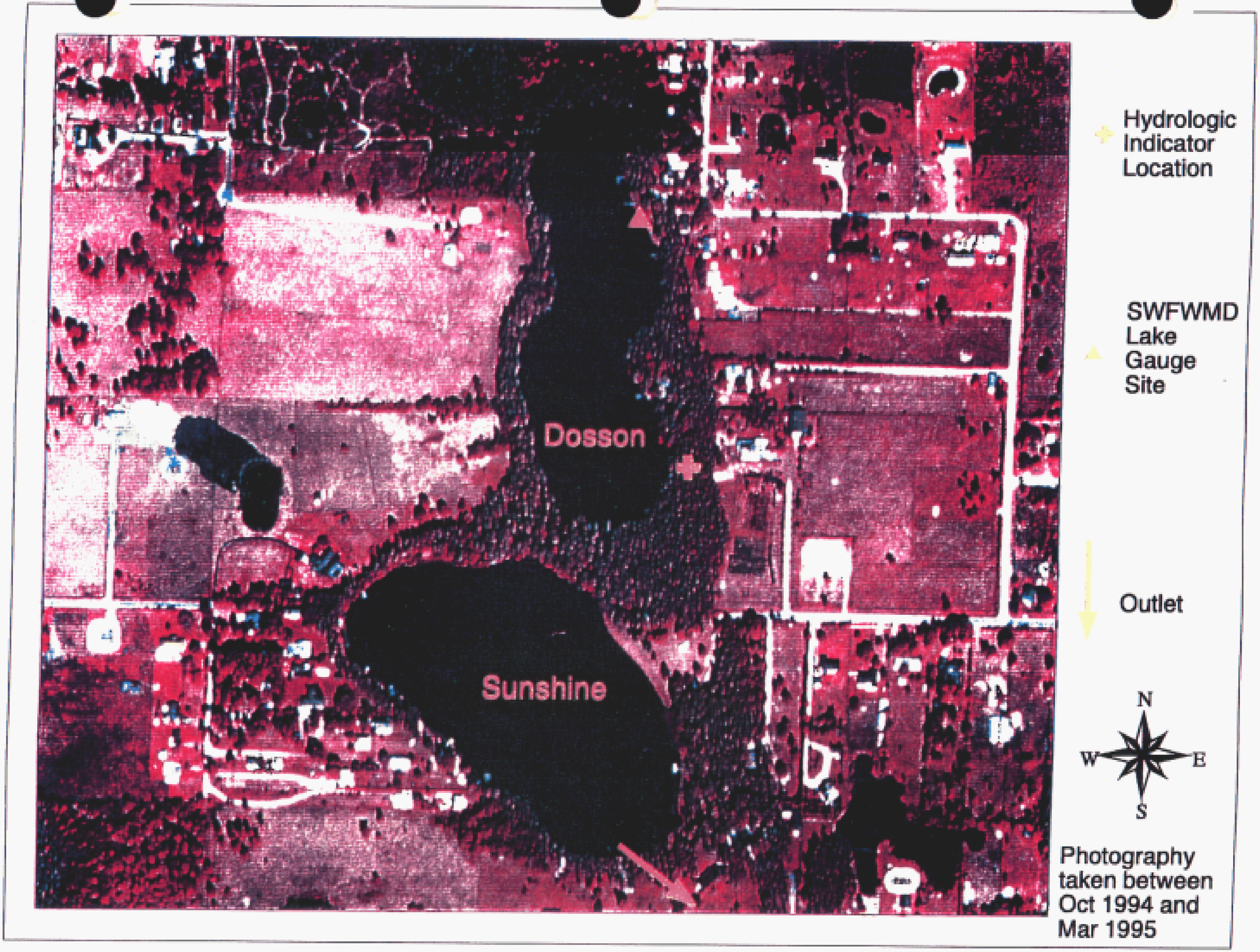
Hydrologic indicators for Dosson & Sunshine on 3/17/98, water level: 53.2 ft, NGVD

HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	1.4	54.7
Cypress buttress	1.4	54.7
Cypress buttress	1.4	54.7
Cypress buttress	1.5	54.7
Cypress buttress	1.5	54.7
Cypress buttress	1.4	54.7
Cypress buttress	1.5	54.7
Cypress buttress	1.3	54.5
Cypress buttress	1.3	54.5
Cypress buttress	1.3	54.5
Base of Lyonia	1.5	54.7
Average hydrologic indicator elevation (ft, NGVD)		54.6
Standard deviation ($\sigma xn-1$)		0.1

Structural Alteration/Control Point

Numbers identify points on the figure showing the outlet conveyance system of the lake.

- #1: Shallow poorly maintained ditch cut through cypress wetland with invert of 52.1' NGVD.
- #2: Control point - high point along profile of well maintained ditch at 52.78' NGVD, running north-south and jogging west along roadside
- #3: 24" x 34" elliptical culvert under Whirley Road
- #4: Series of small wetlands that carry flow to Brushy Creek


Dosson
Sunshine
Hydrologic Indicator Location
SWFWMD Lake Gauge Site
Outlet
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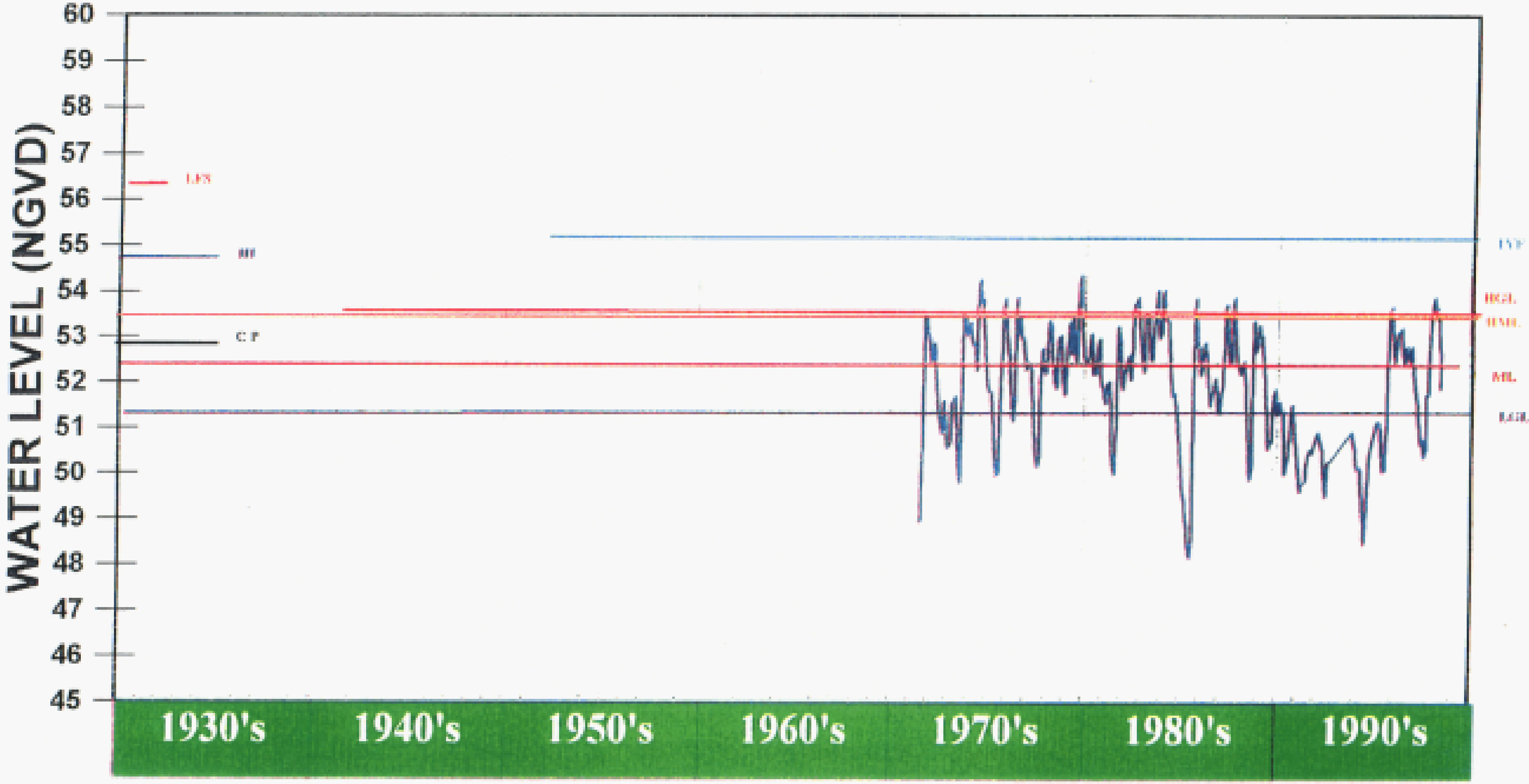
Photography taken between Oct 1994 and Mar 1995

Dosson and Sunshine



GUIDANCE AND MINIMUM LEVELS

TYF = Ten Year Flood = 55.1

HGL = High Guidance Level = 53.4

HML = High Minimum Level = 53.4

ML = Minimum Level = 52.4

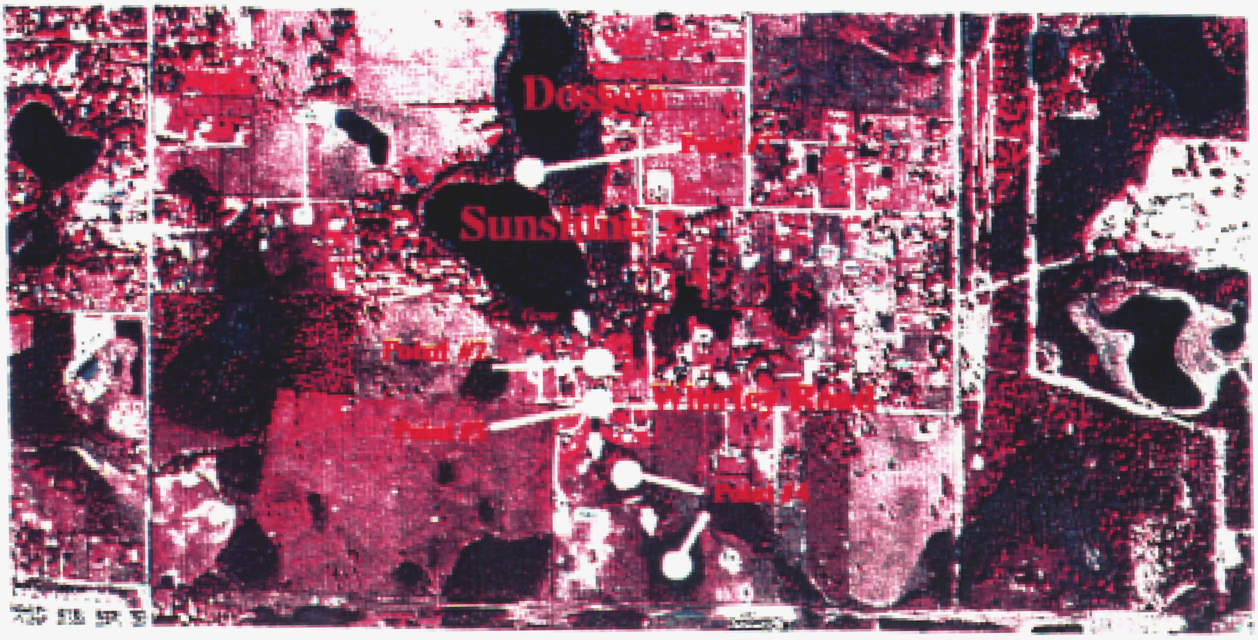
LGL = Low Guidance Level = 57.3

LAKE FEATURES

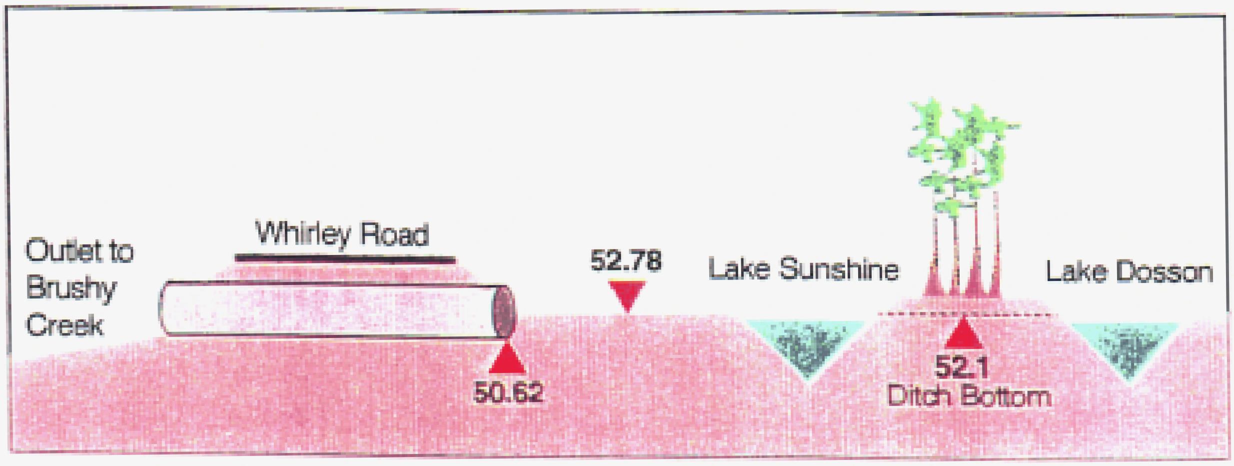
CP = Control Point Invert = 52.8

HI = Hydrologic Indicators = 54.7

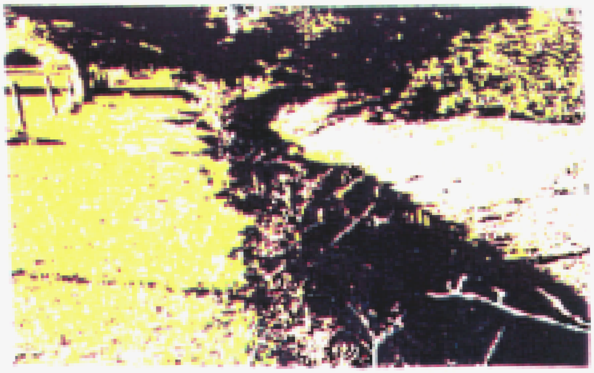
LFS = Lowest Floor Slab = 56.3



Aerial View of Outlet Conveyance System



Profile of Outlet Conveyance System



Poin #2 - Trapezodial Conveyance System

Lake Juanita

Lake Juanita has wetlands and is structurally altered. The magnitude of the structural alteration places this lake in Category 2 for purposes of calculating the High Minimum and Minimum Levels. There are no historic data. Current data for the period from July 1971 to September 1997 were used to calculate the Current P10 and P50 elevations. The Historic P50 was calculated from the Current P10 minus the RLWR50.

Summary of Elevation Data (ft, NGVD)		**Proposed Levels (ft, NGVD)**	
LFS	43.6	10-yr	43.8
NP	43.2	HGL	41.7 *($P10_{cur}$)*
P10cur	41.7	HML	41.7
Sig. change	41.4	ML	40.7
P50hist	40.7 *(P10cur-RLWR50)*	LGL	39.6
CP	40.5		
P50cur	39.4		

Hydrologic Indicators of Normal Pool

Hydrologic indicators were measured by Hillsborough County Environmental Protection Commission staff in a cypress wetland on the northwestern shore of the lake.

Hydrologic indicators for Lake Juanita on 3/18/98, water level: 41.9 ft, NGVD

HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	1.7	43.6
Cypress buttress	1.2	43.1
Cypress buttress	1.2	43.1
Cypress buttress	1.3	43.2
Cypress buttress	1.1	43.0
Cypress buttress	1.2	43.1
Average hydrologic indicator elevation (ft, NGVD)		43.2
Standard deviation (σxn-1)		0.2

Structural Alteration/Control Point

Numbers identify points on the figure showing the outlet conveyance system of the lake.

#1: 100' trapezoidal ditch with bottom width of approximately 2' and 2:1 side slopes

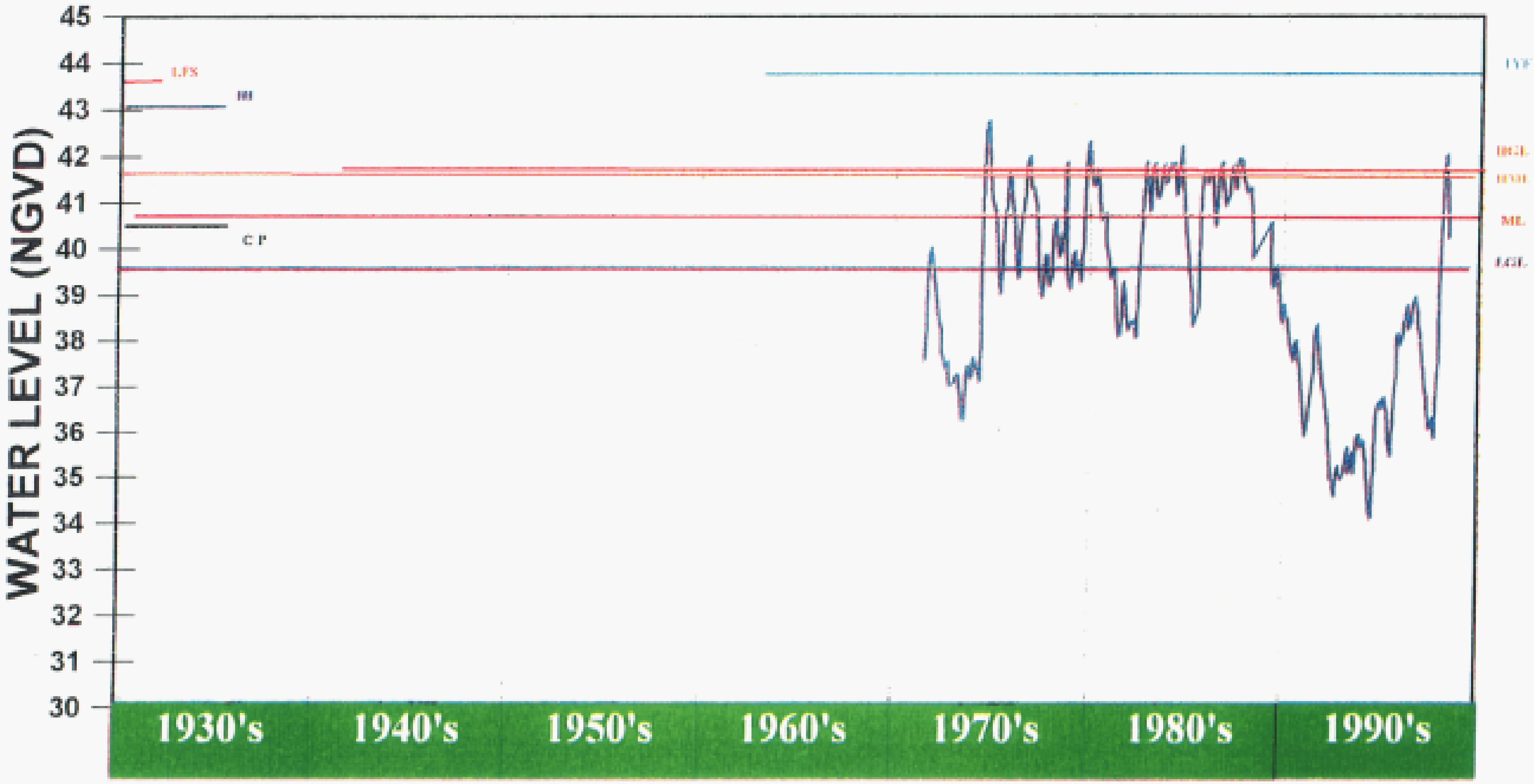
#2: Control point - 28" corrugated metal pipe approximately 15' long with inverts on the east and west of 40.46' and 40.52', respectively

#3: 26" x 38" elliptical reinforced concrete pipe under Crawley Road with inverts of 40.36' and 39.96' NGVD at the east and west ends respectively

#4: Ditch running approximately 500' west toward Rainbow Lake.


Juanita
Hydrologic Indicator Location
SWFWMD Lake Gauge Site
Outlet
N
W
E
S
Photography taken between Oct 1994 and Mar 1995

Lake Juanita - Hillsborough County

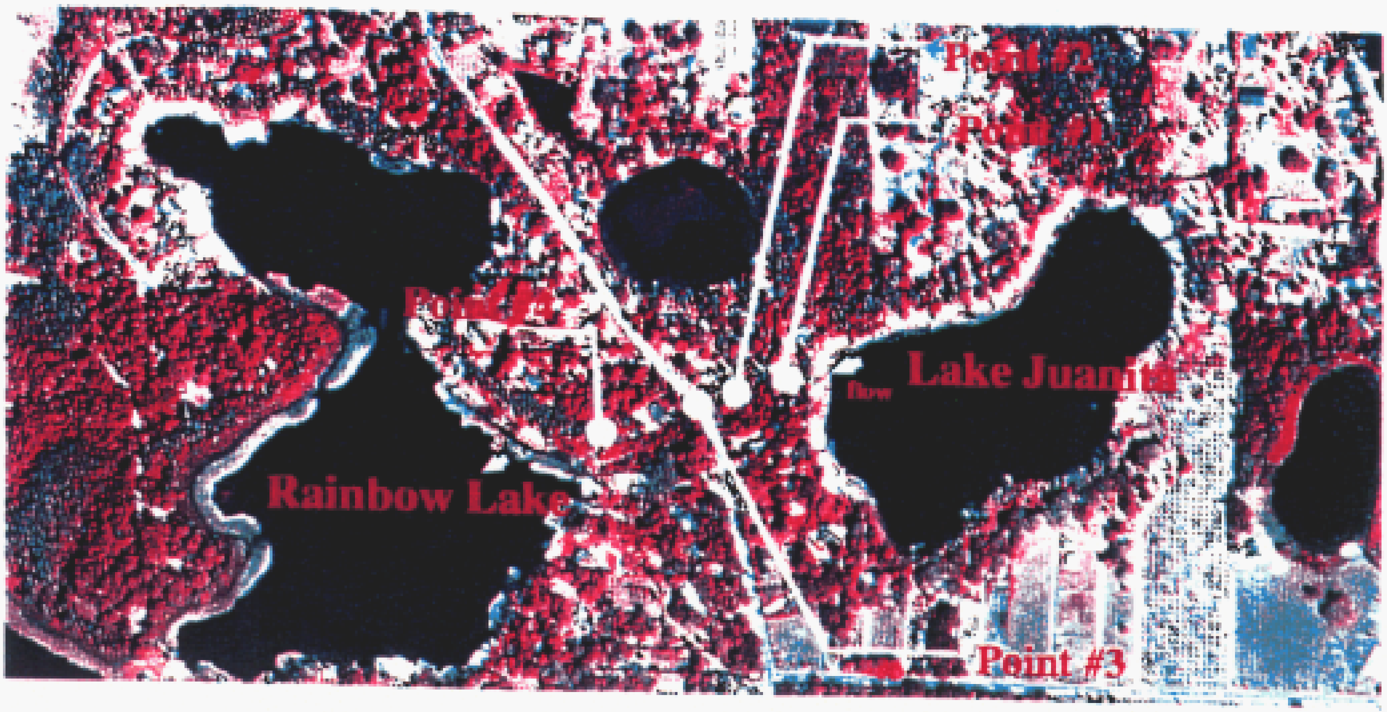


GUIDANCE AND MINIMUM

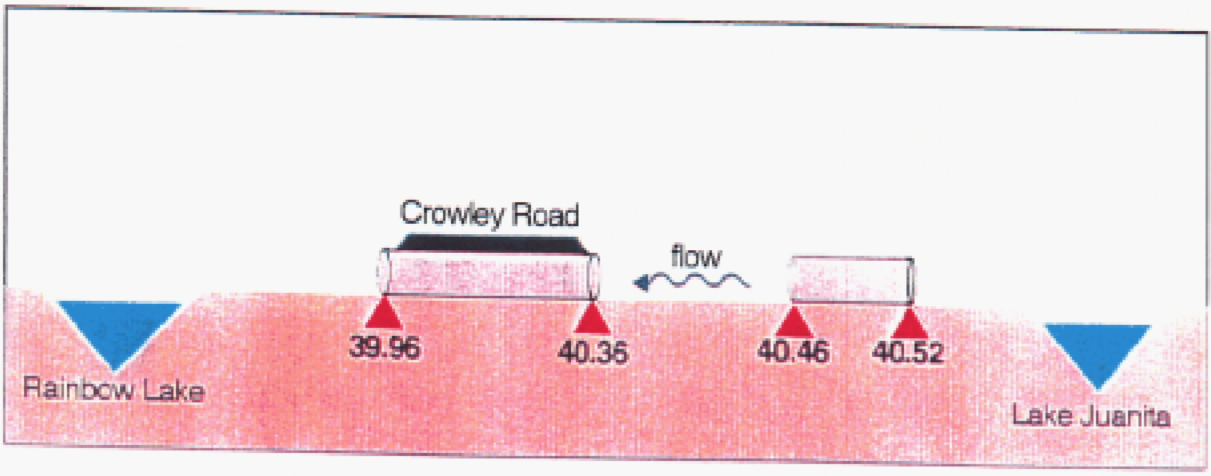
TYF = Ten Year Flood = 43.8
HGL = High Guidance Level = 41.7
HML = High Minimum Level = 41.7
ML = Minimum Level = 40.7
LGL = Low Guidance Level = 39.6

LAKE FEATURES

CP = Control Point Invert = 40.5
HI =Hydrologic Indicators = 43.1
LFS = Lowest Floor Slab = 43.6



Aerial View of Outlet Conveyance System



Profile of Outlet Conveyance System

Looking East from Crawly Road Toward Lake Juanita (CMP Control Not in View)

Little Moon/Rainbow Lakes

Little Moon and Rainbow Lakes are connected through an improved channel. The lakes have wetlands and are structurally altered. The magnitude of the structural alteration places these lakes in Category 2 for purposes of calculating the High Minimum and Minimum Levels. There are no historic data. Current data for the period from June 1971 to October 1997 were used to calculate the Current P10 and P50 elevations. The Historic P50 was calculated from the Current P10 minus the RLWR50.

Summary of Elevation Data (ft, NGVD)		Proposed Levels (ft, NGVD)	
LFS	42.5	10-yr	40.8
NP	40.9	HGL	39.1 *($P10_{curr}$)*
Sig. change	39.1	HML	39.1
P10cur	39.1	ML	38.1
CP	39.0	LGL	37.0
P50hist	38.1 *(P10cur-RLWR50)*		
P50cur	36.3		

Hydrologic Indicators of Normal Pool

Hydrologic indicators of normal pool were measure in a cypress wetland west of Rainbow lake and north of Little Moon Lake. This wetlands is adjacent to the Boyscout Camp.

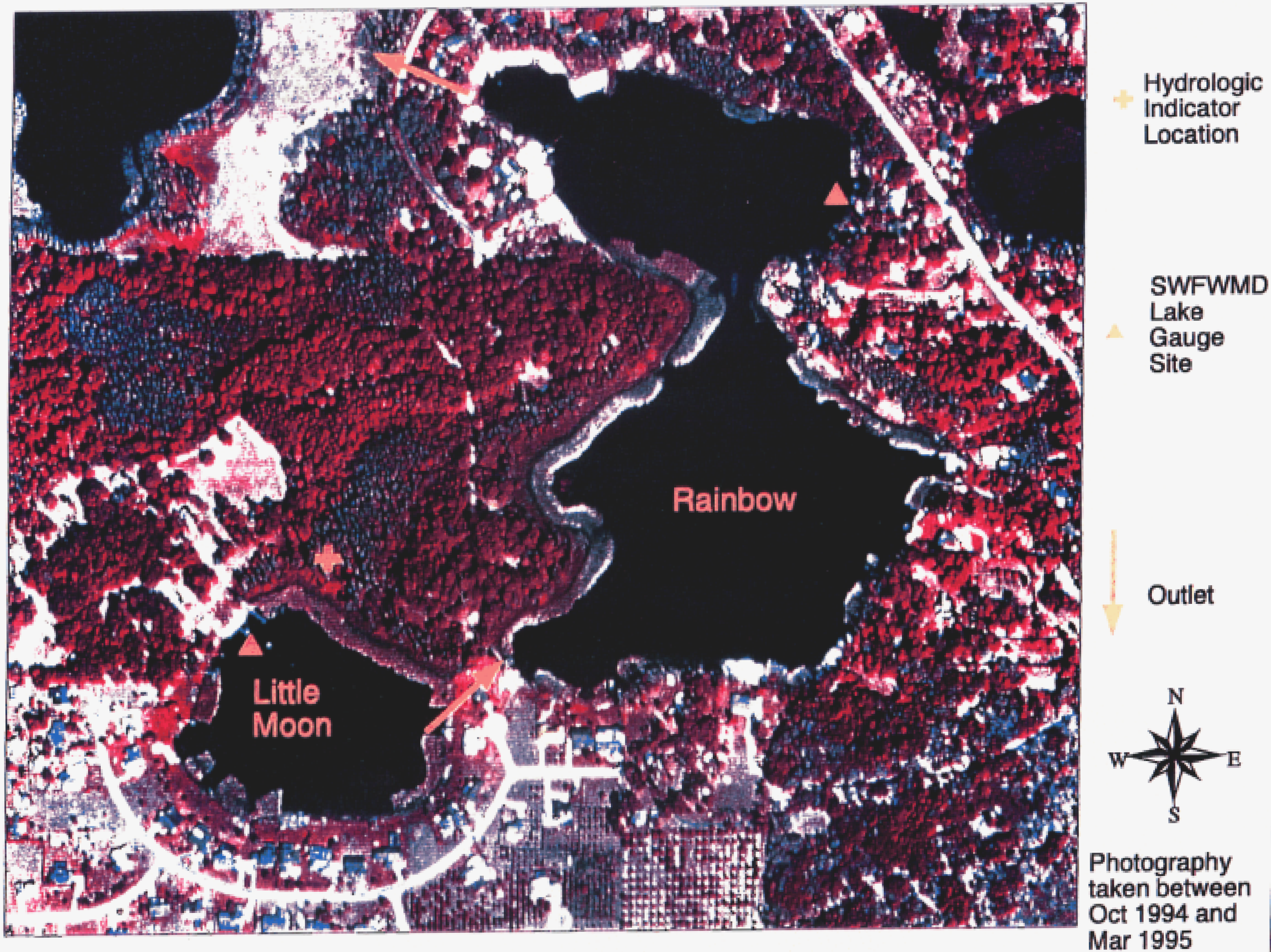
Hydrologic indicator elevations for Little Moon/Rainbow lakes on 3/17/98, water level: 39.5 ft, NGVD

HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	1.6	41.0
Cypress buttress	1.3	40.8
Cypress buttress	1.3	40.8
Cypress buttress	1.6	41.0
Cypress buttress	1.6	41.0
Average hydrologic indicator elevation (ft, NGVD)		40.9
Standard deviation (σxn-1)		0.1

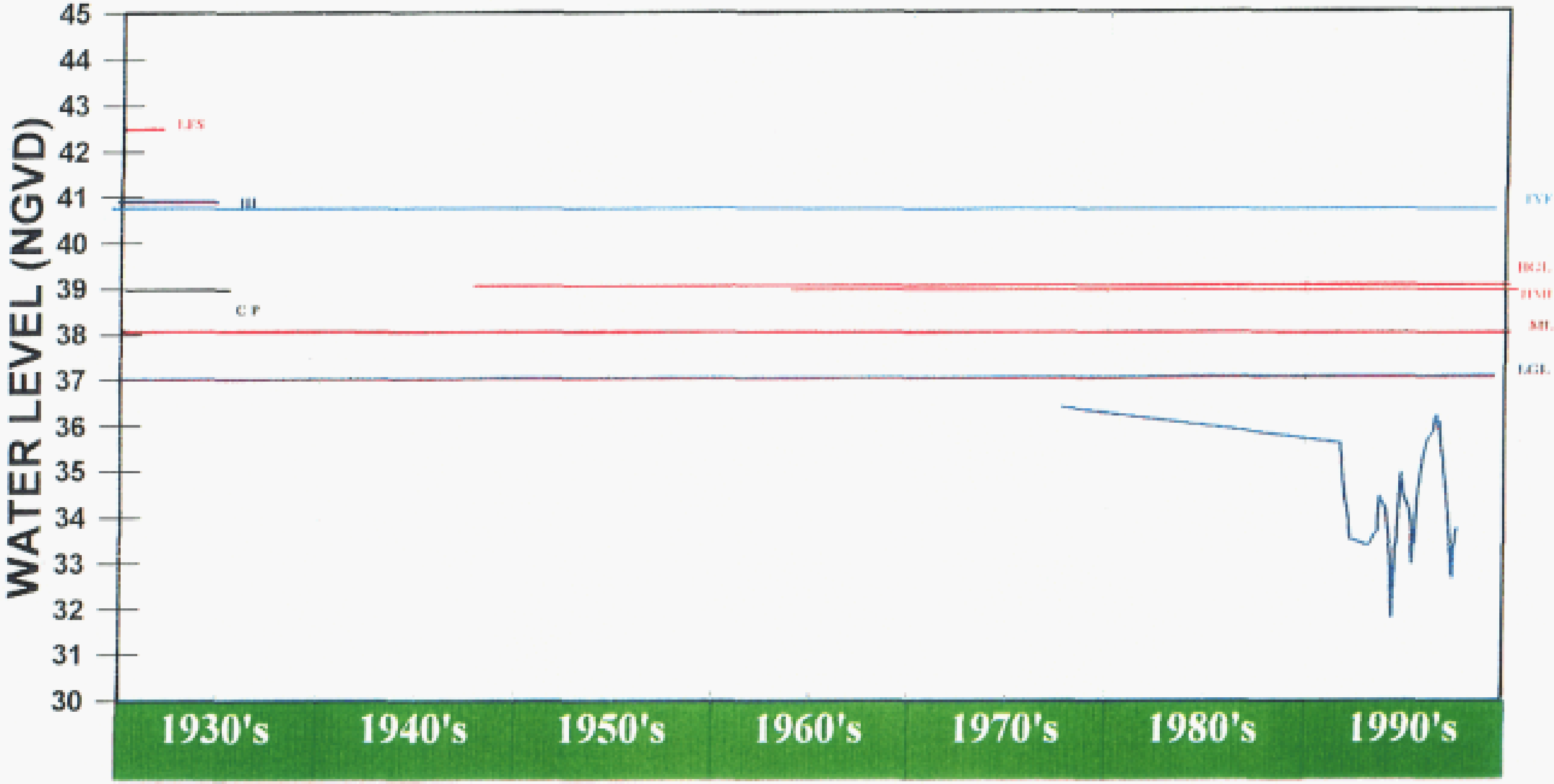
Structural Alteration/Control Point

Numbers identify points on the figure showing the outlet conveyance system of the lake.

#1: Canal excavated through wetlands with high point along the profile of 34.7' NGVD.
#2: Elliptical corrugated metal pipes at 38.5' NGVD
#3: 18 inch diameter corrugated metal pipe with a invert of 39.1' NGVD.
#4: Control point - concrete slab at 39.0' NGVD.


Rainbow
Little Moon
Hydrologic Indicator Location
SWFWMD Lake Gauge Site
Outlet
N
W
E
S
Photography taken between Oct 1994 and Mar 1995

Lake Little Moon - Hillsborough County



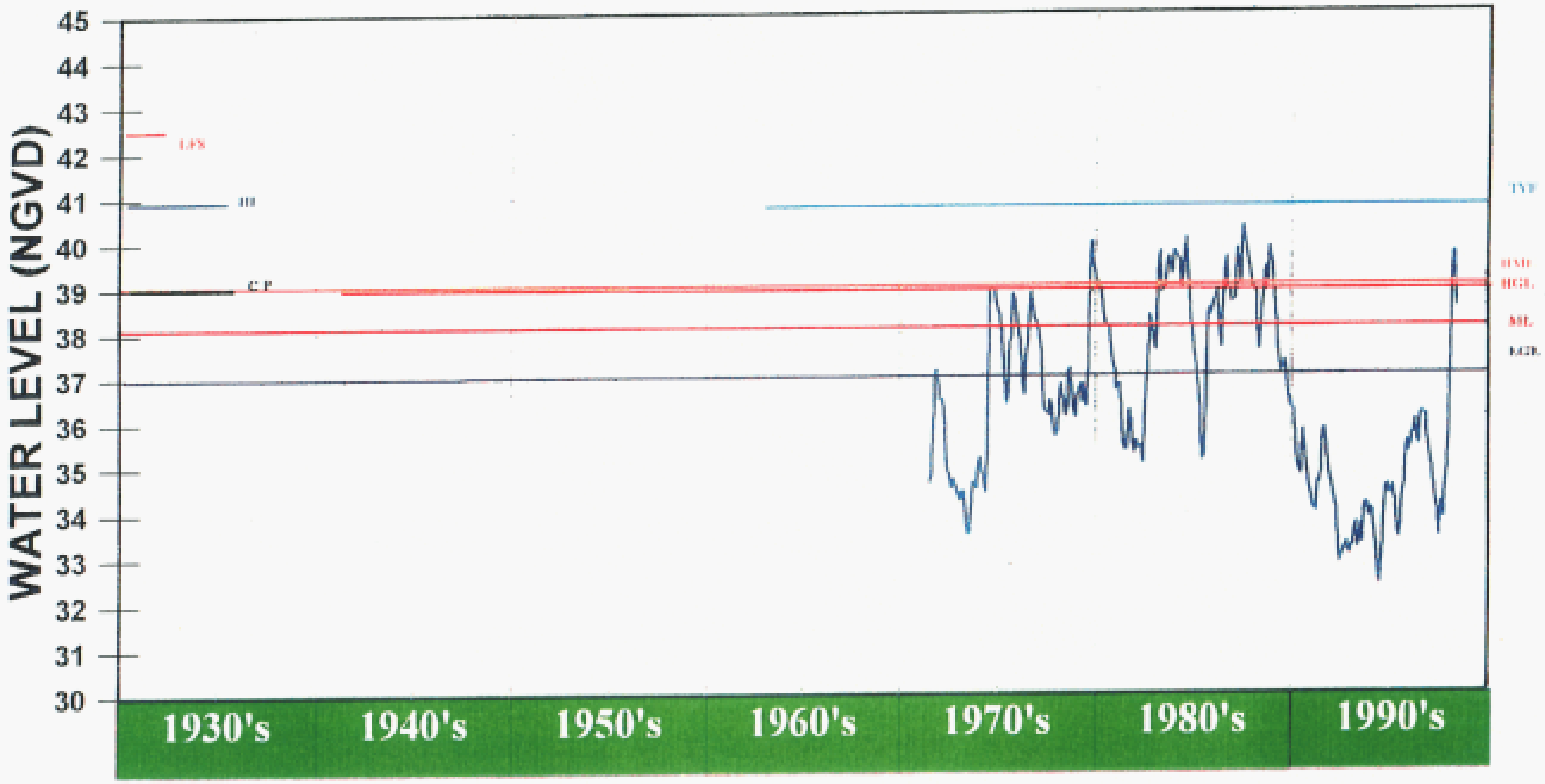
GUIDANCE AND MINIMUM

TYF = Ten Year Flood = 40.8
HGL = High Guidance Level = 39.1
HML = High Minimum Level = 39.1
ML = Minimum Level = 38.1
LGL = Low Guidance Level = 37.0

LAKE FEATURES

CP = Control Point Invert = 39.0
HI = Hydrologic Indicators = 40.9
LFS = Lowest Floor Slab = 42.5

Lake Rainbow - Hillsborough County

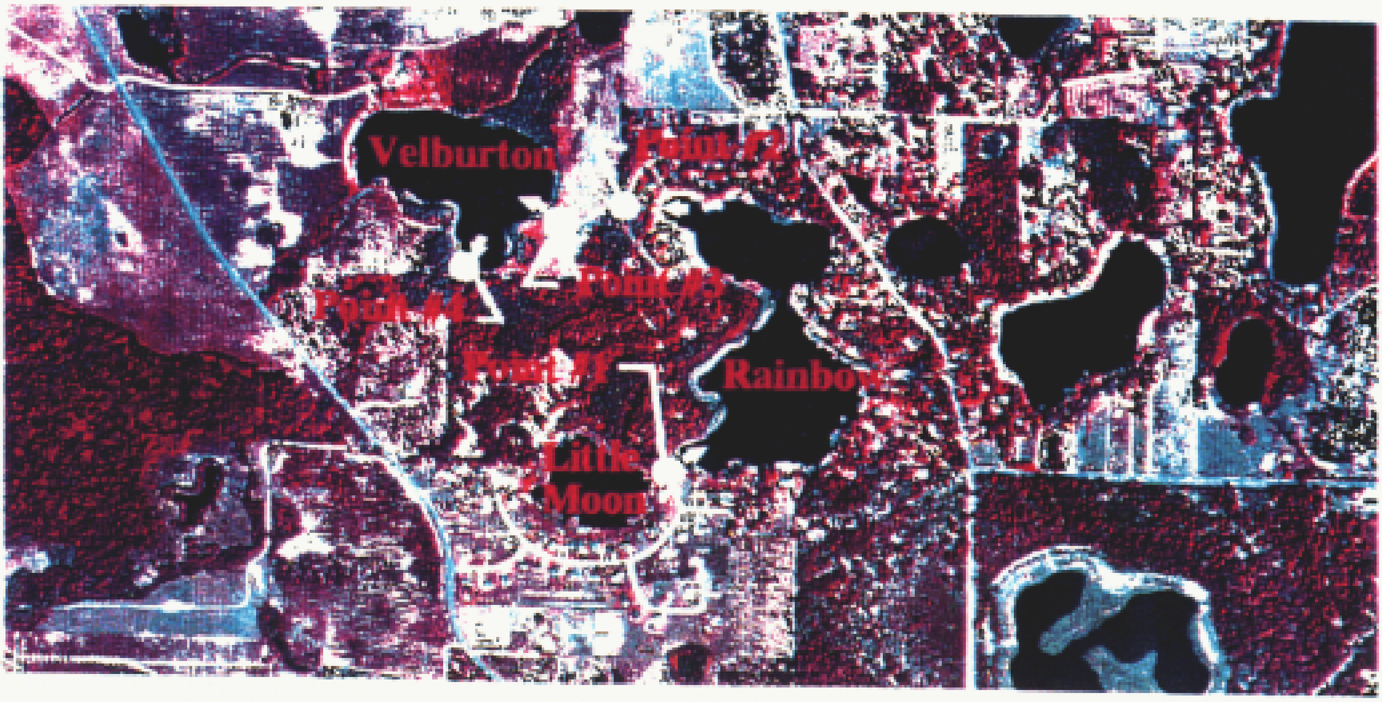


GUIDANCE AND MINIMUM

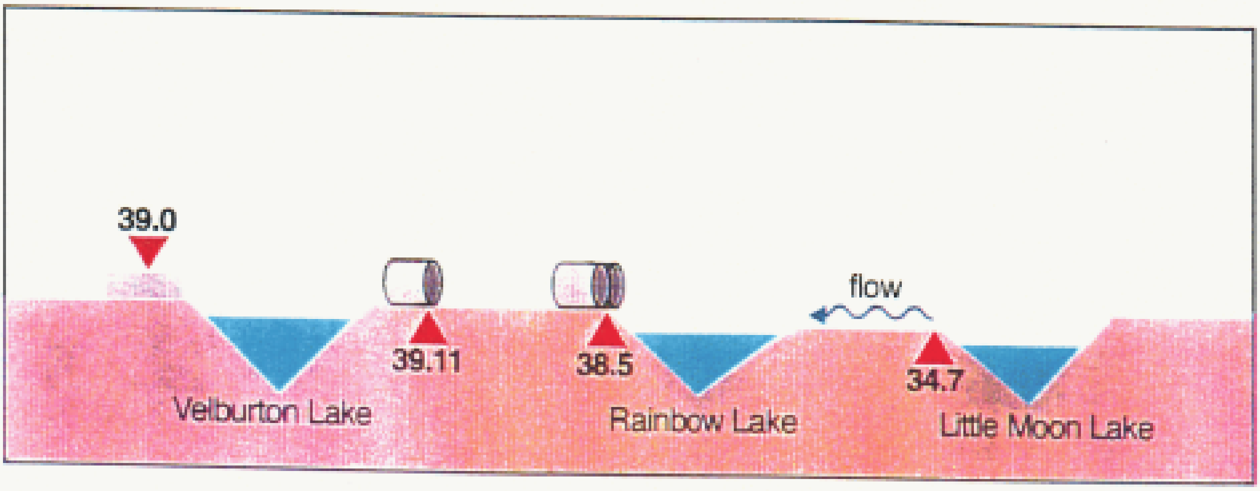
TYF = Ten Year Flood = 40.8
HGL = High Guidance Level = 39.1
HML = High Minimum Level = 39.1
ML = Minimum Level = 38.1
LGL = Low Guidance Level = 37.0

LAKE FEATURES

CP = Control Point Invert = 39.0
HI = Hydrologic Indicators = 40.9
LFS = Lowest Floor Slab = 42.5



Aerial View of Outlet Conveyance System



Profile of Outlet Conveyance System

Point #3 - Grass Field Looking South at CMP

Merrywater Lake

Merrywater Lake has wetlands and is structurally altered. The magnitude of the structural alteration places this lake in Category 2 for purposes of calculating the High Minimum and Minimum Levels. There are no historic data. Current data for the period from October 1977 to October 1997 were used to calculate the Current P10 and P50 elevations. The Historic P50 was calculated using Current P10 minus the RLWR50.

Summary of Elevation Data (ft, NGVD)		Proposed Levels (ft, NGVD)	
NP	58.5	10-yr	58.0
LFS	58.0	HGL	55.8 *($P10_{cur}$)*
Sig. change	56.7	HML	55.8
P10cur	55.8	ML	54.8
CP	55.5	LGL	53.7
P50hist	54.8 *(P10cur-RLWR50)*		
P50cur	51.0		

Hydrologic Indicators of Normal Pool

Hydrologic indicators of normal pool were measured on the northwest shore of the lake.

Hydrologic indicators elevations for Lake Merrywater on 3/17/98, water level: 56.7 ft, NGVD

HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	1.8	58.5
Cypress buttress	1.6	58.3
Cypress buttress	2.0	58.7
Average hydrologic indicator elevation (ft, NGVD)		58.5
Standard deviation (σxn-1)		0.2

Structural Alteration/Control Point

Numbers identify points on the figure showing the outlet conveyance system of the lake.

#1: 54" diameter corrugated metal pipe with inverts on the west and east of 53.87' and 53.56' NGVD, respectively

#2: Control point is the highest point in a shallow trapezoidal ditch approximately 750' long. The highest point is 55.53' located about the center of the length of the ditch.

#3: 42" x 72" elliptical corrugated metal pipe with an operable riser structure on the upstream end. Elevations of the top of the riser, and the north and south ends of the corrugated metal pipe are 57.83', 54.38', and 53.1' NGVD, respectively.

#3: 24" corrugated metal pipe with inverts of 54.38' and 53.51' NGVD on the north and south ends respectively

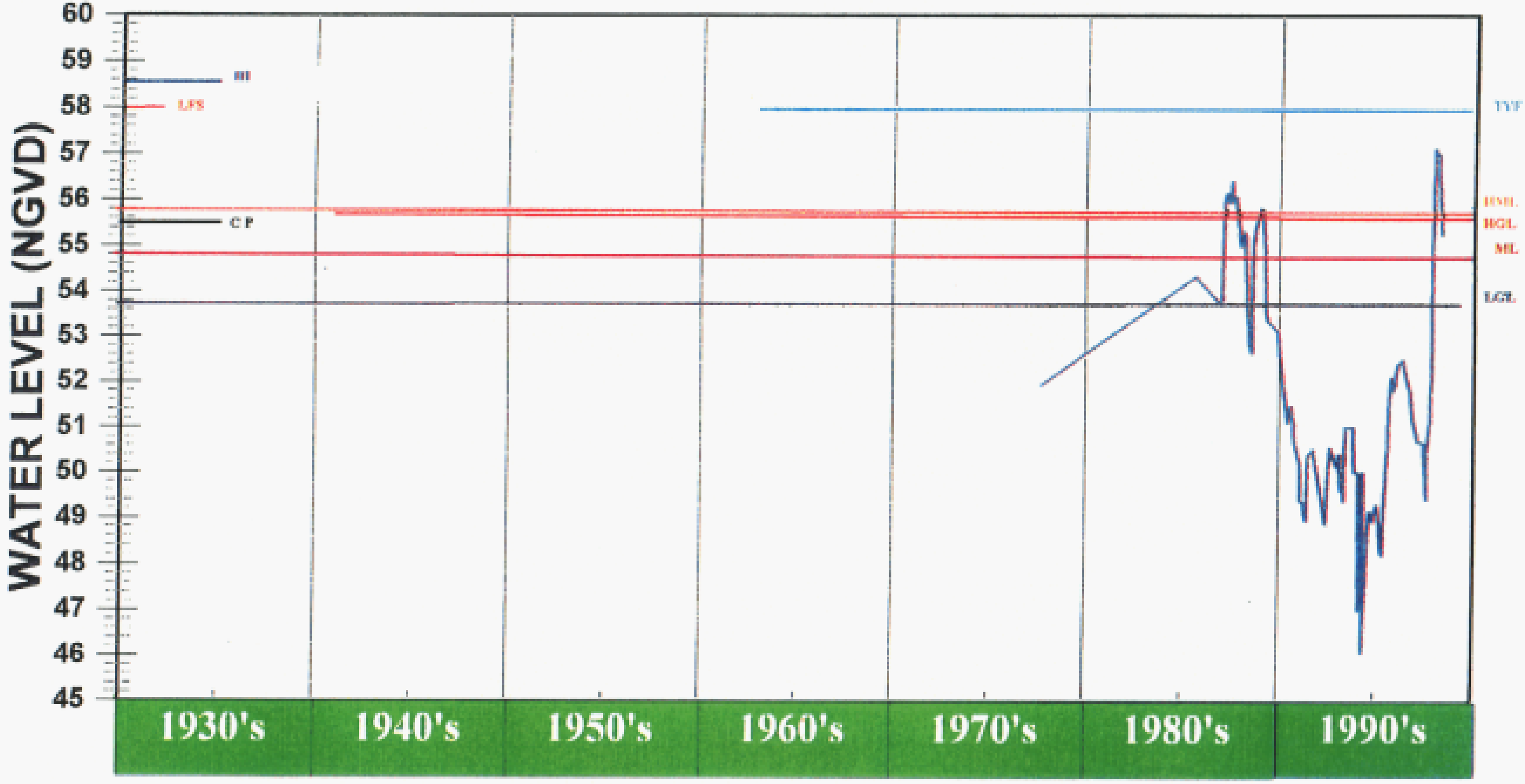
#4: Excavated livestock pond with approximate diameter of 120' and depth of approximately 12'

#5: Corrugated metal pipe with operable riser oriented north-south with inverts of 55.10' and 54.07' NGVD respectively. Top of riser is 57.83' NGVD. The north end of riser discharges to Crenshaw Lake Road.

#6: Two elliptical corrugated metal pipes oriented north-south and discharge to the interceptor canal. The western corrugated metal pipe has inverts on the north and south of 53.34' and 53.26' NGVD respectively. The eastern corrugated metal pipe has inverts on the north and south of 53.67' and 53.44' NGVD, respectively.


Merrywater
Hydrologic Indicator Location
SWFWMD Lake Gauge Site
Outlet
N
W
E
S
Photography taken between Oct 1994 and Mar 1995

Lake Merrywater - Hillsborough County



GUIDANCE AND MINIMUM LEVELS

TYF = Ten Year Flood = 58.0

HGL = High Guidance Level = 55.8

HML = High Minimum Level = 55.8

ML = Minimum Level = 54.8

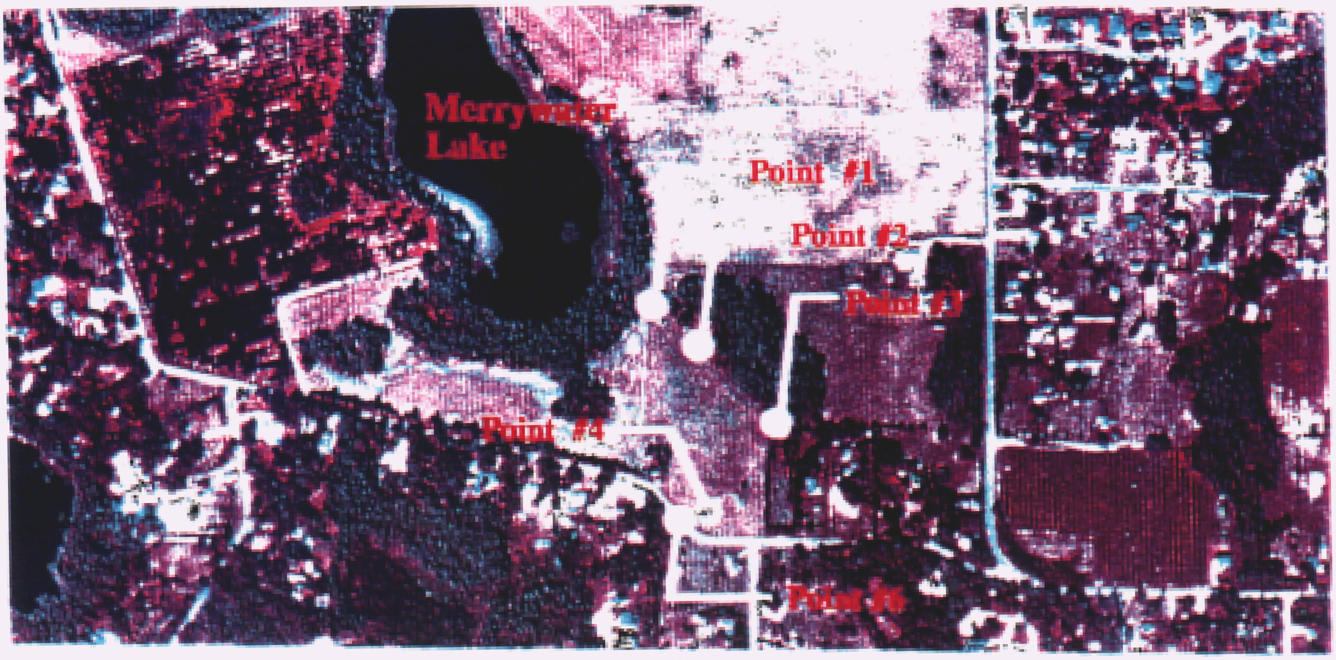
LGL = Low Guidance Level = 53.7

LAKE FEATURES

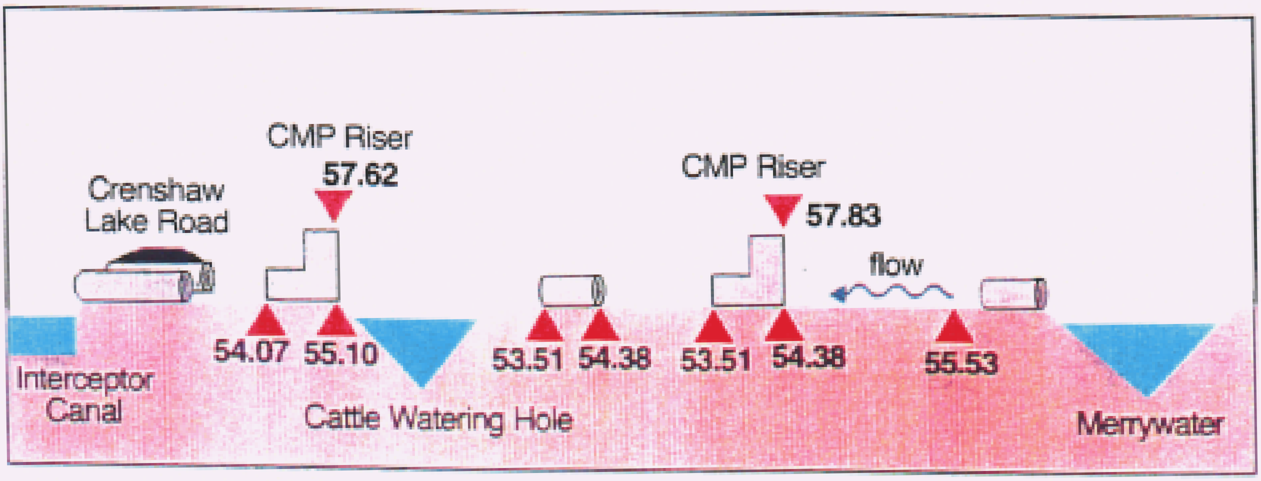
CP = Control Point Invert = 55.5

HI = Hydrologic Indicators = 58.5

LHS = Lowest Floor Slab = 58.0



Aerial View of Outlet Conveyance System



Profile of Outlet Conveyance System

Point #2 - Approximate (Obscured by High Water)

Sapphire Lake

Sapphire Lake has wetlands and is not structurally altered. This lake is a Category 1 lake for purposes of calculating the High Minimum and Minimum Levels. There are no historic data. Current data for the period February 1993 to August 1997 were used to calculate the Current P10 and P50 elevations. The Historic P50 was calculated from the control point minus the RLWR50.

Summary of Elevation Data (ft, NGVD)		Proposed Levels (ft, NGVD)	
LFS	64.9	10-yr	64.1
NP	63.4	HGL	63.4 *(NP)*
CP	63.2	HML	63.0
P10cur	short record	ML	61.6
P50hist	62.2 *(CP-RLWR50)*	LGL	61.3
Sig. change	61.6		
P50cur	short record		

Hydrologic Indicators of Normal Pool

Hydrologic indicators of normal pool were measured in a wetland on the northwest shore of the lake.

Elevations of hydrologic indicators for Sapphire Lake on 4/21/98, water level: 62.9 ft, NGVD

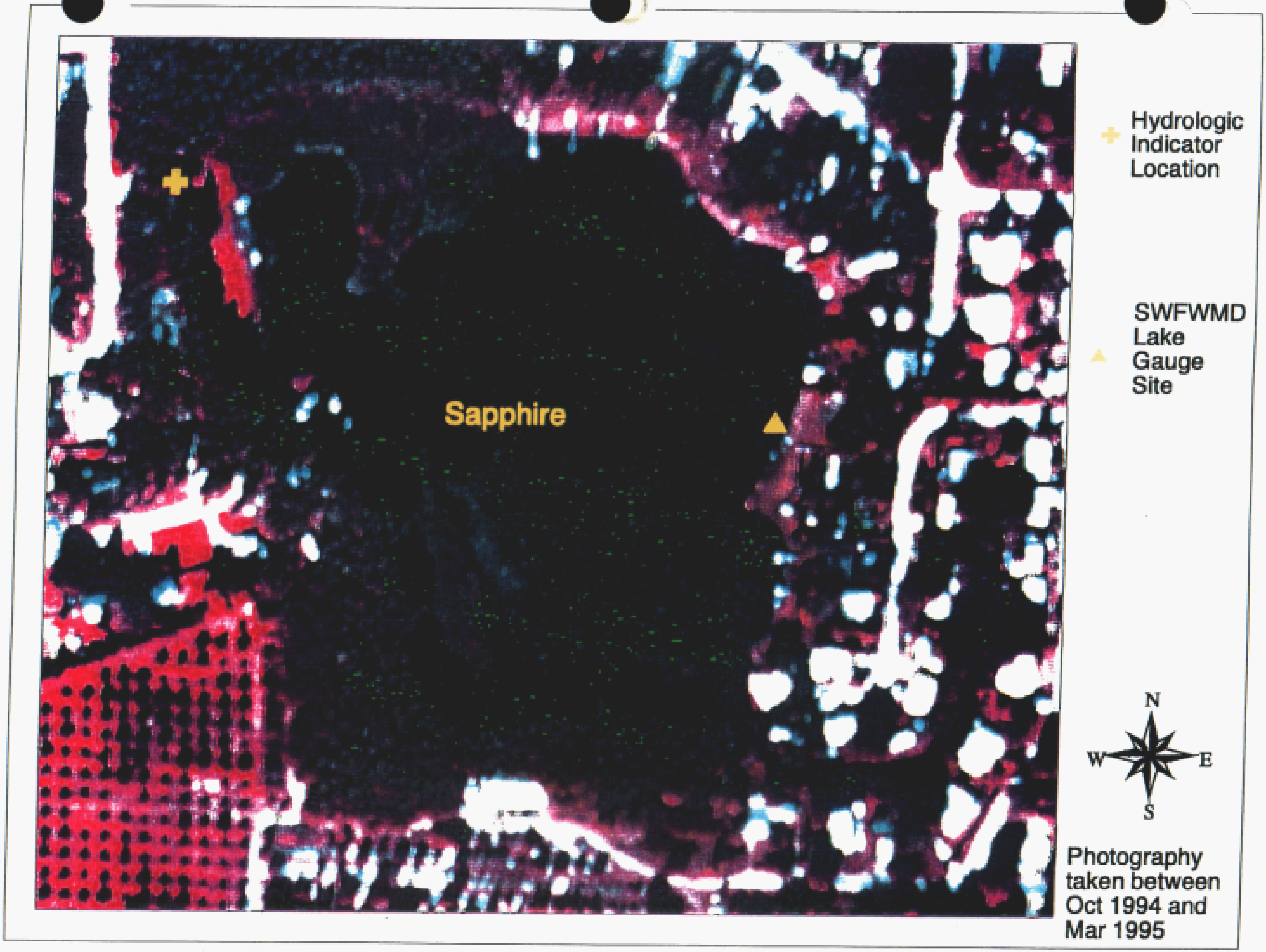
HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	0.5	63.4
Cypress buttress	0.6	63.5
Average hydrologic indicator elevation (ft, NGVD)		63.4
Standard deviation (σxn-1)		0.1

Structural Alteration/Control Point

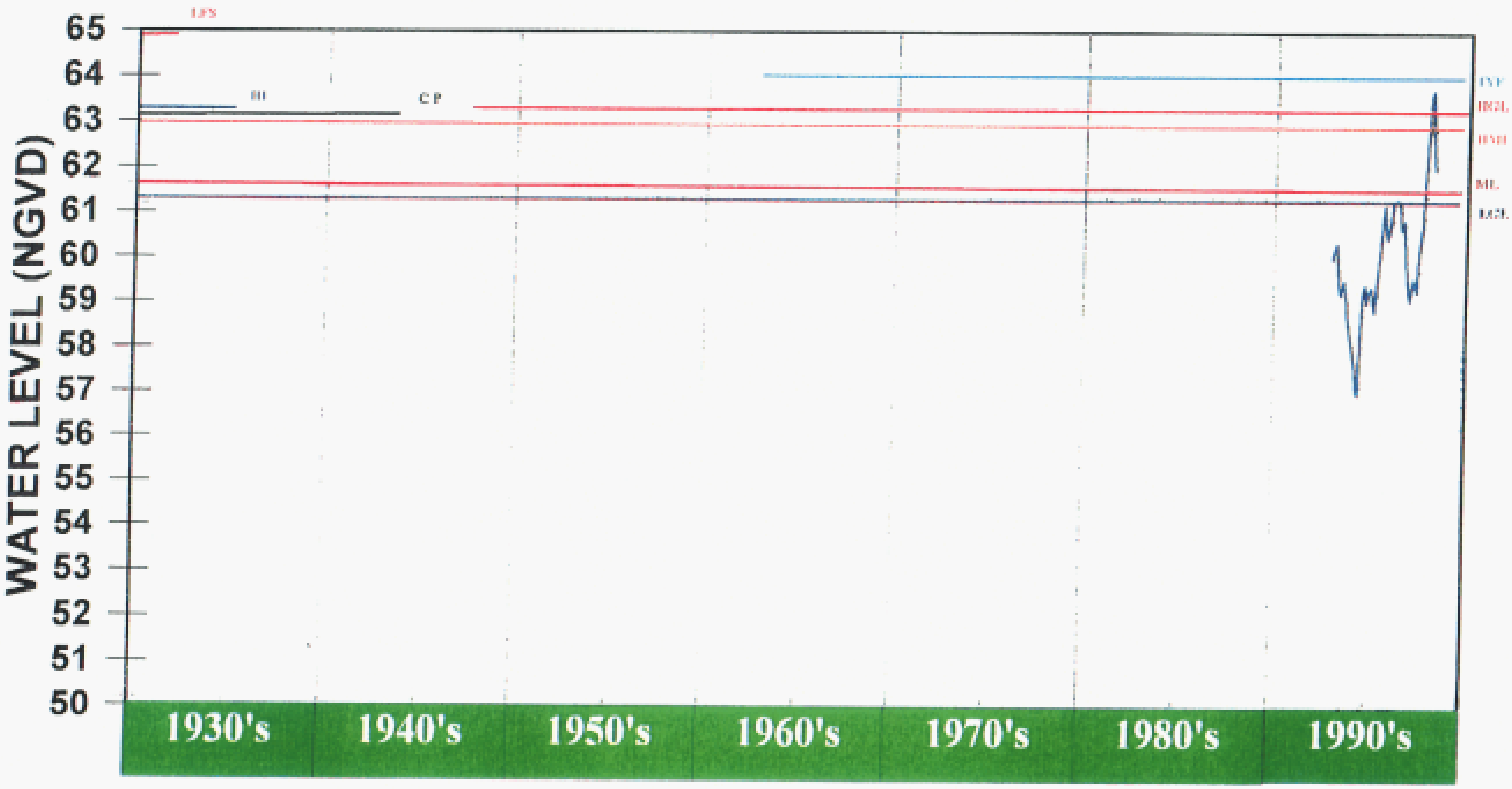
Numbers identify points on the figure showing the outlet conveyance system of the lake.

#1: Control point - lowest spot of 63.2' NGVD in fill in cypress wetland fringe

#2: 18" diameter pipe under Abbey Lane extending westward and connecting to Lake Thomas


Sapphire
Hydrologic Indicator Location
SWFWMD Lake Gauge Site
N
W
E
S
Photography taken between Oct 1994 and Mar 1995

Lake Sapphire - Hillsborough County



GUIDANCE AND MINIMUM LEVELS

TYF = Ten Year Flood

HGL = High Guidance Level

HML = High Minimum Level

ML = Minimum Level

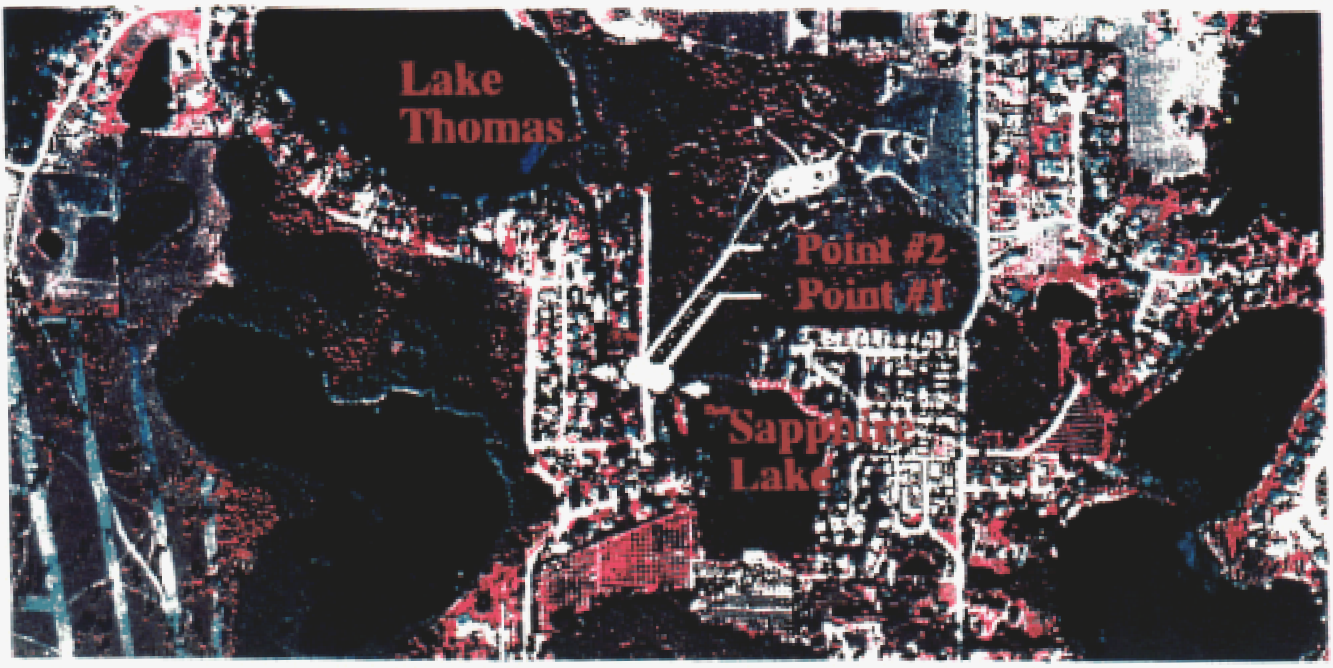
LGL = Low Guidance Level

LAKE FEATURES

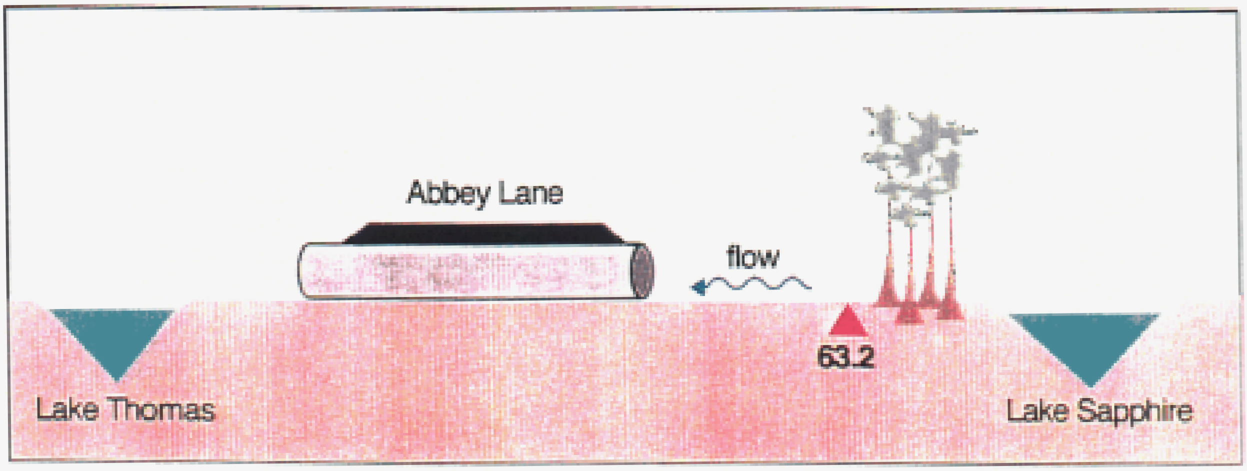
CP = Control Point Invert

HI = Hydrologic Indicators

LFS = Lowest Floor Slab



Aerial View of Outlet Conveyance System



Profile of Outlet Conveyance System

Point #1 - Person Pointing to Control Point Inside Tree Line

Point #2 - Inlet of CMP under Abbey Lane

Lake Stemper

Lake Stemper has wetlands and is structurally altered. The structure is an operable structure and operation of the structure at 61.2' was assumed to be the typical condition. Based on this assumption the lake is within Category 1 for purposes of calculating the High Minimum and Minimum Levels. There are no historic data. Current data for the period June 1974 to September 1997 were used to calculate the Current P10 and P50 elevations. The Historic P50 was calculated from the elevation of the control point minus the RLWR50.

Summary of Elevation Data (ft, NGVD)		Proposed Levels (ft, NGVD)	
LFS	63.7	10-yr	62.6
NP	61.2	HGL	61.2 *(CP/NP)*
CP	61.2	HML	60.8
P10cur	61.1	ML	59.4
P50hist	60.2 *(CP- RLWR50)*	LGL	59.1
P50cur	59.5		
Sig. change	59.4		

Hydrologic Indicators of Normal Pool

Hydrologic indicators were measured in the wetland adjacent to control structure and in a wetland on the northeast shore of the lake.

Hydrologic indicator elevations for Lake Stemper on 3/30/98, water level: 60.7 ft, NGVD

HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	0.2	60.9
Cypress buttress	0.3	61.0
Cypress buttress	0.3	61.1
Cypress buttress	0.3	61.1
Cypress buttress	0.4	61.1
Cypress buttress	0.5	61.2
Cypress buttress	0.8	61.5
Cypress buttress	1.0	61.7
Cypress buttress	0.6	61.3
Average hydrologic indicator elevation (ft, NGVD)		61.2
Standard deviation (σxn-1)		0.3

Structural Alteration/Control Point

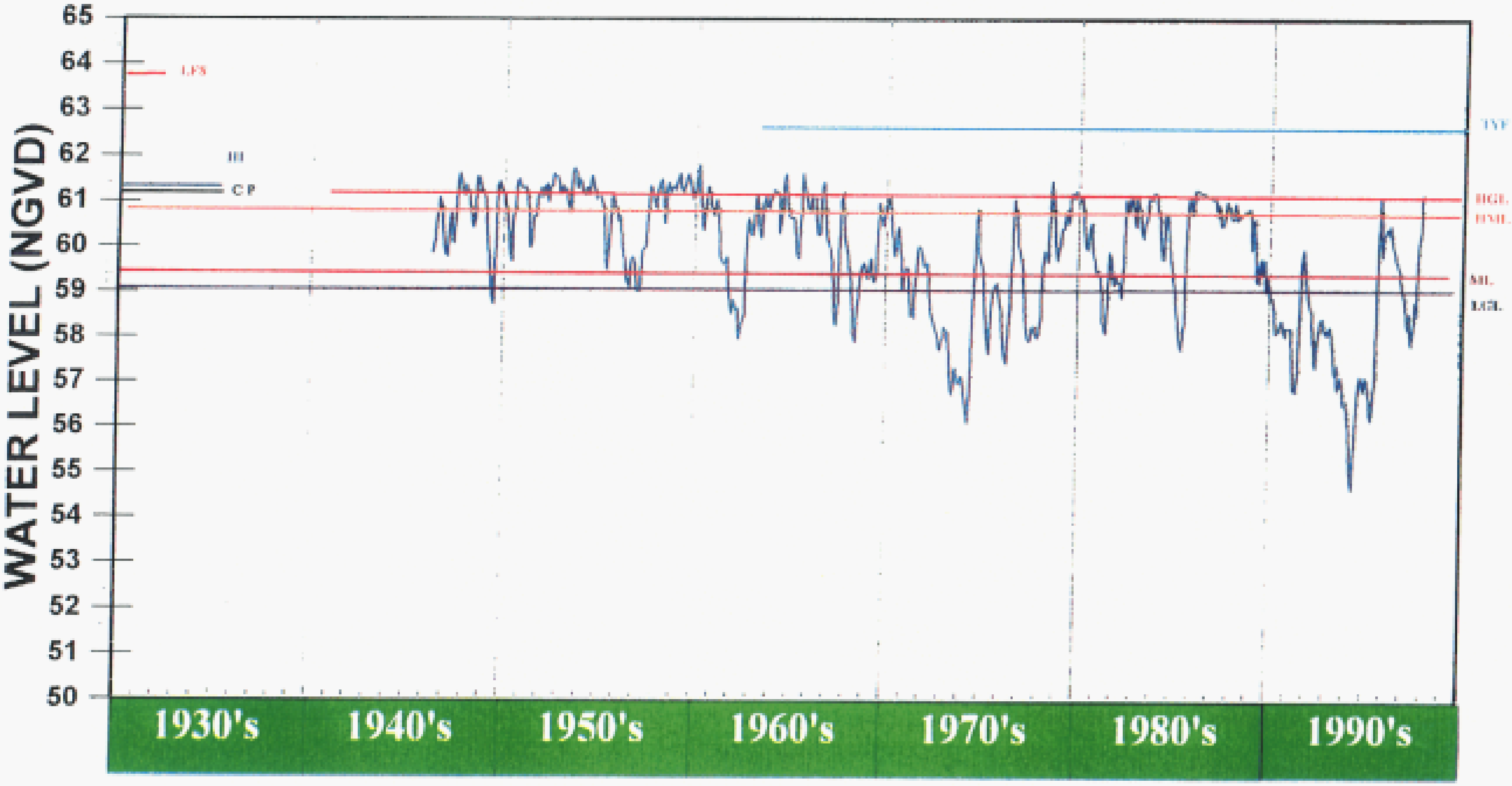
Numbers identify points on the figure showing the outlet conveyance system of the lake.

#1: Wetlands with ditch for improved conveyance to structure

#2: Control point - 11' weir, with a fixed sill elevation of 60.20', and two removable 6" boards (thus a maximum elevation of 61.2 feet).


Stemper
Hydrologic Indicator Location
SWFWMD Lake Gauge Site
Outlet
N
W
E
S
Photography taken between Oct 1994 and Mar 1995

Lake Stemper - Hillsborough County



GUIDANCE AND MINIMUM LEVELS

TYF = Ten Year Flood = 62.6

HGL = High Guidance Level = 61.2

HML = High Minimum Level = 60.8

ML = Minimum Level = 59.4

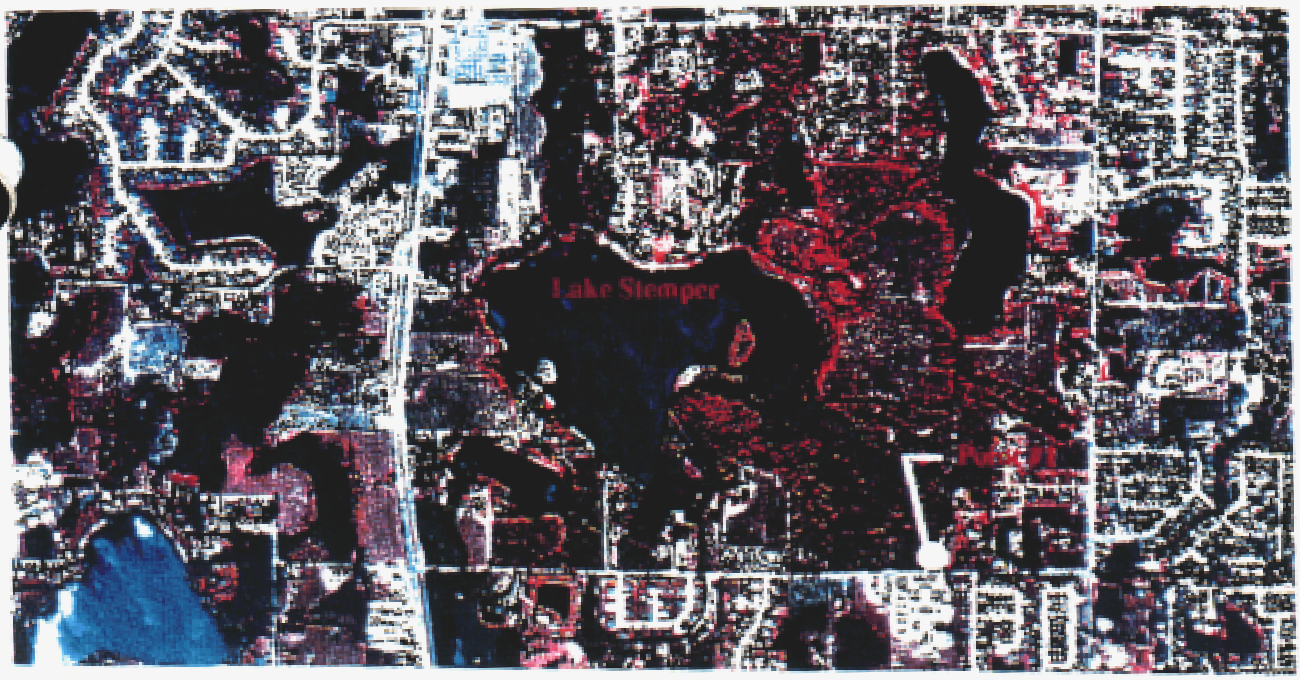
LGL = Low Guidance Level = 59.1

LAKE FEATURES

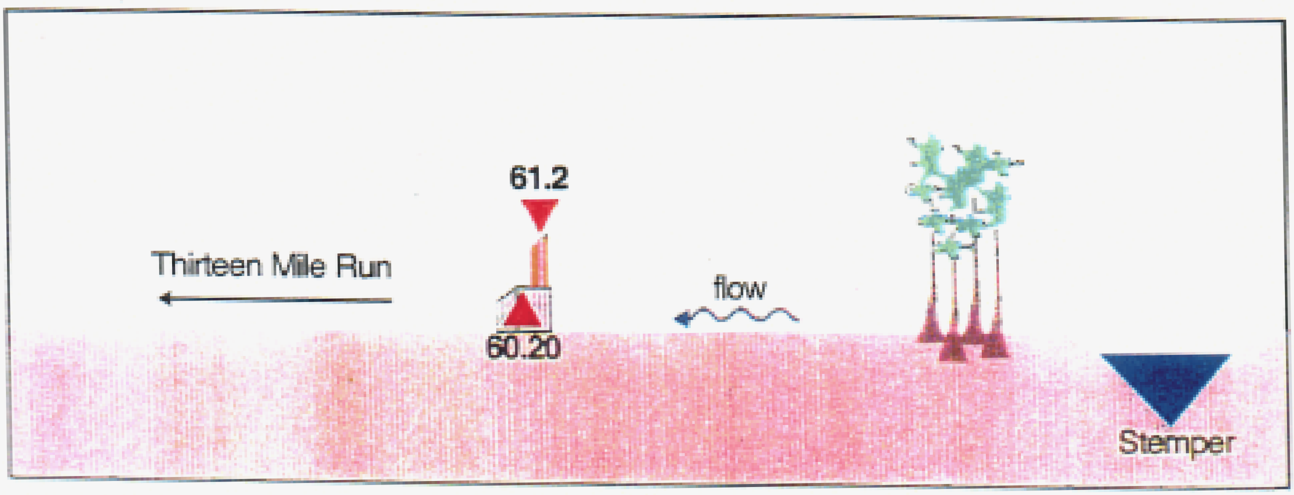
CP = Control Point Invert = 61.2

HI = Hydrologic Indicators = 61.2

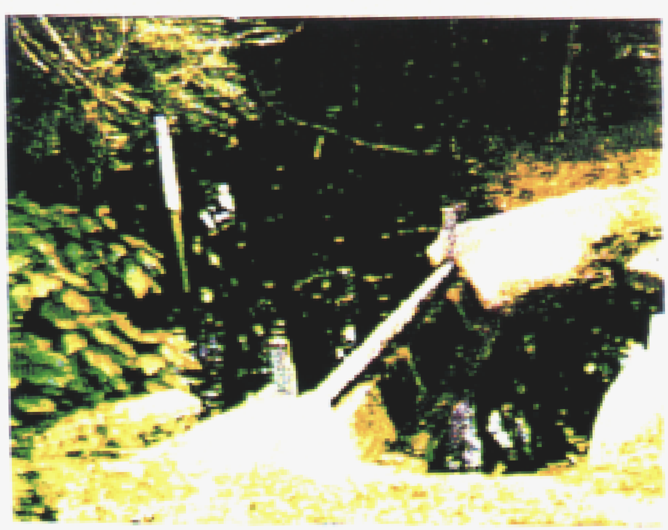
LFS = Lowest Floor Slab = 63.7



Aerial View of Outlet Conveyance System



Profile of Outlet Conveyance System



Point #1 - Weir With Boards Out

Sunset Lake

Sunset Lake has wetlands and is not structurally altered. For purposes of calculating the High Minimum and Minimum Level this lake is in Category 1. There are no historic data. Current data for the period from ? to ? were used to calculate the Current P10 and P50 elevations. However, during this period the lake has been augmented with groundwater. The Current Delta P10-P50 = 0.9', which is less than the RLWR50. The Historic P50 was calculated from the normal pool elevation minus 0.9'. The Current Delta P10-P90 = 2.4, which is greater than the RLWR90. The Low Guidance Level was calculated using the RLWR90 = 2.1.

Summary of Elevation Data (ft, NGVD)		Proposed Levels (ft, NGVD)	
LFS	35.8	10-yr	35.0
CP	35.1	HGL	34.8 *(NP)*
NP	34.8	HML	34.4
P50hist	33.9 *(NP-0.9')*	ML	33.0
Sig. change	33.0	LGL	32.7
*P10cur	33.2		
*P50cur	32.3		
*P90cur	30.8		

* Current percentile calculations are from augmented data.

Hydrologic Indicators of Normal Pool

Elevations of hydrologic indicators of normal pool were measured in a cypress wetland northeast of the lake.

Hydrologic indicator elevations for Sunset Lake on 3/30/98, water level: 33.6 ft, NGVD

HI	NP Height above WL (ft)	NP Elevation (ft, NGVD)
Cypress buttress	1.7	35.2
Cypress buttress	0.4	34.0
Cypress buttress	0.9	34.5
Cypress buttress	2.1	35.7
Cypress buttress	0.4	34.0
Cypress buttress	1.7	35.2
Cypress buttress	1.6	35.2
Average hydrologic indicator elevation (ft, NGVD)		34.8
Standard Deviation (σxn-1)		0.7

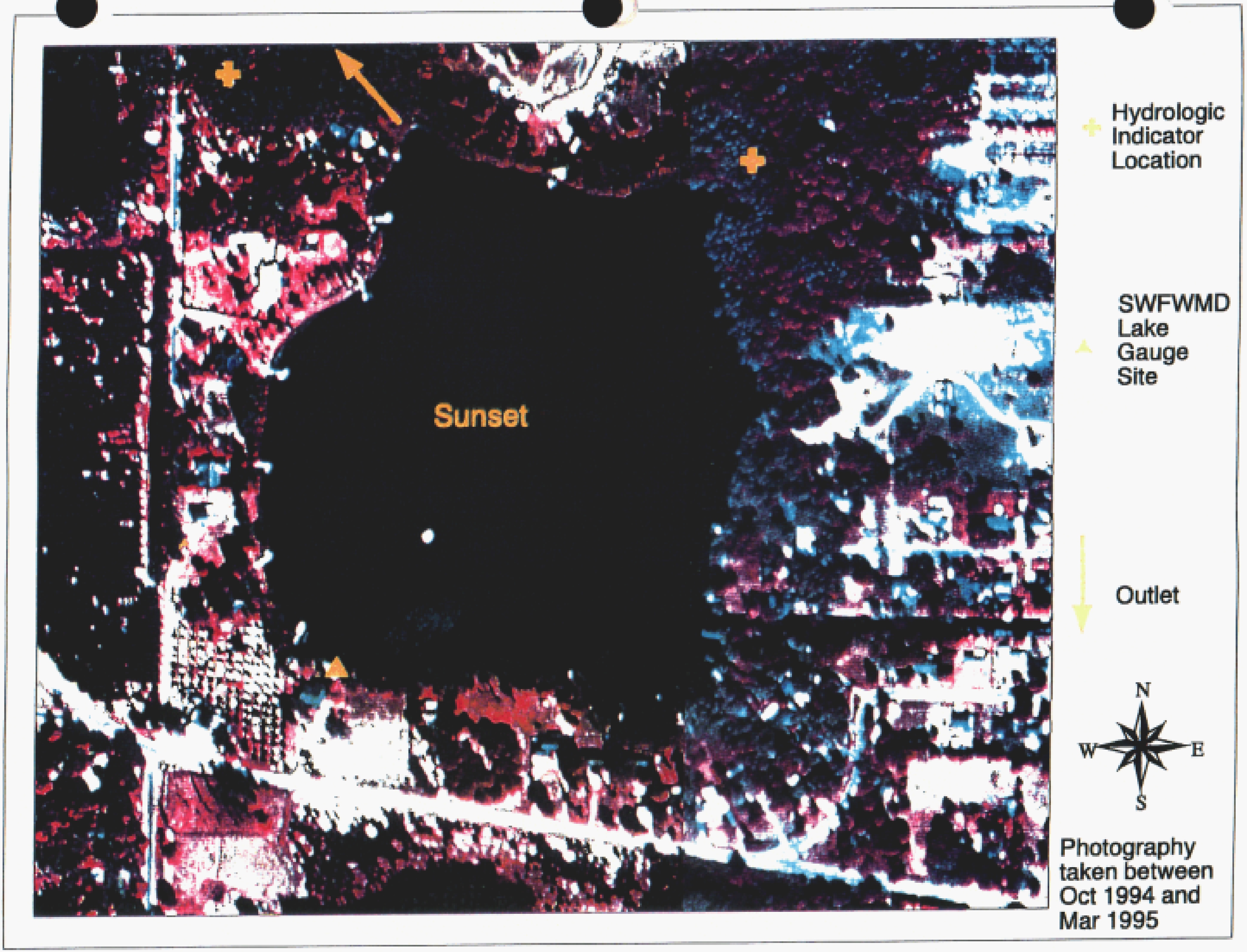
Structural Alteration/Control Point

Numbers identify points on the figure showing the outlet conveyance system of the lake.

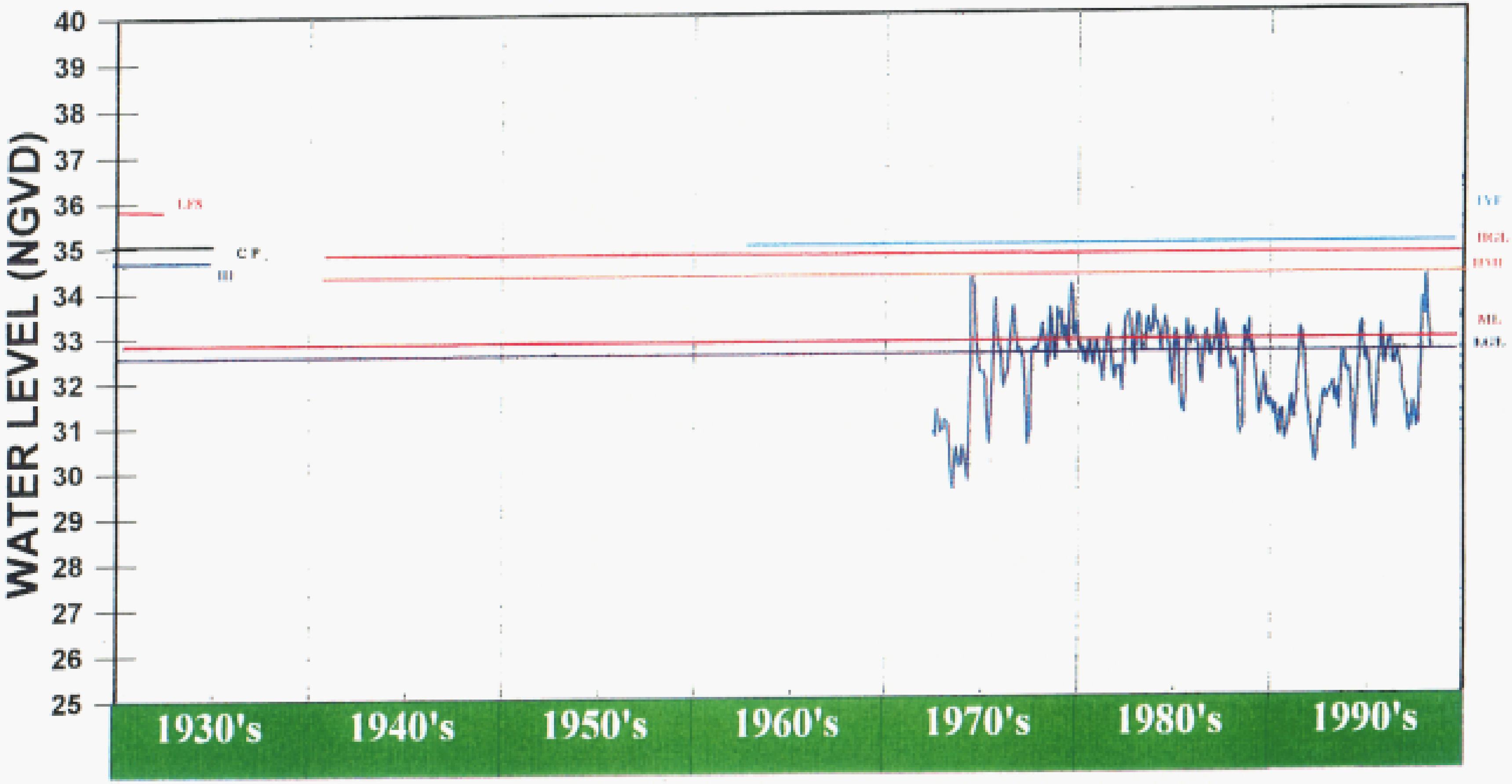
#1: 24" corrugated metal pipe under Burrell Road with inverts at the east and west ends of 30.73' NGVD 31.12' NGVD, respectively

#2: Control point - 36" corrugated metal pipe approximately halfway between Brown Lake and Boy Scout Road, with an invert at the east end of 35.13' NGVD and an invert on the west end of 34.90' NGVD

#3: 4.0' x 2.5' reinforced concrete elliptical pipe under Boy Scout Road with inverts on the west and east of 31.66' NGVD and 31.64' NGVD, respectively


Sunset
Hydrologic Indicator Location
SWFWMD Lake Gauge Site
Outlet
N
E
S
W
Photography taken between Oct 1994 and Mar 1995

Lake Sunset - Hillsborough County

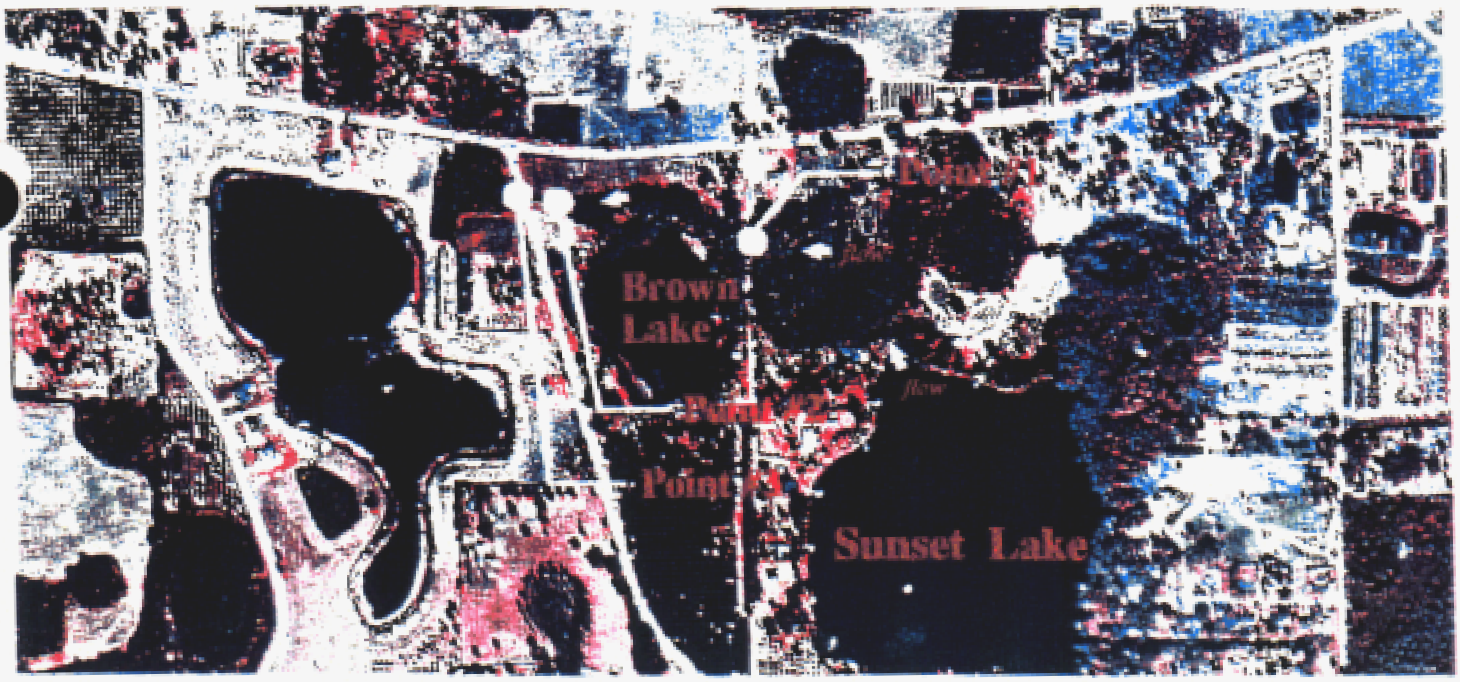


GUIDANCE AND MINIMUM

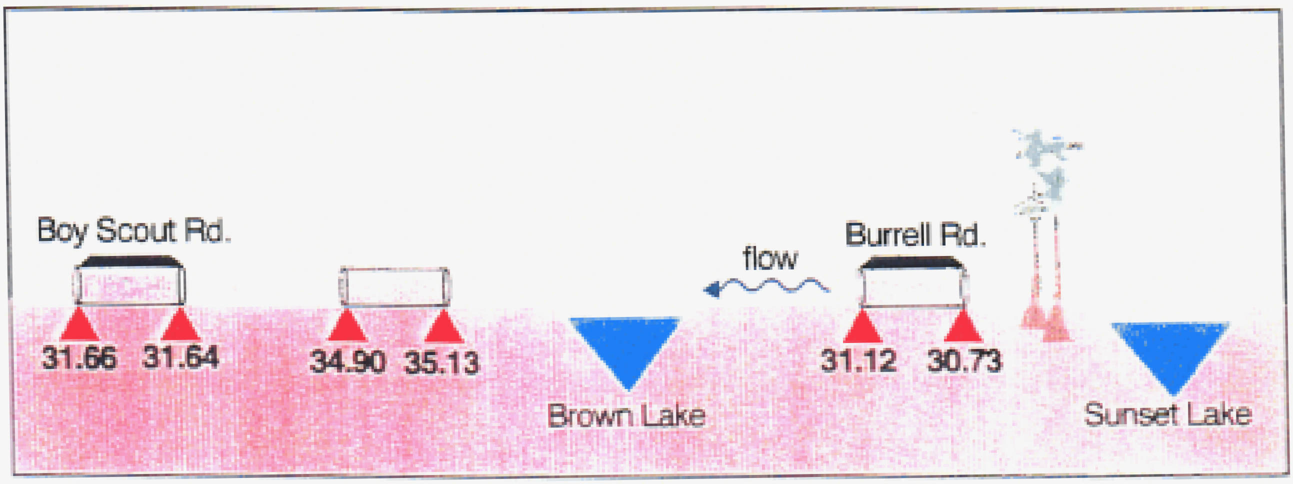
TYF = Ten Year Flood = 35.0
HGL = High Guidance Level = 34.7
HML = High Minimum Level = 34.3
ML = Minimum Level = 32.9
LGL = Low Guidance Level = 32.6

LAKE FEATURES

CP = Control Point Invert = 35.1
HI = Hydrologic Indicators = 34.7
LFS = Lowest Floor Slab = 35.8



Aerial View of Outlet Conveyance System



Profile of Outlet Conveyance System

Point #2 - 36 inch CMP

APPENDIX D
Summary Statistics
for
88 Lakes Reviewed

Table 1a. Summary statistics for lakes located in the Section 21/S. Pasco wellfield area.

NO	SECTION 21/S. PASCO LAKES	CUR. POR*	P10 CUR.	P50 CUR.	P90 CUR.	HIS. POR	P10 HIS.	P50 HIS.	P90 HIS.	Remarks**
1	ALLEN	1974-97	61.7	60.6	58.5					
2	BAY	1982-97	45.5	44.9	43					
3	BELL	1977-97	71.6	70.5	69.5					RL
4	BIG LAKE VIENNA	1986-97	68.8	67.6	66.7					RL
5	BIRD	1978-97	66.8	65.4	64.4					RL
6	BIRD (HILLS CO)	1977-97	49.6	47.7	46.2					ML
7	BRANT	1974-97	58	55.8	53.8					ML
8	BROOKER	1977-97	62.9	61.9	60.2					
9	BROWNS	1974-97	62.5	61.5	59.9					
10	CAMP	1968-95	62.7	59.1	55.2					ML
11	CARROLL	1974-97	36.2	35	34					
12	CHAPMAN	1974-97	51.1	50.3	49.4					
13	CHARLES	1974-97	52.9	51.9	49.7					
14	COOPER	1980-97	60.6	59.4	57.5	1946-56	61.6	61	60.2	RL
15	COW (EAST)	1978-97	78	77.6	76.8					RL
16	CRENSHAW	1974-97	55.5	53.5	50.7					
17	CRYSTAL	1985-97	59.8	57.7	55.7					ML
18	CURVE	1976-97	76.6	75.4	74					RL
19	DEER	1977-97	66.5	64.6	63					ML
20	DOSSON	1974-97	53.4	52.2	50.1					
21	ECKLES	1974-97	31.2	30.3	29.4					
22	ELLEN	1974-97	40.5	39.8	38.7	1946-56	40.6	39.9	38.9	RL
23	GENEVA (MUD)	1981-97	49.8	49.2	48.2					RL
24	GERACI	1991-93	IR	IR	IR					
25	GOOSENECK	1978-97	72.8	70.4	68.4					RL
26	HANNA	1974-97	61.3	60.35	58.5	1946-55	61.7	61.2	59.9	RL
27	HARVEY	1974-97	61.7	60.4	58.1					
28	HOBBS	1974-97	65.4	62.6	60.3	1947-62	67	65.9	63.8	RL
29	HOG ISLAND	1978-97	66	63.7	61.6					
30	KEENE	1978-97	62.4	61.3	59					
31	KELL	1974-97	65.9	65.3	63.7					
32	KING	1976-97	72.6	71.7	70.4					RL
33	LINDA	1969-97	65.7	64.5	62.6					
34	LIPSEY	1974-97	40.4	39.6	38.7					
35	MAGDALENE	1974-97	49.15	48.1	46.55					
36	MERRYWATER	1977-97	55.8	51	48.9					ML
37	MOON	1965-97	40	38.6	36.4					RL
38	PADGETT	1965-97	70.5	69.6	68.5					RL
39	PLATT	1974-97	49.5	48.2	46.4	1946-56	49.8	48.9	47.8	RL
39	REINHEIMER	1977-97	58.3	56.8	55.7					

NO	SECTION 21/S. PASCO. LAKES	CUR. POR*	P10 CUR.	P50 CUR.	P90 CUR.	HIS. POR	P10 HIS.	P50 HIS.	P90 HIS.	Remarks**
40	ROUND	1974-96	54.2	53.4	53.2					
41	SAPPHIRE	1993-97	IR	IR	IR					ML
42	SAXON	1983-97	70.5	69.6	68.5					RL
43	STARVATION	1974-97	51.8	48.9	45.7					
44	STEMPER	1974-97	61.1	59.45	57	1946-62	61.5	61	59.4	RL, ML
45	STRAWBERRY	1974-97	60.8	59.4	57.4					
46	TAMPA	1978-97	64.3	62.85	60.95					RL
47	THOMAS	1968-97	74.6	73.5	72.3					RL
48	THOMAS (HILLS)	1974-97	62.8	61.7	60					
49	TWIN	1977-97	31.2	30.8	30.6					
50	VAN DYKE	1974-96	55.7	55	53.4					
51	VIRGINIA	1977-97	61.5	59.5	57.5					
52	WHITE TROUT	1974-97	35.8	35	34.1					

Note:
Elevations = Ft. NGVD
IR = Incomplete Stage Record
* Post 1973 stage data used for current period unless lake defined as a reference lake
** ML = Minimum Level Lake
RL = Reference Lake

Table 1b. Summary statistics for lakes located within the Cosme-Odessa wellfield area.

No.	COSME-ODESSA LAKES	CUR. POR*	P10 CUR.	P50 CUR.	P90 CUR.	HIS. POR	P10 HIS.	P50 HIS.	P90 HIS.	Remarks**
1	ALICE	1971-97	40	37.9	36.2					ML
2	ARMISTEAD	1977-97	41.2	40.2	39.4					
3	ARTILLERY	1974-97	42.8	42.3	41.2					
4	BUCK	1972-97	32.1	31.3	29.8					
5	CALM	1965-97	49.2	47.5	45.1					
6	CHURCH	1964-97	35.7	33.8	30.8					
7	CRESCENT	1971-97	41.9	40.8	38.5					
8	CYPRESS	1993-97	IR	IR	IR					
9	ECHO	1971-96	IR	IR	IR					
10	ELIZABETH	1977-97	52.8	50.7	49.1					
11	FAIRY (MAURINE)	1977-97	33.4	32.4	30.8					
12	FERN	1977-97	43.1	42.3	41.8					
13	HALFMOON	1977-97	44.3	42.1	39.6					
14	HIAWATHA	1981-97	50.2	49.3	48.5					
15	HORSE	1964-97	45.4	42.6	38.8					
16	ISLAND FORD	1971-97	41	39.9	38.2					
17	JOSEPHINE	1986-97	44.3	43.7	42.2					
18	JUANITA	1971-97	41.7	39.4	35.9					ML
19	KEYSTONE	1964-97	41.5	40.6	39.3					
20	LECLARE	1977-97	50.6	48.9	47.6					
21	LITTLE	1964-97	45.3	43.8	40					
22	LITTLE MOON	1977-97	SR	SR	SR					
23	MINNIOLA	1981-97	49.8	49.3	48.2					RL
24	MOUND	1972-97	50.2	49.5	48.4					
25	OSCEOLA	1964-97	46.4	45.2	43.9					
26	PARKER (ANN)	1969-97	48	46.8	45.6					RL
27	PRETTY	1971-97	44.1	43.1	41.9					
28	RAINBOW	1971-97	39.1	36.3	34					ML
29	RALEIGH	1964-97	40.5	37.5	30.6					
30	ROCK	1977-97	44.35	43.4	41.95					
31	ROGERS	1964-96	37.9	35.7	29.9					
32	SEMINOLE	1969-97	48.2	46.9	45.9					RL
33	SUNSET	1972-97	33.2	32.3	30.8					ML

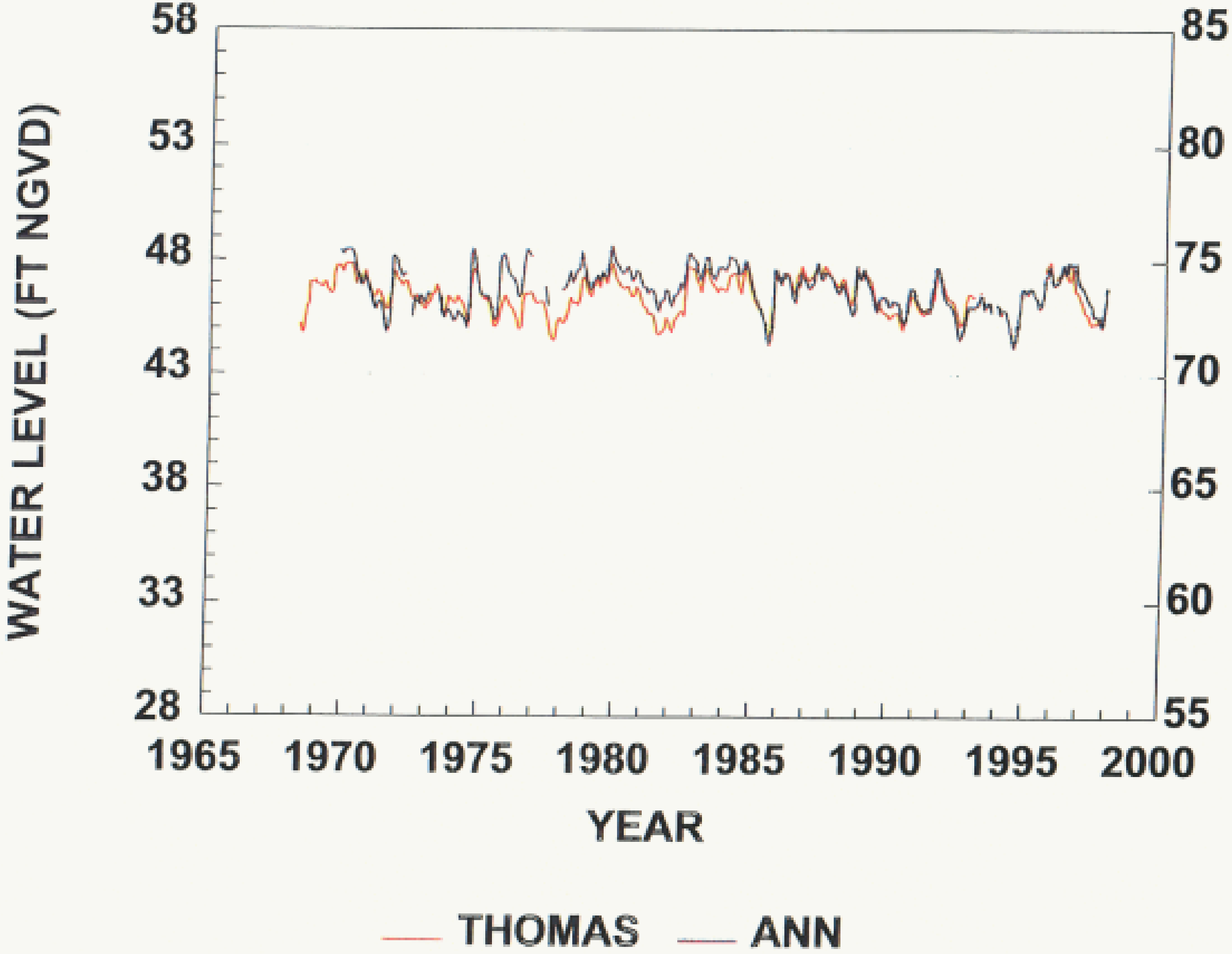
No	COSME-ODESSA LAKES	CUR. POR*	P10 CUR.	P50 CUR.	P90 CUR.	HIS. POR	P10 HIS.	P50 HIS.	P90 HIS.	Remarks**
34	TAYLOR	1971-97	38.1	37.1	35.5					
35	TURKEY FORD	1974-97	52.5	51.3	50.5					
36	VELBURTON	1977-97	IR	IR	IR					

Note:
Elevations = Ft. NGVD
IR = Incomplete Stage Record
* Post 1963 stage data used for current period unless lake defined as a reference lake
** ML = Minimum Level Lake
RL = Reference Lake

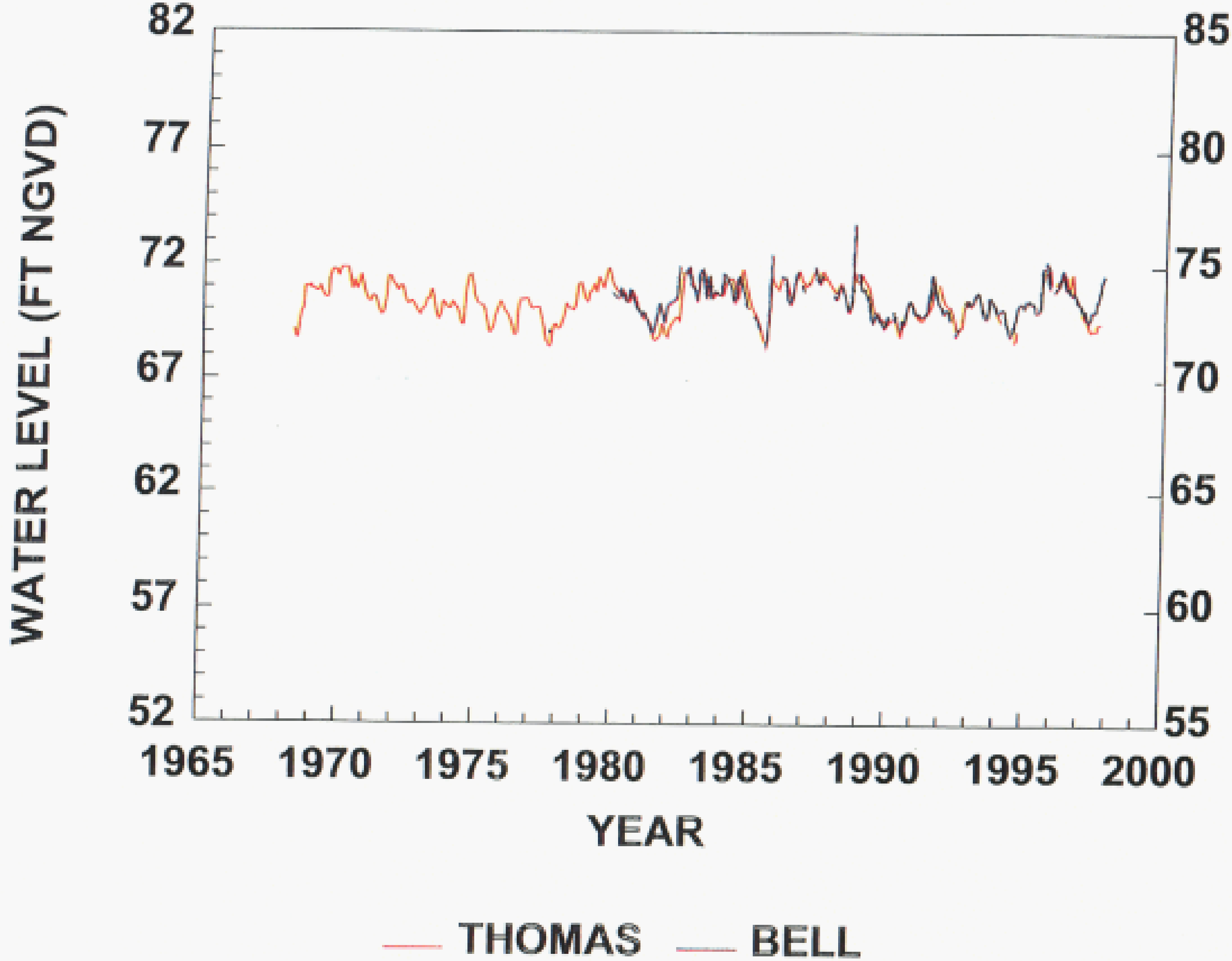
March 1999

APPENDIX E
Comparison of Lake Thomas
to
14 Other Lakes Located in the Land O' Lakes Region

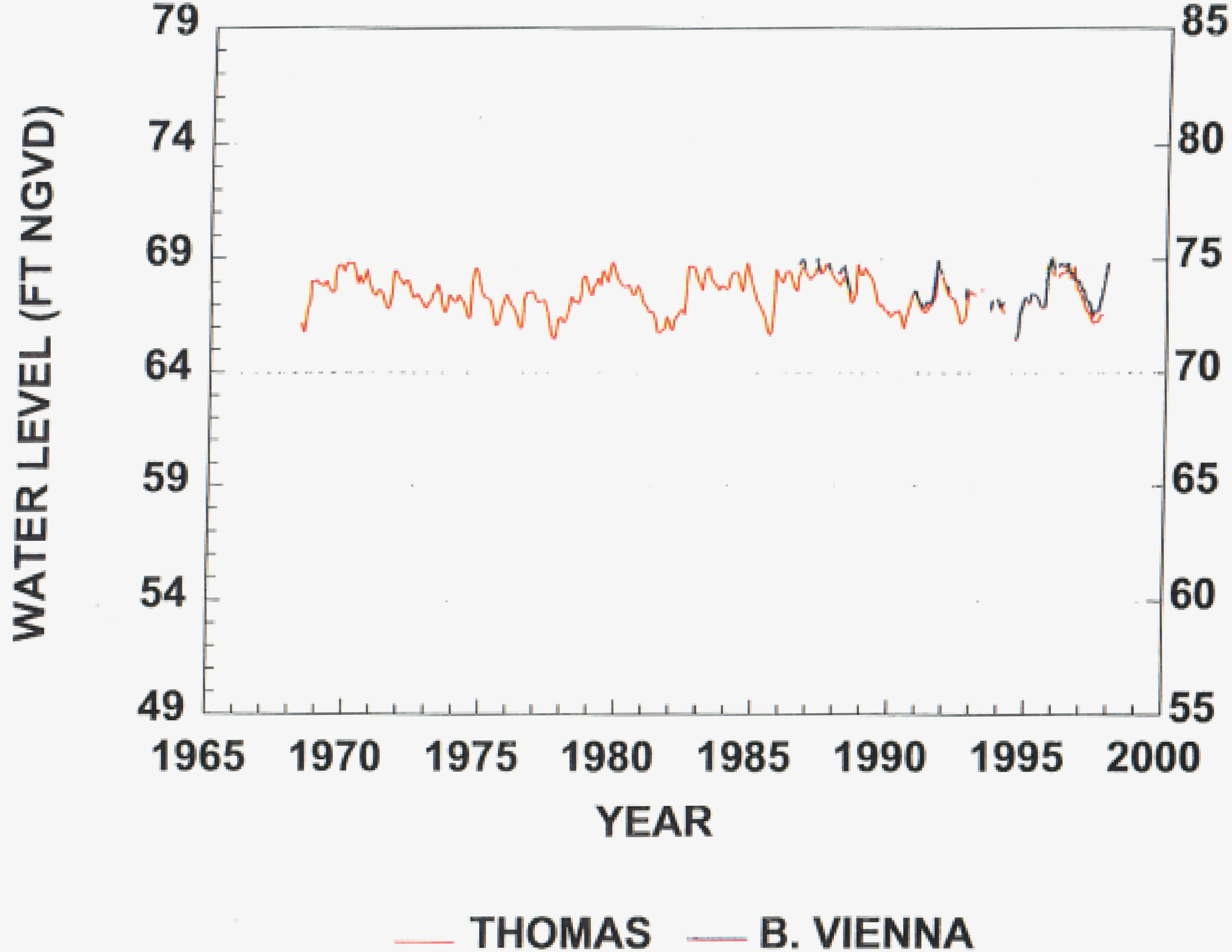
LAKE ANN vs LAKE THOMAS
STAGE HISTORY



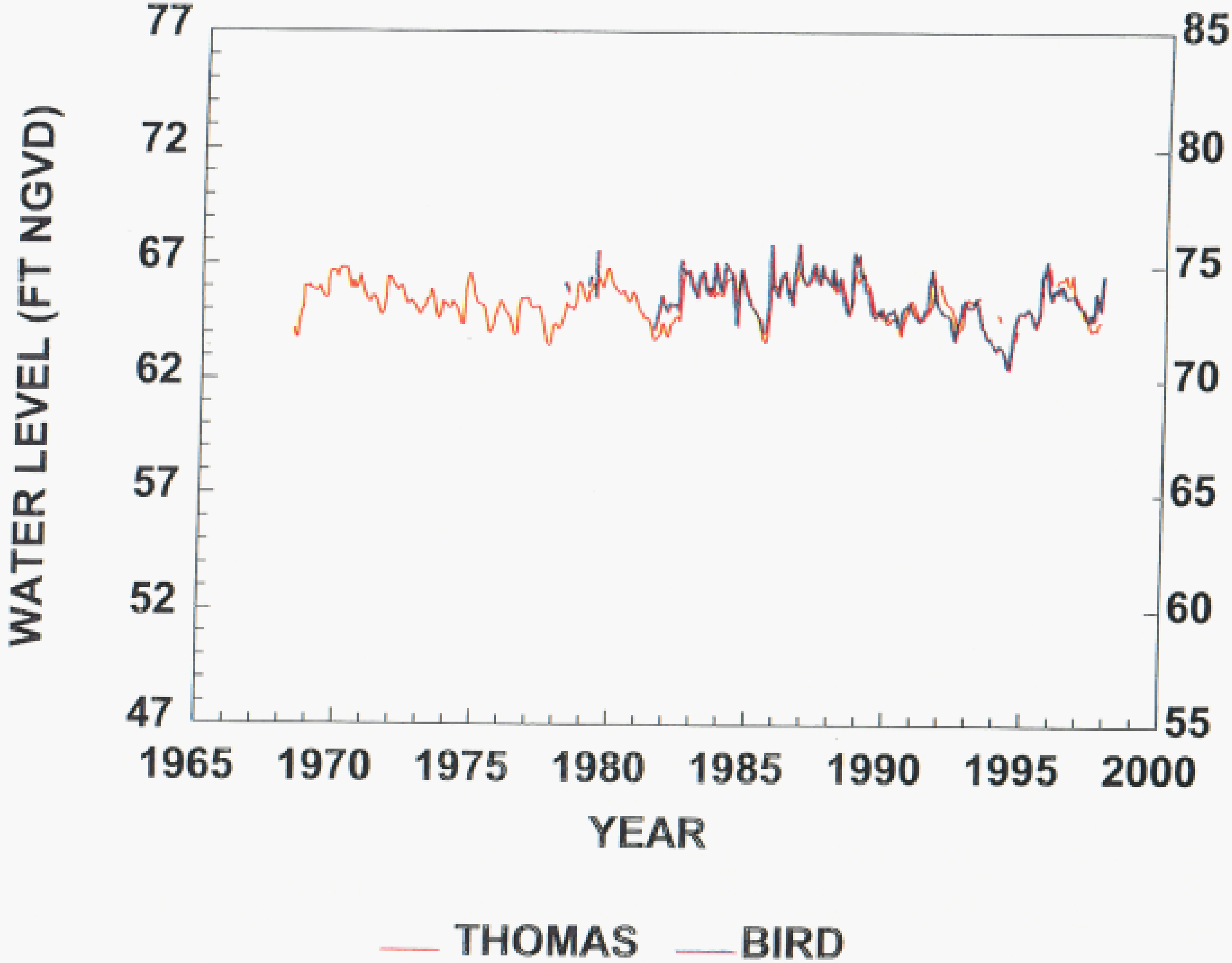
LAKE BELL vs LAKE THOMAS
STAGE HISTORY



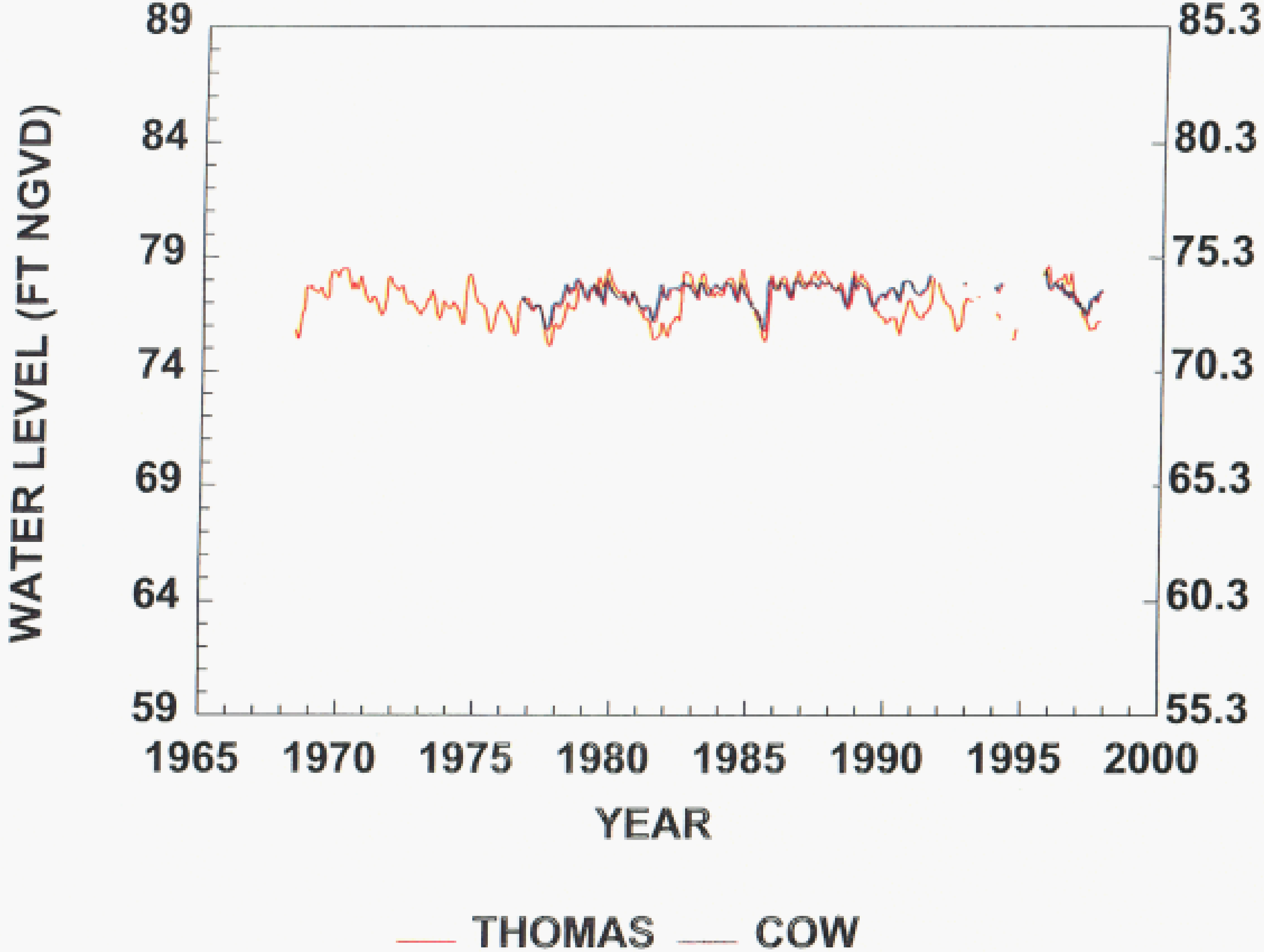
LAKE BIG VIENNA vs LAKE THOMAS
STAGE HISTORY



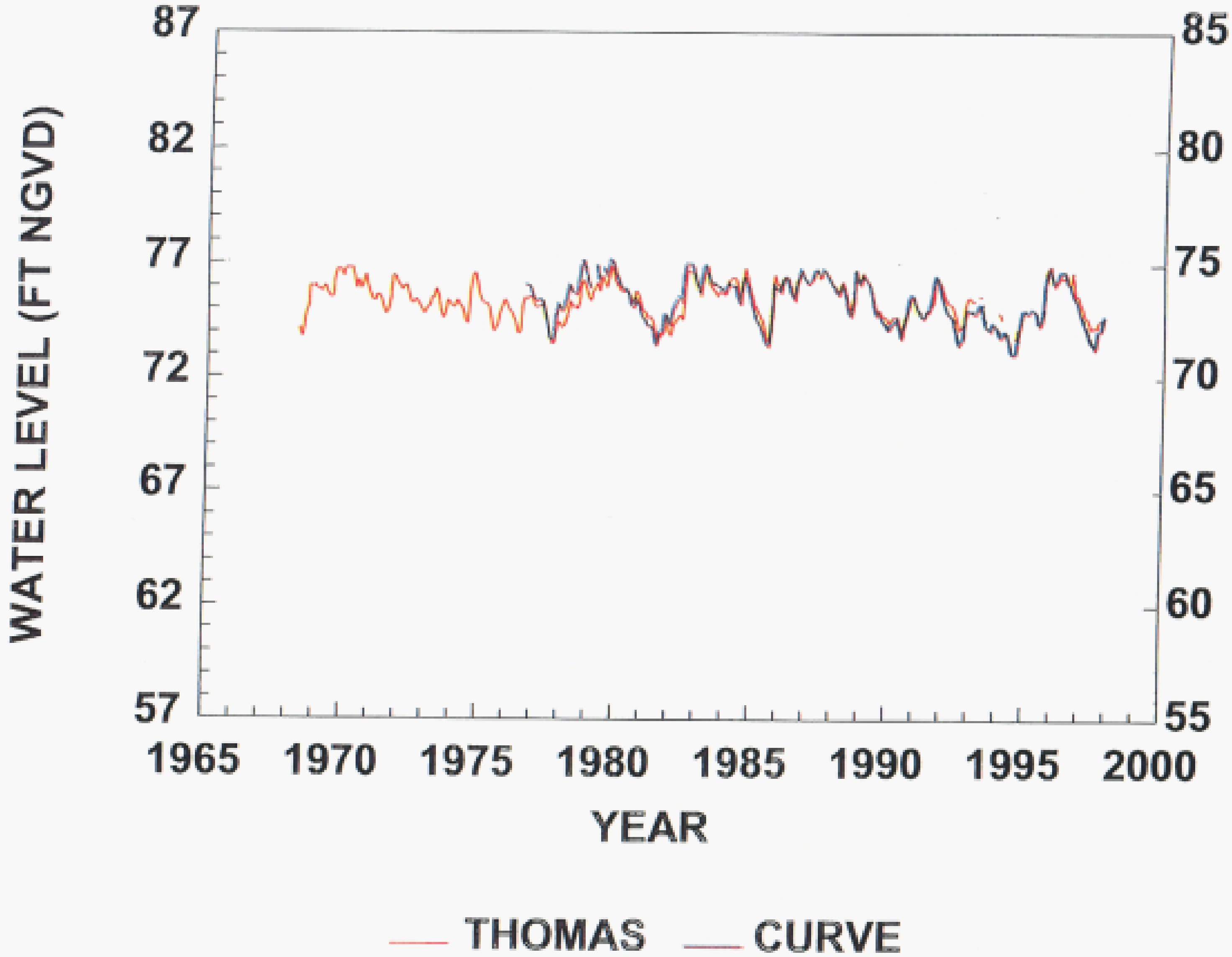
LAKE BIRD (PASCO CO) vs LAKE THOMAS
STAGE HISTORY



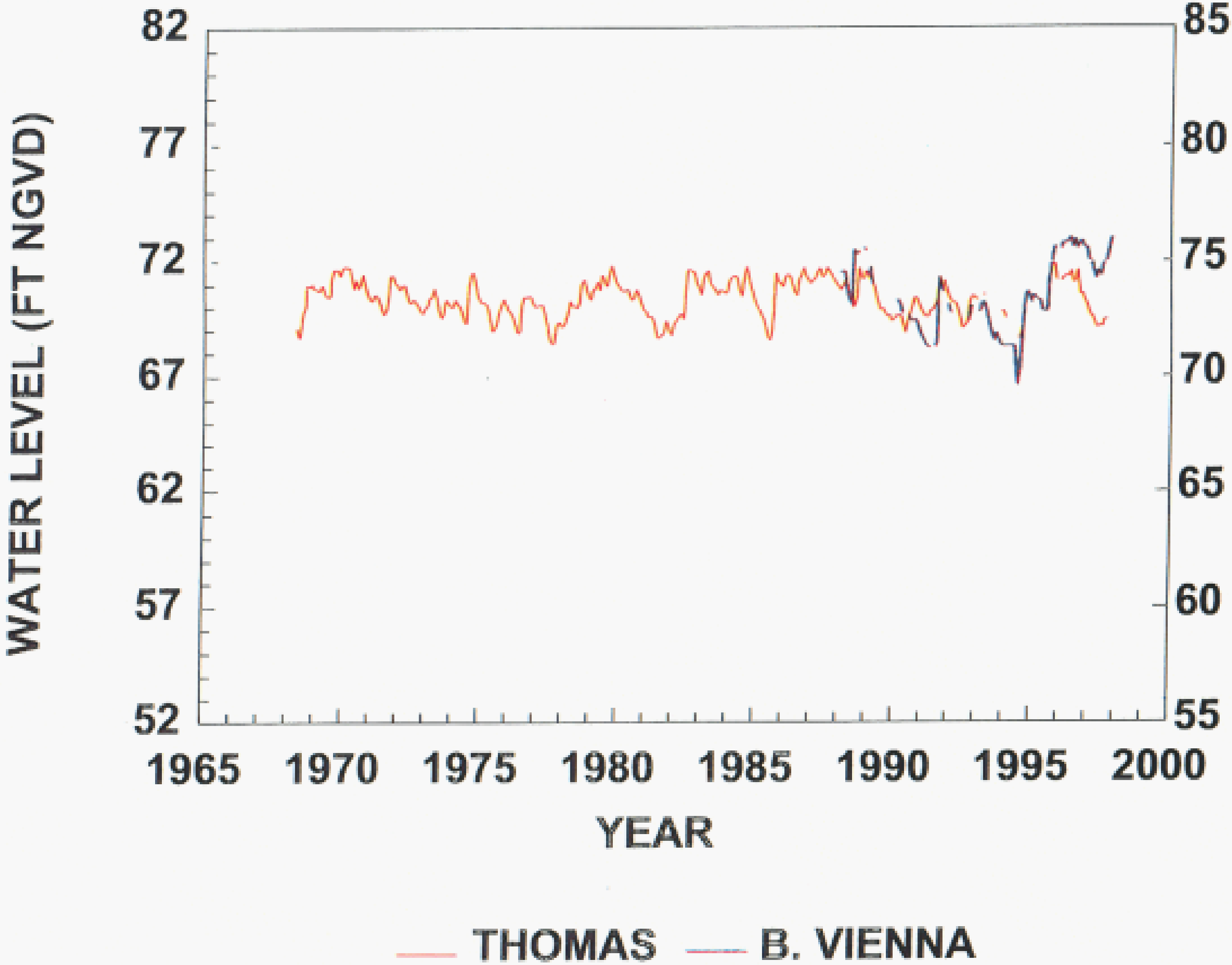
LAKE COW vs LAKE THOMAS
STAGE HISTORY



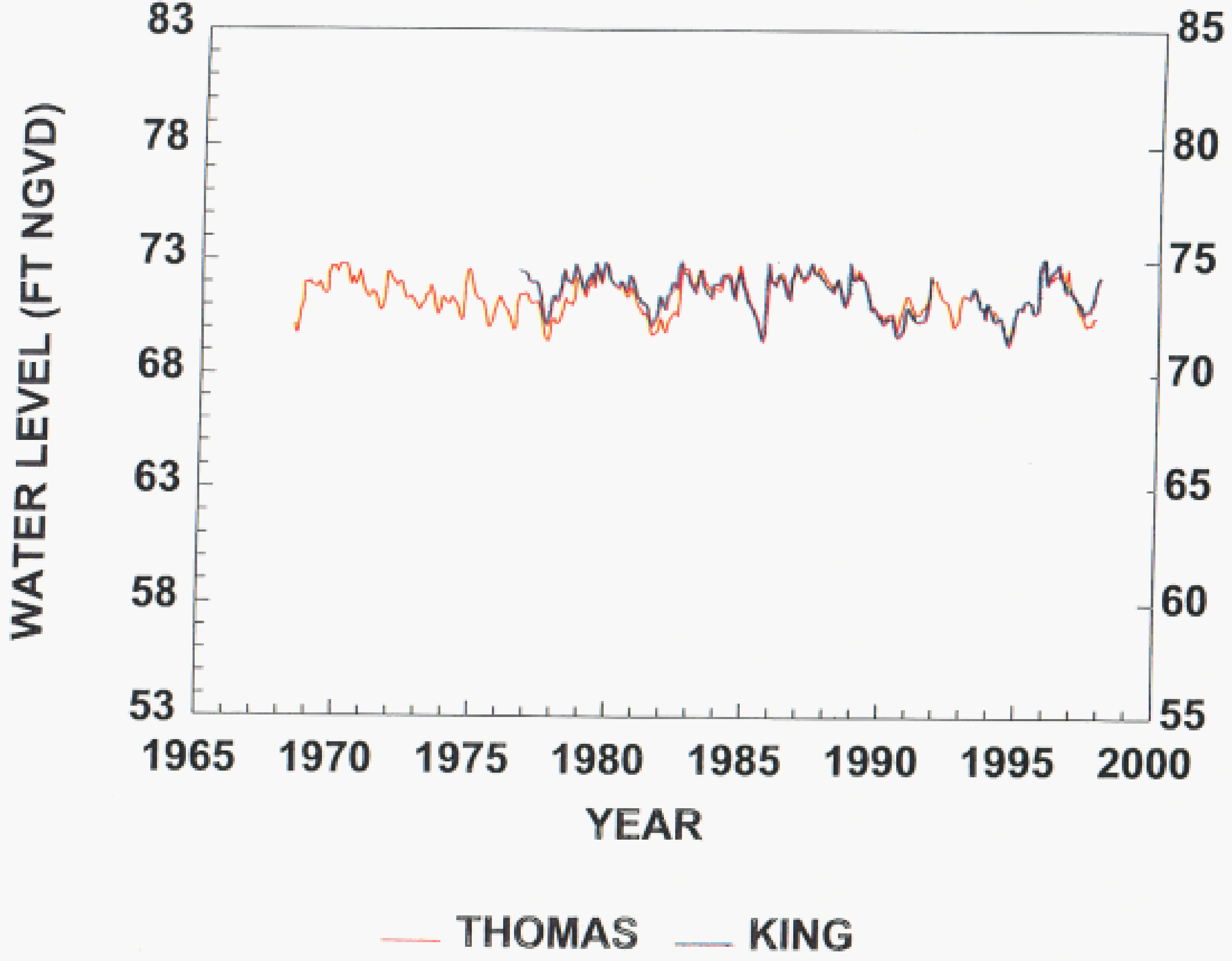
LAKE CURVE vs LAKE THOMAS
STAGE HISTORY



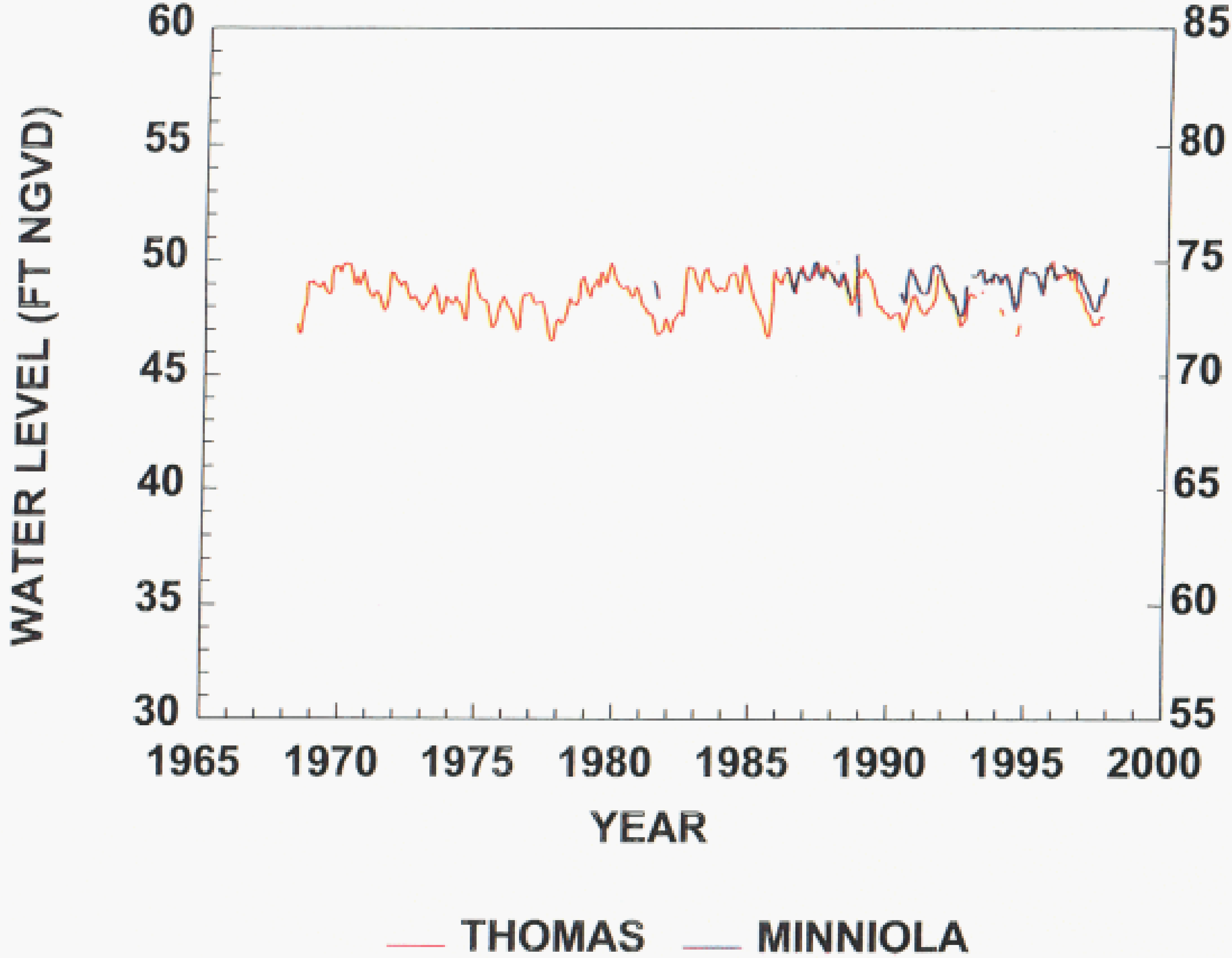
LAKE GOOSENECK vs LAKE THOMAS
STAGE HISTORY



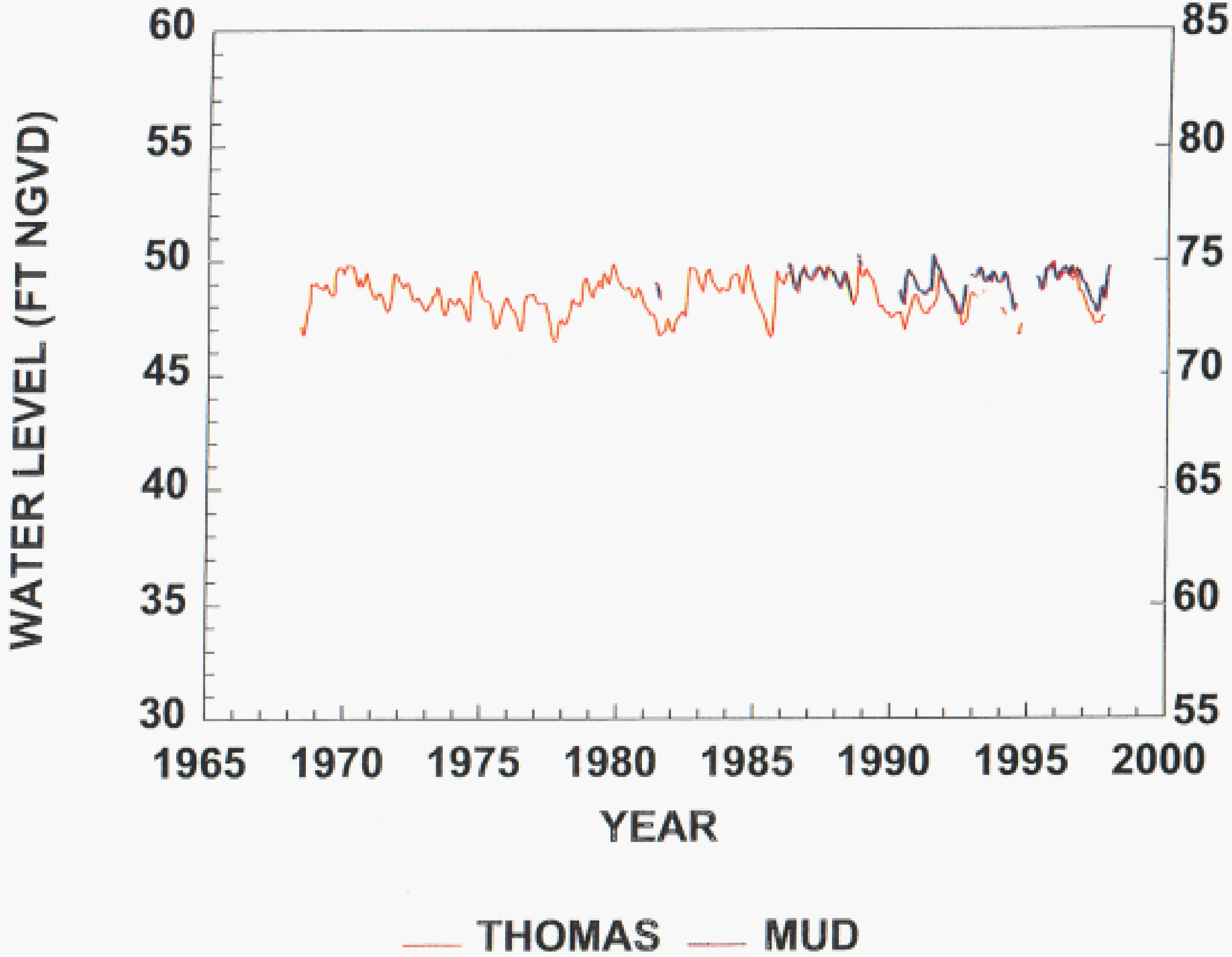
LAKE KING vs LAKE THOMAS
STAGE HISTORY



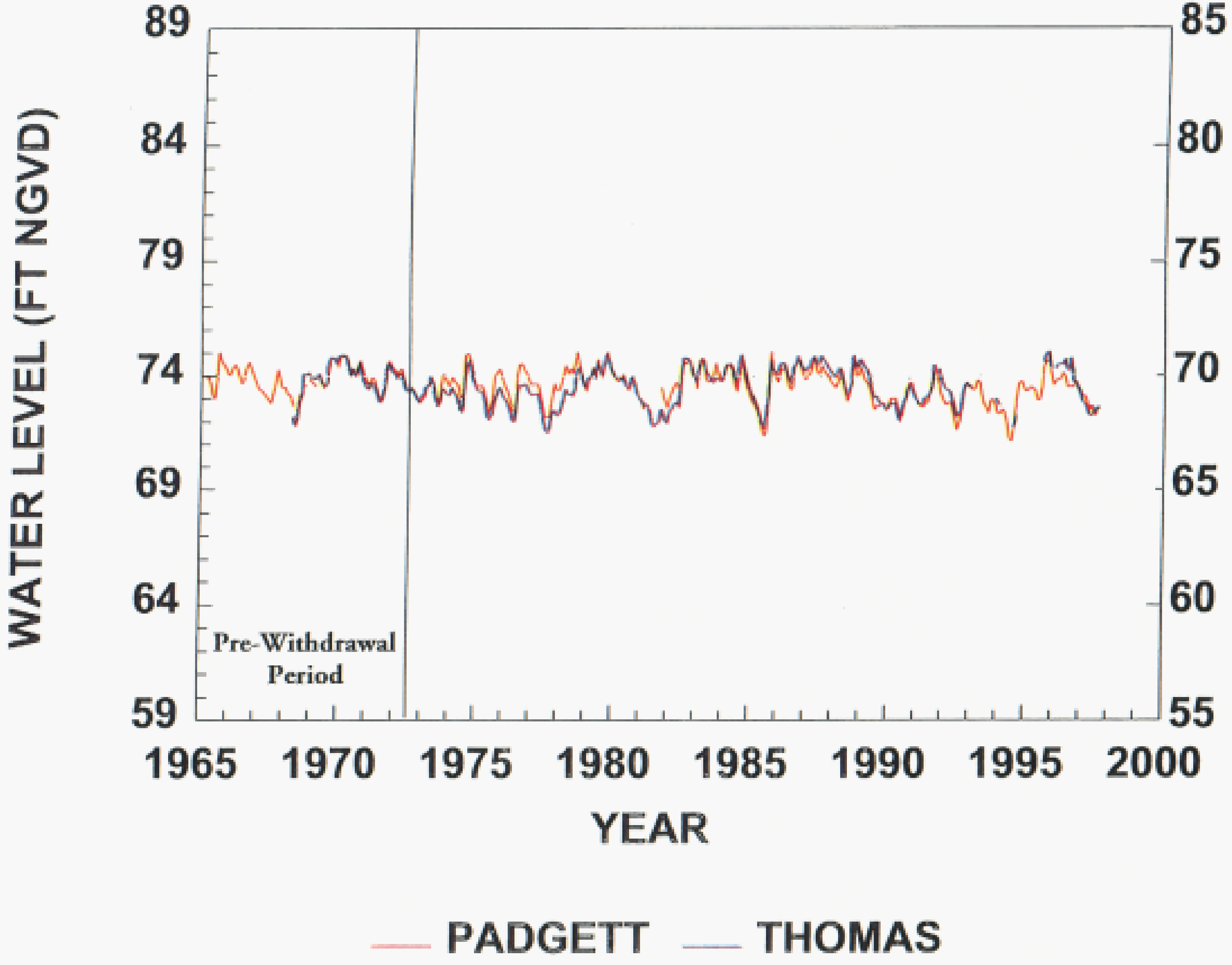
LAKE MINNIOLA vs LAKE THOMAS
STAGE HISTORY



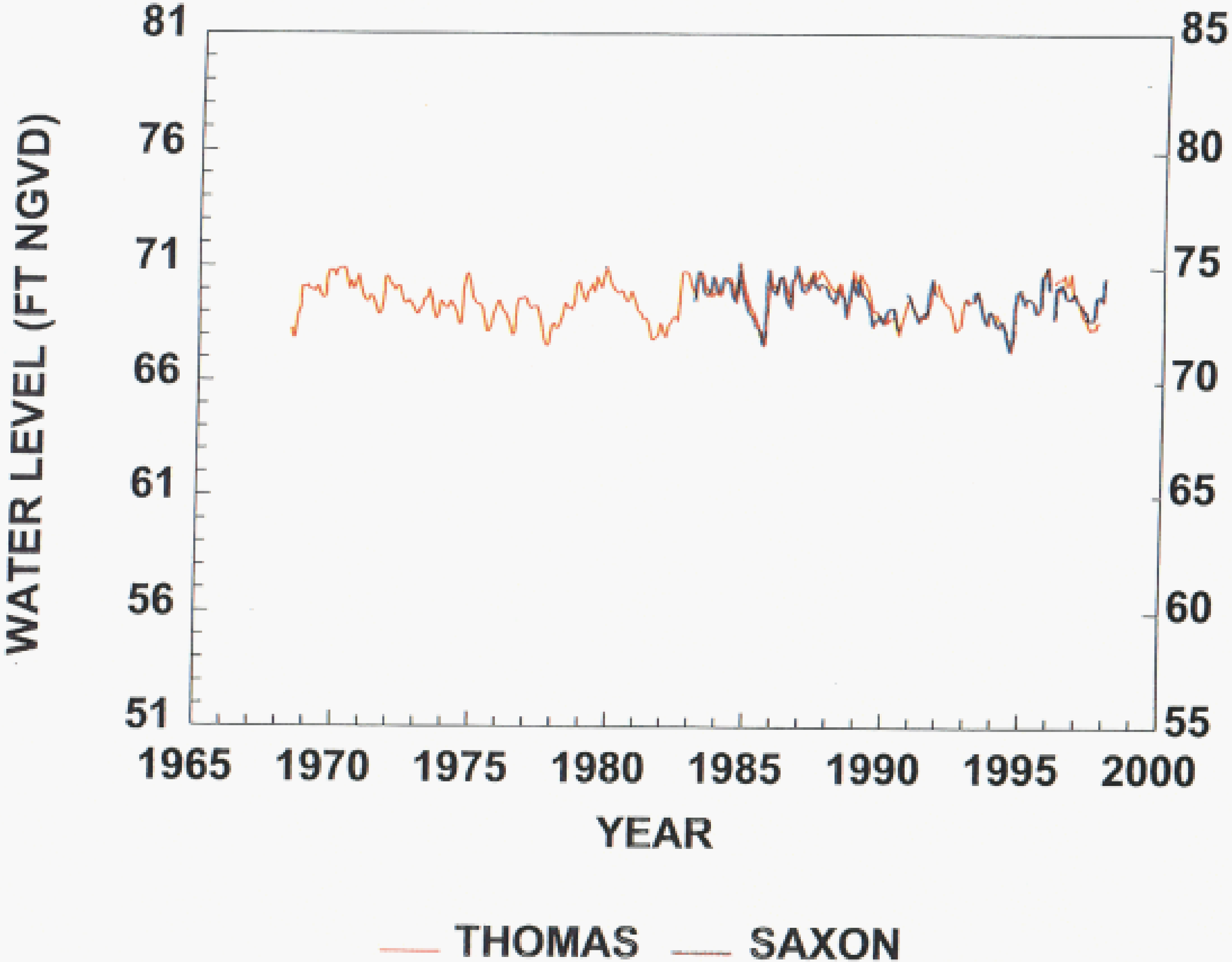
LAKE MUD vs LAKE THOMAS
STAGE HISTORY



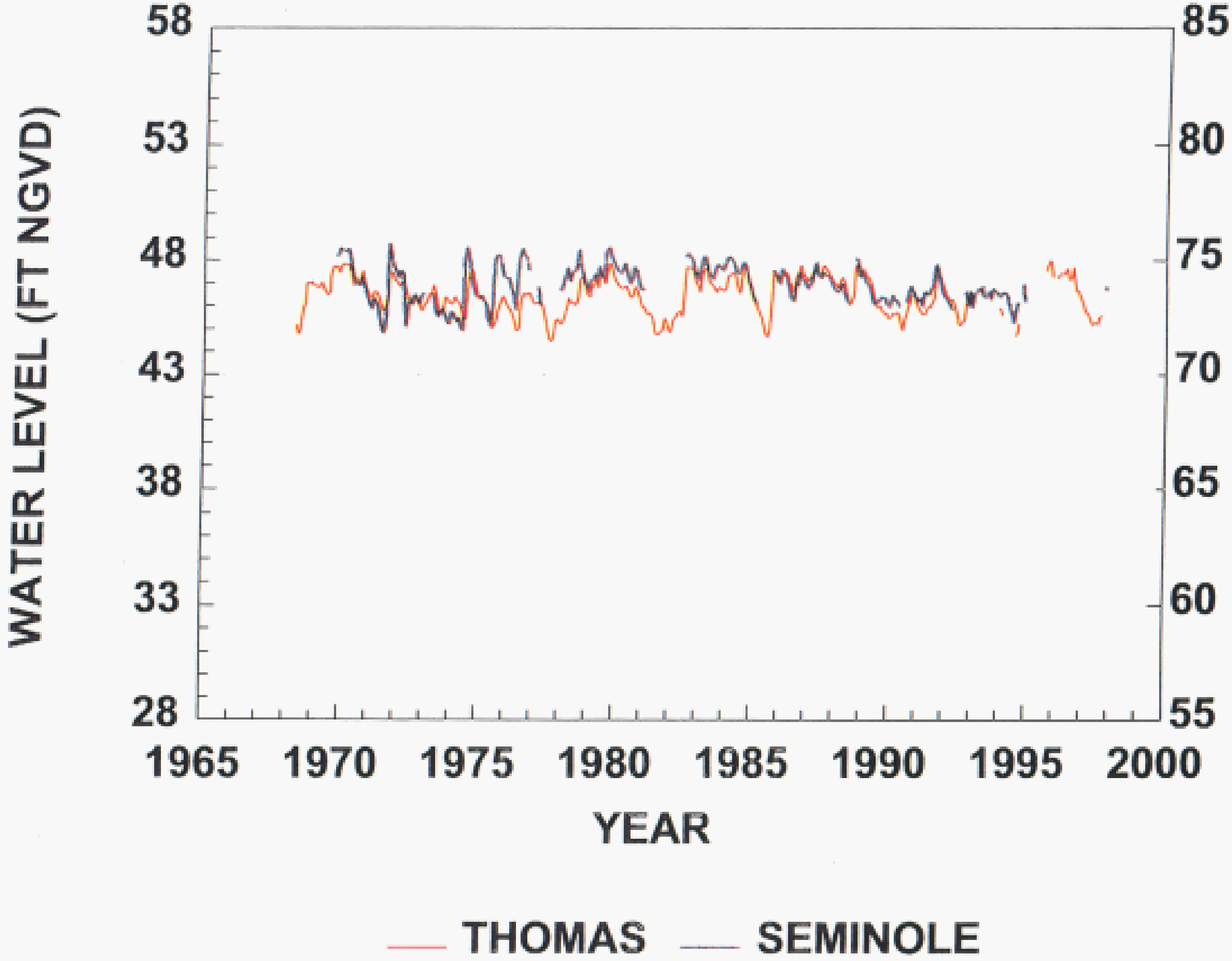
LAKE PADGETT vs LAKE THOMAS
STAGE HISTORY



LAKE SAXON vs LAKE THOMAS
STAGE HISTORY



LAKE SEMINOLE (PASCO) vs LAKE THOMAS
STAGE HISTORY



LAKE TAMPA vs LAKE THOMAS
STAGE HISTORY