Adopted Minimum and Guidance Levels for Lake Hobbs in Hillsborough County, Florida

March 15, 2015

Water Resources Bureau
Resource Evaluation Section
Southwest Florida Water Management District

Adopted Minimum and Guidance Levels for Lake Hobbs in Hillsborough County, Florida

March 15, 2015

By: Christina Uranowski
Michael Hancock
Doug Leeper

Water Resources Bureau
Resource Evaluation Section
Southwest Florida Water Management District
Brooksville, Florida 34604-6899

Cover: Hobbs Lake taken June 2011 by lake resident C.D. Bellengsley.

Table of Contents

Introduction

Reevaluation of Minimum Flows and Levels

This report describes the development of minimum levels for Lake Hobbs in Hillsborough County, Florida. The levels were developed based on the reevaluation of minimum levels (and guidance) levels approved by the Southwest Florida Water Management District Governing Board and previously adopted into District rules in October 2003. The current adopted minimum and guidance levels represent necessary revisions to the previously adopted levels.

Lake Hobbs was selected for reevaluation based on development of modeling tools used to simulate natural water level fluctuations in lake basins that were not available when the previously adopted minimum levels for the lake were developed. The previously adopted levels for Lake Hobbs were also reevaluated to support ongoing District considerations of minimum flows and levels in the northern Tampa Bay Water Use Caution Area, a region of the District where recovery strategies are being implemented to support recovery to minimum flow and level thresholds.

Minimum Flows and Levels Program Overview

Legal Directives

Section 373.042, Florida Statutes (F.S.) directs the Department of Environmental Protection or the water management districts to establish minimum flows and levels for lakes, wetlands, rivers and aquifers. Section 373.042(1)(a), F.S., states that “[t]he minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." Section 373.042(1)(b), F.S., defines the minimum water level of an aquifer or surface water body as "…the level of groundwater in an aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area." Minimum flows and levels are established and used by the Southwest Florida Water Management District (SWFWMD or District) for water resource planning, as one of the criteria used for evaluating water use permit applications, and for the design, construction and use of surface water management systems.

Established minimum flows and levels are key components of resource protection, recovery and regulatory compliance, as Section 373.0421(2) F.S., requires the development of a recovery or prevention strategy for water bodies “[i]f the existing flow or level in a water body is below, or is projected to fall within 20 years below, the applicable minimum flow or level established pursuant to S. 373.042.” Section 373.0421(2)(a), Fla. Stat, requires that recovery or prevention strategies be developed to: "(a) [a]chieve recovery to the established minimum flow or level as soon as practicable; or (b) [p]revent the existing flow or level from falling below the established minimum flow or level."

Periodic reevaluation and, as necessary, revision of established minimum flows and levels are required by Section 373.0421(3), F.S.

Minimum flows and levels are to be established based upon the best information available, and when appropriate, may be calculated to reflect seasonal variations (Section 373.042(1), F.S.). Also, establishment of minimum flows and levels is to involve consideration of, and at the governing board or department's discretion, may provide for the protection of nonconsumptive uses (Section 373.042(1), F.S.). Consideration must also be given to "…changes and structural alterations to watersheds, surface waters and aquifers, and the effects such changes or alterations have had, and the constraints such changes or alterations have placed, on the hydrology of the affected watershed, surface water, or aquifer…", with the requirement that these considerations shall not allow significant harm caused by withdrawals (Section 373.0421(1)(a), F.S.). Sections 373.042 and 373.0421 provide additional information regarding the prioritization and scheduling of minimum flows and levels, the independent scientific review of scientific or technical data, methodologies, models and scientific and technical assumptions employed in each model used to establish a minimum flow or level, and exclusions that may be considered when setting identifying the need for establishment of minimum flows and levels.

The Florida Water Resource Implementation Rule, specifically Rule 62-40.473, Florida Administrative Code (F.A.C.), provides additional guidance for the establishment of minimum flows and levels, requiring that "…consideration shall be given to natural seasonal fluctuations in water flows or levels, nonconsumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic and wetlands ecology, including: a) Recreation in and on the water; b) Fish and wildlife habitats and the passage of fish; c) Estuarine resources; d) Transfer of detrital material; e) Maintenance of freshwater storage and supply; f) Aesthetic and scenic attributes; g) Filtration and absorption of nutrients and other pollutants; h) Sediment loads; i) Water quality; and j) Navigation."

Rule 62-40.473, F.S., also indicates that "[m]inimum flows and levels should be expressed as multiple flows or levels defining a minimum hydrologic regime, to the extent practical and necessary to establish the limit beyond which further withdrawals would be significantly harmful to the water resources or the ecology of the area as provided in Section 373.042(1), F.S." It further notes that, "…a minimum flow or level need not be expressed as multiple flows or levels if other resource protection tools, such as reservations implemented to protect fish and wildlife or public health and safety, that provide equivalent or greater protection of the hydrologic regime of the water body, are developed and adopted in coordination with the minimum flow or level." The rule also includes provision addressing: protection of minimum flows and levels during the construction and operation of water resource projects; the issuance of permits pursuant to Section 373.086 and Parts II and IV of Chapter 373, F.S.; water shortage declarations; development of recovery or prevention strategies, development and updates to a minimum flow and level priority list and schedule, and peer review for minimum flows and levels establishment.

Development of Minimum Lake Levels in the Southwest Florida Water Management District

Programmatic Description and Major Assumptions

Since the enactment of the Florida Water Resources Act of 1972 (Chapter 373, F. S.), in which the legislative directive to establish minimum flows and levels originated, and following subsequent modifications to this directive and adoption of relevant requirements in the Water Resource Implementation Rule, the District has actively pursued the adoption, *i.e.*, establishment of minimum flows and levels for priority water bodies. The District implements established minimum flows and levels primarily through its water supply planning, water use permitting and environmental resource permitting programs, and through the funding of water resource and water supply development projects that are part of a recovery or prevention strategy. The District's Minimum Flow and Levels program addresses all relevant requirements expressed in the Florida Water Resources Act and the Water Resource Implementation Rule.

A substantial portion of the District's organizational resources has been dedicated to its Minimum Flows and Levels Program, which logistically addresses six major tasks: 1) development and reassessment of methods for establishing minimum flows and levels; 2) adoption of minimum flows and levels for priority water bodies (including the prioritization of water bodies and facilitation of public and independent scientific review of proposed minimum flows and levels and methods used for their development); 3) monitoring and compliance evaluations; 4) development and implementation of recovery strategies; 5) minimum flows and levels compliance reporting; and 6) ongoing support for minimum flow and level regulatory concerns and prevention strategies. Many of these tasks are discussed or addressed in this minimum levels report for Lake Hobbs; additional information on all tasks associated with the District's Minimum Flows and Levels Program is summarized by Hancock *et al.* (2010).

The District's MFLs Program is implemented based on a three fundamental assumptions. First, it is assumed that many water resource values and associated features are dependent upon and affected by long-term hydrology and/or changes in long-term hydrology. Second, it is assumed that relationships between some of these variables can be quantified and used to develop significant harm thresholds or criteria that are useful for establishing MFLs. Third, the approach assumes that alternative hydrologic regimes may exist that differ from non-withdrawal impacted conditions but are sufficient to protect water resources and the ecology of these resources from significant harm.

Support for these assumptions is provided by a large body of published scientific work addressing relationships between hydrology, ecology and human-use values associated with water resources (e.g., see reviews and syntheses by Postel and Ricther 2003, Wantzen *et al.* 2008, Poff *et al.* 2010, Poff and Zimmerman 2010). This body of knowledge has been used by the District and other water management districts within the state to identify significant harm thresholds or criteria supporting development of minimum flows and levels for hundreds of Florida water bodies, as summarized in the numerous publications associated with these efforts (e.g., SFWMD 2000, 2006, Flannery *et al*. 2002, SRWMD 2004, 2005, Neubauer *et al.* 2008, Mace 2009).

With regard to the assumption associated with alternative hydrologic regimes, consider a historic condition for an unaltered river or lake system with no local groundwater or surface water withdrawal impacts. A new hydrologic regime for the system would be associated with each increase in water use, from small withdrawals that have no measurable effect on the historic regime to large withdrawals that could substantially alter the regime. A threshold hydrologic regime may exist that is lower or less than the historic regime, but which protects the water resources and ecology of the system from significant harm. This threshold regime could conceptually allow for water withdrawals, while protecting the water resources and ecology of the area. Thus, MFLs may represent minimum acceptable rather than historic or potentially optimal hydrologic conditions.

Consideration of Changes and Structural Alterations and Environmental Values

When establishing minimum flows and levels, the District considers "…changes and structural alterations to watersheds, surface waters and aquifers, and the effects such changes or alterations have had, and the constraints such changes or alterations have placed, on the hydrology of the affected watershed, surface water, or aquifer…" in accordance with Section 373.0421(1)(a), F. S. Also, as required by statute, the District does not establish minimum flows and levels that would allow significant harm caused by withdrawals when considering the changes, alterations and their associated effects and constraints. These considerations are based on review and analysis of best available information, such as water level records, environmental and construction permit information, water control structure and drainage alteration histories, and observation of current site conditions.

When establishing, reviewing or implementing minimum flows and levels, considerations of changes and structural alterations may be used to:

- adjust measured flow or water level historical records to account for existing changes/alterations;
- model or simulate flow or water level records that reflect long-term conditions that would be expected based on existing changes/alterations and in the absence of measurable withdrawal impacts;
- develop or identify significant harm standards, thresholds and other criteria;
- aid in the characterization or classification of lake types or classes based on the changes/alterations;
- evaluate the compliance status for water bodies with proposed or established minimum flows and levels (*i.e.*, determine whether the flow and/or water level are below, or are projected to fall below the applicable minimum flow or level); and
- support development of lake guidance levels (described in the following paragraph).

The District has developed specific methodologies for establishing minimum flows or levels for lakes, wetlands, rivers, estuaries and aquifers, subjected the methodologies to independent, scientific peer-review, and incorporated the methods for some system types, including lakes, into its Water Level and Rates of Flow Rule (Chapter 40D-8, F.A.C.). The rule also provides for the establishment of Guidance Levels for lakes, which serve as advisory information for the District, lakeshore residents and local governments, or to aid in the management or control of adjustable water level structures.

Information regarding the development of adopted methods for establishing minimum and guidance lake levels is included in Southwest Florida Water Management District (1999a, b) and Leeper *et al.* (2001). Additional information relevant to developing lake levels is presented by Schultz et al. (2004), Carr and Rochow (2004), Caffrey *et al.* (2006, 2007), Carr *et al.* (2006), Hancock (2006), Hoyer *et al*. (2006), Leeper (2006), Hancock (2007) and Emery *et al.* (2009). Independent scientific peer-review findings regarding the lake level methods are summarized by Bedient *et al.* (1999), Dierberg and Wagner (2001) and Wagner and Dierberg (2006).

For lakes, 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 Lakes. Lakes with less than 0.5 acre of fringing cypress wetlands are classified as Category 3 Lakes.

Categorical significant change standards and other available information are developed to identify criteria that are sensitive to long-term changes in hydrology and can be used for establishing minimum levels. For all lake categories, the most sensitive, appropriate criterion or criteria are used to develop recommended minimum levels. For Category 1 or 2 Lakes, a significant change standard, referred to as the Cypress Standard, is developed. For Category 3 lakes, six significant change standards, including a Basin Connectivity Standard, a Recreation/Ski Standard, an Aesthetics Standard, a Species Richness Standard, a Lake Mixing Standard and a Dock-Use Standard are typically developed. Other available information, including potential changes in the coverage of herbaceous wetland and submersed aquatic plants is also considered when establishing minimum levels for Category 3 Lakes. The standards and other available information are associated with the environmental values identified for consideration in Rule 62-40.473, F.A.C., when establishing minimum flows or levels (Table 1). Descriptions of the specific standards and other information evaluated to support development of minimum levels for Lake Hobbs are provided in subsequent sections of this report. More general information on the standards and other information used for consideration when developing minimum lake levels is available in the documents identified in the preceding sub-section of this report.

Table 1. Environmental values identified in the state Water Resource Implementation Rule for consideration when establishing minimum flows and levels and associated significant change standards and other information considered by the District.

Environmental Value	**Associated Significant Change Standards and Other Information for Consideration**
Recreation in and on the water	Basin Connectivity Standard Recreation/Ski Standard Aesthetics Standard Species Richness Standard Dock-Use Standard Herbaceous Wetland Information Submersed Aquatic Macrophyte Information
Fish and wildlife habitats and the passage of fish	Cypress Standard Wetland Offset Standard Basin Connectivity Standard Species Richness Standard Herbaceous Wetland Information Submersed Aquatic Macrophyte Information
Estuarine resources	NA[1]
Transfer of detrital material	Cypress Standard Wetland Offset Basin Connectivity Standard Lake Mixing Standard Herbaceous Wetland Information Submersed Aquatic Macrophyte Information
Maintenance of freshwater storage and supply	NA[2]
Aesthetic and scenic attributes	Cypress Standard Dock-Use Standard Wetland Offset Aesthetics Standard Species Richness Standard Herbaceous Wetland Information Submersed Aquatic Macrophyte Information
Filtration and absorption of nutrients and other pollutants	Cypress Standard Wetland Offset Lake Mixing Standard Herbaceous Wetland Information Submersed Aquatic Macrophyte Information
Sediment loads	Lake Mixing Standard Cypress Standard Herbaceous Wetland Information Submersed Aquatic Macrophyte Information
Water quality	Cypress Standard Wetland Offset Lake Mixing Standard Dock-Use Standard Herbaceous Wetland Information Submersed Aquatic Macrophyte Information
Navigation	Basin Connectivity Standard Submersed Aquatic Macrophyte Information

NA[1] = Not applicable for consideration for most priority lakes;

NA[2] = Based on appropriate significant change standards and other information and use of minimum levels in District permitting programs

Two Minimum Levels and two Guidance Levels are typically established for lakes. Upon completion of a public input/review process and, if necessary completion of an independent scientific review, either of which may result in modification of the levels, the levels were adopted by the District Governing Board on April 24, 2015 for incorporation into Chapter 40D-8, F.A.C. (see Hancock *et al.* 2010 for more information on the adoption process). The levels, which are expressed as elevations in feet above the National Geodetic Vertical Datum of 1929 (NGVD 29), may include the following (refer to Rule 40D-8.624, F.A.C.).

- A **High Guidance Level** that is provided as an advisory guideline for construction of lake shore development, water dependent structures, and operation of water management structures. The High Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ten percent of the time on a long-term basis.

- A **High Minimum Lake Level** that 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.

- A **Minimum Lake Level** that is the elevation that the lake's water levels are required to equal or exceed 50 percent of the time on a long-term basis.

- A **Low Guidance Level** that is provided as an advisory guideline for water dependent structures, information for lakeshore residents and operation of water management structures. The Low Guidance Level is the elevation that a lake's water levels are expected to equal or exceed 90 percent of the time on a long-term basis.

In accordance with Chapter 40D-8, F.A.C., Minimum and Guidance Levels were developed for Lake Hobbs (Table 2), a Category 2 lake located in Northwest Hillsborough County, Florida. The levels were established using best available information, including field data that were obtained specifically for the purpose of minimum levels development. The data and analyses used for development of the levels are described in the remainder of this report. Following a public input process, the Governing Board approved incorporation of the levels into Rule 40D-8.624, F.A.C., to replace previously adopted Guidance Levels. Section 373.042, Florida Statutes (F.S.) directs the Department of Environmental Protection or the water management districts to establish minimum flows and levels for lakes, wetlands, rivers and aquifers.

The District is in the process of converting from use of the NGVD 29 datum to use of the North American Vertical Datum of 1988 (NAVD 88). While the NGVD 29 datum is used for most elevation values included within this report, in some circumstances notations are made for elevation data that was collected or reported relative to mean sea level or relative to NAVD 88 and converted to elevations relative to NGVD 29. All datum conversions were derived using the Corpscon 6.0 software distributed by the United States Army Corps of Engineers.

Table 2. Minimum and Guidance Levels for Lake Hobbs.

Minimum and Guidance Levels	Elevation (feet above NGVD 29)
High Guidance Level	65.7
High Minimum Lake Level	65.7
Minimum Lake Level	64.0
Low Guidance Level	61.9

Data and Analyses Supporting Development of Minimum and Guidance Levels for Lake Hobbs

Lake Hobbs Setting and Description

Lake Hobbs (Figure 1) is located in the Northwest Hillsborough Basin in Hillsborough County, Florida. The lake extends into portions of Sections 1, 2, 11 and 12, Township 27S, Range 18E and is generally centered around 28^0 9' 32.07", latitude and -$82^0$28'3.51" longitude. Lake Hobbs is part of a chain of lakes called the Deer Group of lakes (Water & Air 1997). The lake chain begins with Deer Lake through a series of natural flow ways and ditches to Little Deer, Lake Hobbs, and Little Hobbs and discharges to Lake Cooper (Figure 2). It is noted that Little Hobbs is considered to be a part of Lake Hobbs for this MFL evaluation.

Physiography and Hydrogeology

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 Tampa Limestone. The southward downward and generally very flat topographic relief of the Tampa Plain is between 50 and 80 feet above mean sea level (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 10 to 30 feet thick and overlies the limestone of the Upper Floridan aquifer that averages nearly 1,000 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).

As part of the Florida Department of Environmental Protection's Lake Bioassessment/Regionalization Initiative, the area has been identified as an area of numerous neutral to slightly alkaline, low to moderate nutrient, clear-water lakes (Griffith *et al.* 1997).

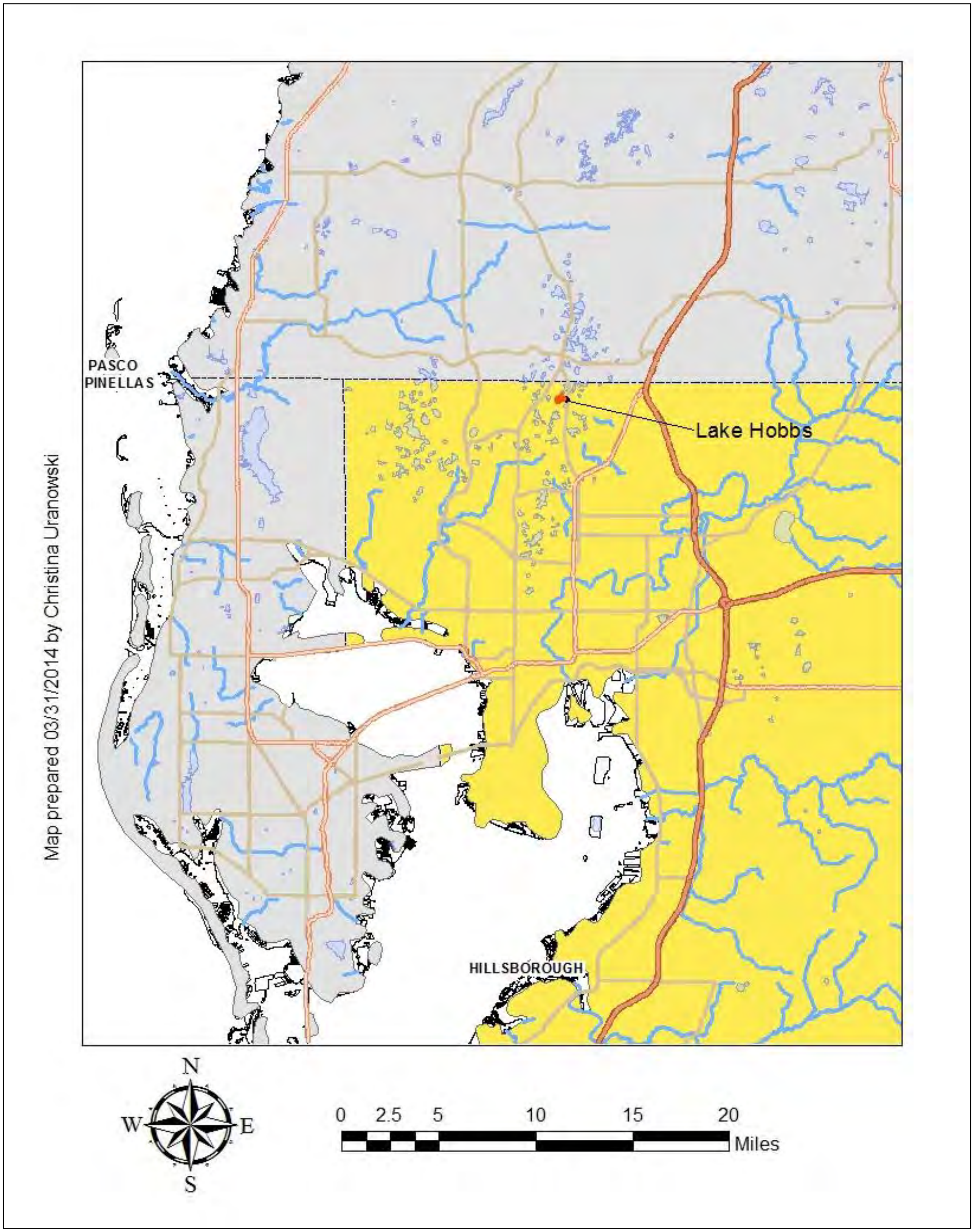

Figure 1 Location of Lake Hobbs in Hillsborough County, Florida

Basin/Watershed and Bathymetry Description

Lake Hobbs lies within the contributing Brushy Creek watershed, an area of approximately 459 acres (Hancock 2014). This includes an overland flow area around the lake and a receiving channel flow from a chain of lakes beginning with Deer Lake (Figure 2). Regular outflow occur down the chain from Little Hobbs through a series of ditches, canals and wetlands. When outflow occurs the flow drains southwest to Lake Cooper. There is no public access to Lake Hobbs.

The lake basin has had moderate alterations in the form of residential/urban development. Aerial photographs from 1938 through present illustrate the increase mainly in medium density residential housing (Figure 3). The greatest density of land use within the immediate watershed is wetlands and agriculture followed by medium density residential urban built-up property with a sizable acreage of upland forests (Figure 4).

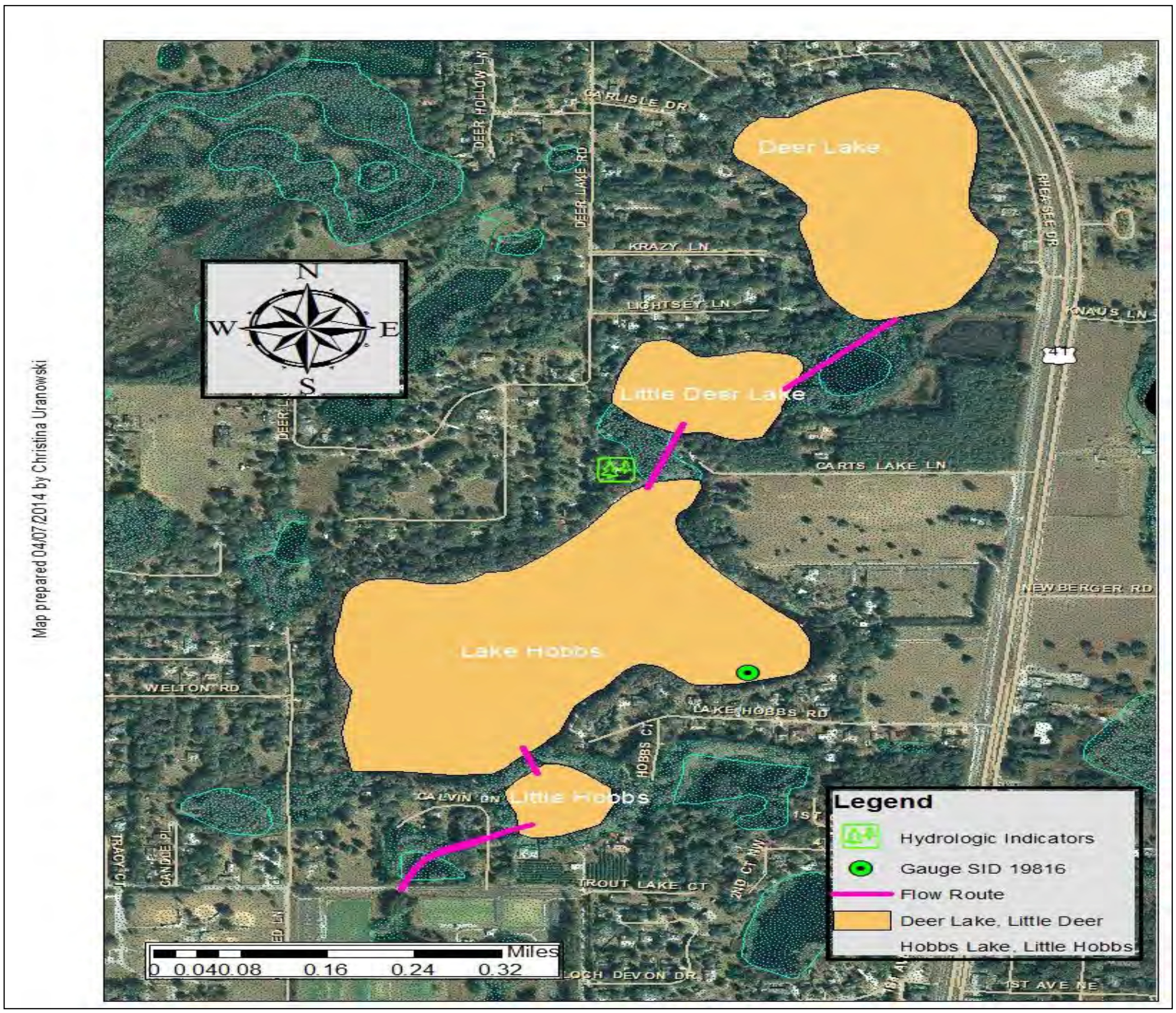

Figure 2 Chain of Lakes flow pattern with gauge and hydrologic indicator locations.

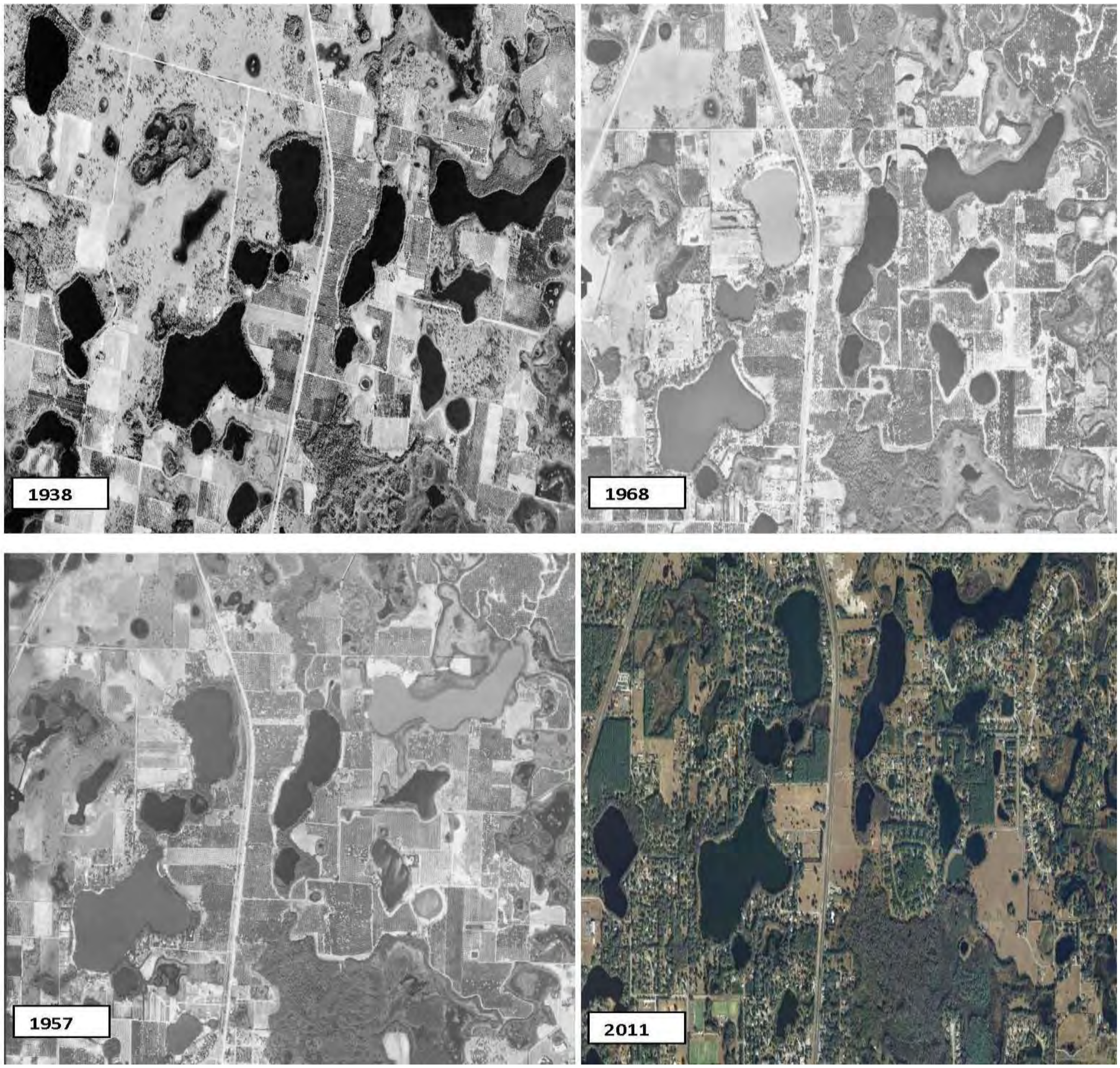

Figure 3 Selected aerial photographs of Lake Hobbs that include the years 1938, 1957, 1968 and 2011.

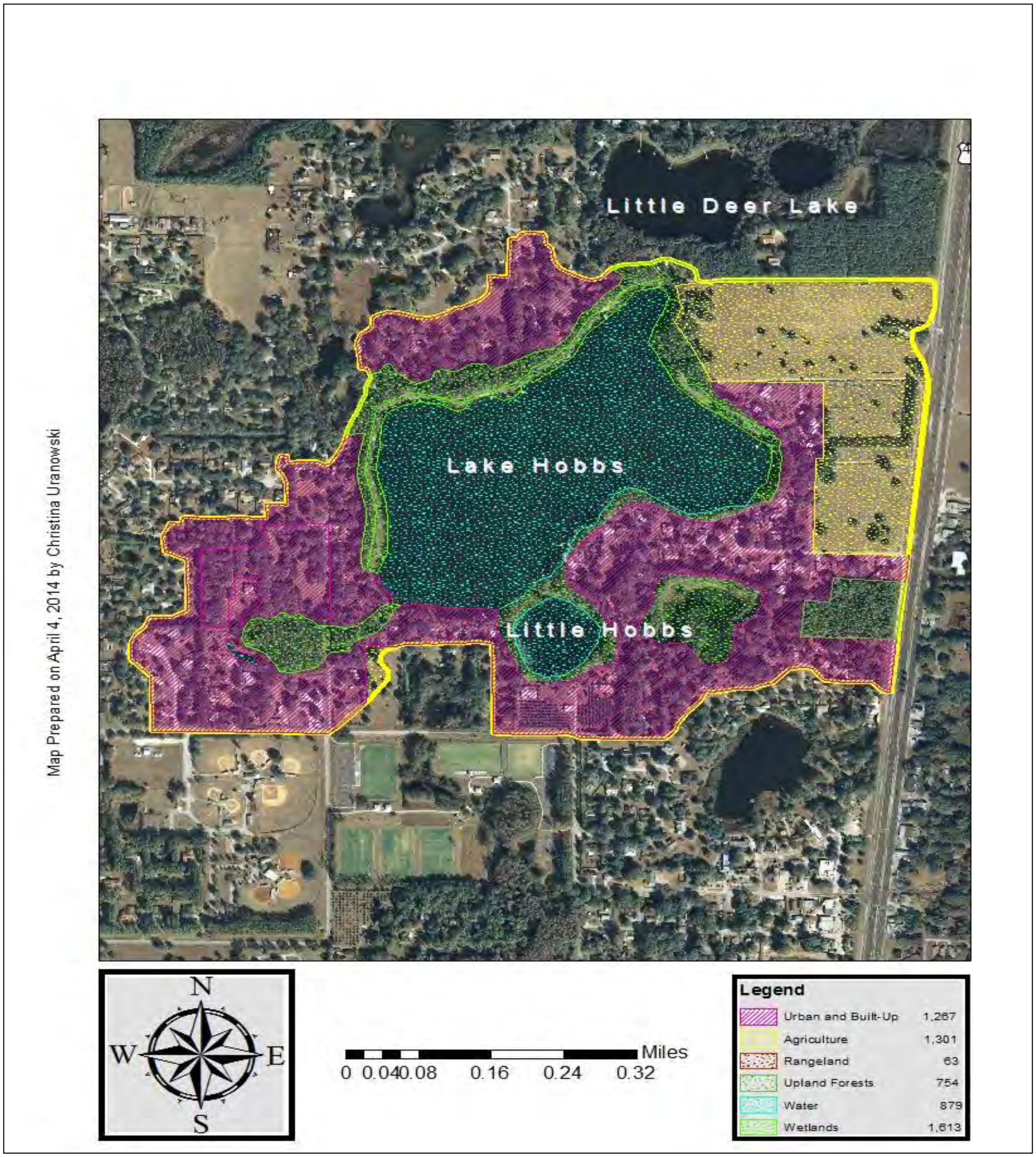

Figure 4 Lake Hobbs land use within the watershed boundary.

Lake Hobbs has varied bottom elevations with depths ranging from 8 to 28 feet. The deepest section of the lake at 28 feet (Figure 5) is in the southwestern portion of the western lobe corresponding to an elevation of 42.5 feet above NGVD 29. Additional deep sections ranging within 20 to 23 feet can be found throughout the lake bottom relatively close to the shoreline (Figure 5).

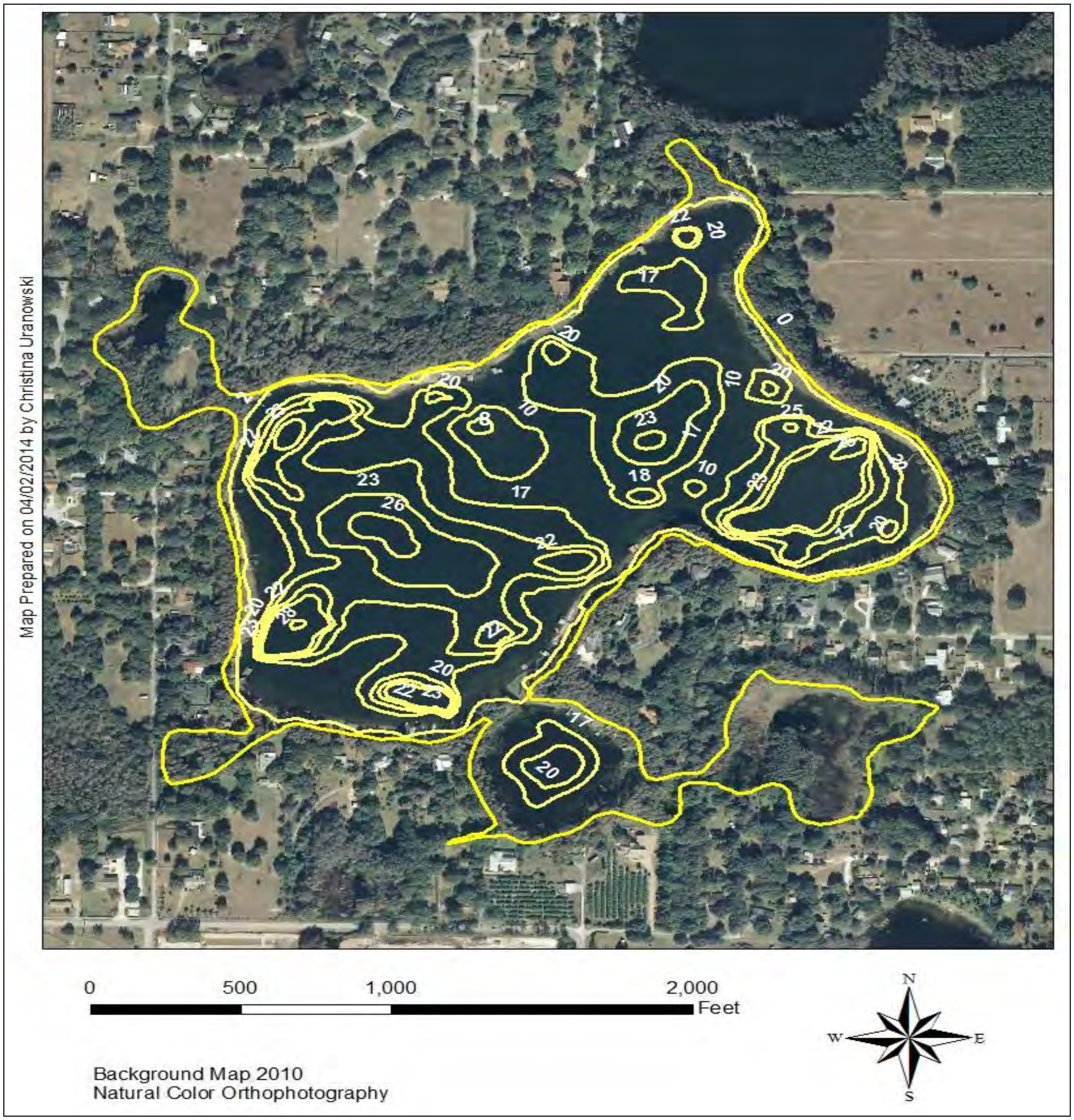

Figure 5 Contour map of Lake Hobbs showing various depths (in feet) within the lake.

Hydrology

Climate and Rainfall

The climate of west-central Florida, where Lake Hobbs occurs, may be characterized as humid subtropical, with warm wet summers and mild winter conditions. Local weather patterns are strongly influenced by the Gulf of Mexico, which moderates winter and summer temperatures. Daily temperatures average about 72° F on an annual basis and typically range from 49°Fahrenheit (F) in January to 91°F in July and August, based on summary information reported for three National Weather Service stations within the Hillsborough River Basin (SWFWMD 1999).

Area-weighted regional records tabulated by the District using NEXRAD (Next-Generation Radar) and other data obtained from the National Weather Service indicate that annual rainfall in Hillsborough County ranged from 37.6 to 79.9 inches and averaged 52.6 inches for the 98-year period from 1916 through 2013 (Figure 6, upper panel). On an annual basis, rainfall for this period was typically highest during the months of June through September (Figure 6, lower panel), likely as a result of the significant rainfall events that may be associated with convective and tropical storms that occur during these wet-season months. Evapotranspiration for the area has been reported at approximately 39 inches per year (Hutchinson 1984) and annual evaporation rates of 47 to 59 inches are reported for shallow, central Florida lakes (Henderson 1983, Schiffer 1998, Swancar *et al.* 2000, Metz and Sacks 2003). Cherry *et al.* (1970) note that evaporation in the region is highest in May and June, prior to and during the early phase of the summer wet season.

A plot of annual departure from the long-term average annual rainfall in Hillsborough County provides another means for identifying periods of above or below average area rainfall. Many years in the 1940s, for example, were relatively wet, as were years 1953, 1957 and 1959. Annual average rainfall was 27.4 inches above the long-term average for 1959, reported as the wettest year on record as more than 76 inches fell in the Tampa Bay area due to the activity of a record number of tropical storms (Morelli 2013; Dunn 1959). Below average annual rainfall has been common in Hillsborough County during many of the past 25 years (1989 through 2013) moderated by significant rainfall due to hurricane activity in 2003 and 2004 and a strong El Nino rainfall in 1998 (Figure 7).

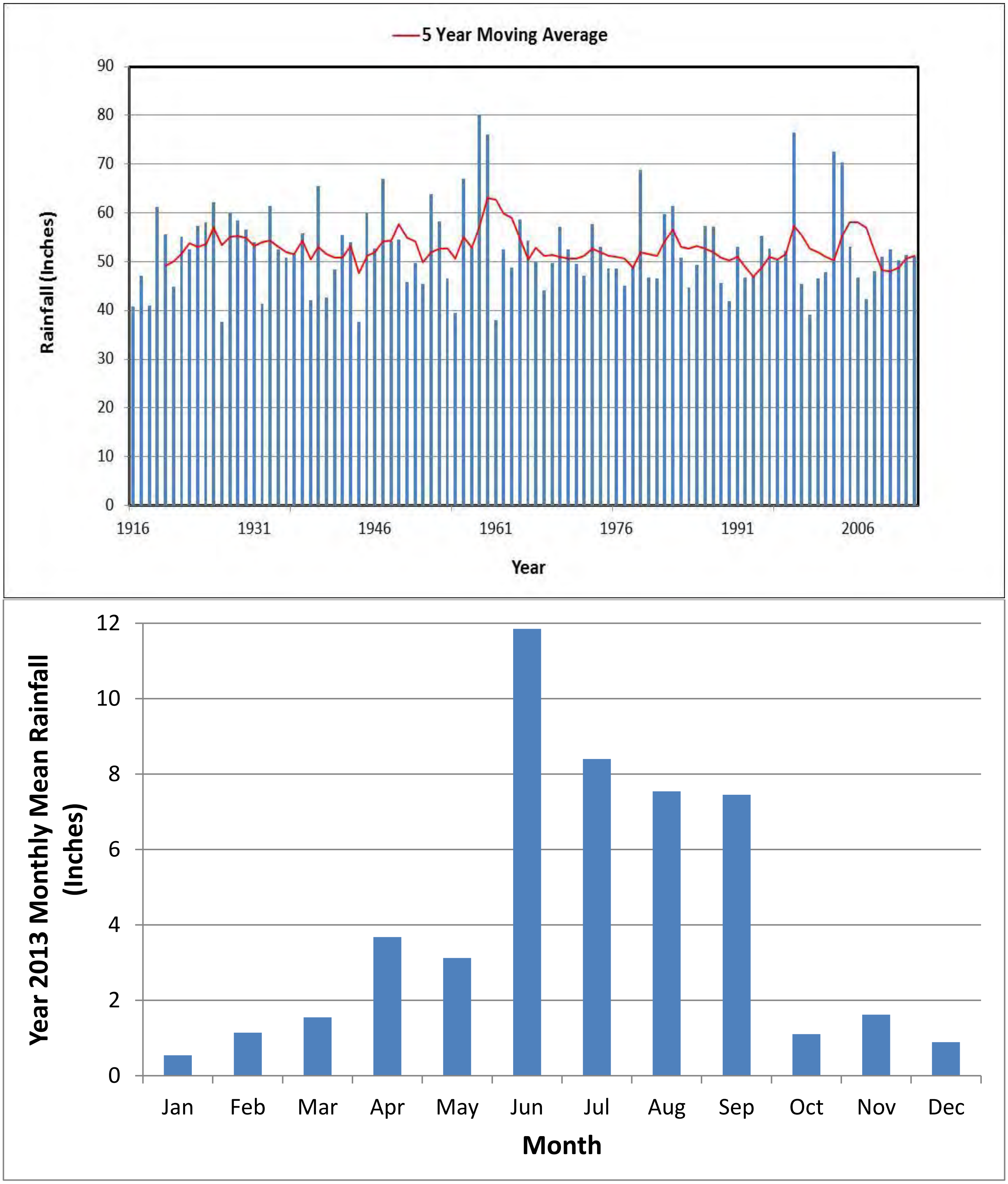

Figure 6 Area-weighted annual (upper panel) and monthly mean (lower panel) rainfall for Hillsborough County between 1916 and 2013 (data source: Southwest Florida Water Management District Rainfall Data Summaries web page at http://www.swfwmd.state.fl.us/data/hydrologic/rainfall_data_summaries.)

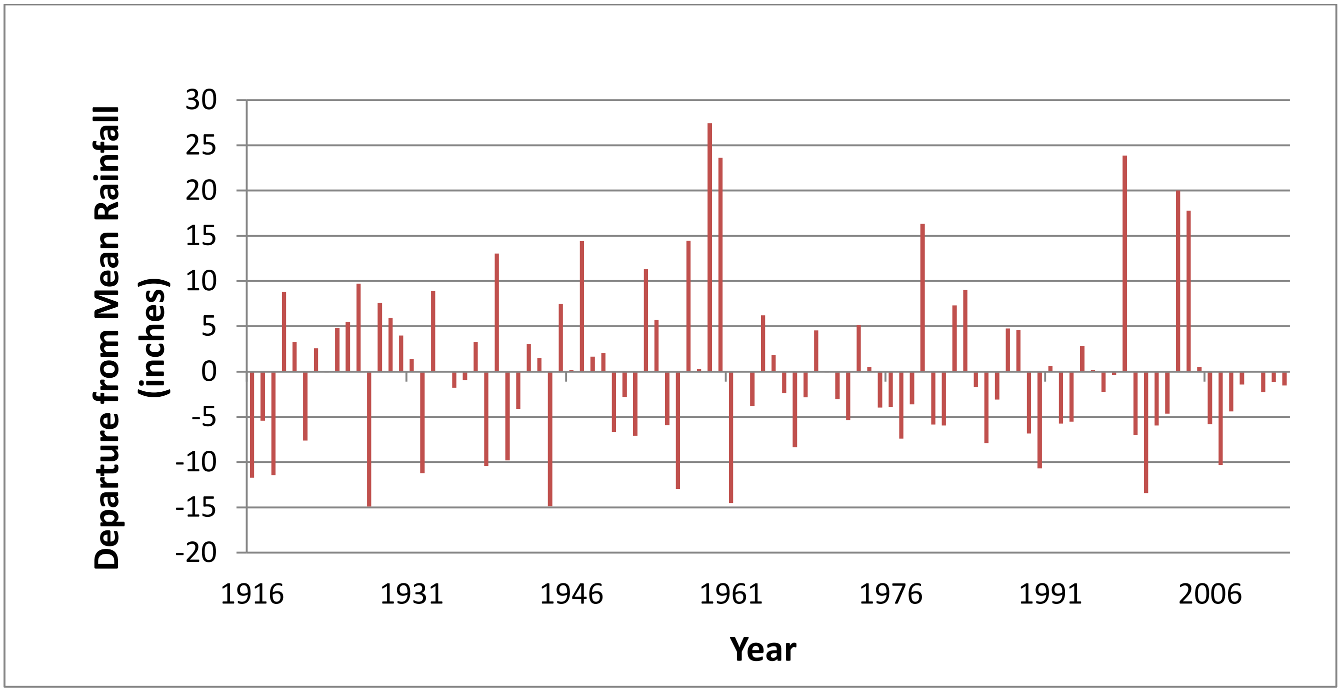

Figure 7 Annual departure from the mean annual rainfall of 54.0 inches for Hillsborough County from 1915 through 2013.

Water Level (Lake Stage) Record

Daily lake stage data, i.e., surface water elevations for Lake Hobbs, are available from the District Water Management Information System for the period from June 20, 1946 through the present time. These continuous data were obtained by the United States Geological Survey and the District at a site along the upper southeastern lakeshore identified as Lake Hobbs near Lutz (Site Identification Number 19816 (Figure 2).

A daily-stage record for the period from January 1, 1974 through December 31, 2011 was constructed using available data from the District's Water Management Information System (Figure 8). The highest surface water elevation for the lake in the record, 68.4 feet above NGVD 29, occurred on March 17, 1960. This elevation is higher than the outflow invert elevation of 65.4 feet above NGVD 29, and higher than the low floor slab of 67.41 feet above NGVD 29. The low of record, 57.69 feet above NGVD 29, was recorded on May 29, 2002.

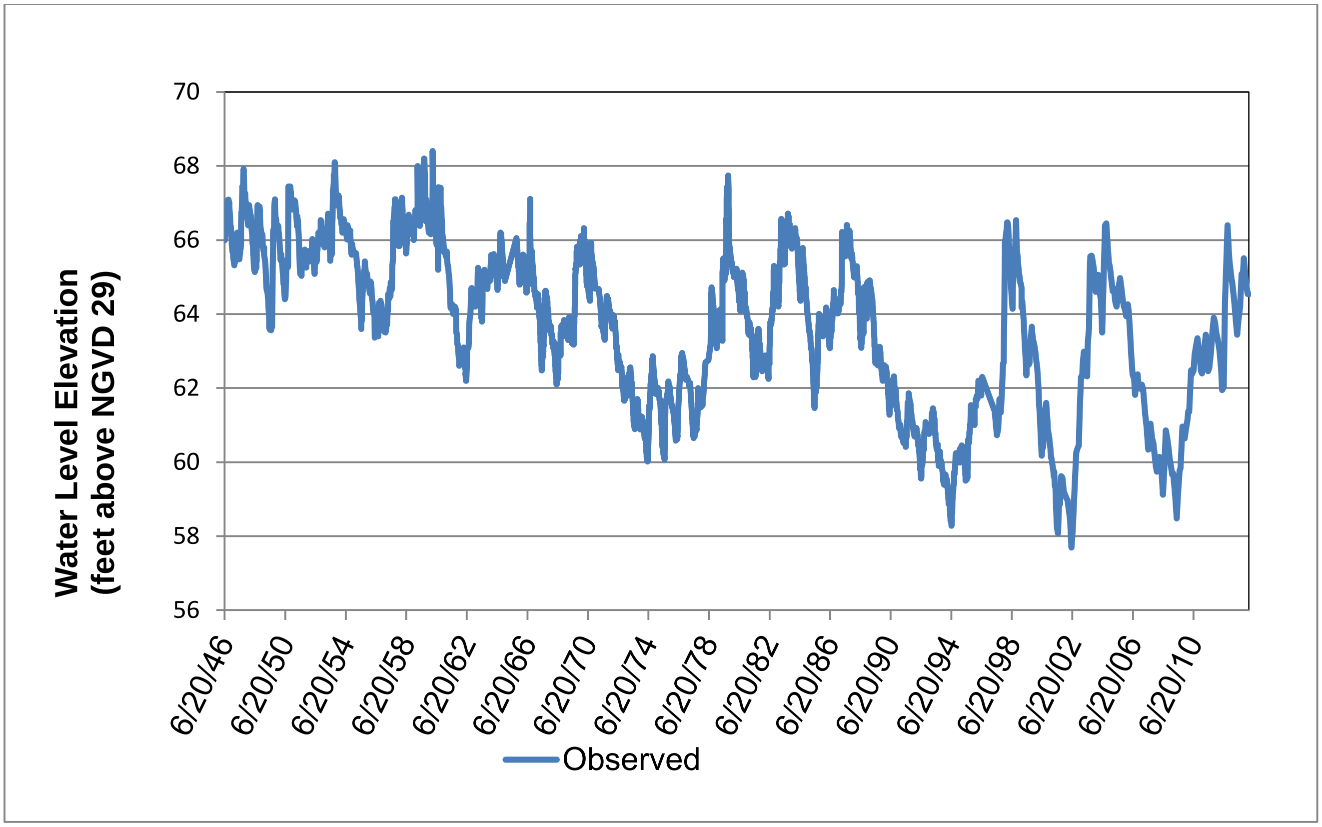

Figure 8 Observed stage record for Lake Hobbs observed from June 1946 through February 2014.

Water Use in the Lake Area and Evaluation of Withdrawal Impacts

Surface water withdrawals from Lake Hobbs may have occurred historically, and there may be small withdrawals from the lake that fall below District permitting thresholds, but there are currently no District-permitted surface withdrawals at the lake. There are, however, numerous permitted groundwater withdrawals in the area (Figure 9). Some of these withdrawals are associated with the operation by Tampa Bay Water of two public water supply wellfields. South Pasco Wellfield in Pasco County is approximately three miles northeast of Lake Hobbs, and Section 21 Wellfield in northern Hillsborough County is approximately three miles southeast of the lake (Figures 10). Groundwater withdrawals began in Section 21 Wellfield in 1963 rising over 20 mgd in 1967 (Hancock 2014). A reduction to approximately 10 mgd occurred when the South Pasco Wellfield went into operation in 1973. Withdrawal rates at the South Pasco Wellfield climbed close to 20 mgd in the mid-1970s (Figure 11).

An analysis of water use from 1992 through 2011 based on metered and estimated use at the Tampa Bay Water's Central System Facilities and other water users indicates that mean monthly water use within one, two, and three miles of Lake Hobbs was 0.2, 0.8 and 1.5 mgd, respectively, for the period from 1992 through 2011 (Figure 12). Mean monthly water use for the same period increased to 21.1, 72.5 and 187.4 mgd, respectively at distances within 5, 10 and 20 miles from the lake. Note that 80 percent of the withdrawals within 5 miles (16.9 mgd) were from the public supply wells at the Section 21 and South Pasco Wellfields.

During subsequent decades, additional wellfields that comprise the current Tampa Bay Water's Central System Facilities became operational, and combined annual withdrawals for the facilities peaked at about 165 million gallons per day (mgd) in 2000. Between 2009 and 2013 12-month moving average withdrawals at the Central System Facilities ranged from 68 to 104 million gallons per day (mgd).

As summarized in the Tampa Bay Planning Region portion of the District Water Management Plan (SWFWMD 2011), investigations of interactions between water use, other factors and the water resources of the northern Tampa Bay area have been completed by the District and many others during the past half century. Much of this work, in particular the information compiled for the District's water resource assessment project for the area (SWFWMD 1996b), contributed to the 1989 establishment and 2007 expansion of the Northern Tampa Bay Water Use Caution Area (NTBWUCA), which includes Pinellas County, a northern portion of Hillsborough County and Pasco County. Water Use Caution Areas are areas where "…regional action is necessary to address cumulative water withdrawals that are causing or may cause adverse impacts to the water and related land resources or the public interest…" (Rule 40D-2.801, F.A.C.).

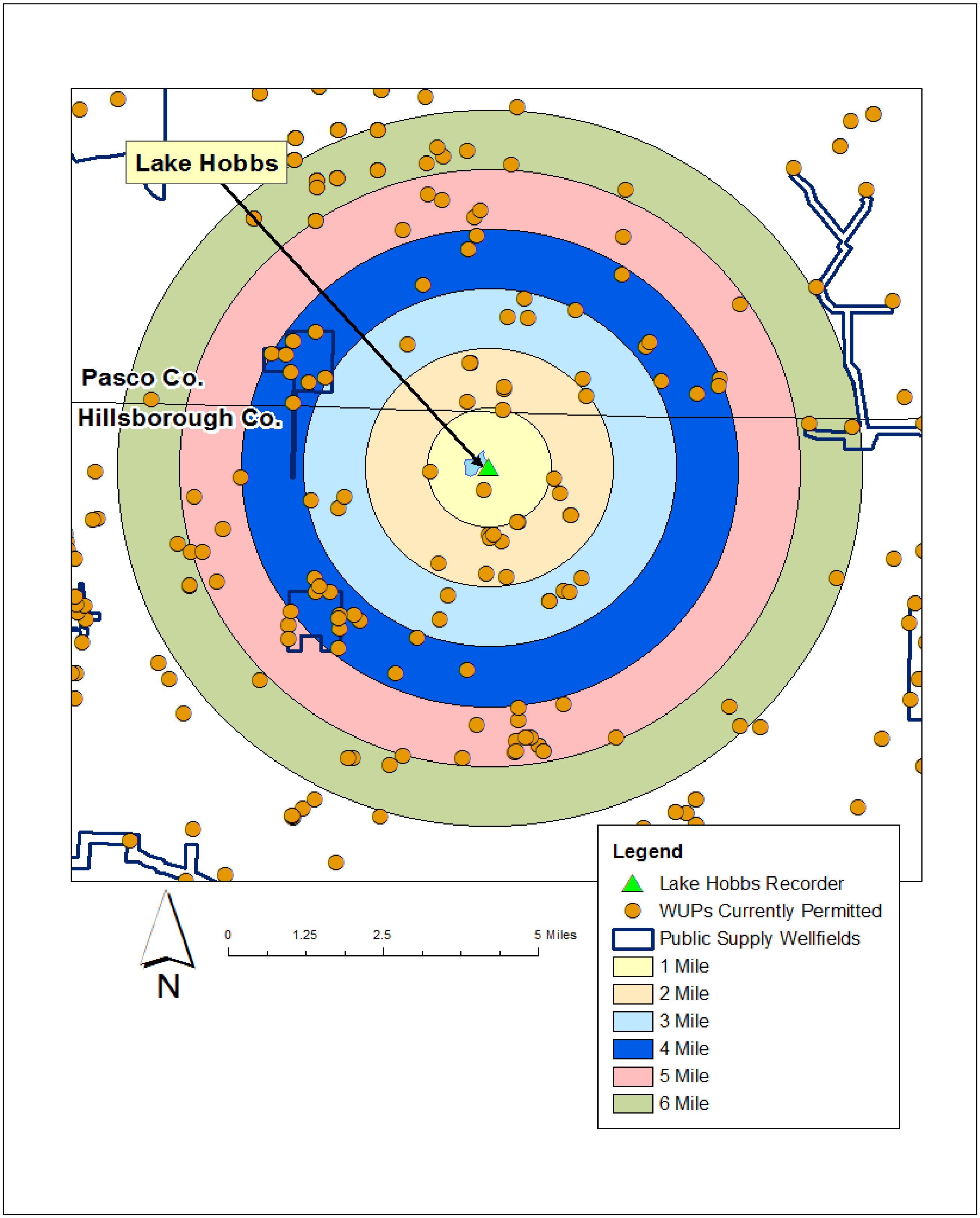

Figure 9 Public supply and individual water use in 1 mile increments within a 6 mile radius of Lake Hobbs.

In an effort to address and better manage regional resource concerns, the District issued a consolidated water use permit to Tampa Bay Water in December 1998 for withdrawals at the Central System Facilities. In that same year the District, Tampa Bay Water and its member governments entered into what was referred to as the Partnership Agreement, which included a phased reduction in annual average groundwater pumping from 158 mgd to 90 mgd at the Central System Facilities by 2008. In accordance with the agreement, the District developed a recovery strategy for the northern Tampa Bay area and adopted a regulatory portion of the strategy into District rules (Chapter 40D-80, F.A.C.). The Partnership Agreement became effective in 2000 and was in place through 2010, when the Partnership Agreement expired.

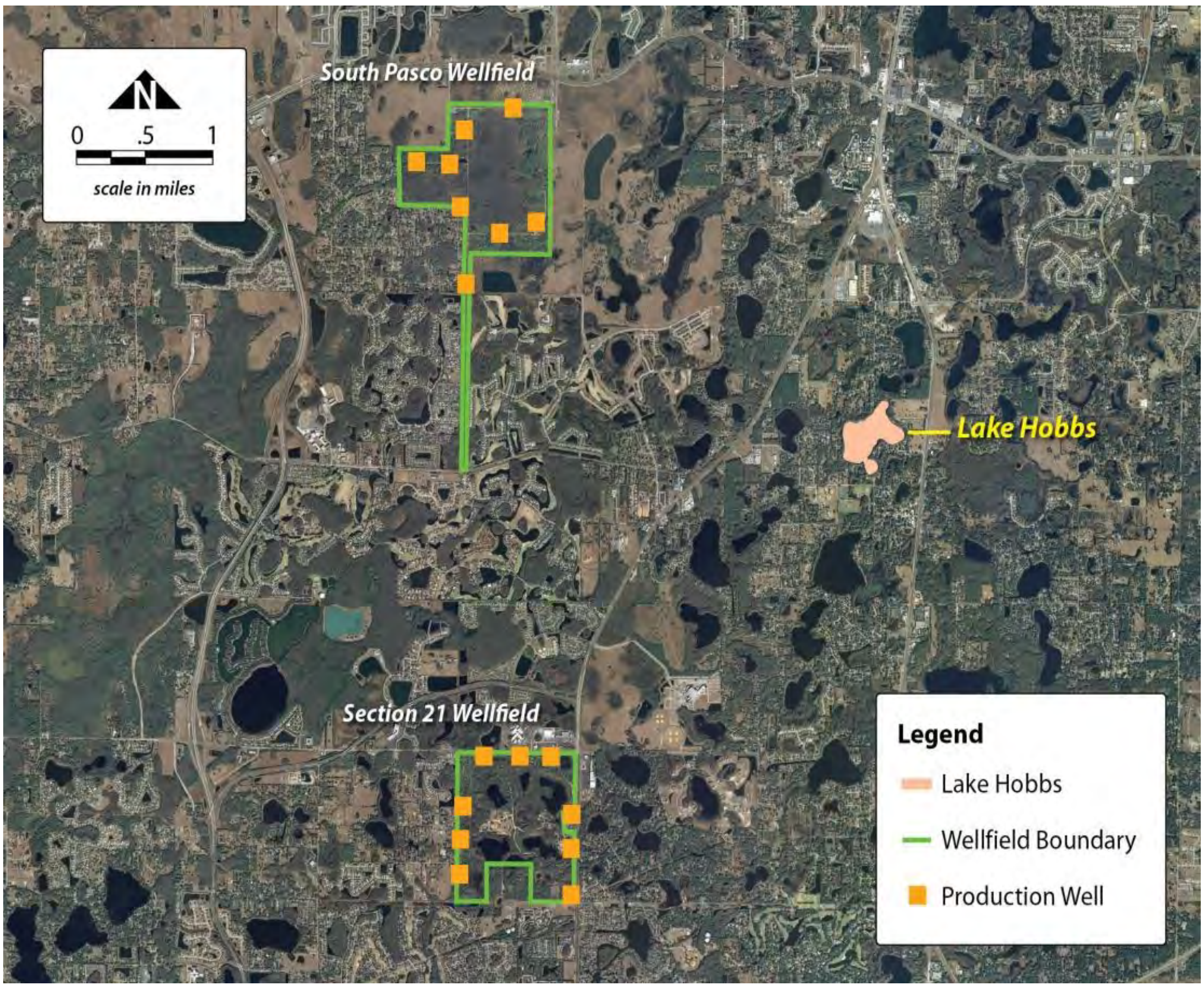

Figure 10 Location of Section 21 and South Pasco Wellfields relative to Lake Hobbs.

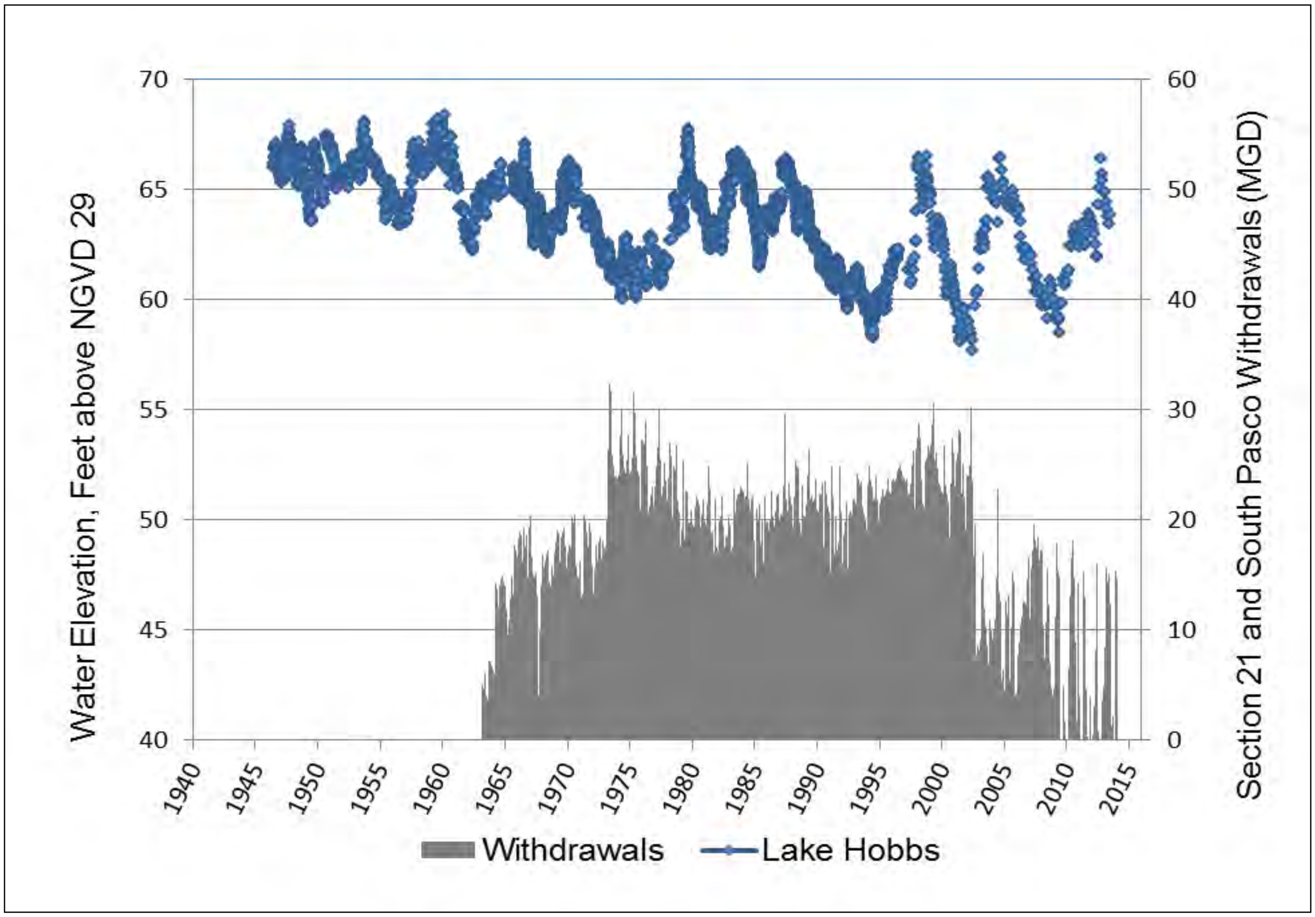

Figure 11 Lake Hobbs long-term water level data and groundwater pumping in Section 21 and South Pasco Wellfields.

Implementation of the original Northern Tampa Bay area recovery strategy contributed to increasing water levels and flows and improving the condition of many wetlands, lakes, streams, springs and aquifer levels, but the reduction had been in place for too short a period for an adequate assessment of the results to be made. To address this need, the District adopted a second phase of the area recovery strategy in 2010. This second recovery phase is referred to as the Comprehensive Environmental Resources Recovery Plan for the Northern Tampa Bay Water Use Caution Area Recovery and Prevention Strategy, or simply the “Comprehensive Plan.” The Comprehensive Plan addresses recovery of minimum flows and levels water bodies and avoidance and mitigation of unacceptable adverse impacts to wetlands, lakes, streams, springs and aquifer levels associated with Central System Facilities and other area facilities, which are collectively referred to in rule as the “90 MGD Facilities” (Rule 40D-80.873, F.A.C.). Adoption of the second phase of the area recovery plan was followed in January 2011 by renewal of the Consolidated Permit addressing withdrawals from the Central System Facilities by Tampa Bay Water through January 2020.

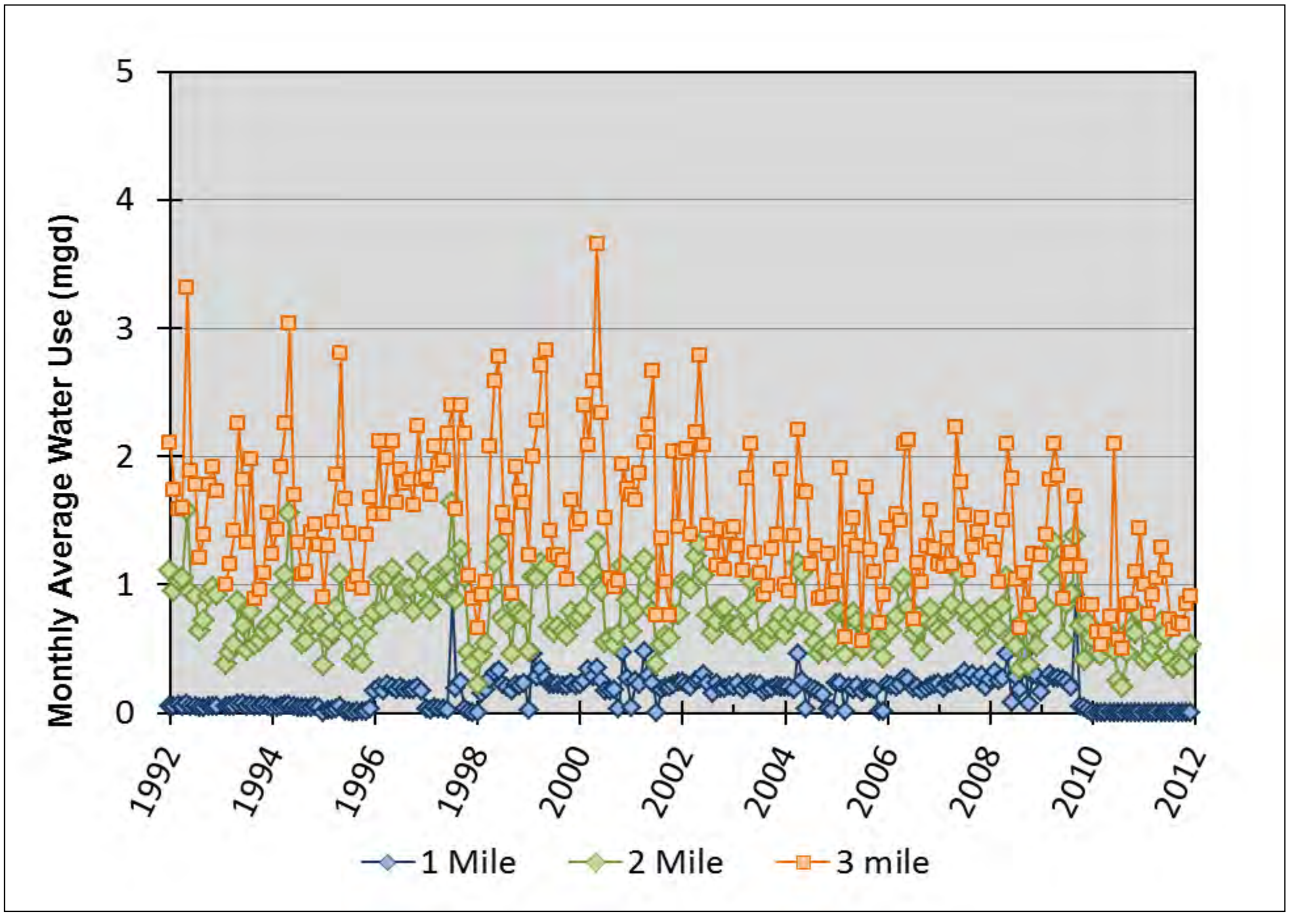

Figure 12 Monthly average water use in mile increments within a 3 mile radius of Lake Hobbs.

Historical Management Levels and Currently Adopted Minimum and Guidance Levels for Lake Hobbs

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 establishing management levels based on hydrologic, biological, physical and cultural aspects of lake ecosystems. By 1996, management levels for nearly 400 lakes had been adopted into District rules.

Based on work conducted in the 1980s (see SWFWMD 1996a), the District adopted management levels, including minimum and flood levels, for Lake Hobbs in April 1985 (Table 3) and incorporated the levels into its Water Levels and Rates of Flow Rules (Chapter 40D-8, F.A.C.). As part of the work leading to the adoption of management levels, a Maximum Desirable Level of 66.25 feet above mean sea level was also developed for the lake, but was not adopted by rule.
Based on changes to sections of the Florida Statutes that address minimum flows and

levels in 1996 and 1997, and the development of new approaches for establishing minimum flows and levels, District Water Levels and Rates of Flow rules were modified in 2000. The modifications included incorporation of rule language addressing minimum flows and levels development and the renaming of established levels as Guidance Levels, as indicated for Hobbs Lake in Table 3. Subsequent revisions to District rules incorporated additional rule language associated with developing minimum lake levels.

Based on the approaches for establishing minimum flows and levels developed in the late 1990s and early 2000s, the District adopted recommended Guidance and Minimum Levels for Hobbs Lake (Leeper 2003) into its Water Levels and Rates of Flow rules in December 2004 (Table 4), and removed the previously adopted management levels for the lake from District rules. A Ten Year Flood Guidance Level of 68.20 feet above NGVD that was adopted for the lake along with the other levels in December 2004 was subsequently removed from Chapter 40D-8, F.A.C. 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 develop revised, Minimum and Guidance Levels for Hobbs Lake, as outlined in this report. Because the previously adopted Minimum and Guidance Levels were developed using methods that differ from those now in use, those levels do not necessarily correspond with the current adopted levels presented in this report. As adopted by the Governing Board, Minimum and Guidance Levels developed using existing methods have replaced the previously adopted levels.

Table 3. Previously Adopted management and Guidance levels for Lake Hobbs

Management and Guidance Levels[a] (as originally adopted)	**Elevation (feet above NGVD)**
Ten Year Flood Guidance Level	68.20
High Level	66.75
Low Level	63.25
Extreme Low Level	61.50

[a]Adopted management levels were renamed as Guidance Levels in District rules in 2000.

Table 4. Previously adopted Minimum and Guidance Levels for Hobbs Lake

Previous Adopted Minimum and Guidance Levels	**Elevation (feet above NGVD)**
Ten Year Flood Guidance Level	67.75
High Guidance Level	65.46
High Minimum Lake Level (Historic P10)	65.46
Minimum Lake Level (Historic P50)	64.46
Low Guidance Level	63.36

Methods, Results and Discussion

Summary Data Used For Minimum and Guidance Levels Development

Minimum and Guidance Levels were developed for Lake Hobbs using the methodology for Category 2 lakes described in Chapter 40D-8, Fla. Admin Code. The adopted levels along with lake surface area for each level are listed in Table 4 along with other information used for development of the MFL. Detailed descriptions of the development and use of these data are provided in subsequent sections of this report.

Table 5. Minimum and Guidance Levels, lake stage exceedance percentiles, Normal Pool, Control Point elevation, significant change standards and associated surface areas for Lake Hobbs.

	Elevation (feet above NGVD)	**Lake Area (acres)**
Lake Stage Exceedance Percentiles	**Adopted**	
Current P10 (2003 through 2013)	65.6	84.5
Current P50 (2003 through 2013)	63.4	67.9
Current P90 (2003 through 2013)	61.2	63.6
Historic P10 [a] (1946 – 2011)	65.7	84.7
Historic P50 [a] (1946 – 2011)	64.0	69.1
Historic P90 [a] (1946 – 2011)	61.9	64.9
Normal Pool and Control Point		
Normal Pool	67.0	>85.5
Control Point	65.4	84.0
Low Floor Slab	67.4	N/A
Low Road	67.8	N/A
Significant Change Standards		
Basin Connectivity Standard [b]	N/A	N/A
Recreation/Ski Standard [b]	61.1	63.4
Wetland Offset Elevation [b]	63.2	67.5
Aesthetic Standard [b]	61.9	64.9
Species Richness Standard [b]	58.7	58.9
Lake Mixing Standard [b]	N/A	N/A
Dock-Use Standard [b]	63.9	68.9
Guidance and Minimum Levels		
High Guidance Level	65.7	84.7
High Minimum Lake Level	65.7	84.7
Minimum Lake Level	64.0	69.1
Low Guidance Level	61.9	64.9

[a] Based on a composite Historic water level that includes measured and modeled values

[b] Developed for comparative purposes only; not used to establish Minimum Levels for Hobbs Lake

Classification of Lake Stage Data and Development of Exceedance Percentiles

For the purpose of minimum levels determination, lake stage data are categorized as "Historic" for periods when there are no measurable impacts due to water withdrawals, and impacts due to structural alterations are similar to existing conditions. In the context of minimum levels development, "structural alteration" means man's physical alteration of the control point, or highest stable point along the outlet conveyance system of a lake, to the degree that water level fluctuations are affected. Lake stage data are categorized as "Current" for periods when there were measurable, stable impacts due to water withdrawals, and impacts due to structural alterations were stable.

Based on water-use estimates and analysis of lake water levels and regional ground water fluctuations, available lake-stage data since 2003 for Lake Hobbs are classified as Current for this effort. However, simulations from the INTB model and available data suggest that regional groundwater withdrawals have contributed to drawdown in the surficial and Upper Floridan aquifers in the vicinity of Lake Hobbs. Therefore, to estimate lake water levels that would be expected in the absence of potential withdrawal-related effects, a line of organic correlation (LOC) was performed using the results from a water budget model and long-term rainfall (Hancock 2014). Development of the modeling for this lake will allow for an estimate of long-term Historic percentiles. The results for these analyses were combined and are referred to as the “hybrid model” For more details on these analyses, see Appendix A.

The spreadsheet based water budget model that includes natural hydrologic processes and engineered alterations that act to control the water volume in the lake was chosen to model Lake Hobbs. The hydrologic processes include:

a. Rainfall and evaporation
b. Overland flow
c. Inflow and discharge via channels
d. Flow from and into the surficial aquifer
e. Flow from and into the Upper Floridan aquifer

The model uses a daily time-step, and tracks inputs, outputs, and lake volume to calculate a daily estimate of lake levels. The model is calibrated from 1974 to 2011, which provides a period of time that is considered long-term for purposes of determining Historic percentiles. The most accurate representation of long term Historic water level fluctuations was a composite data set that consisted of the modeled Historic water level and the measured water level data.

To extend further the water level period of record to determine the Historic Percentiles to be used in the development of the Minimum Levels, a line of organic correlation (LOC) was performed using the results of the water budget model and long-term rainfall. 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 was correlated to the water budget model results for the entire period used in the water budget model (1974-2011), and the results from 1946-2013 (68 years) were produced. For Lake Hobbs, the 3-year weighted model had the highest correlation coefficient, with an R^2 of 0.70. Previous correlations for lakes in the northern Tampa Bay area have consistently had best correlation coefficients in the 2 to 5 year range. The results are presented in Table 6. (Appendix A)

Table 6. Historic percentiles as estimated by the hybrid model from 1946 through 2013 in feet above NGVD (Appendix A)

Percentile	Lake Hobbs
P10	65.7
P50	64.0
P90	61.9

Normal Pool, Control Point Elevation and Determination of Structural Alteration Status

The Normal Pool elevation, a reference elevation used for development of minimum lake and wetland levels, is established using elevations of hydrologic indicators of sustained inundation, including biological and physical features. For development of Minimum Lake Levels, the Normal pool elevation is considered an approximation of the Historic P10. Based on elevations of *Taxodium* ascendens buttress inflection points measured in February 2013 at points along the lake shore an in the wetland between Lake Hobbs and Little Deer Lake, a Normal Pool elevation of 66.7 feet above NGVD was identified for Lake Hobbs (Figure 2, Table 5 and 7).

A Normal Pool elevation was previously reported at a comparable elevation of 66.97 feet above NGVD 29 based on the elevations of *T. ascendens* buttress inflection points measured in February 2003 (Leeper 2003). No significant inconsistencies exist between the current Normal Pool data collection and earlier 2003 Normal Pool data collection both from the small wetland between Lake Hobbs and Little Deer Lake. It is however apparent that the normal pool elevation samples collected at this small wetland resulted in a variation of 1.48 feet between the maximum value of 67.59 feet above NGVD 29 and the minimum value of 66.11 feet above NGVD 29 (Table 7). This was comparable to the 12 elevation samples collected in 1998 and 2000 at a variation of 0.73 feet above NGVD 29. However an additional 9 Normal Pool buttress inflections from the area around the eastern lake edge lobe resulted in a variation of 1.3 feet above NGVD 29 measured between the maximum and minimum sample set (Table 7). The differences between the two current sets of data are consistent with observed water level fluctuations that have occurred over decades (Figure 11). Biological indicators such as buttress inflection points develop as a physiological response to water stress over an extended period of time. These morphological indicators once expressed do not fade; instead if fluctuating water levels continue long enough, several buttress inflection points of varying elevations can occur on the same tree. In addition, as a result of differing age classes, differing elevations of buttress inflection points can result within the same population of trees on the lake. Structural alterations to the lake can reduce the once historic water elevations as well.

Table 7 Comparison of 1998 & 2000 elevation data used for establishing the Category 2 Lake Normal Pool Elevation for Lake Hobbs with current elevation data. Current elevation data were collected by SWFWMD staff February 20, 2014 when the water level elevation was at 64.55 feet above NGVD 29.

Statistic	**Statistic Value (N) or Elevation (feet above NGVD)**		
Location of Data Collection	Wetland Between Lake Hobbs and Little Deer		Lake Edge
Date Collected	Current	1998 & 2000	Current
N	13	12	9
Median	66.7	66.97	68.83
Mean (Standard Deviation)	66.8 (0.49)	66.9 (0.07)	68.81 (0.52)
Minimum	66.11	66.51	68.03
Maximum	67.59	67.24	69.33
Variation	1.48	0.73	1.3

The Control Point elevation is the elevation of the highest stable point along the outlet profile of a surface water conveyance system that principally controls lake water level fluctuations. A Control Point may be established at the invert or crest elevation associated with a water control structure at a lake outlet, or at a high, stable point in a lake-outlet canal, ditch or wetland area. The invert or crest elevations are the lowest point on the portion of a water-control structure that provides for conveyance of water across or through the structure. For non-operable structures, the crest elevation corresponds to the invert elevation. For operable structures, the invert elevation represents the lowest elevation at which flow may occur past the structure, and the crest elevation corresponds to the highest elevation that must be exceeded for flow to occur. The Control Point associated with an operable structure may, therefore, range from the invert elevation to the crest elevation. A Control Point elevation was identified for Lake Hobbs at 65.4 feet above NGVD along the outlet conveyance system that leads to a reinforced concrete pipe running under Lutz Lake Fern Road (Figure 13).

In addition to identification of current and historic outlet conveyance system modifications, comparison of the Control point elevation with the Normal Pool elevation can be used to evaluate the structural alteration status of a lake. If the Control Point elevation is below the Normal Pool, the lake is usually considered to be a structurally altered system. If the Control Point elevation is above the Normal Pool or the lake has no outlet, then the lake may be considered to be not structurally altered. Based on the existence of an obvious outlet conveyance system and given that the Normal Pool elevation (66.7 feet above NGVD) is 1.3 feet above NGVD 29 higher than the Control point elevation (65.4 feet above NGVD), Lake Hobbs was classified as a Category 2 structurally altered lake. This characterization was used to support development of Guidance Levels, Minimum Levels and the modeling of historic lake stage records.

Figure 13 Discharge conveyance system from Lake Hobbs showing location of control point high running to a culvert under Lutz Lake Fern Road.

Lake Classification

Lakes are classified as Category 1, 2 or 3 for the purpose of Minimum Levels development. Systems with fringing cypress wetlands greater than 0.5 acres in size where water levels regularly rise to an elevation expected to fully maintain the integrity of the wetlands, *i.e.,* the Historic P50 is not more than 1.8 feet below the Normal Pool elevation, are classified as Category 1 Lakes. Lakes with fringing cypress wetlands greater than 0.5 acres in size that have been structurally altered such that the Historic P50 is more than 1.8 feet below the Normal Pool elevation are classified as Category 2 Lakes. Lakes without fringing cypress wetlands or with less than 0.5 acres of fringing cypress wetlands are classified as Category 3 Lakes.

Lake Hobbs is contiguous with cypress-dominated wetlands of 0.5 or more acres in size, but because it is structurally altered by ditches and channels it is therefore classified as a Category 2 Structurally Altered Lake for the purpose of minimum levels development. Aquatic macrophytes, including maidencane (*Panicum hemitomum*), cattail (*Typha* sp.), torpedograss (*Panicum repens*), pickerelweed (*Pontedaria cordata*), and spatterdock (*Nuphar luteum*) occur throughout the basin.

Guidance Levels

The **High Guidance Level** is provided as an advisory guideline for construction of lake-shore development, water dependent structures, and operation of water management structures. The High Guidance Level is the expected Historic P10 of the lake and is established using historic lake stage data if it is available, or is estimated using a hydrologic model. Based on the long-term Historic data developed by the hybrid water budget rainfall modeling for Lake Hobbs, the High Guidance Level was established at the Historic P10 elevation of **65.7 feet above NGVD 29** (Figures 14, 15; Table 5).

The **Low Guidance Level** is provided as an advisory guideline for water dependent structures, information for lake shore residents, and operation of water management structures. The Low Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ninety percent of the time (P90) on a long-term basis. The level is also established by using Historic lake stage data or estimated using a hydrologic model. Based on the long-term Historic data developed by the hybrid model for Lake Hobbs (Appendix A), the Low Guidance Level for Lake Hobbs was established at the long term Historic P90 elevation, **61.9 feet above NGVD 29** (Figures 14, 15; Table 5).

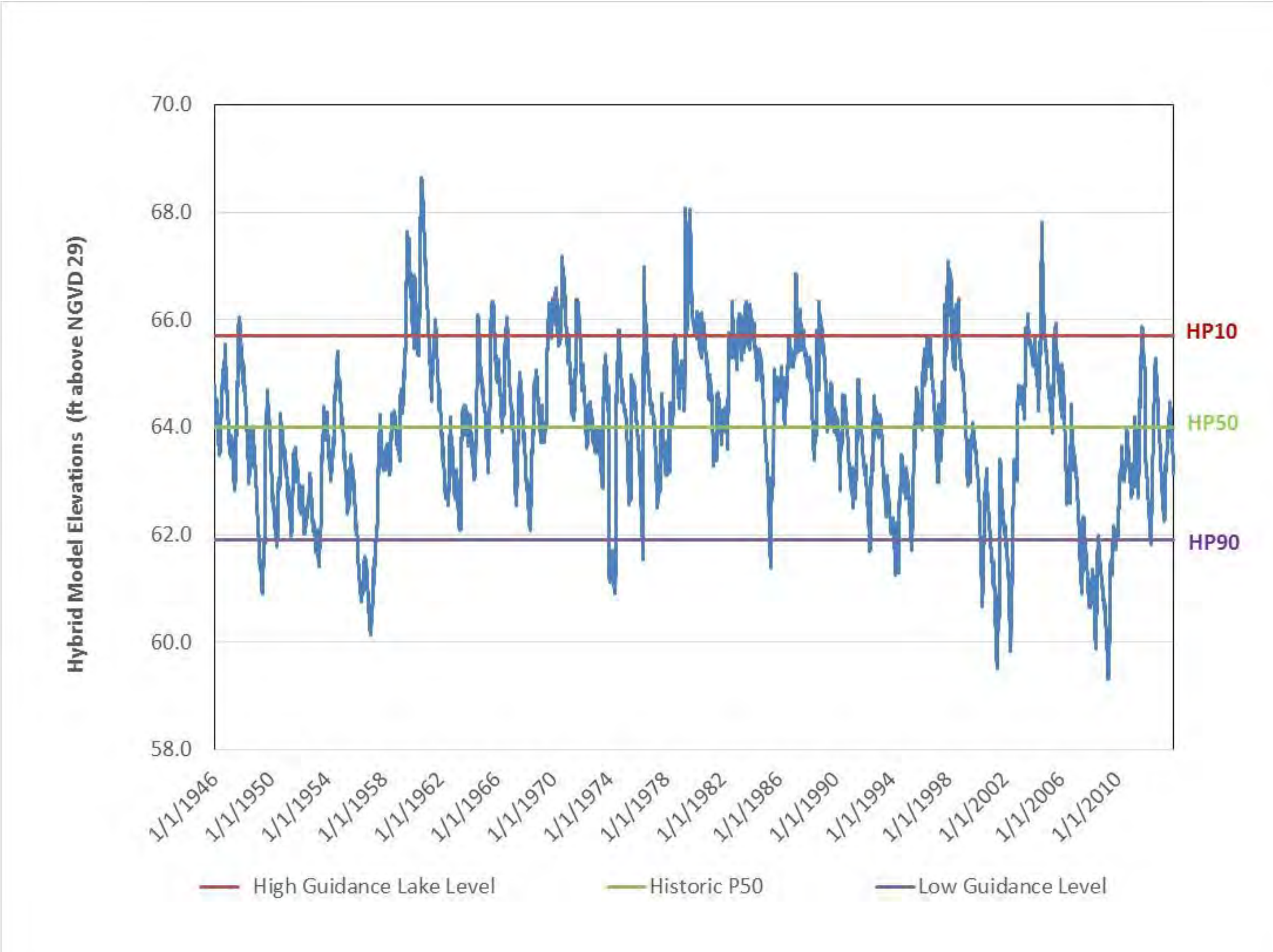

Figure 14 Modeled long term Historic lake stage (as monthly means, red line), High Guidance Level as Historic P10 (65.7), Historic P50 (64.0) and Low Guidance Level as Historic P90 (61.9) measured in elevation in feet above NGVD 29 for Lake Hobbs.

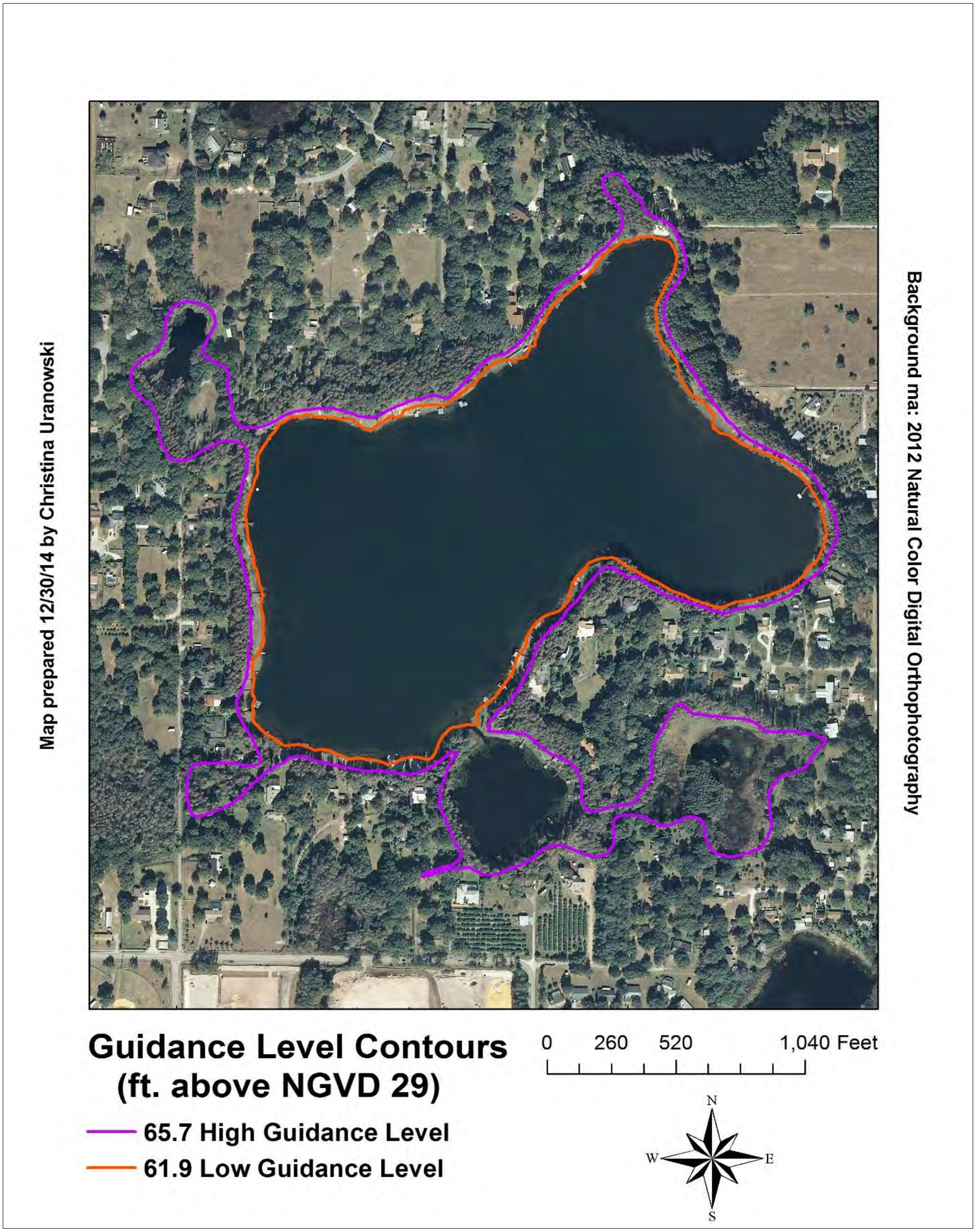

Figure 15 Lake Hobbs Guidance level contours in ft. above NGVD 29. Contours were prepared using LiDAR collected in 2007 with background map in 2012 natural color aerial orthophotography.

Significant Change Standards and Other Information for Consideration

Lake-specific significant change standards and other available information are developed for establishing minimum levels for Category 3 Lakes. The standards are used to identify thresholds for preventing significant harm to cultural and natural system values associated with lakes in accordance with guidance provided in the Florida Water Resources Implementation Rule (Chapter 62-40.473, F.A.C.). Other information taken into consideration includes potential changes in the coverage of herbaceous wetland vegetation and aquatic plants.

Typically, six significant change standards are developed for Category 3 Lakes that include an Aesthetics Standard, a Species Richness Standard, a Recreation/Ski Standard, a Dock-Use Standard, a Basin Connectivity Standard, and a Lake Mixing Standard. A Wetland Offset Elevation is also developed and used along with the significant change standards to identify desired median lake stage elevations that if achieved, are intended to preserve various natural system and human-use lake values. Lake Hobbs is a Category 2 Lake and as a result the significant change standards were developed for comparative purposes only and not used to establish the Minimum Levels.

The **Species Richness Standard** is developed to prevent a decline in the number of bird species that may be expected to occur at or utilize a lake. Based on an empirical relationship between lake surface area and the number of birds expected to occur at Florida lakes, the standard is established at the lowest elevation associated with less than a 15 percent reduction in lake surface area relative to lake area at the Historic P50 elevation (Figure 14, Table 5) for a plot of lake surface area versus lake stage). For Lake Hobbs, the Species Richness Standard was established at **58.7 feet above NGVD 29**. The Species Richness Standard was equaled or exceeded 100 percent of the time, based on the modeled Historic water level record.

The **Aesthetics Standard** is developed to protect aesthetic values associated with the inundation of lake basins. The standard is intended to protect aesthetic values associated with the median lake stage from becoming degraded below the values associated with the lake when it is staged at the Low Guidance Level. The Aesthetic Standard was established at the Low Guidance Level, which for Lake Hobbs is **61.9 feet above NGVD 29**. Because the Low Guidance Level was established at the Historic P90 elevation, water levels equaled or exceeded the Aesthetics Standard 90 percent of the time during the Historic long term period (Figure 14, Table 5).

The **Basin Connectivity Standard** is developed to protect surface water connections between lake basins or among sub-basins within lake basins to allow for movement of aquatic biota, such as fish, and support recreational uses. The Basin Connectivity Standard is determined in areas of the lake that have potential surface water connectivity among sub-basins within the lake basin or between the lake, or other lakes. Lake Hobbs has no natural or permitted connection to Little Lake Hobbs, the only potential surface water connection. Therefore, because Lake Hobbs has no sub-basin within the lake, the Basin Connectivity Standard does not apply.

Herbaceous Wetland information is taken into consideration to determine the elevation at which change in lake stage would result in substantial change in potential wetland area within the lake basin (i.e., basin area with a water depth less than or equal to four feet). Similarly, changes in lake stage associated with changes in lake area available for colonization by rooted submersed or floating-leaved macrophytes are also evaluated, based on water transparency values. Review of changes in potential herbaceous wetland area in relation to change in lake stage did not indicate that there would be a significant increase or decrease in the area of herbaceous wetland vegetation associated with use of the applicable significant change standards (Figure 16, Table 5). Based on a recent review (Hancock 2006) of the development of minimum level methods for cypress-dominated wetlands, it was determined that up to an 0.8 foot decrease in the Historic P50 elevation would not likely be associated with significant changes in the herbaceous wetlands occurring within lake basins. A Wetland Offset elevation of **63.2 feet above NGVD 29** was therefore established for Lake Hobbs by subtracting 0.8 feet from the Historic P50 elevation. The standard elevation was equaled or exceeded 70 percent of the time, based on the Historic water level record. Review of changes in potential wetland area in relation to change in lake stage at the Historic P50 elevation indicated there would not be a substantial increase or decrease in potential wetland area within the lake basin at the Wetland Offset elevation (36 percent of the lake basin) relative to the potential wetland area at the Historic P50 elevation (50 percent of the lake basin).

A Dock-Use Standard that was established and adopted in December 2004 at **63.9 feet above NGVD**, based on the difference between the Historic P50 and Historic P90 (2.1 feet) and a Dock-End Sediment elevation of 61.65 feet, which was developed from measurement of 33 docks remains.

A **Recreational Ski Standard** that was established at **61.1 feet above NGVD**, based on a critical ski elevation of 59 feet and the difference between the Historic P50 and the Historic P90. This area was determined to be in the lower southwestern portion of the lake.

The **Lake Mixing Standard** is developed to prevent significant changes in patterns of wind-driven mixing of the lake water column and sediment re-suspension. The standard is established at the highest elevation at or below the Historic P50 elevation where the dynamic ratio (see Bachmann et al. 2000) shifts from a value of <0.8 to a value >0.8, or from a value >0.8 to a value <0.8. Because the dynamic ratio does not shift across the 0.8 threshold over the range of water levels that may be expected within the basin, a Lake Mixing Standard was not developed.

Minimum Levels

Minimum Lake Levels are developed using specific lake-category significant change standards and other available information or unique factors, including: substantial changes in the coverage of herbaceous wetland vegetation and aquatic macrophytes; elevations associated with residential dwellings, roads or other structures; frequent submergence of dock platforms; faunal surveys; aerial photographs; typical uses of lakes (e.g., recreation, aesthetics, navigation, and irrigation); surrounding land-uses; socio-economic effects; and public health, safety and welfare matters. Minimum Levels development is also contingent upon lake classification, i.e., whether a lake is classified as a Category 1, 2 or 3 lake.

The **Minimum Lake Level (MLL)** is the elevation that a lake's water levels are required to equal or exceed 50 percent of the time on a long-term basis. For Category 2 Lakes, the Minimum Lake Level is established at the Historic P50 elevation of **64.0 feet above NGVD 29** (Figure 17, 18; Table 5).

The **High Minimum Lake Level (HMLL)** 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. For Category 2 lakes, the High Minimum Lake Level is developed at the Historic P10 of **65.7 feet above NGVD 29** (Figure 17, 18; Table 5).

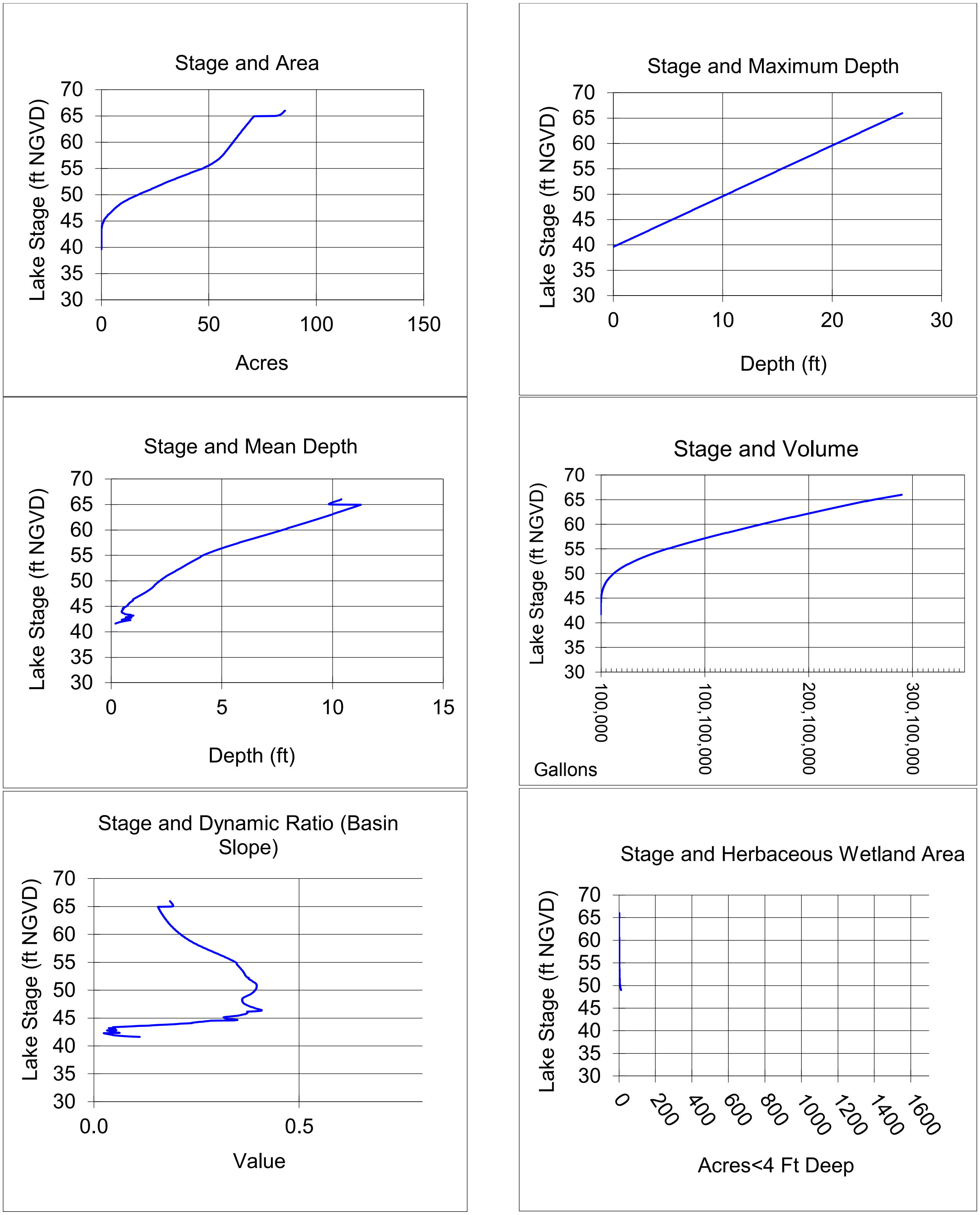

Figure 16 Stage, area and volume, mean and maximum depth, herbaceous wetland area, and dynamic ratio versus lake stage for Lake Hobbs in Hillsborough County, Florida.

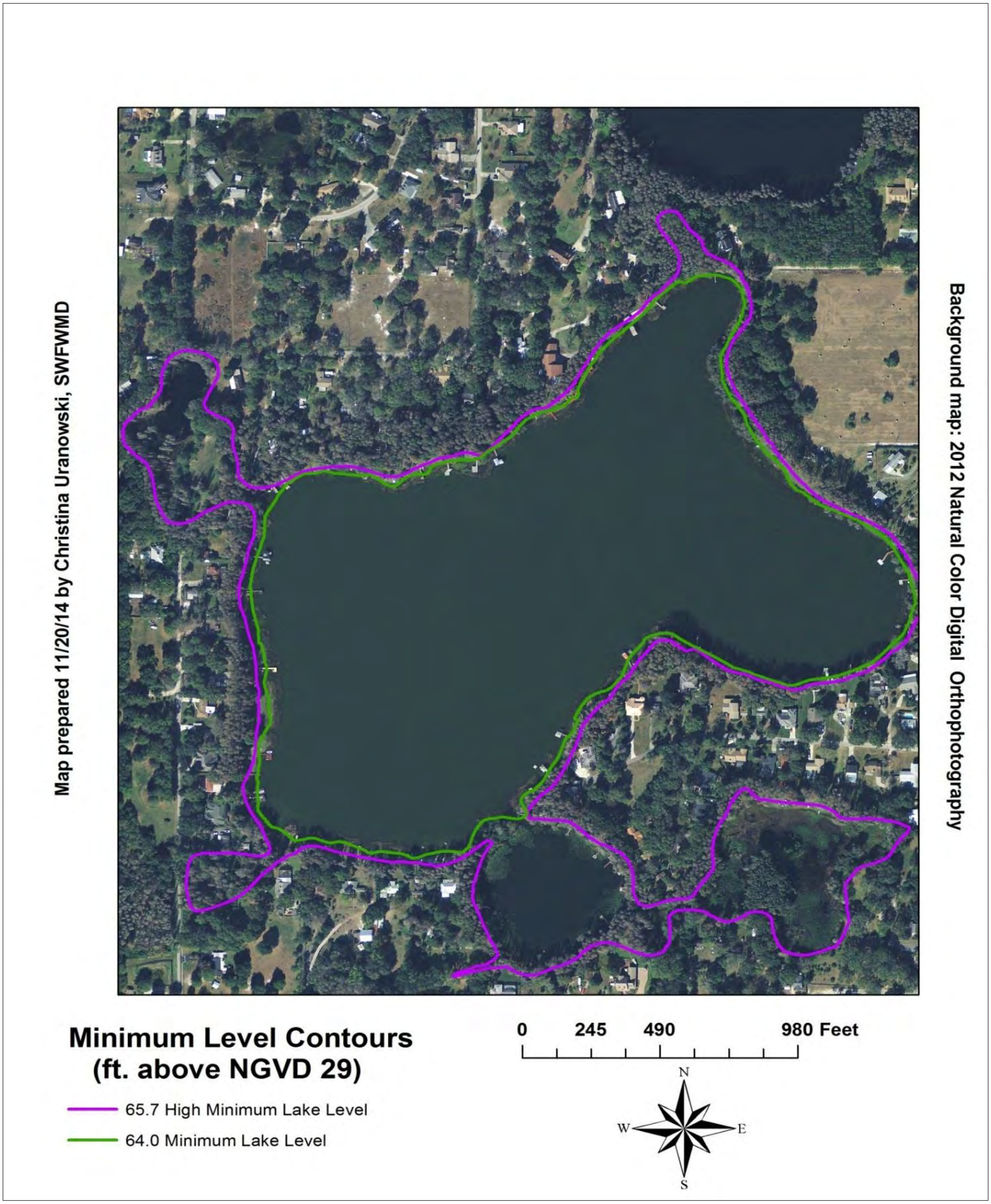

Figure 17 Lake Hobbs Minimum level contours in ft. above NGVD 29. Contours were prepared using LiDAR collected in 2007 with background map in 2012 natural color aerial orthophotography.

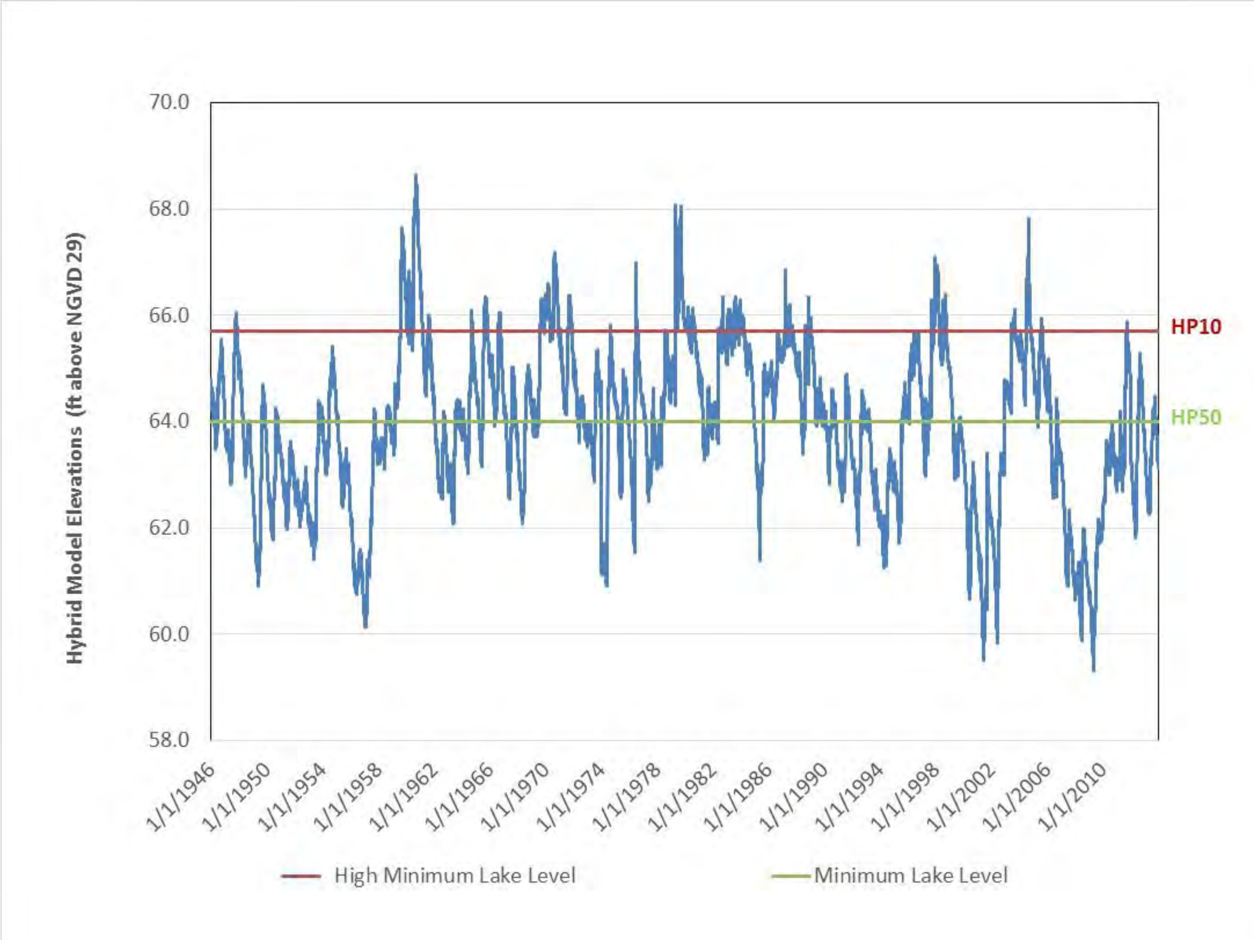

Figure 18 Modeled long term Historic lake stage (as monthly means, red line), High Minimum Lake Level as Historic P10 (65.7), and Minimum Lake Level as Historic P50 (64.0) measured in elevation in feet above NGVD 29 for Lake Hobbs.

Consideration of Environmental Values

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.

Nine of the ten environmental values identified in Rule 62-40.473, F.A.C., are protected by the minimum levels for Lake Hobbs. Each significant standard are lower than the High

Guidance Level and the High Minimum Lake Level with the exception of the Cypress Standard. The Environmental Values associated with the Significant Change Standards set for Lake Hobbs are:

-Recreation in and on the water
-Fish and wildlife habitats and the passage of fish
-Maintenance of freshwater supply
-Transfer of detrital material
-Aesthetic and scenic attributes
-Filtration and absorption of nutrients and other pollutants
-Sediment loads
-Water quality
-Navigation

The Standards associated with these Environmental values are found in Table 2. The environmental value, maintenance of freshwater storage and supply is protected by the minimum levels based on the relatively modest potential changes in storage associated with the minimum flows hydrologic regime as compared to the non-withdrawal impacted historic condition. Maintenance of freshwater supply is also expected to be protected by the minimum levels based on inclusion of conditions in water use permits that stipulate that permitted withdrawals will not lead to violation of adopted minimum flows and levels.

Estuarine resources were not considered relevant because the lake is only remotely connected to the estuarine resources associated with the downstream receiving waters of Tampa Bay, and water level fluctuations in the lake are expected to exert little effect on the ecological structure and functions of the bay.

If met, the Minimum Levels for Lake Hobbs are expected to be protective of all relevant environmental values identified for consideration in the Water Resource Implementation Rule when establishing minimum flows and levels. The Minimum and Guidance levels for Lake Hobbs are plotted in Figure 19.

Status Assessment

The status of Lake Hobbs water levels compared to the Minimum Lake Level and High Minimum Lake Level was evaluated through use of the Integrated Northern Tampa Bay (INTB) model (Geurink and Basso, 2013), the Lake Hobbs Water Budget model, and the Linear Organic Correlation (LOC) model, (Appendix B). Based on the information presented in Appendix B, it is concluded that Lake Hobbs water levels are currently below the Minimum Lake Level and High Minimum Lake Level for the lake.

The District plans to continue regular monitoring of water levels in Lake Hobbs and will also routinely evaluate the status of the lake's water levels with respect to minimum levels for the lake that are adopted into Chapter 40D-8, F.A.C. The lake lies within the region of the District covered by an existing recovery strategy, the Comprehensive Environmental Resources Recovery Plan for the Northern Tampa Bay Water Use Caution Area and the Hillsborough River Strategy (Rule 40D80-073, F.A.C.).

It is recommended that Tampa Bay Water continue to assess, in cooperation with the District, the specific needs for recovery in Lake Hobbs affected by their groundwater withdrawals as part of the Permit Recovery Assessment Plan (required by Chapter 40D-80, F.A.C., and the Consolidated Permit (20011771.001). By 2020, if not sooner, an alternative restoration project will be proposed if Lake Hobbs is found to not be meeting its adopted minimum levels. The draft results of the Permit Recovery Assessment Plan are due to the District by December 31, 2018.

Documents Cited and Reviewed for Development of Guidance and Minimum Levels for Lake Hobbs

Brooks, H. K. 1981. Physiographic divisions of Florida: map and guide. Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida.

Bachmann, R. W., Hoyer, M. V., and Canfield, D. E., Jr. 2000. The potential for wave disturbance in shallow Florida lakes. Lake and Reservoir Management 16: 281-291.

Bedient, P., Brinson, M., Dierberg, F., Gorelick, S., Jenkins, K., Ross, D., Wagner, K., and Stephenson, D. 1999. Report of the Scientific Peer Review Panel on the data, theories, and methodologies supporting the Minimum Flows and Levels Rule for northern Tampa Bay Area, Florida. Prepared for the Southwest Florida Water Management District, the Environmental Confederation of Southwest Florida, Hillsborough County, and Tampa Bay Water. Published by the Southwest Florida Water Management District. Brooksville, Florida.

Caffrey, A.J., Hoyer, M.V. and Canfield, D.E., Jr. 2006. Factors affecting the maximum depth of colonization by submersed aquatic macrophytes in Florida lakes. University of Florida Institute of Food and Agricultural Sciences Department of Fisheries and Aquatic Sciences. Gainesville, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Caffrey, A.J., Hoyer, M.V. and Canfield, D.E., Jr. 2007. Factors affecting the maximum depth of colonization by submersed aquatic macrophytes in Florida lakes. Lake and Reservoir Management 23: 287-297

Carr, D.W. and Rochow, T.F. 2004. Technical memorandum to file dated April 19, 2004. Subject: comparison of six biological indicators of hydrology in isolated Taxodium acsendens domes. Southwest Florida Water Management District. Brooksville, Florida.

Carr, D.W., Leeper, D.A., and Rochow, T.E. 2006. Comparison of six biological indicators of hydrology and the landward extent of hydric soils in west-central Florida, USA cypress domes. Wetlands 26: 1012-1019.

Cherry, R.N., Stewart, J.W. and Mann, J.A. 1970. General hydrology of the middle Gulf area, Florida. Report of Investigation No. 56. State of Florida Department of Natural Resources, Bureau of Geology. Tallahassee, Florida.

Dierberg, F. E. and Wagner, K. J. 2001. A review of “A multiple-parameter approach for establishing minimum levels for Category 3 Lakes of the Southwest Florida Water Management District” June 2001 draft by D. Leeper, M. Kelly, A. Munson, and R. Gant. Prepared for the Southwest Florida Water Management District, Brooksville, Florida.

Emery, S., Martin, D., Sumpter, D., Bowman, R., Paul, R. 2009. Lake surface area and bird species richness: analysis for minimum flows and levels rule review. University of

South Florida Institute for Environmental Studies. Tampa, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Flannery, M.S., Peebles, E.B. and Montgomery, R.T. 2002. A percent-of-flow approach for managing reductions in freshwater flows from unimpounded rivers to southwest Florida estuaries. Estuaries 25: 1318-1332.

Geurink, J.S. and R. Basso. 2013. Development, Calibration, and Evaluation of the Integrated Northern Tampa Bay Hydrologic Model. Prepared for Tampa Bay Water and Southwest Florida Water Management District. March 2013.

Gordon E. Dunn (1959). "The Hurricane Season of 1959". Weather Bureau Office. Retrieved 2007-04-05.

Griffith, G., Canfield, D., Jr., Horsburgh, C., Omernik, J. and Azevedo, S. 1997. Lake regions of Florida (map). United States Environmental Protection Agency, University of Florida Institute of Food and Agricultural Sciences, Florida Lakewatch, Florida Department of Environmental Protection, and the Florida Lake Management Society.

Hancock, M.C. and R. Basso. 1996. Northern Tampa Bay Water Resource Assessment Project: Volume One. Surface-Water/Ground-Water Interrelationships. Southwest Floridan Water Management District. Brooksville, Florida.

Hancock, M. 2006. Draft memorandum to file, dated April 24, 2006. Subject: a proposed interim method for determining minimum levels in isolated wetlands. Southwest Florida Water Management District. Brooksville, Florida.

Hancock, M. 2007. Recent development in MFL establishment and assessment. Southwest Florida Water Management District, draft 2/22/2007. Brooksville, Florida.

Hancock, M.C. 2014. Lake Hobbs Water Budget Model, Rainfall Correlation Model, and Historic Percentile Estimations. Southwest Florida Water Management District. Brooksville, Florida. Water Resources Bureau. Draft Technical Memorandum.

Hancock, M.C., Leeper, D.A., Barcelo, M.D. and Kelly, M.H. 2010. Minimum flows and levels development, compliance, and reporting in the Southwest Florida Water Management District. Southwest Florida Water Management District. Brooksville, Florida.

Henderson, S.E. 1983. Hydrology of Lake Padgett, Saxon Lake and adjacent area, Pasco County, Florida. U.S. Geological Survey Water-Resources Investigations Open-File Report 82-759. Tallahassee, Florida.

Hillsborough County 1998. Rocky/Brushy Creek area stormwater management master plan. Public Works Department/Engineering Division, Stormwater Management Section, Tampa, Florida.

Hutchison, C.B. 1984. Hydrogeology of well-field areas near Tampa, Florida, phase 2 – development and documentation of a quasi-three-dimensional finite-difference model for simulation of steady-state groundwater flow. United States Geological Survey Open-File Report 84-4002.

Leeper, D. 2006. Proposed methodological revisions regarding consideration of structural alterations for establishing Category 3 Lake minimum levels in the Southwest Florida Water Management District, April 21, 2006 peer-review draft. Southwest Florida Water Management District. Brooksville, Florida.

Leeper, D., Kelly, M., Munson, A. and Gant, R. 2001. A multiple-parameter approach for establishing minimum levels for Category 3 Lakes of the Southwest Florida Water Management District, June14, 2001 draft. Southwest Florida Water Management District. Brooksville, Florida.

Mace, J. 2009. Minimum levels reevaluation: Gore Lake Flagler County, Florida. Technical Publication SJ2009003. St. Johns River Water Management District. Palatka, Florida.

Metz, P.A. and Sachs, L.A. 2003. Comparison of the hydrogeology and water quality of a ground-water augmented lake with two non-augmented lakes in northwest Hillsborough County, Florida. United States Geological Survey Water-Resources Investigation Report 02-4032. Tallahassee, Florida.

Miller, J.A. 1986. Hydrogeologic framework of the Floridan aquifer system in Florida and in parts of Georgia, Alabama, and South Carolina. United States Geological Survey Professional Paper 1403-B. Washington, D.C.

Morelli, K. 2013. Florida once again spared hurricane landfall. tbo/com/news/breaking-news/florida-once-again-spared-hurricane-landfall 20131229

Murphy, W.R., Jr., Evans, R.P., and Whalen, J.K. 1984. Flooding in northwestern Hillsborough and southern Pasco Counties, Florida, in 1979. Open-File Report 82-96. U.S. Geological Survey, Tallahassee, Florida.

Neubauer, C.P., Hall, G.B., Lowe, E.F., Robison, C.P., Hupalo, R.B., and Keenan, L.W. 2008. Minimum flows and levels method of the St. Johns River Water Management District, Florida, USA. Environmental Management 42: 1101-1114.

Poff, N.L, Richter, B.D., Arthington, A.H., Bunn, S.E., Naiman, R.J., Kendy, E., Acreman, M., Apse, C., Bledsoe, B.P., Freeman, M.C., Henriksen, J., Jacobson, R.B., Kennan, J.G., Merritt, D.M., O'Keefe, J.H., Olden, J.D., Rogers, K., Tharme, R.E. and Warner, A. 2010. The ecological limits of hydrologic alteration (ELOHA): a new framework for developing regional flow standards. Freshwater Biology 55: 147-170.

Poff, N.L. and Zimmerman, K.H. 2010. Ecological responses to altered flow regimes: a literature review to inform science and management of environmental flows. Freshwater Biology 55: 194-205.

Postel, S. and Richter, B. 2003. Rivers for life: Managing water for people and nature. Island Press. Washington, D.C.

Robertson, R. 1971. Water Levels Northwest Hillsborough Basin. SWFWMD, Brooksville, Fl.

Sacks, L.A. 2002. Estimating ground-water inflow to lakes in central Florida using the isotope mass-balance approach. Water Resources Investigations Report 02-4192. U.S. Geological Survey, Tallahassee, Florida.

Schiffer, D.M. 1998. Hydrology of central Florida lakes – a primer. United States Geological Survey Circular 1137. Washington, D.C. Prepared in cooperation with the Saint Johns River Water Management District and the South Florida Water Management District. Palatka and West Palm Beach, Florida.

Schultz, R., Hancock, M., Hood, J., Carr, D. and Rochow, T. 2005. Technical memorandum to File, NTB II. Subject: use of biological indicators for the establishment of historic normal pool. Southwest Florida Water Management District. Brooksville, Florida.

Shafer, M.D., Dickinson, R.E., Heaney, J.P., and Huber, W.C. 1986. Gazetteer of Florida lakes. Publication no. 96, Water Resources Research Center, University of Florida, Gainesville, Florida.

Southwest Florida Water Management District. 1981. An evaluation of lake regulatory stage levels on selected lakes in the Northwest Hillsborough Basin. Brooksville, Florida.

Southwest Florida Water Management District. 1981. Northwest Hillsborough Basin Northwest Hillsborough Re-Map, aerial photography with contours. Sheet No. 01-27-18. Brooksville, Florida. Prepared by Abrams Aerial Survey Corporation of Florida, St. Petersburg, Florida.

Southwest Florida Water Management District. 1981. Northwest Hillsborough Basin Northwest Hillsborough Re-Map, aerial photography with contours. Sheet No. 02-27-18. Brooksville, Florida. Prepared by Abrams Aerial Survey Corporation of Florida, St. Petersburg, Florida.

Southwest Florida Water Management District. 1981. Northwest Hillsborough Basin Northwest Hillsborough Re-Map, aerial photography with contours. Sheet No. 11-27-18. Brooksville, Florida. Prepared by Abrams Aerial Survey Corporation of Florida, St. Petersburg, Florida.

Southwest Florida Water Management District. 1981. Northwest Hillsborough Basin Northwest Hillsborough Re-Map, aerial photography with contours. Sheet No. 12-27-18. Brooksville, Florida. Prepared by Abrams Aerial Survey Corporation of Florida, St. Petersburg, Florida.

Southwest Florida Water Management District. 1996. Lake Levels Program lake data sheets / 1977-1996, NW Hillsborough Basin – 14, Volume #1 – Lake H thru Z. Brooksville, Florida.

Southwest Florida Water Management District. 1999. Establishment of minimum levels for Category 1 and Category 2 lakes, *in* Northern Tampa Bay minimum flows and 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. Brooksville, Florida.

Southwest Florida Water Management District. 2002. Special purpose survey, Section 1, 2, 11, 12, Township 27 South, Range 18 East, Hillsborough County; Northwest Hillsborough Basin, Minimum Flows & Levels, Lake Hobbs. Brooksville, Florida.

Suwannee River Water Management District. 2005. Technical report, MFL establishment for the lower Suwannee River & estuary, Little Fanning, Fanning & Manatee springs. Live Oak, Florida.

Swancar, A., Lee, T.M. and O'Hare, T.M. 2000. Hydrogeologic setting, water budget, and preliminary analysis of ground-water exchange at Lake Starr, a seepage lake in Polk County, Florida. United States Geological Survey Water-Resources Investigations Report 00-4030. Tallahassee, Florida.

United States Geological Survey. 1974. Lutz quadrangle, Florida-Hillsborough Co., 7.5 minute series (topographic) map; Lutz, Fla., 28082-B4-TF-024, 1974, photorevised 1987, DMA 4540 III NW-Series V847. Department of Interior, Washington, D.C.

Wagner, K. and Dierberg, F. 2006. A review of "Proposed methodological revisions regarding consideration of structural alterations for establishing Category 3 Lake minimum levels in the Southwest Florida Water Management District" by D. Leeper, 2006. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Wantzen, K.M., Rothhaupt, K.O., Morti, M., Cantonati, M.G., Toth, L.G. and Fisher, P. (editors). 2008. Ecological effects of water-level fluctuations in lakes. Development in Hydrobiologiy, Volume 204. Springer Netherlands.

Wantzen, K.M., Rothhaupt, K.O., Morti, M. Cantonati, M.G., Toth, L.G. and Fisher, P. (editors). 2008. Ecological effects of water-level fluctuations in lakes. Hydrobiologia 613:1-4.

Water and Air Research, Inc. 1997. Determination of lake chains and hydrologic overview for the King and Deer groups of lakes in the Land O' Lakes and Lutz areas of Pasco and Hillsborough Counties. Gainesville, Florida. Prepared for the West Coast Regional Water Supply Authority, Clearwater, Florida.

Appendix A

Technical Memorandum

August 15, 2014

TO: Christina Uranowski, Senior Env. Scientist, Water Resources Bureau

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

FROM: Michael C. Hancock, P.E., Senior Prof. Engineer, Water Resources Bureau

Subject: Lake Hobbs Water Budget Model, Rainfall Correlation Model, and Historic Percentile Estimations

---

A. Introduction

Water budget and rainfall correlation models were developed to assist the Southwest Florida Water Management District (District) in the reassessment of minimum levels for Lake Hobbs in northwest Hillsborough County. This document will discuss the development of the Lake Hobbs models and use of the models for development of Historic lake stage exceedance percentiles.

B. Background and Setting

Lake Hobbs is located in northwest Hillsborough County, approximately 800 feet west of U.S. 41 and north of Lake Hobbs Road in Lutz (Figure 1). The lake lies within the Brushy Creek watershed. Brushy Creek is a tributary to Rocky Creek. Surface-water inflow occurs from Deer Lake and Little Deer Lake to the north (Figure 2) during high flow periods. The topography is very flat, however, and flows are often negligible. A small lake to the southeast of Lake Hobbs, Trout Lake, also discharges to Lake Hobbs. Discharge from Lake Hobbs can occur via a ditch and culvert system, which eventually discharges to Lake Cooper.

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. The topography is very flat, and drainage into the lake is a combination of overland flow and flow through drainage swales and minor conveyance systems.

The hydrogeology of the area includes a sand surficial aquifer; a discontinuous, intermediate clay confining unit; and the thick carbonate Upper Floridan aquifer. In

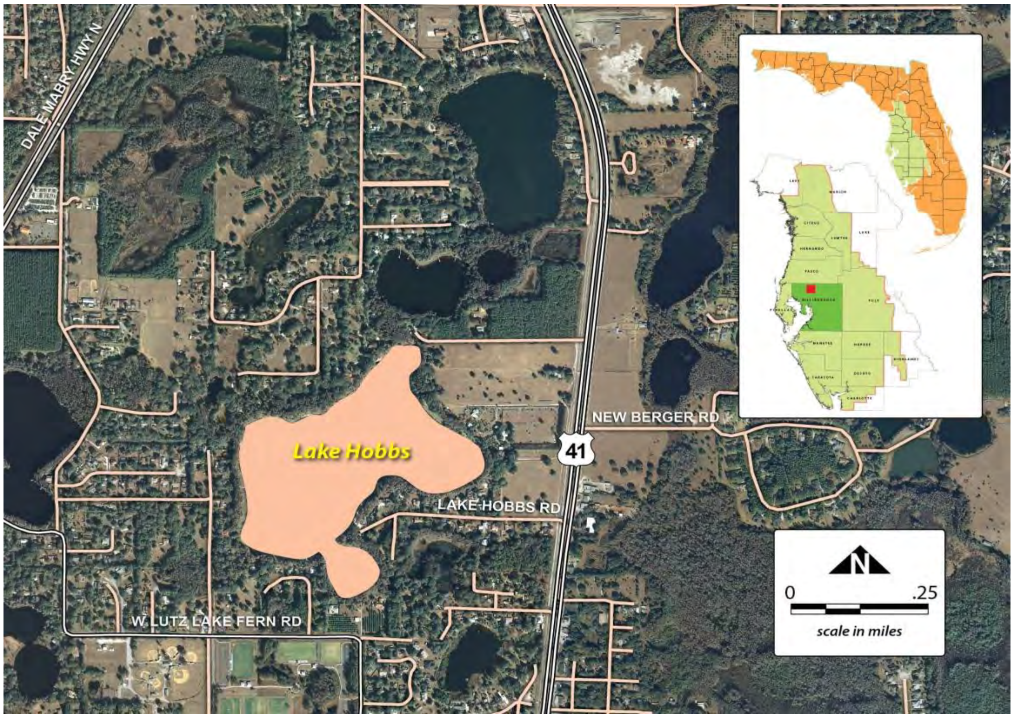

Figure 6. Location of Lake Hobbs in Hillsborough County, Florida.

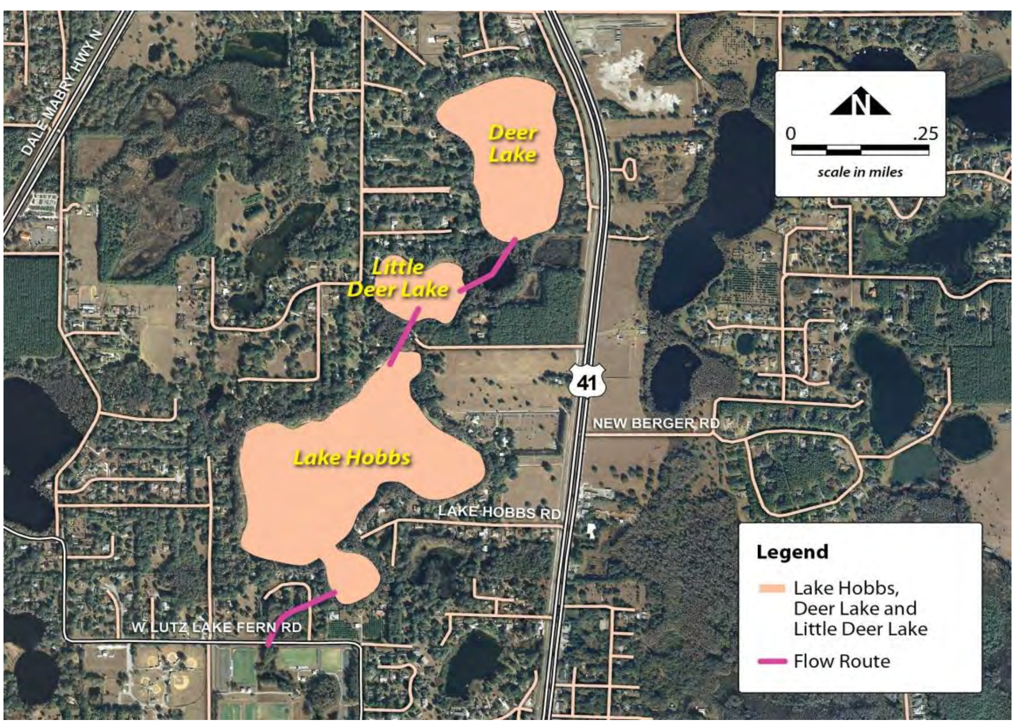

Figure 7. Flow between Deer Lake and Lake Hobbs.

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).

Lake Hobbs is located approximately three miles southeast of the South Pasco Wellfield, and less than 3 miles northeast of the Section 21 wellfield, two of eleven regional water supply wellfields operated by Tampa Bay Water (Figure 3). 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 4). 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.

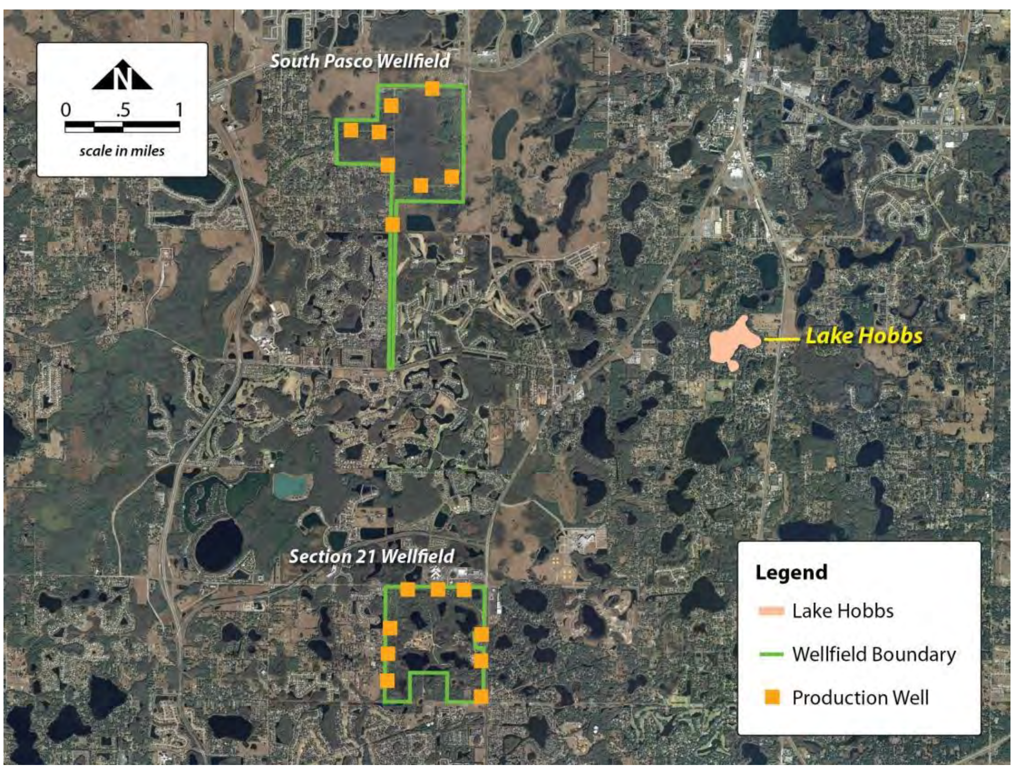

Figure 3. Lake Hobbs and the Section 21 and South Pasco Wellfields.

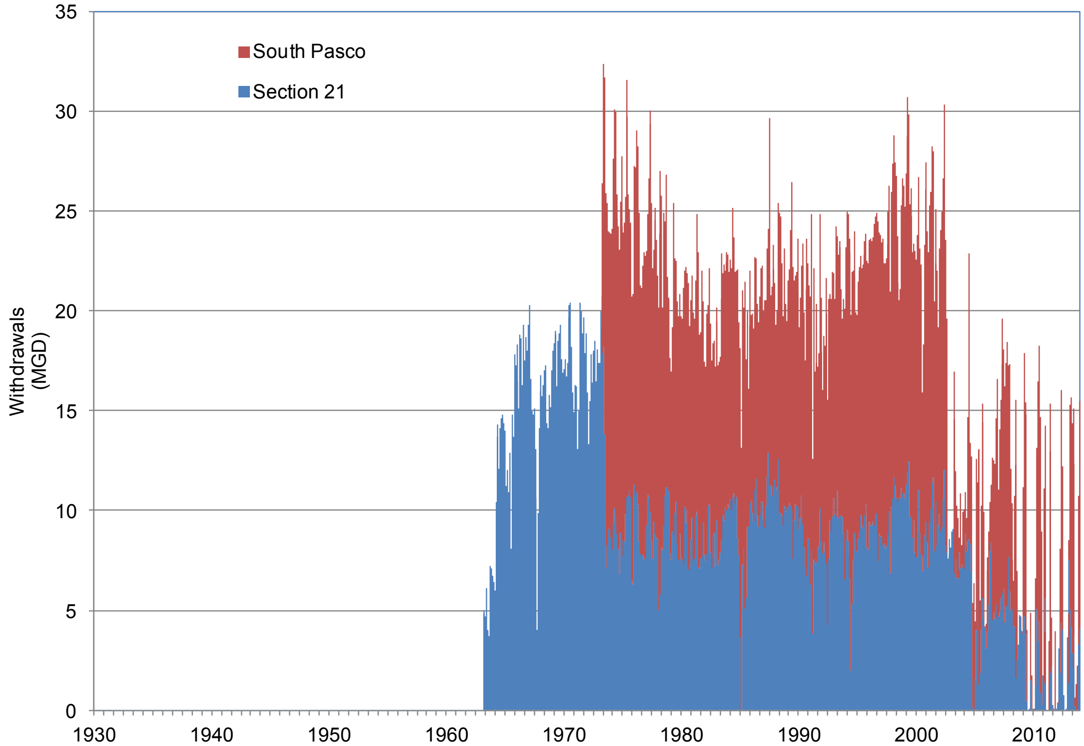

Figure 4. Section 21 and South Pasco Wellfield withdrawals.

Water level data collection at Lake Hobbs began in mid-1946, providing several years of pre-withdrawal data for the lake (Figure 5). The United States Geological Survey (USGS) began data collection via a data recorder, with a frequency that varied from daily to weekly. The District took over data collection responsibilities in October 1983.

Three Upper Floridan and surficial aquifer monitor well nests were assessed for the analysis. Water levels from the Debuel Road Deep Floridan aquifer and Debuel Road Shallow surficial aquifer monitor wells have been collected since August 1965, making them two of the longest term monitor wells in Hillsborough County (Figures 6 and 7). The wells are located approximately 2.5 miles to the southeast of Lake Hobbs. The data collection frequency began as weekly, and became daily in the mid-1970s (Figure 7). The Newberger Road Floridan and surficial aquifer monitor wells are located approximately 4,700 feet to the east of Lake Hobbs (Figure 6). Monthly data is available from this well back to July 1989 (Figure 8). The Lutz Park Floridan and surficial aquifer monitor wells are located approximately 2,100 feet to the southwest of Lake Hobbs (Figure 6). Monthly data is available from this well back to March 1989 (Figure 9).

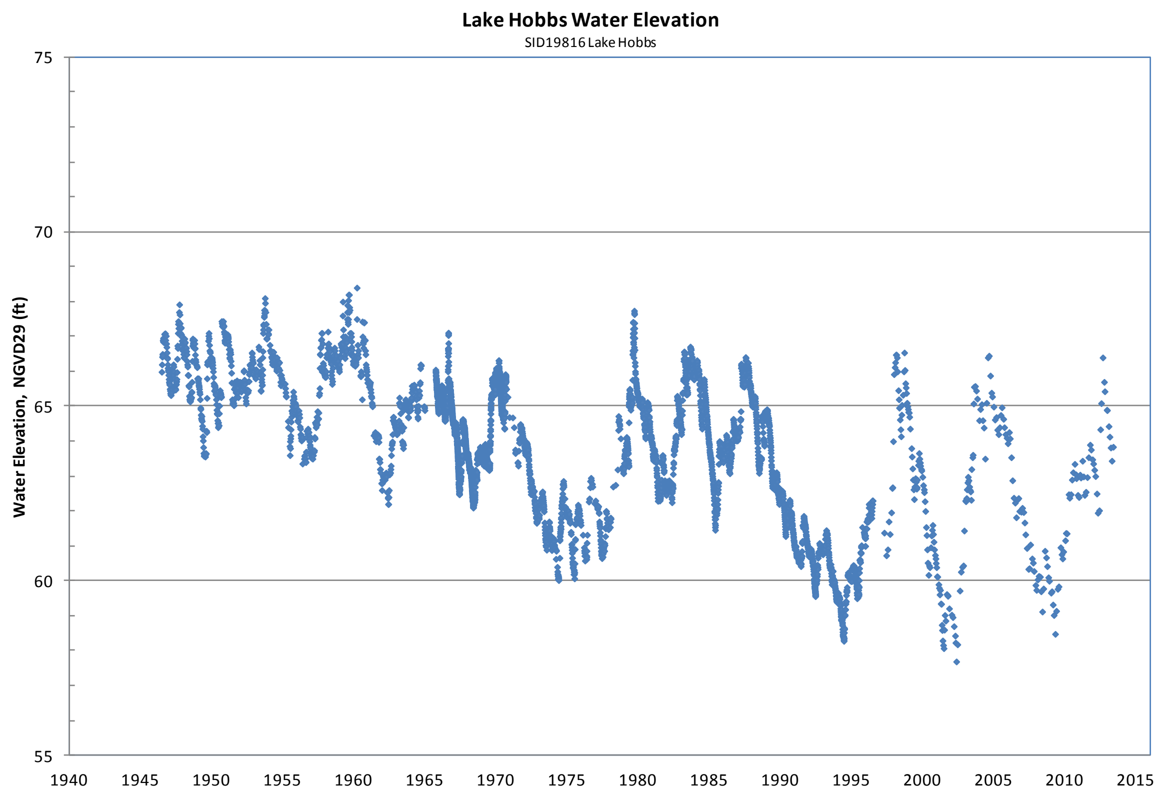

Figure 5. Lake Hobbs water levels.

Figure 6. Location of monitor wells near Lake Hobbs.

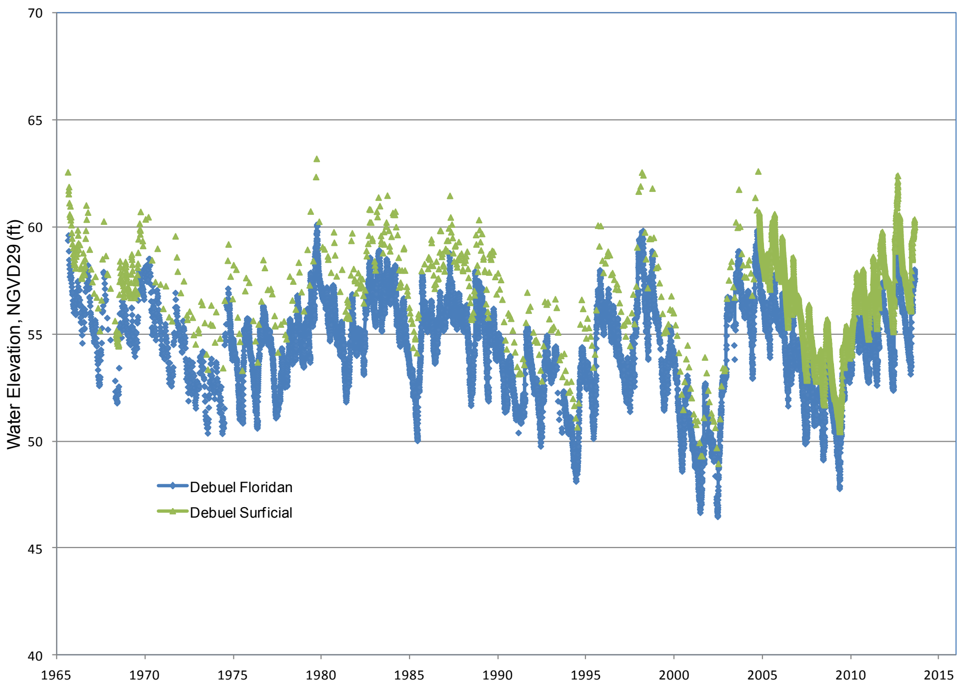

Figure 7. Water levels in the Debuel Road Surficial and Floridan aquifer monitor wells.

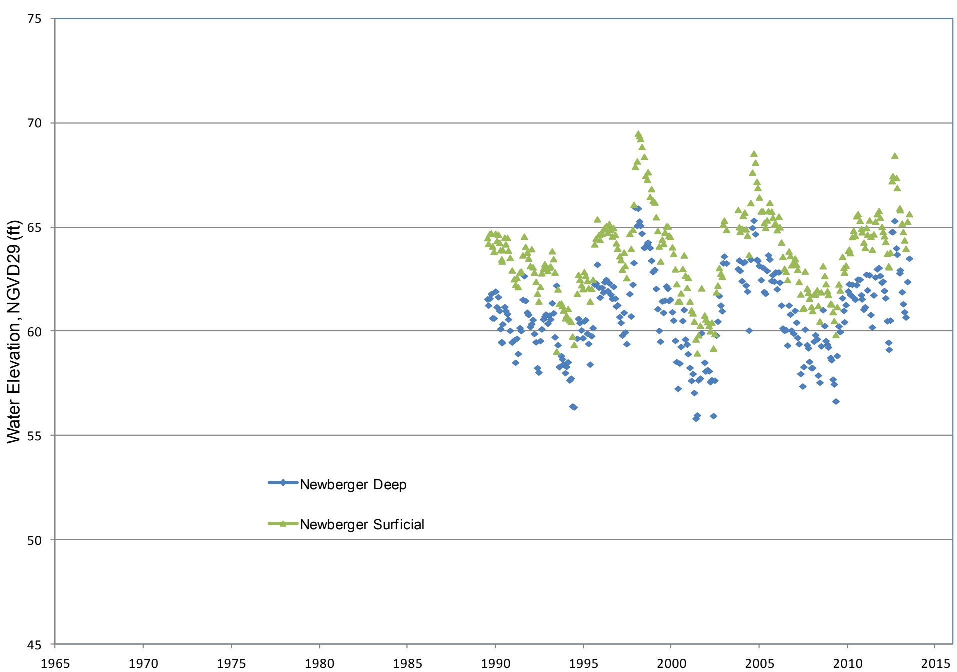

Figure 8. Water levels in the Newberger Road Surficial and Floridan aquifer monitor wells.

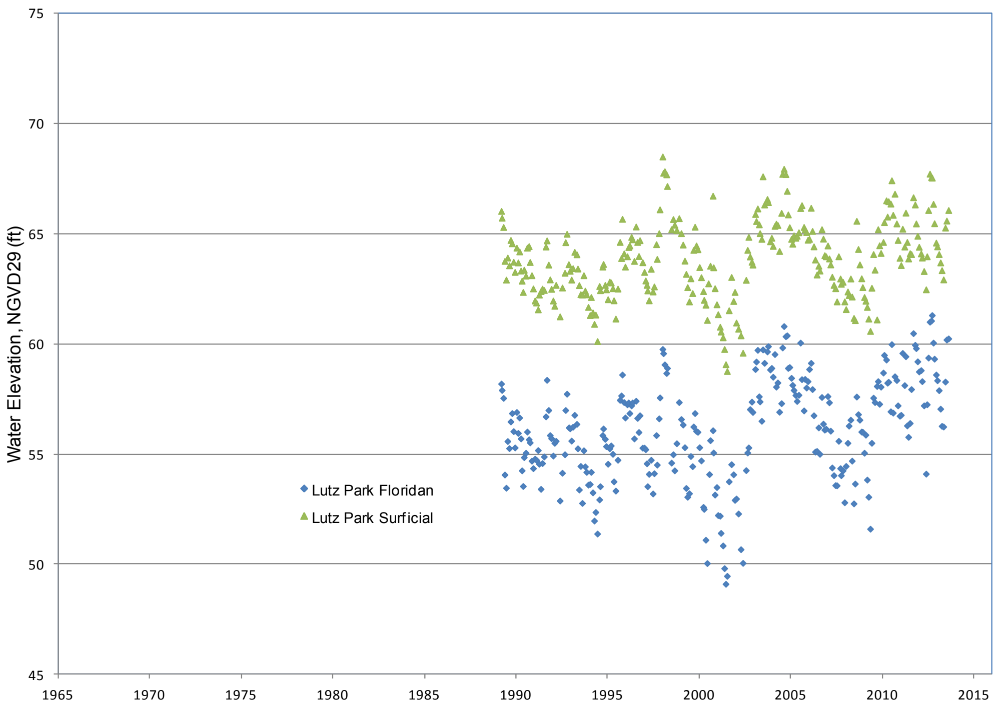

Figure 9. Water levels in the Lutz Park Surficial and Floridan aquifer monitor wells.

Water levels in Lake Hobbs have dropped significantly since public supply groundwater withdrawals began in the area (Figures 10 and 11). Comparing the 1968 aerial photograph below with the 1938 aerial, a significant amount of lake bottom is exposed along the shore in the 1968 aerial. A similar situation is seen in the 1974 aerial. A similar amount of lake bottom continues to be exposed in the 2010 photo, although vegetation has filled in the exposed area. Sinclair (1982) discusses the observed formation of dozens of sinkholes following the initiation of groundwater withdrawals at the Section 21 Wellfield in 1963. Sinkholes were documented as far as several miles away (including several in the Lake Hobbs area and beyond), and they continued to appear around the wellfield years later. It is possible that a change in leakance properties between Lake Hobbs and the Upper Floridan aquifer (possibly due to karst activity beneath or surrounding the lakes) has occurred that has not reversed since that time.

The relationship between sinkhole formation or karst activity and hydrologic stress in the northwest Hillsborough County area has been well established and thoroughly discussed (Bredehoeft and others, 1965; Sinclair, 1973; Stewart and Hughes, 1974; Sinclair, 1982; Sinclair and others, 1985; Hancock and Basso, 1996; Metz and Sacks, 2002; and, Metz, 2011). Man-induced or natural hydrologic stress can cause sediments in karst formations to unravel or can lower water levels that support overburden covering voids in the limestone aquifer. This can result in sinkholes that appear on the surface, or can result in changes that occur underground and cannot be seen at the surface. These changes, in turn, can result in pathways for water to connect lakes, wetlands, or the surficial aquifer in general, to the underlying Upper Floridan aquifer.

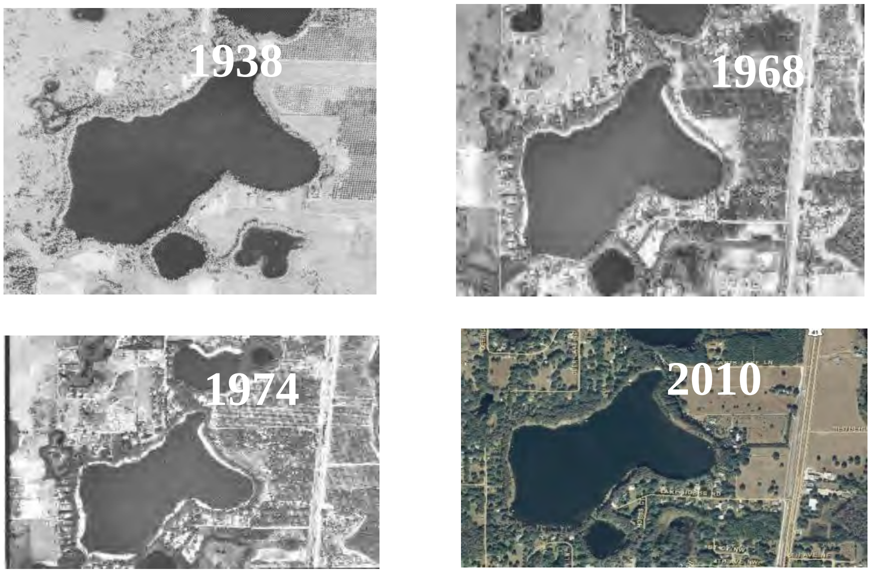

Figure 10. Water level changes in Lake Hobbs.

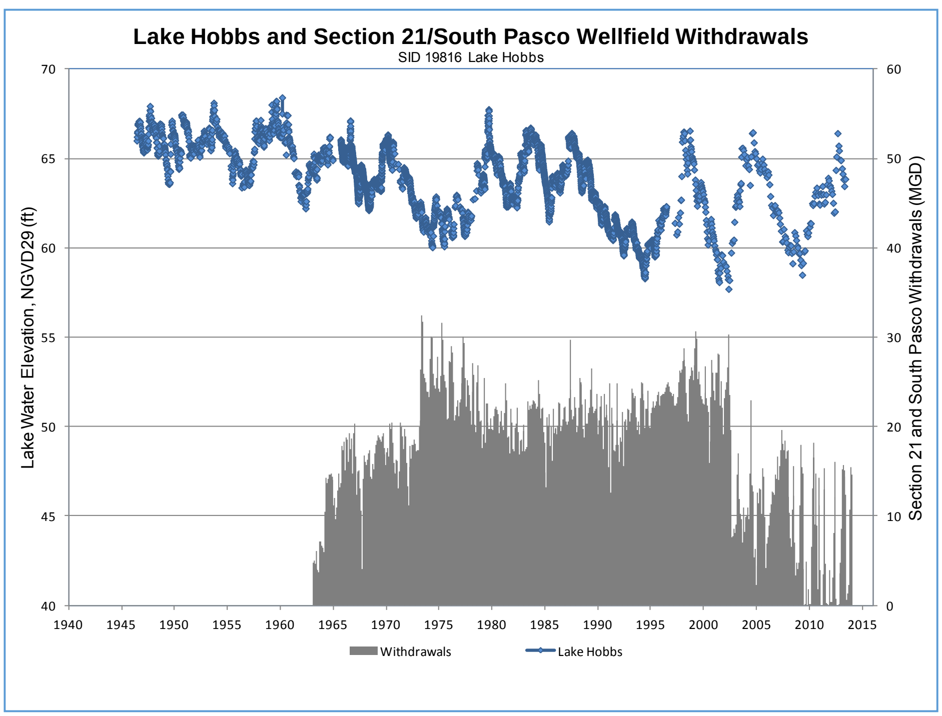

Figure 11. Water levels in Lake Hobbs.

C. Purpose of Models

Prior to establishment of Minimum Levels, long-term lake stage percentiles are developed to serve as the starting elevations for the determination of the lake's High Minimum Lake Level and the Minimum Lake Level. A critical task in this process is the delineation of a Historic time period. The Historic time period is defined as a period of time when there is little to no groundwater withdrawal impact on the lake, and the lake's structural condition is similar or the same as present day. The existence of data from a Historic time period is significant, since it provides the opportunity to establish strong predictive relationships between rainfall, groundwater withdrawals, and lake stage fluctuation that represent the lake's natural state in the absence of groundwater withdrawals. This relationship can then be used to calculate long-term Historic lake stage exceedance percentiles such as the P10, P50, and P90, which are, respectively, the water levels equaled or exceeded ten, fifty, and ninety percent of the time. If data representative of a Historic time period does not exist, or available Historic time period data is considered too short to represent long-term conditions, then a model is developed to approximate Long-term Historic data.

In the case of Lake Hobbs, the Section 21 Wellfield has potentially affected lake water levels since early 1963, while the South Pasco Wellfield has potentially affected water level since 1973. Other groundwater withdrawals (including other wellfields) in the area could also affect levels, but the effect of such withdrawals would be much smaller and less consistent. Nearly 17 years of lake water data are available for the period prior to the initiation of groundwater withdrawals at the Section 21 Wellfield. Field indicators of historic normal pool (an elevation associated with hydrologic indicators representing approximate Historic P10 conditions) suggest that the water level records collected prior to the initiation of the wellfield withdrawals are consistent with the historic indicators. However, the drainage system associated with Lake Hobbs and the lakes upstream and downstream of the lake may have changed the hydrologic characteristics of Lake Hobbs since that time. Therefore, the development of a water budget model coupled with a rainfall correlation model for the lake was considered essential for estimating long-term Historic percentiles, accounting for changes in the lake's drainage system, and simulating effects of changing groundwater withdrawal rates.

D. Water Budget Model Overview

The Lake Hobbs water budget model is a spreadsheet-based tool that includes natural hydrologic processes and engineered alterations acting on the control volume of the lake. The control volume consists of the free water surface within the lake extending down to the elevation of the greatest lake depth. A stage-volume curve was derived for the lake that produced a unique lake stage for any total water volume within the control volume.

The hydrologic processes in the water budget model include:

a. Rainfall and evaporation

b. Overland flow
c. Inflow and discharge via channels
d. Flow from and into the surficial aquifer
e. Flow from and into the Upper Floridan aquifer

The water budget model uses a daily time-step, and tracks inputs, outputs, and lake volume to calculate a daily estimate of lake levels for the lake. The water budget model for Lake Hobbs is calibrated from 1974 through 2011. This period provides the best balance of using available data for all parts of the water budget and the desire to develop a long-term water level record.

E. Water Budget Model Components

Lake Stage/Volume

Lake stage area and stage volume estimates were determined by building a terrain model of the lake and surrounding watersheds. Lake bottom elevations and land surface elevations were used to build the model with LP360 (by QCoherent) for ArcGIS, ESRI's ArcMap 10.1, the 3D Analyst ArcMap Extension, Python, and XTools Pro. The overall process involves merging the terrain morphology of the lake drainage basin with the underlying lake basin morphology to develop one continuous three-dimensional (3D) digital elevation model. The 3D digital elevation model was then used to calculate area of the lake and the associated volume of the lake at different elevations, starting at the extent of the lake at its flood stage and working downward to the lowest elevation within the basin.

Precipitation

After a review of several rain gages in the area, a composite of several stations was used for the Lake Hobbs water budget model (Figure 12). The goal was to use the closest available data to the lake, as long as the data appeared to be high quality. Rainfall data was collected adjacent to the lake from January 1, 1986 to August 31, 1995 (Lake Hobbs, SID 18301). Data from the Lutz station (SID 19629) was used from the beginning of the simulation (January 1, 1974) to December 31, 1985, and again from September 1, 1995 to May 31, 1997. A combination of data from the Lutz, Whalen (SID 19492), and Lake Hanna (SID 18593) stations was used through the end of the modeled period (December 31, 2011). All rainfall stations used are maintained by the District.

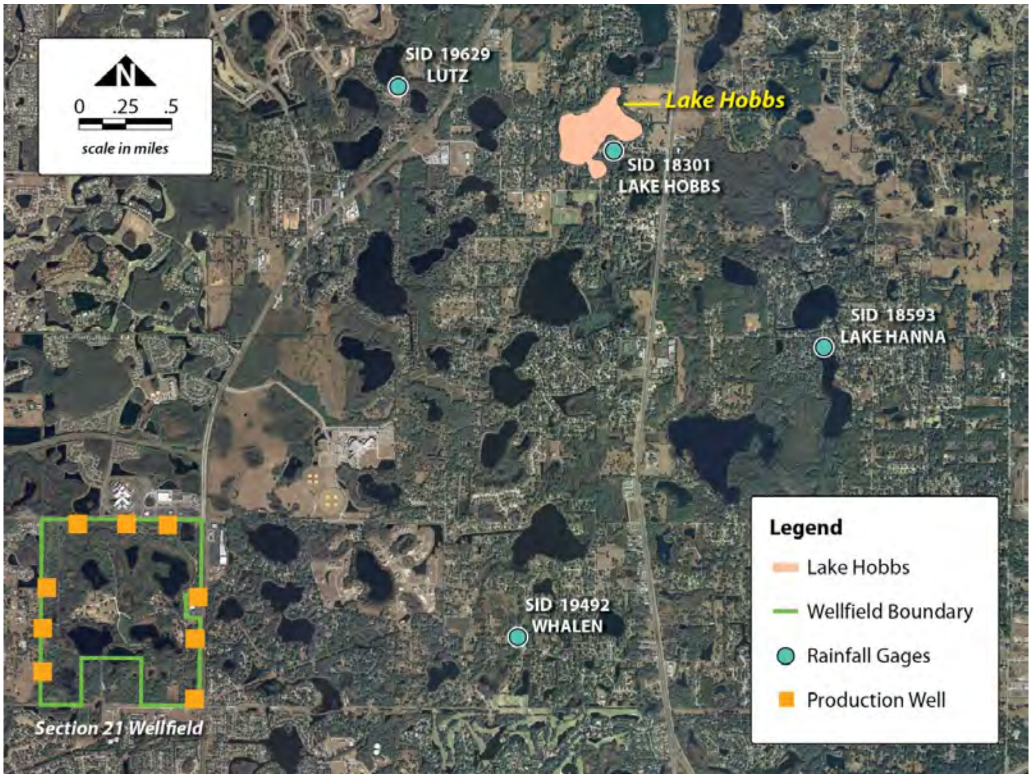

Figure 12. Rain gages used in the Lake Hobbs water budget model.

<u>*Lake Evaporation*</u>

Lake evaporation was estimated through use of monthly energy budget evaporation data collected by the U.S. Geological Survey (USGS) at Lake Starr in Polk County (Swancar and others, 2000) (Figure 13). The data was collected from August of 1996 through July of 2011. Monthly Lake Starr evaporation data were used in the Lake Hobbs water budget model when available, and monthly averages for the period of record were used for those months when Lake Starr evaporation data were not available.

A recent study compared monthly energy budget evaporation data collected from both Lake Starr and Calm Lake (Swancar, 2011, personal communications). Calm Lake is located approximately 6.5 miles to the southwest of Lake Hobbs (Figure 13). The assessment concluded that the evaporation rates between the two lakes were nearly identical, with small differences attributed to measurement error and monthly differences in latent heat associated with differences in lake depth.

Jacobs (2007) produced daily potential evapotranspiration (PET) estimates on a 2-square kilometer grid for the entire state of Florida. The estimates begin in 1995, and are updated annually. These estimates, available from a website maintained by the USGS, were calculated through the use of solar radiation data measured by a Geostationary Operational Environmental Satellite (GOES). Because PET is equal to lake evaporation over open water areas, using the values derived from the grid nodes over the modeled lake was considered. A decision was made to instead use the Lake Starr evaporation data since the GOES data nodes typically include both upland and lake estimates, with no clear way of subdividing the two. It was thought that using the daily PET estimates based on the GOES data would increase model error more than using the Lake Starr data directly.

Figure 13. Location of Lakes Hobbs, Calm and Starr (see map inset).

<u>*Overland Flow*</u>

The water budget model was set up to estimate overland flow via a modified version of the U.S. Department of Agriculture, Soil Conservation Service (SCS) Curve Number method (SCS, 1972), and via directly connected impervious area calculations. The free water area of each lake was subtracted from the total watershed area at each time step to estimate the watershed area contributing to surface runoff. The directly connected impervious area (DCIA) was subtracted from the watershed for the SCS calculation, and then added to the lake water budget separately. Additionally, the curve number (CN) chosen for the watershed of the lake takes into account the amount of DCIA in the watershed that has been handled separately.

The modified SCS method was suggested for use in Florida by CH2M HILL (2003), and has been used in several other analyses. The modification adds a fourth category of antecedent moisture condition (AMC) to the original SCS method (SCS, 1972) to account for Florida’s frequent rainfall events.

The topography in the area of Lake Hobbs is relatively flat, so determining watersheds based on relatively subtle divides can be challenging. Several slightly varying estimates of watershed boundaries have been performed in the past for different modeling efforts in the area. One of the most recent set of estimates was developed as part of an effort to model the Rocky Creek watershed for flood assessment purposes (Parsons, 2010). The watershed area values developed by Parsons were adopted for the Lake Hobbs model (Table 1) after an independent check confirming that they are reasonable for modeling purposes.

Lake Hobbs has an immediate watershed from which it receives overland flow, and a contributing watershed to the north from which it can receive channel flow from Little Deer and Deer lakes (Figure 14). The entire area of the contributing watersheds is approximately 459 acres (including the lake), while the area of the direct overland flow watershed is approximately 278.6 acres (including the lake).

Because Lake Hobbs has a direct overland flow basin and contributing basins, it can be modeled as one large basin using the modified SCS method, or by modeling the overland flow portion of the contributing basin using the modified SCS method, and modeling the contributing basin using lake stage at Deer Lake and a control elevation. Both approaches were evaluated, and the latter was chosen since it was believed that modeling the lake using both channel and overland flow was more realistic, and would allow the model to be used to evaluate effects of variations in structural alterations to assist with potential recovery project assessments.

The DCIA and SCS CN used for the direct overland flow portion of the watershed are listed in Table 1. Curve numbers were difficult to assess. Most of the soils in the area are B/D soils, which means that the characteristics of the soils are highly dependent on how well they are drained. A “D” soil will generally have a higher amount of runoff per quantity of rain than a “B” soil. Because of the proximity of the wellfields to the area being modeled, water levels have been historically lowered by the withdrawals, and soils in the area may have had lower runoff rates (characteristic of “B” soils). Groundwater withdrawals during the period of model calibration were, however, significantly reduced relative to historic withdrawal rates, so the soils in the area may have begun to exhibit runoff properties more characteristic of “D” soils.

For purposes of this model, taking into account the range of conditions experienced, a compromise was used for the CN. No direct discharges to the lake were identified, so the DCIA of the watershed is zero.

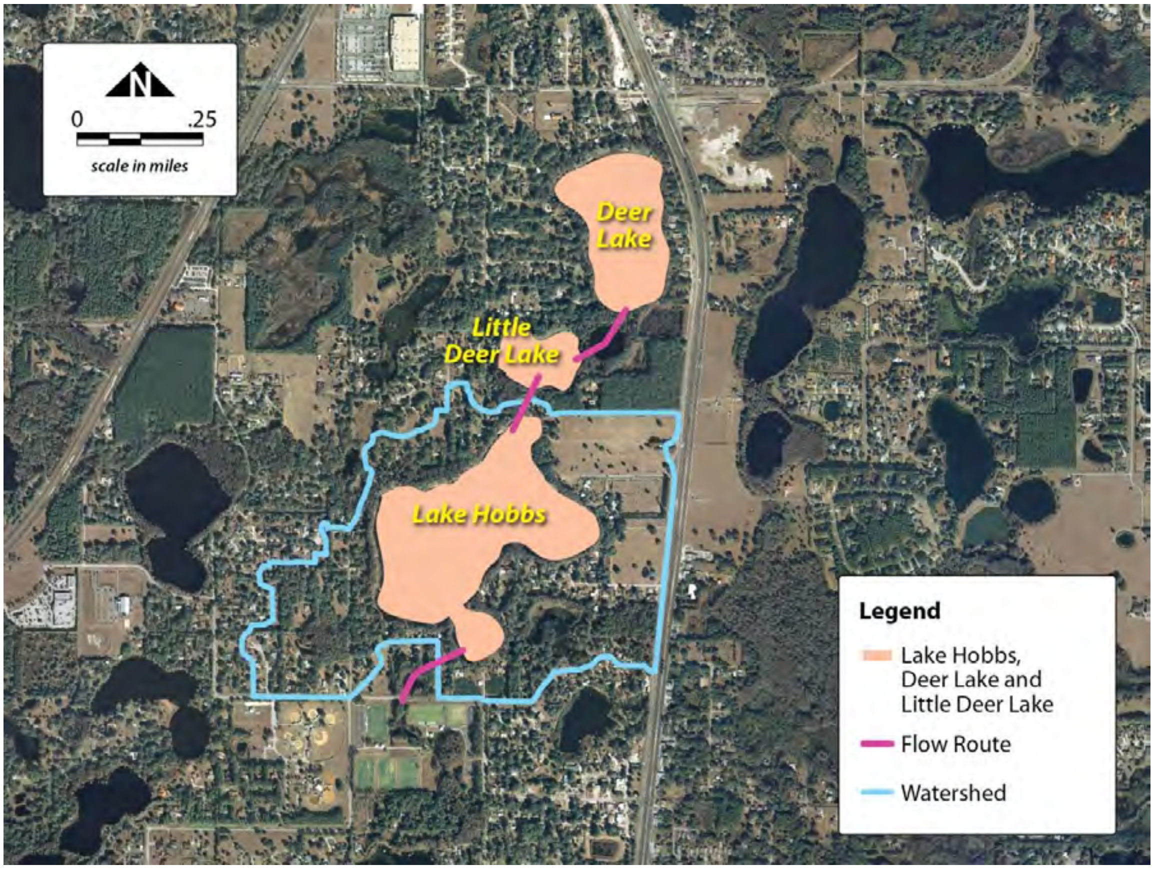

Figure 14. Direct overland flow portion of the Lake Hobbs watershed.

Table 1. Model inputs for the Lake Hobbs water budget model.

Input Variable	Value
Overland Flow Watershed Size (acres)	248.7
SCS CN of watershed	75
Percent Directly Connected	0
FL Monitor Well Used	Lutz Park and Debuel Road Floridan
Surf. Aq. Monitor Well(s) Used	Lutz Park and Debuel Road Surficial
Surf. Aq. Leakance Coefficient (ft/day/ft)	0.002
Fl. Aq. Leakance Coefficient (ft/day/ft)	0.0016
Outflow K	0.05
Outflow Invert (ft NGVD29)	65.4
Inflow K	0.02
Inflow Invert (ft NGVD29)	66.0

Inflow and Discharge via Channels from Outside Watersheds

Inflow and outflow via channels from or to the lake's watershed (i.e. "channel flow") is an important component of the Lake Hobbs water budget, although the gradients of the channels are relatively flat, and inflows to the lake likely occur only during high rainfall events.

To estimate flow out of Lake Hobbs, the predicted elevation of the lake from the previous day is compared to the controlling elevation. Control elevations were determined based on professional surveying performed in the area. If the lake elevation is above the controlling elevation, the difference is multiplied by the current area of the lake and an "outflow coefficient." The coefficient represents a measure of channel and structure efficiency, and produces a rough estimate of volume lost from the lake. This volume is then subtracted from the current estimate of volume in the lake. To estimate flow into the lake, the same approach was applied. Daily lake stage information from Deer Lake was included in the model, and the elevation of Deer Lake each day was compared to the controlling elevation in the channels from Deer Lake to Lake Hobbs. Because the elevations of Little Deer Lake and Lake Deer are relatively equalized, this system can be treated as one hydrologic unit. If the Deer Lake elevation is above the controlling elevation, the difference is multiplied by the current area of Lake Hobbs and an outflow coefficient. The resulting volume is then added to the current estimate of volume in Lake Hobbs.

A wetland system exists between Deer Lake and Lake Hobbs (with Little Deer Lake and a small unnamed lake in between – Figure 2). A high area in wetland between the Little Lake Deer and Lake Hobbs was surveyed at 66.0 feet NGVD29, which was used as the controlling elevation for Deer Lake. A discharge ditch system exists on the south shore of a small embayment to the south of the main body of Lake Hobbs. The ditch system passes through a small forested wetland and under Lutz Lake Fern Road, and eventually discharges to Lake Cooper. A high point in the channel was surveyed at 65.4 feet NGVD29, which serves as the control point elevation of Lake Hobbs (Table 1).

Flow from and into the surficial aquifer and Upper Floridan aquifer

Water exchange between Lake Hobbs and underlying aquifers is estimated using a leakance coefficient and the head difference between the lake and the aquifer levels. For each model time step, surficial aquifer and Upper Floridan aquifer leakage volumes were calculated independently. Leakance coefficients for each aquifer were determined through calibration.

The Lutz Park Floridan well is the closest Upper Floridan aquifer monitor well to Lake Hobbs, located approximately 0.4 miles from the lake's southwest shore (Figures 5 and 8), and was used to represent the potentiometric surface under the lake for the period when data exists. Prior to 1989, the Debuel Road Deep Upper Floridan aquifer monitor well (Figures 5 and 6) was used by adjusting the well by the median head difference between the two wells during the period of record of the Lutz Park well. This value calculated to be 2.4 feet (with the Lutz Park well data being higher). Missing daily water level values were in-filled using the previously recorded value.

Similarly, a combination of the Lutz Park and Debuel Road surficial aquifer monitoring wells was used to represent the water table in the surficial aquifer (Figures 5, 6, and 8). In this case, the data from the Debuel Road surficial aquifer monitor well was adjusted up by 5.8 feet to represent the water table in the vicinity of the Lutz Park surficial aquifer monitor well and Lake Hobbs, since 5.8 was calculated to be the median head difference between the two wells when data exist for both wells. Monthly or missing data were in-filled based on the approach used for the Upper Floridan aquifer monitoring wells.

F. Water Budget Model Approach

The primary reason for the development of the water budget model was to estimate Historic lake stage exceedance percentiles that could be used to support development of Minimum and Guidance Levels for the lake. Model calibration was therefore focused on matching long-term percentiles based on measured water levels, rather than short-term high and low levels.

Measured data from the lake were used for comparison with modeled water levels. Daily values are generated from the model, but only actual lake data points are used for the calibration.

Figure 15 presents the calibration results for the model. Table 2 presents a comparison of the percentiles of the measured data versus the model results. Table 3 presents modeled water budget components for the model calibration.

G. Water Budget Model Calibration Discussion

Based on a visual inspection of Figure 15, the model appears to be reasonably well calibrated. There are a few periods when the peaks in the modeled hydrograph are higher or lower than the measured values, and these differences contributed to minor differences between the modeled and measured percentiles associated with higher and lower lake levels, i.e., the P10 and P90 percentiles. Reduced precision in the higher and lower ranges of the stage-volume relationships for the lake may also have contributed to the percentile differences.

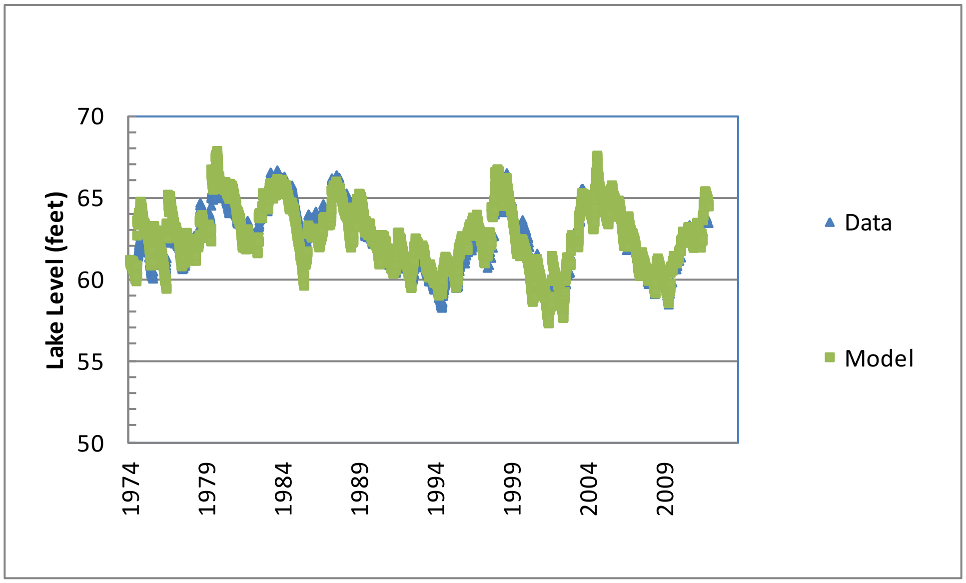

Figure 15. Modeled water levels predicted for the calibrated Lake Hobbs water budget model (Model) and measured levels used for the model calibration (Data).

Table 2. Comparison of percentiles of measured lake level data compared to calibration percentiles from the model (all in feet NGVD29).

	Data	Model
P10	65.6	65.5
P50	62.7	62.7
P90	60.1	60.4

Table 3. Lake Hobbs Water Budget (1974-2011)

Inflows	Rainfall	Surficial Aquifer Groundwater Inflow	Floridan Aquifer Groundwater Inflow	Runoff	DCIA Runoff	Inflow via channel	Total
Inches/year	57.0	10.3	0.00	35.7	0.00	10.5	113.4
Percentage	50.3	9.0	0.00	31.5	0.00	9.2	100.0
Outflows	**Evaporation**	**Surficial Aquifer Groundwater Outflow**	**Floridan Aquifer Groundwater Outflow**			**Outflow via channel**	**Total**
Inches/year	58.1	1.6	43.2			9.5	112.4
Percentage	51.7	1.5	38.4			8.4	100.0

A review of Table 2 shows that the differences in median percentile (P50) and P10 percentiles between the data and model for the lake are the same within 0.1 feet, while the P90 is off by 0.3 feet. Attempts at better calibration of the P90 resulted in larger differences between the medians. Some of the differences at the higher and lower percentiles may be due to less detail in the higher and lower stage-volume relationships.

The water budget component values in the model can be difficult to judge since they are expressed as inches per year over the average lake area for the period of the model run. Leakage rates (and leakance coefficients), for example, represent conditions below the lake only, and may be very different than those values expected in the general area. Runoff also represents a volume over the average lake area, and when the resulting values are divided by the watershed area, they actually represent fairly low runoff rates.

H. Water Budget Model Results

Groundwater withdrawals are not directly included in the Lake Hobbs water budget model, but are indirectly represented by their effects on water levels in the Upper Floridan aquifer. Metered groundwater withdrawal rates from the Section 21 and South Pasco Wellfields are available for the model calibration period, so if a relationship between withdrawal rates and Upper Floridan aquifer potentiometric levels can be established, the effect of changes in groundwater withdrawals can be estimated by adjusting Upper Floridan aquifer levels in the model.

The Integrated Northern Tampa Bay (INTB) model (Geurink and Basso, 2013) is an integrated model developed for the northern Tampa Bay area. The INTB model has the ability to account for groundwater and surface-water, as well as the interaction between them. The domain of the INTB application includes the Lake Hobbs area, and represents the most current understanding of the hydrogeologic system in the area.

The INTB was used to determine the drawdown in the surficial aquifer and Upper Floridan aquifer in response to groundwater withdrawals in the area. Drawdown in both aquifers was calculated for two withdrawal rates representing the effects of Tampa Bay Water's regional wellfields before and after cutbacks from approximately 150 mgd to 90 mgd. The pre-cutback period in the model is from 1974 through 2002, while the post-cutback period is 2003 through 2011. The model results allowed the drawdowns associated with all permitted withdrawals to be calculated before and after wellfield cutbacks, assuming changes in all other withdrawals are consistent for the modeled period.

The INTB model was run for each withdrawal scenario from 1996 to 2006 using a daily integration step. Drawdown values in feet were calculated by running the model with and without groundwater withdrawals, and were calculated for each node in the model. The INTB model uses a one-quarter mile grid spacing in the area of the wellfields. Groundwater withdrawal rates from the Section 21 Wellfield in each scenario were 8.9

mgd and 4.2 mgd, respectively, while groundwater withdrawals from the South Pasco wellfield in each scenario were 14.9 mgd and 4.4 mgd, respectively.

Results from the INTB modeling scenarios showed that there is a fairly linear relationship between Upper Floridan aquifer drawdown and withdrawal rates at the wellfields. Because of the leaky nature of the confining unit in the area of Lake Hobbs, and because the water table in the model is not active, the relationship between groundwater withdrawals in the Upper Floridan and water levels in the surficial aquifer was also of interest. Using the drawdowns determined through the INTB model, the Upper Floridan aquifer and surficial monitor well data in the model can be adjusted to reflect changes in groundwater withdrawals.

To estimate lake levels without the influence of groundwater withdrawals, the Upper Floridan aquifer and surficial aquifer wells in the water budget model were adjusted to represent zero withdrawals. For the 1974 through 2011 water budget model period, two adjustment periods were used to reflect the cutbacks that took place at the Section 21 and South Pasco Wellfields. Adjustments to each Upper Floridan aquifer and surficial aquifer well and the associated adjustment periods are found in Table 4.

Table 4. Aquifer water level adjustments to the Lake Hobbs Model to represent Historic percentiles

Well	**Adjustment (feet) 1974 through 2002**	**Adjustment (feet) 2003 through 2011**
Floridan aquifer	3.2	1.1
Surficial aquifer	1.6	0.5

Figure 16 presents measured water level data for the lake along with the model-simulated lake levels in the lake under Historic condition, i.e. in the absence of groundwater withdrawals with structural alterations similar to current conditions. Table 5 presents the Historic percentiles based on the model output.

Historic normal pool elevations are established for lakes, ponds and wetlands 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). The normal pool 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 Historic P10 in natural wetlands and lakes, based on observation of many control sites in the northern Tampa Bay area.

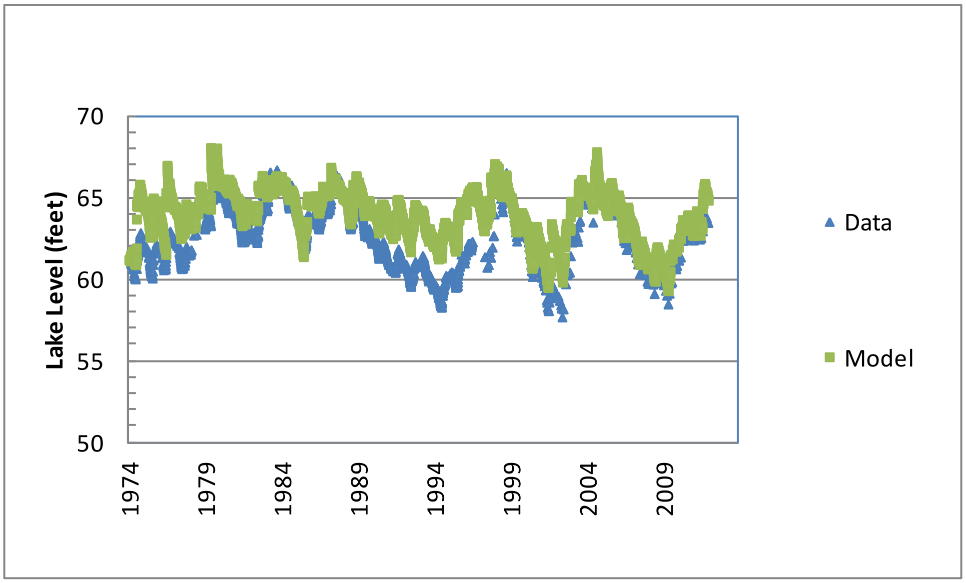

Figure 16. Measured lake levels (Data) and Historic water levels predicted with the calibrated Lake Hobbs model (Model).

Table 5. Historic percentiles estimated using the Lake Hobbs water budget model (in feet NGVD29).

Percentile	Elevation
P10	65.8
P50	64.4
P90	62.3

Historic normal pool was determined for Lake Hobbs based on inflection points of remaining cypress trees. The Historic normal pool for Lake Hobbs was determined to be 67.0 feet NGVD29. While the Historic normal pool and natural P10 in lakes and wetlands in the northern Tampa Bay area may differ by several tenths of a foot in many cases, the model's estimate of the Historic P10 for Lake Hobbs is much lower than the field determined Historic normal pool. Therefore, in this case, the natural water levels experienced prior to wellfield establishment and the installation of drainage appear to be unachievable, at least for the P10.

I. Rainfall Correlation Model

In an effort to extend the period of record of the water levels used to determine the Historic percentiles to be used in the development of the Minimum Levels, a line of organic correlation (LOC) was performed using the results of the water budget model and long-term rainfall. 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.

In this application, the simulated lake water levels representing Historic conditions were correlated with Long-term rainfall. For the correlation, additional representative rainfall records were added to the rainfall records used in the water budget model (1974-2011). Rainfall from the Lake Hanna gage (Figure 12) was used to extend the data through 2013. Data from the Cosme rain gage (located on the Cosme wellfield), which was replaced by the Cosme 18 due to quality control issues, was used to extend the rain data back to 1945. The quality control issues at the gage reported occurred after 1995, and there is no evidence that there were quality control issues at the Cosme gage prior to that time. Finally, rainfall data from the St. Leo gage (Figure 17) were used to extend the data back to 1930. Although the St. Leo gage is approximately 17.5 miles from Lake Hobbs, it is one of only a few rain gages in the vicinity with data preceding 1945, and in this case, is only used in the first few years of the correlation.

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.

Rainfall was correlated to the water budget model results for the entire period used in the water budget model (1974-2011), and the results from 1946-2013 (68 years) were produced as the Hybrid model. For Lake Hobbs, the 3-year weighted model had the highest correlation coefficient, with an R^2 of 0.70. Previous correlations for lakes in the northern Tampa Bay area have consistently had best correlation coefficients in the 2 to 5 year range. The results are presented in Figure 18.

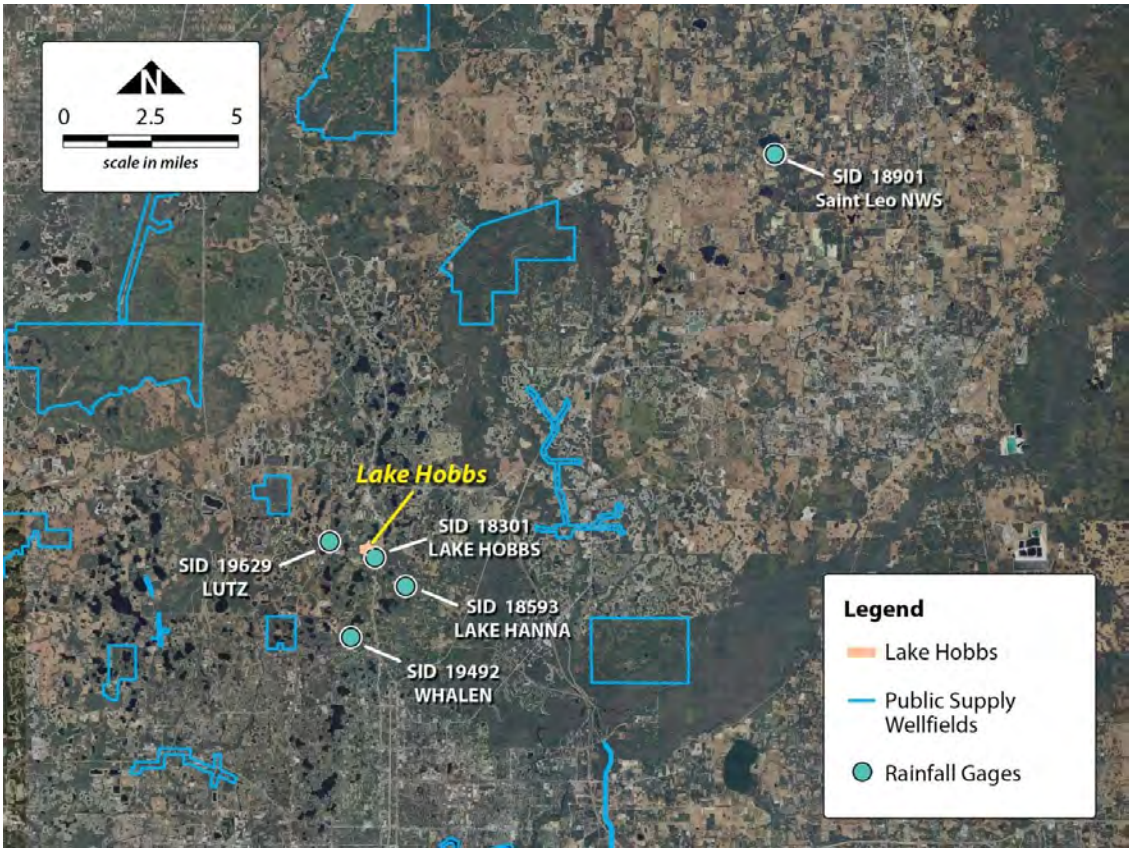

Figure 17. Location of rain stations used for the rainfall correlation model.

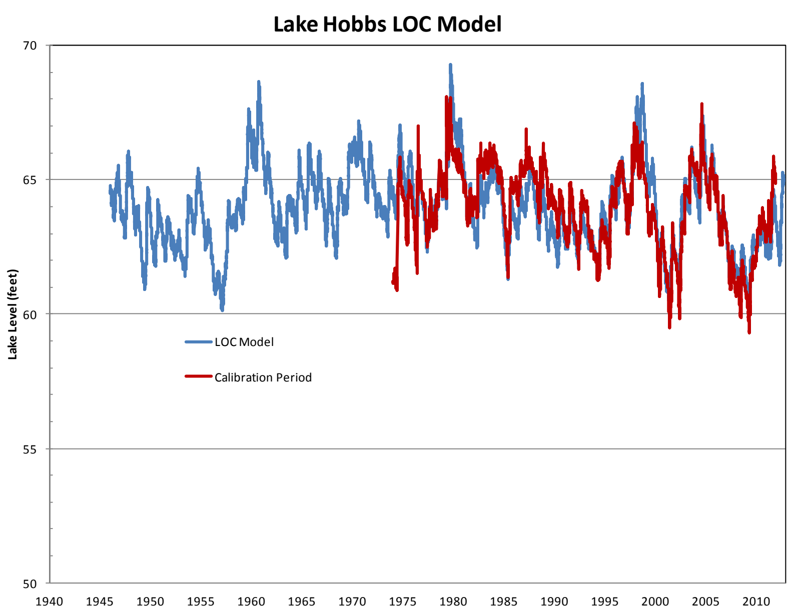

Figure 18. LOC model results for Lake Hobbs.

In an attempt to produce Historic percentiles that apply significant weight to the results of the water budget models, the rainfall LOC results for the period of the water budget model are replaced with the water budget model results. Therefore, the LOC rainfall model results are used for the period of 1946-1973 and 2012-2013, while the water budget results are used for the period of 1974-2011. These results are referred to as the “hybrid model.” The resulting Historic percentiles for the hybrid model are presented in Table 6. Note that the difference between the P10, P50, and P90 percentiles from the water budget model (Table 5) and those from the hybrid rainfall model (Table 6) for Lake Hobbs are 0.2, 0.0, and 0.3 feet, respectively. Therefore, there are relatively small changes to the Historic percentiles between the two models.

Table 6. Historic percentiles as estimated by the hybrid model from 1946 to 2013 (feet NGVD 29).

Percentile	Lake Hobbs
P10	65.7
P50	64.0
P90	61.9

J. Conclusions

Based on the model results and the available data, the Lake Hobbs water budget and LOC rainfall models are useful tools for assessing long-term percentiles in the lake. Based on the same information, lake stage exceedance percentiles developed through use of the models appear to be reasonable estimates for Historic conditions.

K. References

Biological Research Associates. 1996. Use of lasting indicators of historic inundation patterns in isolated wetlands as reference elevations to determine areal extent and intensity of reduced water levels near areas of groundwater withdrawals. Report submitted to the West Coast Regional Water Supply Authority. November 1996.

Bredehoeft, J.D., I.S. Papadopulos, and J.W. Stewart. 1965. Hydrologic Effects of Ground-Water Pumping in Northwest Hillsborough County, Florida. Open File Report 65001. U.S. Geological Survey.

Brooks, H.K. 1981. Physiographic divisions of Florida: map and guide. Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida.

CH2MHILL. 2003. Local Runoff Prediction for the Lower Hillsborough River and Tampa Bypass Canal Watersheds. Draft Technical Memorandum. Prepared for Tampa Bay Water. Clearwater, FL.

Geurink, J.S. and R. Basso. 2013. Development, Calibration, and Evaluation of the Integrated Northern Tampa Bay Hydrologic Model. Prepared for Tampa Bay Water and Southwest Florida Water Management District. March 2013.

Hancock, M.C. and R. Basso. 1996. Northern Tampa Bay Water Resource Assessment Project: Volume One. Surface-Water/Ground-Water Interrelationships. Southwest Florida Water Management District. Brooksville, Florida.

Hull, H.C., J.M. Post Jr., M. Lopez, and R.G. Perry. 1989. Analysis of water level indicators in wetlands: Implications for the design of surface water management systems. In Wetlands: Concerns and Successes. Proceeding of the American Water Resources Association, Tampa. D. Fisk (ed.), pages 195-204.

Jacobs, J. 2007. Satellite-Based Solar Radiation, Net Radiation, and Potential and Reference Evapotranspiration Estimates over Florida: Task. 4. Calculation of Daily PET and Reference ET from 1995 to 2004. University of New Hampshire.

Miller, J.A. 1986. Hydrogeologic framework of the Floridan aquifer system in Florida and in parts of Georgia, Alabama, and South Carolina. U.S. Geological Survey Water-Resources Investigations Report.

Metz, P.A and L.A. Sacks. 2002. Comparison of the Hydrogeology and Water Quality of a Ground-Water Augmented Lake with Two Non-Augmented Lakes in Northwest Hillsborough County, Florida. Water-Resources Investigations report 02-4032. U.S. Geological Survey.

Metz, P.A. 2011. Factors that Influence the Hydrologic Recovery of Wetlands in the Northern Tampa Bay Area, Florida. Scientific Investigations Report 2011-5127. U.S. Geological Survey.

Miller, J.A. 1986. Hydrogeologic framework of the Floridan aquifer system in Florida and in parts of Georgia, Alabama, and South Carolina. U.S. Geological Survey Water-Resources Investigations Report.

Parsons. 2010. Rocky-Brushy Creek Area Watershed Management Master Plan Update. Chapters 1-6, 13, and 15. October.

PBS&J. 2006. Stormwater Management Master Plan (Update No. 2): Brooker Creek. Prepared for the Hillsborough County Board of County Commissioners. September 2006.

Sinclair, W.C. 1973. Hydrogeologic Characteristics of the Surficial Aquifer in Northwest Hillsborough County, Florida. Open File Report 73023. U.S. Geological Survey.

Sinclair, W.C. 1982. Sinkhole Development resulting from Ground-Water Withdrawal in the Tampa Area, Florida. Water Resources Investigations 81-50. U.S. Geological Survey.

Sinclair, W.C., J.W. Stewart, R.L. Knutilla, and A.E. Gilboy. 1985. Types, Features, and Occurrence of Sinkholes in the Karst of West-Central, Florida. Water Resources Investigations report 85-4126. U. S. Geological Survey.

Soil Conservation Service. 1972. National Engineering Handbook. August 1972.

Southwest Florida Water Management District. 1988. Basis of Review for Surface Water Permit Applications in the Southwest Florida Water Management District.

Stewart, J.W. and G.H. Hughes. 1974. Hydrologic Consequences of Using Ground Water to Maintain Lake Levels Affected by Water Wells near Tampa, Florida. Open File Report 74006. U.S. Geological Survey.

Swancar, A., T.M. Lee, and T.M. O'Hare. 2000. Hydrogeologic Setting, Water Budget, and Preliminary Analysis of Ground-Water Exchange at Lake Starr, a Seepage Lake in Polk County, Florida. Water-Resources Investigations Report 00-4030. U.S. Geological Survey. Tallahassee, Florida.

Appendix B

Draft Technical Memorandum

November 13, 2014

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

FROM: Michael C. Hancock, P.E., Senior Professional Engineer, Water Resources Bureau
Christina Uranowski, Senior Environmental Scientist, Water Resources Bureau

Subject: Lake Hobbs Initial Minimum Levels Status Assessment

A. Introduction

The Southwest Florida Water Management District (District) is reevaluating adopted minimum levels for Lake Hobbs and is proposing revised minimum levels for the lake, in accordance with Section 373.042 and 373.0421, Florida Statutes (F.S). Documentation regarding development of the revised minimum levels is provided by Hancock (2014) and Uranowski (2014).

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 Hobbs and other waterbodies 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 such as Lake Hobbs that are located in the area affected by the Consolidated Permit wellfields (i.e., the Central System Facilities) operated by Tampa Bay Water. This document provides information and analyses to be considered for evaluating the status (i.e., compliance) of the revised minimum levels for Lake Hobbs and any recovery that may be necessary for the lake.

B. Background

Lake Hobbs is located in Hillsborough County approximately 3 miles southeast of the South Pasco wellfield and less than 3 miles northeast of the Section 21 wellfield, which are two of the eleven regional water supply wellfields comprising the Central System Facilities (Figure 1). From 2002 to 2005, a cutback in the withdrawal rates at most Central System Facility wellfields occurred in response to the development of several

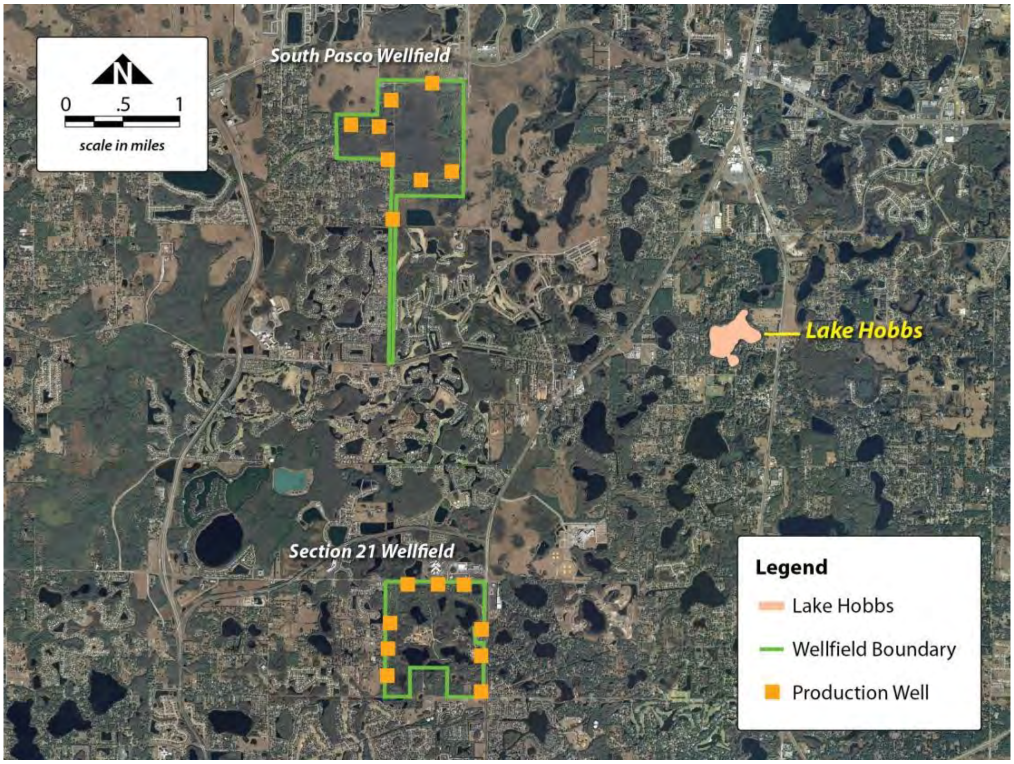

Figure 1. Location of Lake Hobbs and the Section 21 Wellfield.

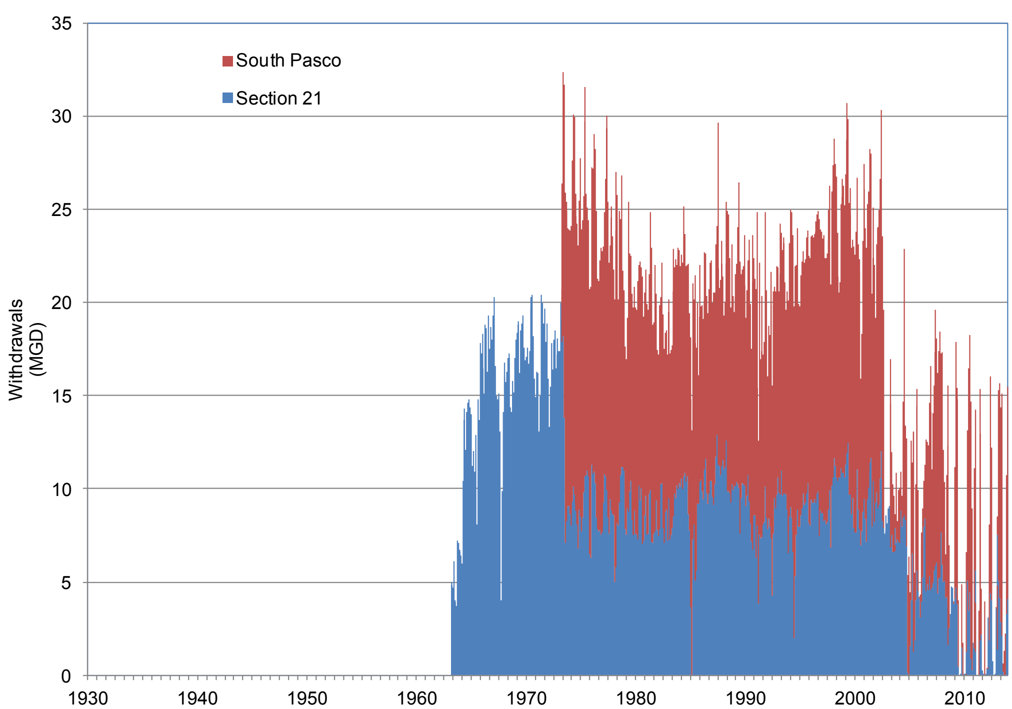

Figure 2. Section 21 and South Pasco wellfield withdrawals in million gallons per day (MGD).

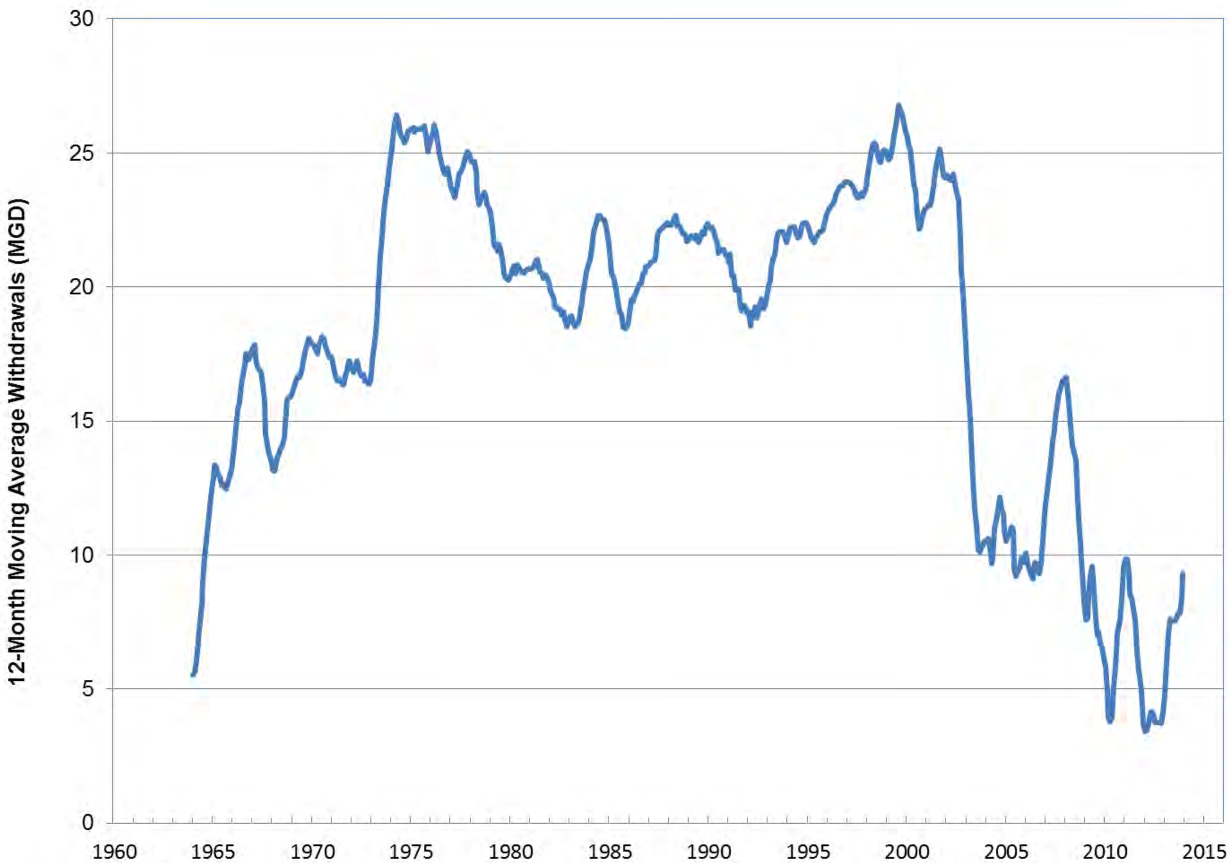

Figure 3. 12-month moving average of combined Section 21 and South Pasco wellfield withdrawals in million gallons per day (MGD).

alternative water supply sources. As a whole, the wellfields were reduced from approximately 158 mgd to 90 mgd, although the timing and amount of reduction at each wellfield was variable. These cutbacks are evident in the withdrawal rates reported for the Section 21 and South Pasco wellfields (Figures 2 and 3).

C. Revised Minimum Levels for Lake Hobbs

Revised minimum levels for Lake Hobbs are presented in Table 1 and discussed in more detail by Uranowski 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 10th percentile

(P10) of long-term water levels. To determine the status of minimum levels for Lake Hobbs or minimum flows and levels for any other water body, long-term data or model results must be used.

Table 1. Minimum Levels for Lake Hobbs.

Minimum Levels	**Elevation in Feet** NGVD 29
High Minimum Lake Level	65.7
Minimum Lake Level	64.0

D. Status Assessment

Three models were used in this assessment, including the Integrated Northern Tampa Bay (INTB) model (Geurink and Basso, 2013), the Lake Hobbs Water Budget model (Hancock, 2014), and the Lake Hobbs Linear Organic Correlation (LOC) model (Hancock, 2014). Using these models, three approaches were used to assess the status of Lake Hobbs.

Use of the Integrated Northern Tampa Bay (INTB) model

The Integrated Northern Tampa Bay (INTB) model was used in the development of the minimum levels for Lake Hobbs (Hancock, 2014) and in this MFL status assessment to estimate drawdowns in the surficial and Upper Floridan aquifers in response to various rates of groundwater withdrawals. All INTB model simulations were performed for an 11-year period corresponding to conditions from 1996 through 2006 using a daily integration step. Average pre-cutback wellfield withdrawals for an initial simulation were represented by the actual 1997 distribution and quantity of withdrawals for the eleven Central System Facility wellfields, which represented pre-cutback withdrawal rates. Post-cutback wellfield withdrawals for a second simulation were represented by the actual 2008 distribution and quantities of withdrawals for the eleven Central System Facility wellfields. The 2008 distribution and quantities were considered representative of forecasted long-term average withdrawal conditions for the post-cutback period. These withdrawal distributions and quantities were repeated for each year of the 11-year simulations. All other area withdrawals not associated with the Central System Facilities were included in the simulations based on their actual quantities and distributions from 1996 through 2006. Results for the two withdrawal rate simulations were compared to an 11-year INTB model run with no withdrawals to estimate drawdown. The pre- and post-cutback withdrawal rates used for the South Pasco and Section 21 Wellfields for the two simulations are presented in Table 2. The modeled drawdowns in the surficial and Upper Floridan aquifer systems in the vicinity of Lake Hobbs (calculated as the average of the drawdown in the three model cells on which Lake Hobbs is located) for the two simulations are presented in Table 3.

Table 2. Withdrawal rates used for pre- and post-cutback withdrawal INTB simulations.

Wellfield	Pre-cutback Withdrawal Rate (MGD)	Post-cutback Withdrawal Rate (MGD)
South Pasco	14.9	4.4
Section 21	8.9	4.2

MGD = million gallons per day

Table 3. Resulting drawdown at Lake Hobbs from pre- and post-cutback withdrawal INTB simulations.

Simulation	Surficial Aquifer Drawdown (feet)	Upper Floridan Aquifer Drawdown (feet)
Pre-cutback	1.6	3.2
Post-cutback	0.5	1.2

Use of the Lake Hobbs Water Budget and Line of Organic Correlation (LOC) Models

The Lake Hobbs Water Budget and Line of Organic Correlation (LOC) models were created as part of the development of the revised minimum levels for Lake Hobbs. The Lake Hobbs Water Budget model (Hancock, 2014) is a spreadsheet-based tool that includes natural hydrologic processes and engineered alterations acting on the control volume of the lake. The water budget model uses a daily time-step, and tracks inputs, outputs, and lake volume to calculate a daily estimate of lake levels. The water budget model for Lake Hobbs was calibrated from 1974 to 2011. This period provided the best balance between using available data for all parts of the water budget and the desire to have a long-term period. The calibrated model can be used to assess the effect of changes in the various water budget components on lake water levels.

The Lake Hobbs LOC model (Hancock, 2014) was developed to extend the period of record of the water levels produced by various simulations of the water budget model. LOC model 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). An LOC model is a preferred method for developing long-term water level records since it results in predictions that retain the variance (and therefore best retains the "character") of the original data. Through this process, rainfall is correlated with the water budget model results, and long-term lake levels are then estimated using long-term rainfall data. In this application, lake levels were simulated using rainfall data collected in the region back to 1946, allowing assessment of a relatively long period that takes into account lake level variability caused by variation in rainfall conditions.

Lake Hobbs Status Assessment

First Approach

The first lake status assessment approach involved three steps, including: 1) adjusting the Upper Floridan and surficial aquifer levels in the Lake Hobbs Water Budget model to represent expected long-term post-cutback average wellfield withdrawal rates, 2) use of the LOC model to estimate lake levels associated with the withdrawal rates over a long period of time, and 3) development of a composite or "hybrid" long-term water level (i.e., stage) record based on output from the water budget and LOC models.

For the first step in the analysis, the water budget model was run for the 1974 through 2011 period based on drawdown in the Upper Floridan aquifer associated with the post-cutback wellfield withdrawal rates estimated with the INTB model. These interim results are provided in Table 4. Next, these results were correlated with rainfall through the LOC model to develop a 68-year stage record (1946-2013) to represent lake levels subjected to the post-cutback withdrawal rates. The correlation lag-period with the best correlation coefficient was 3 years (as was the correlation performed in the LOC model developed to set the minimum levels). The correlation coefficient for the 3-year lag was 0.73. Finally, to apply significant weight to the period of the water budget model results, the LOC lake stage values for the period of the water budget simulation were replaced with the results of the water budget simulation. The LOC rainfall model results were therefore used for the periods from 1946 through 1973 and 2012 through 2013, while the water budget model results were used for the period from 1974 through 2011. The resulting composite lake stage series is referred to as the Lake Hobbs "hybrid" results. Lake stage exceedance percentiles calculated from these results are provided in Table 5. The results of this analysis are compared to revised Minimum Levels for Lake Hobbs in Table 6.

Table 4. Lake stage exceedance percentiles for Lake Hobbs derived using the Lake Hobbs Water Budget Model. Percentiles include lake stage values equaled or exceeded ten (P10), fifty (P50) and ninety (P90) percent of the time.

Percentile	**Water Budget Model Post-cutback Wellfield Withdrawal Scenario Results** Elevation in feet NGVD 29
P10	65.7
P50	63.8
P90	61.5

Table 5. Lake stage exceedance percentiles for Lake Hobbs based on the Lake Hobbs hybrid results.

Percentile	**Water Budget/LOC Model Hybrid Post-cutback Wellfield Withdrawal Scenario Results** Elevation in feet NGVD 29
P10	65.6
P50	63.4
P90	61.2

Differences in exceedance percentiles presented in Tables 4 and 5 are likely attributable to differences in rainfall between the 1946-2013 period used to derive the Lake Hobbs hybrid model results and the 1974-2011 period used to develop the Lake Hobbs Water Budget model results.

Table 6. Comparison of hybrid lake stage exceedance percentiles from the models and the revised minimum levels for Lake Hobbs.

Percentile	**Water Budget/LOC Model Hybrid Current Pumping Scenario Results** Elevation in feet NGVD 29	**MLs** Elevation in feet NGVD 29
P10	65.6	65.7
P50	63.4	64.0

Second Approach

The second lake status assessment approach involves using actual lake stage data for Lake Hobbs from 2003 through 2013 (representing the period of wellfield cutbacks) to develop an LOC model, combining the LOC and lake stage data into a hybrid result, and comparing the hybrid results to the minimum levels. This analysis was intended for development of a long-term model (1946-2013) based on measured lake levels. The model was calibrated to the post cutback period (2003-2011), which integrated effects of withdrawal rates that occurred during this period, rather than pre-cutback withdrawal rates, which were higher.

The best resulting correlation was again for the 3-year weighted period (consistent with all previous LOC analyses for Lake Hobbs), with a correlation coefficient of 0.79. As before, “hybrid” results were created by replacing the rainfall LOC results with the actual Lake Hobbs data for the period of 2003 to 2013. However, because the measured data was recorded on a monthly, rather than a daily basis, the calculated stage exceedance percentiles from the direct LOC results and the “hybrid” data were the same to one-tenth of a foot. The resulting lake stage exceedance percentiles are presented in Table 7.

Table 7. Comparison of lake stage exceedance percentiles derived from the lake stage/LOC hybrid results and the revised minimum levels for Lake Hobbs.

Percentile	**Lake Stage/LOC Model Hybrid Post-cutback Wellfield Withdrawal Scenario Results** Elevation in feet NGVD 29	**Minimum Levels** Elevation in feet NGVD 29
P10	65.7	65.7
P50	63.2	64.0

Third Approach

The third approach involved comparison of lake stage exceedance percentiles based directly on measured lake level data for Lake Hobbs for the period from 2003 through 2013 with the minimum levels. No models were used for this approach. A limitation of this analysis is that the resulting lake stage exceedance percentiles are representative of rainfall conditions during only the past 11 years, rather than the longer-term rainfall conditions represented in the 1946 to 2013 LOC model simulations. Results for the third approach are presented in Table 8.

Table 8. Comparison of lake stage exceedance percentiles derived from measured water level records at Lake Hobbs from 2003 through 2013 (post-cutback) and the revised minimum levels for the lake.

Percentile	**2003 to 2013 Data** Elevation in feet NGVD 29	**MLs** Elevation in feet NGVD 29
P10	65.1	65.7
P50	63.0	64.0

Discussion

Table 9 summarizes the results of all three approaches.

Table 9. Comparison of lake stage exceedance percentiles derived from each approach compared to the revised minimum levels for the lake.

Percentile	**Approach 1[a]** Elevation in feet NGVD 29	**Approach 2[b]** Elevation in feet NGVD 29	**Approach 3[c]** Elevation in feet NGVD 29	**Minimum Levels** Elevation in feet NGVD 29
P10	65.6	65.7	65.1	65.7
P50	63.4	63.2	63.0	64.0

[a] Water budget/LOC hybrid model post-cutback pumping scenario results
[b] Lake stage/LOC hybrid model results based on post-cutback data
[c] Measured lake stage results based on post-cutback data

A comparison of the water budget/LOC hybrid model (Approach 1) with the revised minimum levels for Lake Hobbs indicates that the hybrid long-term P10 is 0.1 feet lower than the High Minimum Lake Level, and the hybrid long-term P50 is 0.6 feet lower than the Minimum Lake Level.

The P10 for the second MFL status assessment approach is equal to the High Minimum Level, while the P50 is 0.8 feet lower than the Minimum Level. The P10 elevation derived from the third approach was 0.6 feet lower than the High Minimum Lake Level and the P50 elevation was 1.0 feet lower than the Minimum Lake Level. Stage exceedance percentiles based on the third analysis were also lower than those derived with the Water Budget and LOC modeling approaches. Differences in rainfall between the shorter 2003 to 2013 period and the longer (1946 to 2013) period used for the LOC modeling analyses likely contribute to the differences in derived lake stage exceedance percentiles. Additionally, differences between actual withdrawal rates and those used in the models may have contributed to the differences.

E. Conclusions

Based on the information presented in this memorandum, it is concluded that Lake Hobbs water levels are currently below the revised Minimum Lake Level and revised High Minimum Lake Level for the lake. These conclusions are supported by comparison of long-term modeled lake stage exceedance percentiles with the minimum levels. The modeling analyses were based on expected post-cutback withdrawal rates from the Central System Facilities. Other analyses presented were consistent with this conclusion.

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 Hobbs 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 Hobbs 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)). Tampa Bay Water, in cooperation with the District, will assess the specific needs for recovery in Lake Hobbs and other water bodies affected by groundwater withdrawals from the regional wellfields. By 2020, if not sooner, an alternative recovery project will be proposed if Lake Hobbs is found to not be meeting its adopted minimum levels. The draft results of the Permit Recovery Assessment Plan are due to the District by December 31, 2018.

F. References

Geurink, J.S. and R. Basso. 2013. Development, Calibration, and Evaluation of the Integrated Northern Tampa Bay Hydrologic Model. Prepared for Tampa Bay Water and Southwest Florida Water Management District. March 2013.

Hancock, M.C., 2014. Technical Memorandum to Christina Uranowski, Subject: Lake Hobbs Water Budget Model, Rainfall Correlation Model, and Historic Percentile Estimations. Southwest Florida Water Management District. Brooksville, Florida.

Uranowski, C., Hancock, M. and Leeper, D. 2014. Minimum and Guidance Levels for Lake Hobbs, Hillsborough County, Florida. Southwest Florida Water Management District. Brooksville, Florida.