Minimum and Guidance Levels for Lake Hanna in Hillsborough County, Florida

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Resource Evaluation Section
Water Resources Bureau
Southwest Florida
Water Management District

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Cover Page: Comparison between 1938 and 2011 aerial views of Lake Hanna. The 1938 imagery was collected by the United States Department of Agriculture, Soil Conservation Service. The 2011 imagery was collected on January 7th by the District through its Geographical Information Services (GIS) program.

Table of Contents

Minimum Flows and Levels Program Overview

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 the 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 level of an aquifer or surface water body as "the level of groundwater in the 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) 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 in supporting 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 if 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." Section 373.0421(2)(a), F.S., requires that recovery or prevention strategies be developed to: "(a) achieve recovery to the established minimum flow or level as soon as practicable; or (b) prevent the existing flow or level from falling below the established minimum flow or level." Periodic re-evaluation 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 "minimum 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 Hanna; 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 Minimum Flows and Levels Program is implemented based on a few 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. It is also 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 minimum flows and levels. Finally, the existence of long-term hydrologic regimes that may differ from non-withdrawal impacted conditions but are sufficient to meet flow or water level requirements associated with established minimum flows and levels and are therefore sufficient to prevent significant harm, is assumed.

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 Richter 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 or hydrologic regime for a river or lake system that is not impacted or affected by groundwater or surface water withdrawals. A new hydrologic regime for the system would be associated with each increase in water use, from small, perhaps distant withdrawals that have no measurable effect on the historic regime to large, perhaps more proximal 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. The threshold regime, resulting primarily from water withdrawals, is expected to maintain the general hydropattern of the historic flow or water level regime, but with differences in the amplitude or duration of flows or levels may result in a general reduction of all or portions of the hydrologic regime. Identification of this threshold hydrologic regime based on use of appropriate significant harm thresholds or criteria is expected to allow for water withdrawals while protecting the water resources and ecology from significant harm. Thus, minimum flows and levels 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 (2006, 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 recommend 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 Hanna 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 used by the District for consideration of the environmental values.

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 Wetland Offset 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] = Environmental value is addressed generally by development of minimum levels base 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 are adopted by the District Governing Board 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 (NGVD29), may include the following (refer to Rule 40D-8.624, F. A. C.).

- The **High Guidance Level** is provided as an advisory guideline for construction of lakeshore 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.

- 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** 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 **Low Guidance Level** 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 ninety 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 Hanna (Table 1), a Category 1 lake located in 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.

All elevation data values shown within this report on graphs, bathymetric maps, and within tables are expressed as elevations in feet above the National Geodetic Vertical Datum of 1929 (NGVD 29). Topographic data such as LiDAR collected as North American Vertical Datum of 1988 (NAVD 88) (also as feet) was converted to NGVD 29 using Corpscon 6.0, a computer software program developed by the United States Army Corps of Engineers. The minimum and guidance levels developed for Lake Hanna are listed in both NGVD 29 and NAVD 88 (Table 1). Throughout the remainder of the report only the NGVD 29 elevation is listed.

Table 1. Minimum and Guidance Levels for Lake Hanna. The corresponding NAVD 88 elevation was calculated using the Corpscon conversion of - 0.823 ft.

Minimum and Guidance Levels	Elevation in Feet	Elevation in Feet
	NGVD 29	NAVD 88
High Guidance Level	62.0	61.2
High Minimum Lake Level	61.5	60.7
Minimum Lake Level	60.0	59.2
Low Guidance Level	58.1	57.3

Following a public input process, the District Governing Board approved the minimum and guidance levels for adoption and incorporation into Chapter 40D-8, F.A.C. Public input included a public workshop held on August 13, 2014 near Lake Hanna at a local community library. Upon approval by the District Governing Board, staff prepared and amendment to Rule 40D-8.624, F.A.C. that establishes minimum and guidance levels for Lake Hanna based on current methodologies and replaces the previously adopted guidance levels established in 1993 (see Table 2). The rule amendment was submitted to the Joint Administrative Procedures Committee and notice was provided to the Governor's Office of Fiscal Accountability and Regulatory Reform (OFARR). The effective date of the rule amendment was January 7, 2015.

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

Lake Setting and Description

Lake Hanna is located in northwest Hillsborough County within the Lutz region (Section 18, Township 27S, Range 19E)(Figure 1). The "Gazetteer of Florida Lakes" (Shafer et al. 1986) lists the lake area as 30 acres. A topographic map of the basin generated in support of minimum levels development indicates Lake Hanna is 46 acres at a stage of 63.0 ft NGVD 29 and is a more accurate determination of lake size.

Lake Hanna is part of the Thirteen Mile Run drainage system also known as the Cypress Creek Lake Chain (Figure 2). This system constitutes the western part of the much larger Cypress Creek watershed, a subwatershed of the Hillsborough River basin. At roughly 7400 acres the Thirteen Mile Run comprises roughly 1/3 of the 21,000 acre Cypress Creek watershed and consists of several interconnected cascading lakes in southwest Pasco County and northwest Hillsborough County with surface water flows generally from north to south. There are no operable structures within the lakes located within the northern portion (Pasco County of Thirteen Mile Run). Flow between the lakes is controlled by numerous culverts with some flow lines occurring through natural channels within cypress strands between lakes. Lake Hanna is located within the southern portion (Hillsborough County) of the Thirteen Mile Run system. The lakes

within the southern portion of the lake chain include Kell, Keene, Hanna, and Stemper. Lake Hanna and Lake Stemper are located at the southern end of the lake chain. Lake Hanna receives flow from Lake Keene and discharges to both the east to Cypress Creek and also to the west, to Lake Stemper (Figure 3). Detailed information about the structures and operation is provided by Interflow Engineering (2011).

A series of seven water conservation structures control discharge between these lakes and interconnected wetlands. The structures are operated by the District. Five of the structures have been in place since 1968 and were constructed to help restore historical water levels and increase storage. A sixth structure was constructed in 1999 at Sherry Brook to restore drainage alterations that diverted flow away from the Lakes Keene, Hanna, and Stemper. Each structure consists of a concrete weir with removable stop logs or boards. Stop logs are typically removed when flood conditions are occurring or expected, and then replaced during times of falling levels for the purpose of water conservation. A seventh structure was constructed in 2010 within the conveyance ditch between Lake Hanna and Stemper to improve water levels in Lake Hanna. The structure is the smallest of all the structures and is comprised of one stop log mounted between two concrete retaining walls that line the edge of conveyance ditch.

There are no surface water withdrawals from the lake currently permitted by the District. Within 3 miles of the lake there are approximately fifty-four permitted groundwater withdrawals (Figure 7) with 1.5 million gallons per day (mgd) reported as the average groundwater withdrawn from 1992 to 2006.

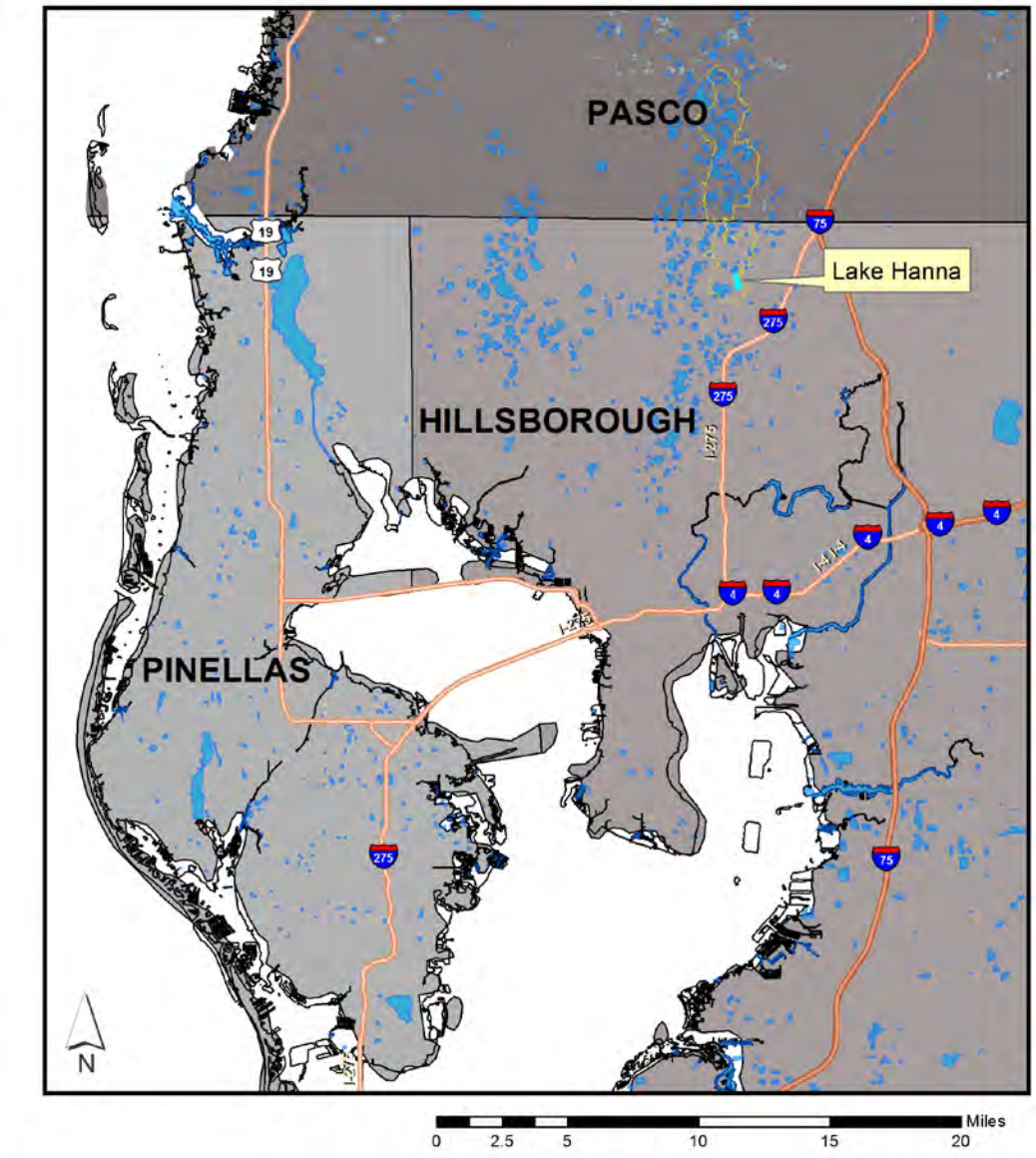

Figure 1. General location of Lake Hanna in Hillsborough County, Florida.

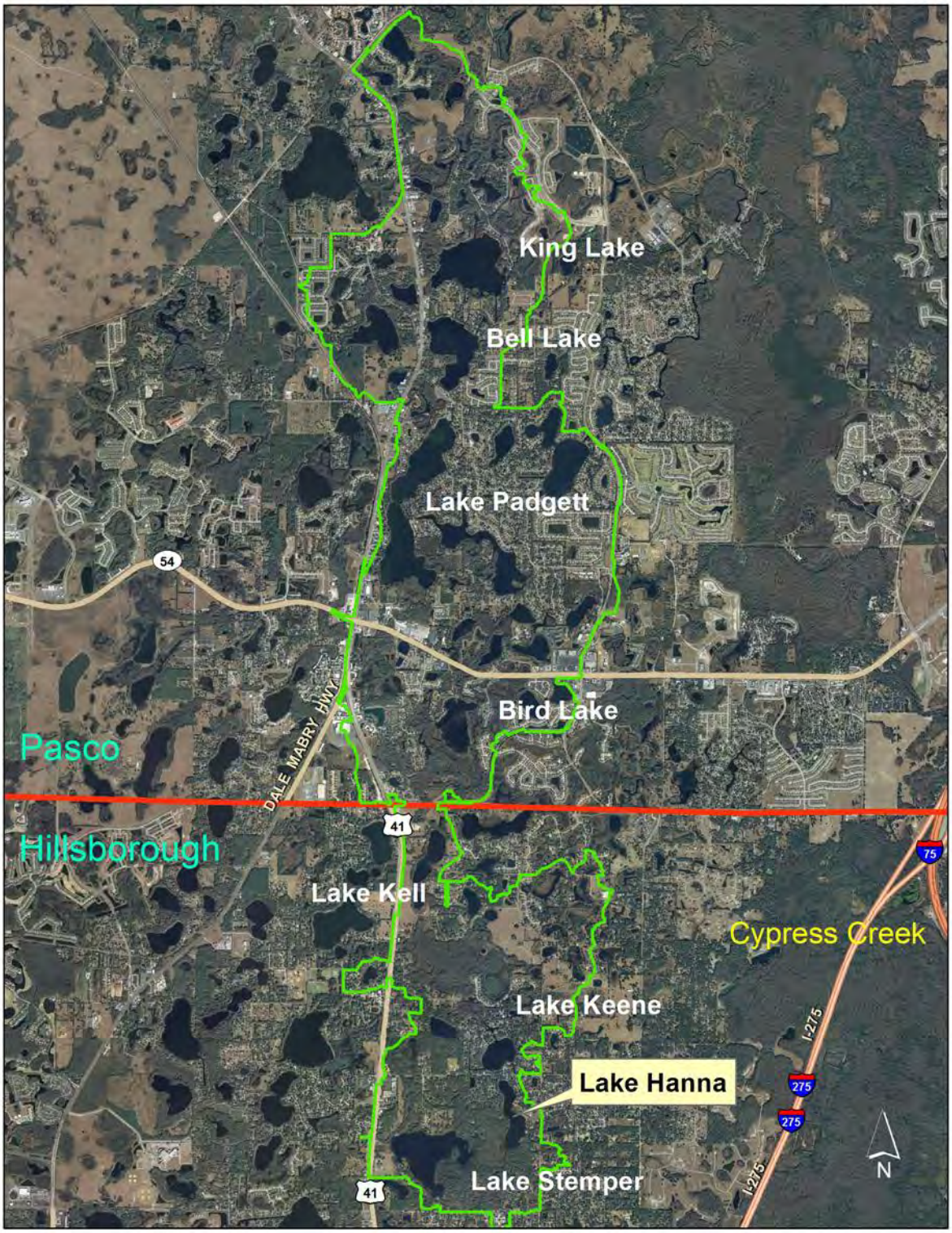

Figure 2. General location of Lake Hanna in relation to the Thirteen Mile Run drainage basin.

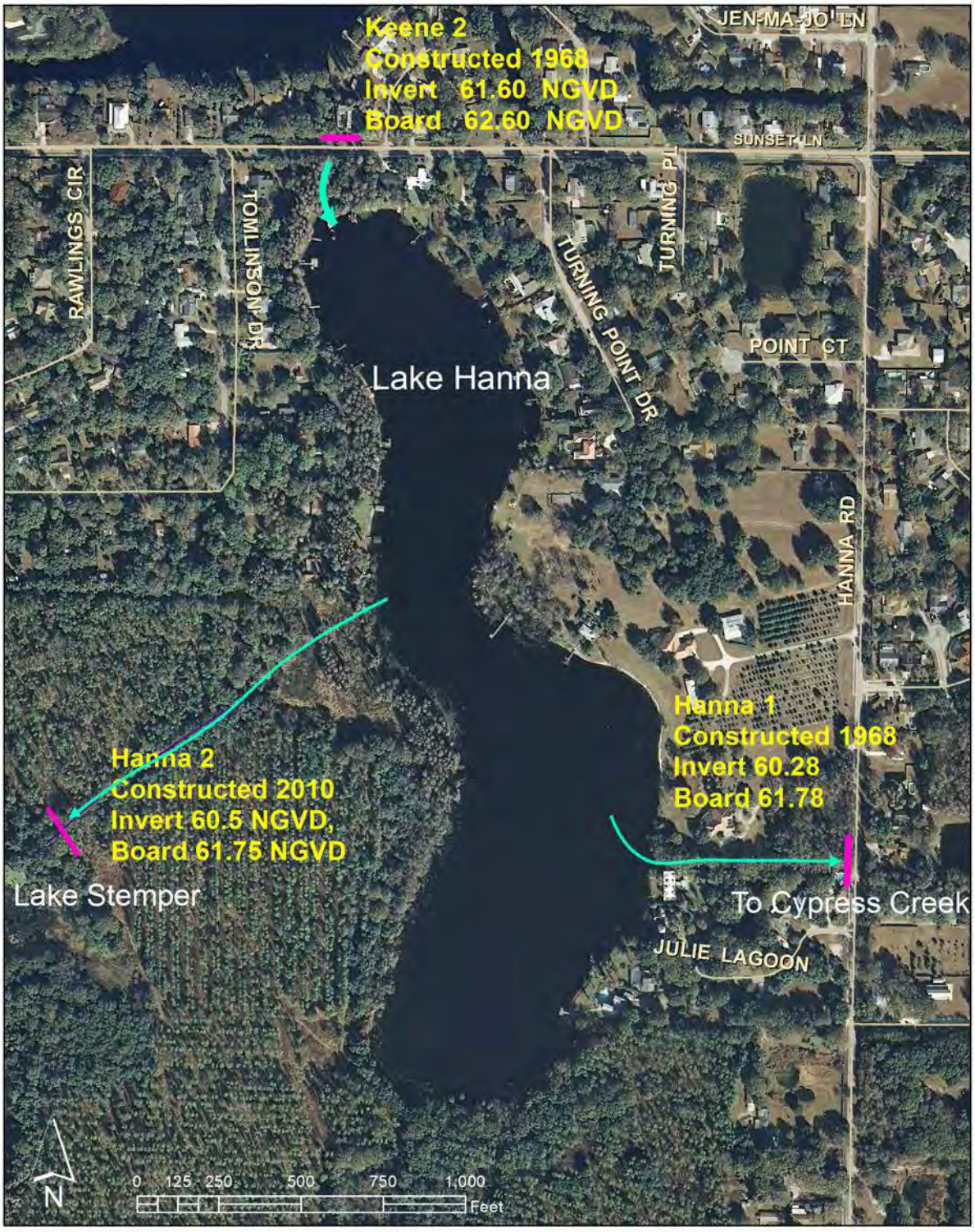

Figure 3. Location of water conservation structures on Lake Hanna and Keene shown with both crest elevation and elevation with all boards in place.

Figure 4. Location of vegetative indicators and water level gage at Lake Hanna, WMIS site ID 19178

Figure 5. Two-foot contour lines within Lake Hanna. Values shown are elevations in feet as NGVD 29.

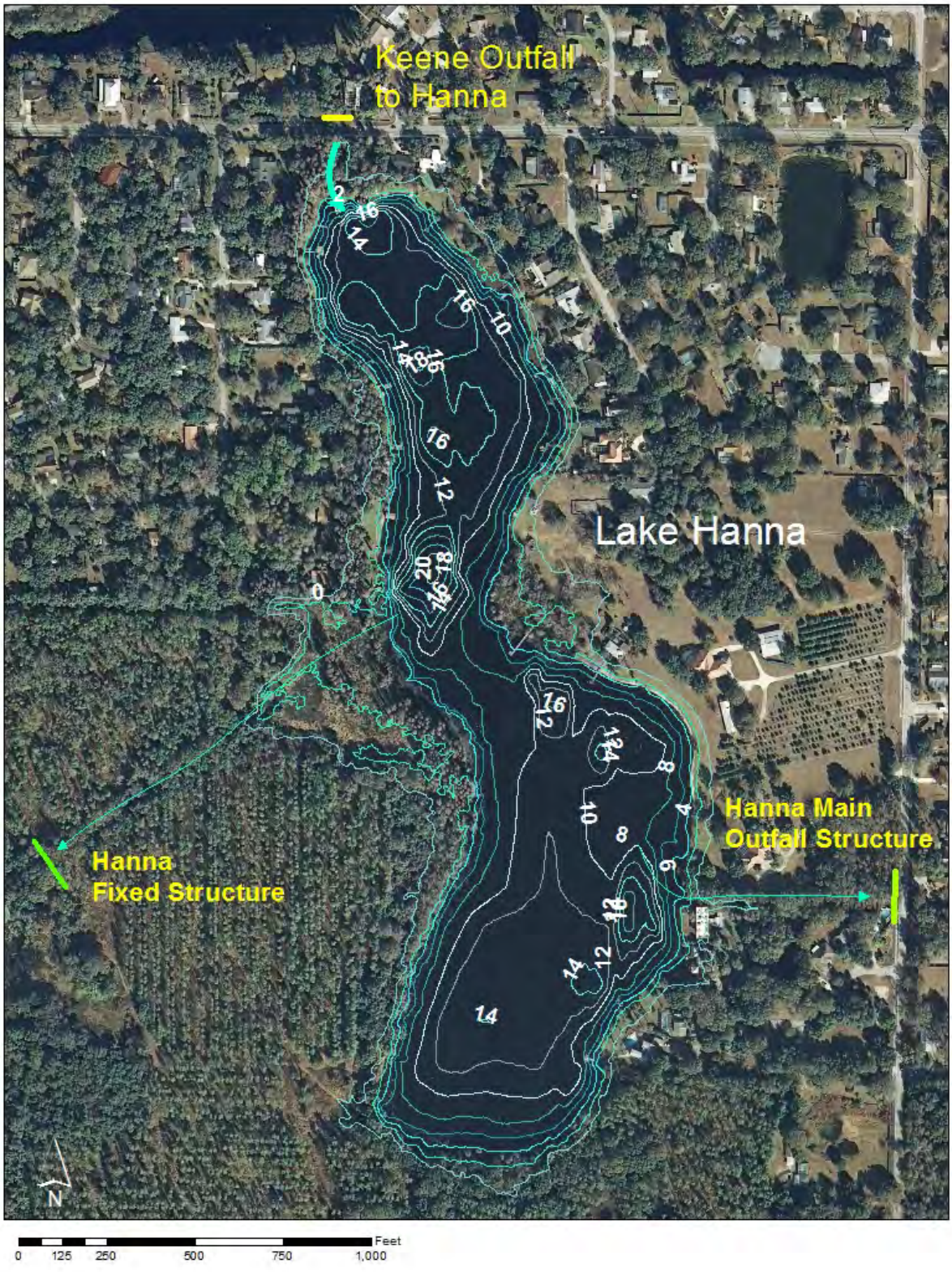

Figure 6. Bathymetric map of Lake Hanna showing approximate bottom depths at a lake stage of 63.0 NGVD 29.

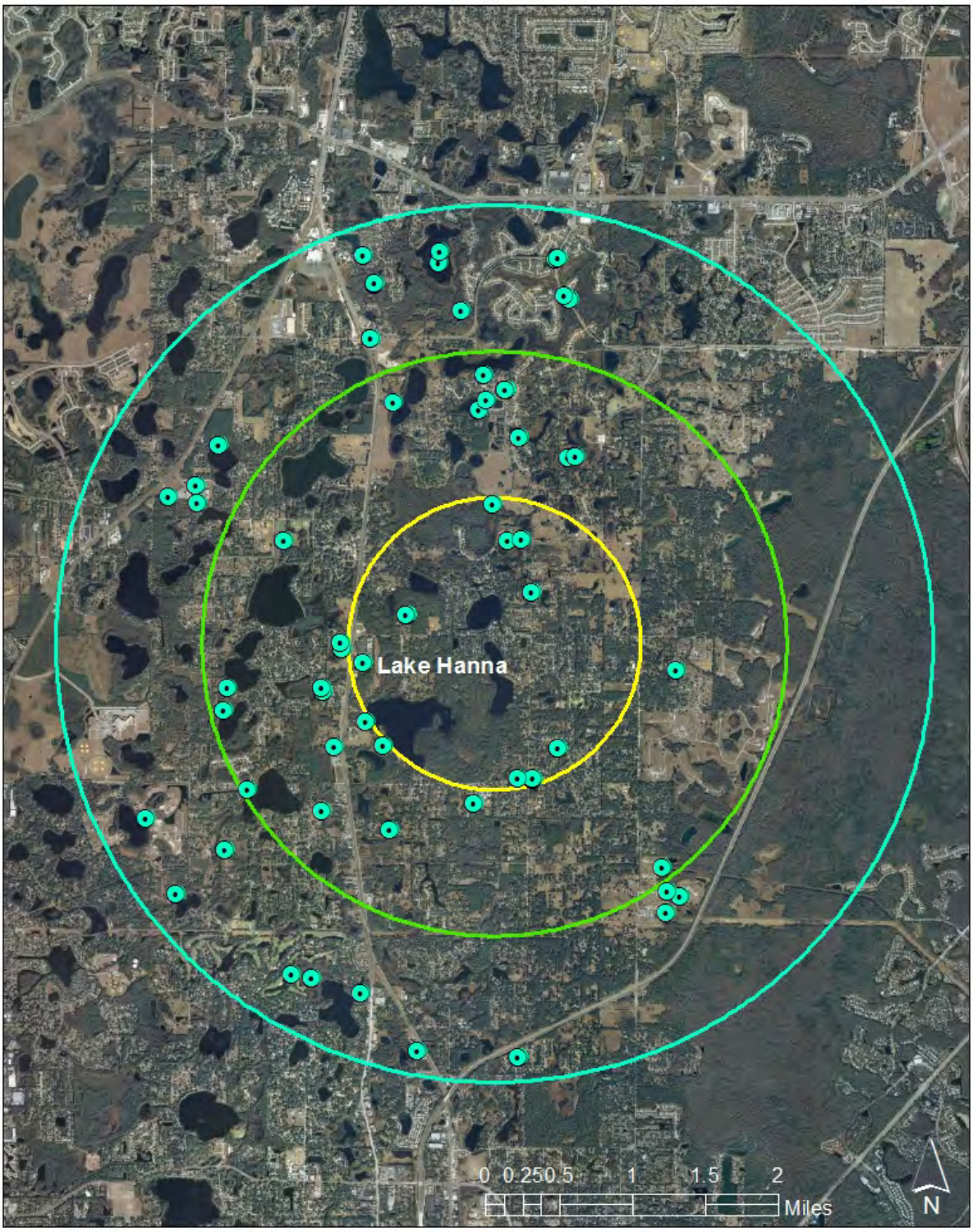

Figure 7. Permitted groundwater withdrawals within one, two, and three miles of Lake Hanna, Hillsborough County.

Currently Adopted Guidance Levels

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

Based on work conducted in the 1970s (see SWFWMD 1996), the District Governing Board adopted management levels (currently referred to as Guidance Levels) for Lake Hanna in January 1993 (Table 2). A Maximum Desirable Level of 63.50 NGVD was also developed, but was not adopted by the Governing Board. The adopted Guidance Levels and Maximum Desirable Level were developed using a methodology that differs from the current District approach for establishing Minimum and Guidance Levels. The levels do not, therefore, necessarily correspond with levels developed using current methods. Minimum and Guidance Levels developed using current methods will replace existing Guidance Levels upon adoption by the District Governing Board into Chapter 40D-8, F.A.C. One of the management levels, a Ten Year Flood Guidance Level of 65.10 NGVD, was removed from Chapter 40D-8 in 2007, when the District Governing Board determined that flood-stage elevations should not be included in the District's Water Levels and Rates of Flow rules.

Annually since 1991, a list of stressed lakes has been developed to support the District's consumptive water use permitting program as referenced in the District's Water Use Permit (WUP) Handbook (Part B) dated May 19, 2014. This reference defines a stressed condition for a lake" as "chronic fluctuation below the normal range of lake level fluctuations". For lakes with District-established management levels, a stressed condition is a chronic fluctuation below the minimum low management level. A stressed condition is based on continuous monthly data for the most recent five-year period, with the latest readings being within the past 12 months. A lake is determined as stressed if a two-thirds of the values within the most recent five-year period are at or below the adopted minimum low management level. Although Lake Hanna was not listed as stressed during recent years (2012-0124), it was designated as stressed during 1994, 1995, 1996, 1997, 1998, and 2011 (Gant *et al.* 1994, 1995, 1996, 1997, 1998, and 2011). It was determined that the lake level was below the minimum management level for 40 of the 60 months of continuous data for each of the years listed above.

Table 2. Adopted Guidance Levels for Lake Hanna as listed in Table 8-3 of subsection 40D-8.624, F.A.C.

Guidance Levels	Elevation in Feet NGVD 29
Ten Year Flood Guidance Level	63.50
High Level	62.50
Low Level	59.50
Extreme Low Level	58.25

Summary Data Used for Development of Minimum and Guidance Levels

Minimum and Guidance Levels for Lake Hanna were developed using the methodology for Category 1 Lakes described in Rule 40D-8.624, F.A.C. The levels and additional detailed information are listed in Table 3, along with lake surface areas for each level or feature/standard elevation. Detailed descriptions of the development and use of these data are provided in the subsequent sections of this report.

Table 3. Minimum and Guidance Levels, lake stage exceedance percentiles, and control point elevations, significant change standards, and associated surface areas for Lake Hanna.

Levels	Elevation in Feet NGVD 29	Lake Area (acres)
Lake Stage Percentiles		
Current P10 (1971 to 2013)	61.4	39.5
Current P50 (1971 to 2013)	60.2	33.8
Current P90 (1971 to 2013)	57.6	29.0
Historic P10 (1946 to 2013)	62.0	42.0
Historic P50 (1946 to 2013)	60.0	33.3
Historic P90 (1946 to 2013)	58.1	29.8
Normal Pool and Control Point		
Normal Pool	61.86	41.6
Control Point (East Outfall Structure)	60.3	34.0
Significant Change Standards		
Dock-Use Standard	62.0	42.1
Cypress Standard	60.06	33.4
Wetland Offset Elevation	59.2	31.7
Species Richness Standard	57.3	28.6
Aesthetics Standard	50.5	8.6
Basin Connectivity Standard	NA	NA
Recreation/Ski Standard	NA	NA
Lake Mixing Standard	NA	NA
Minimum and Guidance Levels		
High Guidance Level	62.0	42.0
High Minimum Lake Level	61.5	40.1
Minimum Lake Level	60.0	33.3
Low Guidance Level	58.1	29.8

Lake Stage Data and Exceedance Percentiles

Lake stage data, *i.e.,* surface water elevations for Lake Hanna relative to NGVD 29 were obtained from the District's Water Management Information System (WMIS) data base (WMIS ID 19177 and 19178). A forty-three year record of continuous lake stage data exists for Lake Hanna (WMIS ID 19178) from July 1971 through present day (Figure 8, see Figure 4 for the location of the SWFWMD lake water level gage). The frequency of collection of lake stage data increased to hourly in August 1999 to assist

the District with operation of the water conservation structures. Lake stage data also exists from January of 1948 through September 1955; however, a sixteen year data gap occurs from September 1955 through July 1971.

The highest recent surface water elevation for the lake recorded for Lake Hanna was 62.9 NGVD 29 occurring in August 1953 and 62.88 NGVD 29 occurring in September 1979. The lake has frequently reached an elevation of 62 NGVD 29 as shown in the hydrograph (Figure 8) rising above the height of the maximum elevation of the adjustable structure (61.78 NGVD 29 with all boards in place). A low stage of 55.12 NGVD 29 was recorded in May 2002.

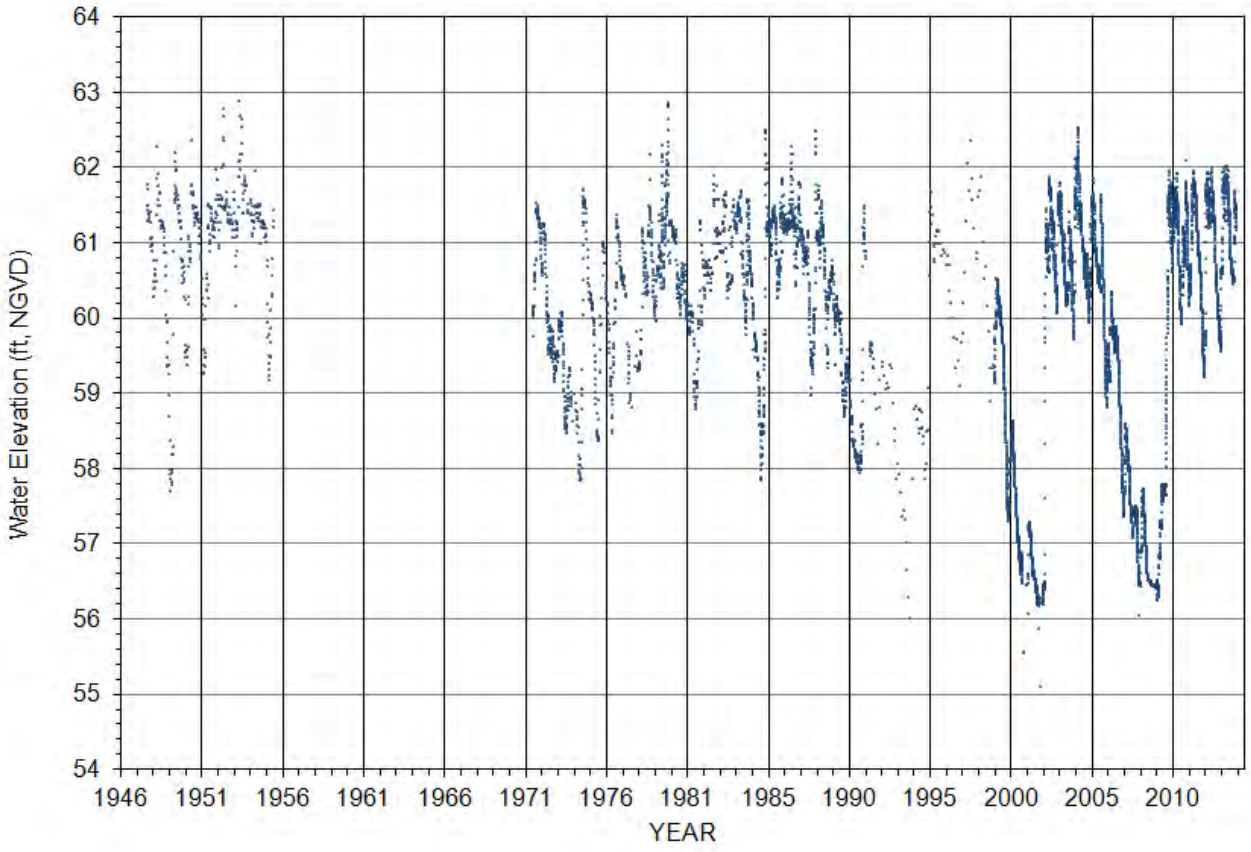

Figure 8. Daily surface water elevations (NGVD 29) through May 2014 for Lake Hanna, SWFWMD WMIS site ID's 19177 and 19178.

For the purpose of Minimum Levels determination, lake stage data are classified as "Historic" for periods when there were no measurable impacts due to water withdrawals, and impacts due to structural alterations were similar to existing conditions. In the context of Minimum Levels development, "structural alterations" 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 classified as "Current" for periods when there were measurable, stable impacts due to water withdrawals, and impacts due to structural alterations were stable. Historic data are from a period when influences of groundwater were absent or not measurable.

Data collected between 1971 and 2013 was determined as Current data based on an assessment of the lake hydrogeology and hydrologic modeling analyses completed for Lake Hanna (Ellison 2014). The mean monthly data was used to calculate the Current P10, P50, and P90 (Table 3). The early data prior to 1963 is considered to be Historic data and for Lake Hanna only data from 1948 through 1955 is available. This early data was used to establish a rainfall correlation model to predict lake stage The method relates local rain gage data to historic lake stage data to produce a regression model that predicts lake stage based on past rainfall amounts. The procedure uses a linear inverse time weighted rainfall sums to establish the relationship (Ellison 2012). Models produced with this method are used to produce a 60-year non-impacted lake stage record that serves as the basis for establishing historic lake-stage exceedance percentiles. A sixty year period is considered sufficient for incorporating the range of lake stage fluctuations that would be expected based on long-term climatic cycles that have been shown to be associated with changes in regional hydrology (Enfield et al. 2001, Basso and Schultz 2003).

The development of the rainfall correlation model involved an inventory of rainfall stations sorted by distance to Lake Hanna and period of record. The general rule of using the closest rainfall gauge or NexRad data first was followed for the majority of the model period. The specific rainfall gauges selected and a description of model methods is provided by Ellison (2014).

The coefficient of determination (r^2) of the resulting rainfall model was 0.66. The model predicts historic conditions and was used to develop long term percentiles to assess the minimum level being set. A graph of the modeled historic water level is shown in Figure 9. The observed lake stage data is also shown to illustrate the model fit. The long-term Historic percentiles developed from modeled lake stage include the Historic P10, P50, and P90. These are defined as the elevation the lake water surface equaled or exceeded ten, fifty, and ninety percent of the time during the historic period. The Historic P10, P50, and P90 developed from the model lake stage were 62.0, 60.0, and 58.1 NGVD 29.

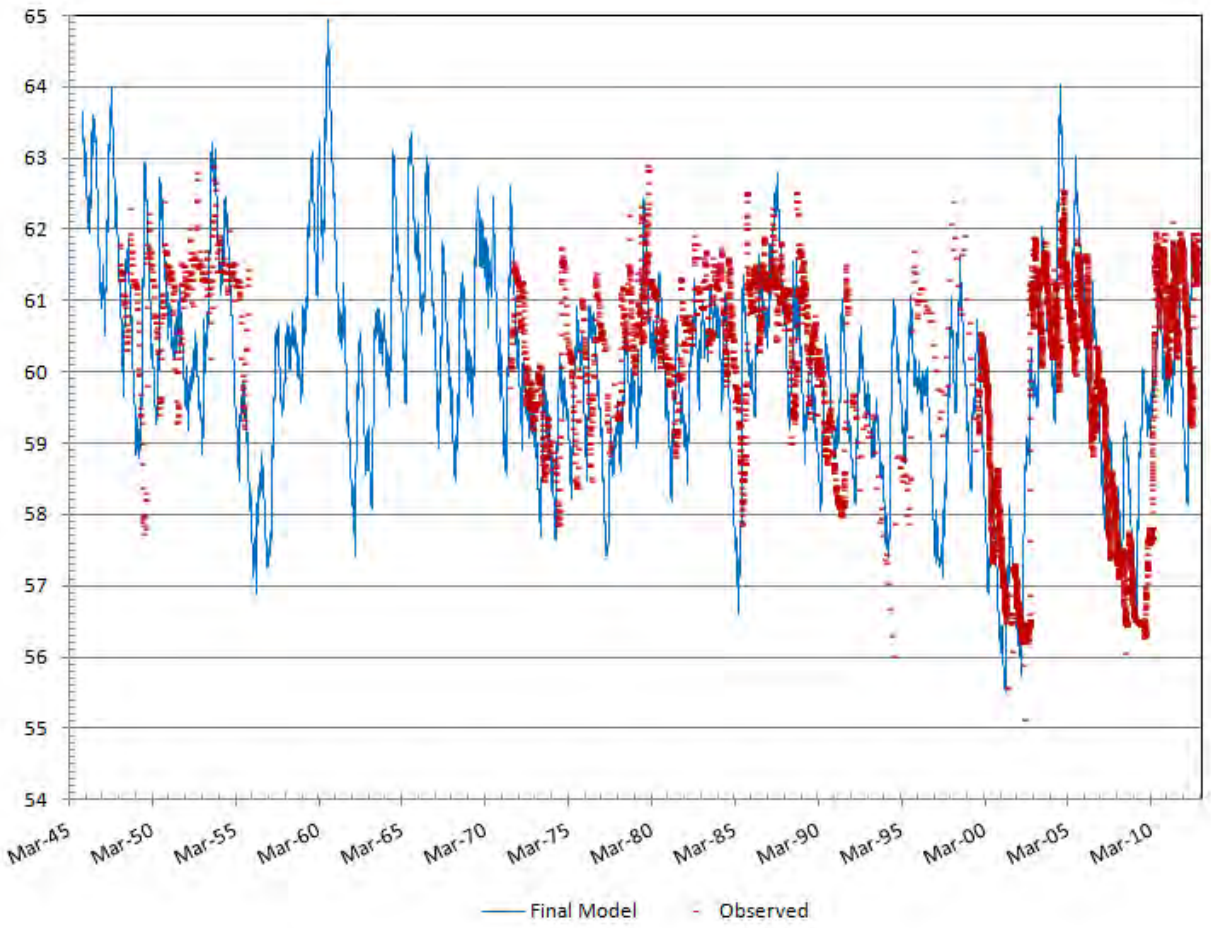

Figure 9. Modeled long term Historic lake stage (as daily, see blue line) from 1946 to 2013 and observed lake stage (as daily, see red points) for Lake Hanna.

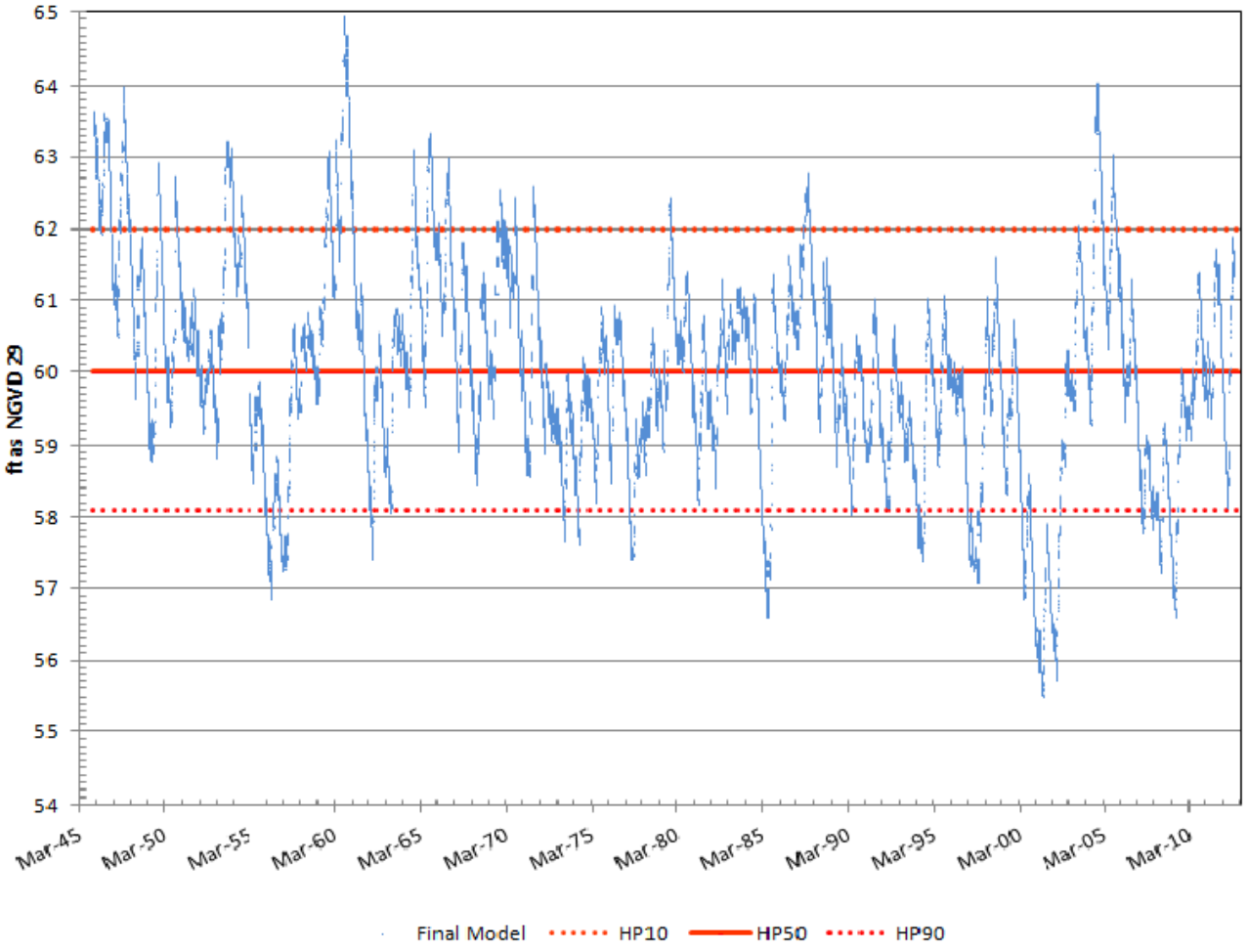

Figure 10. Modeled Historic lake stage for Lake Hanna from January 1946 through July 2013. The long term Historic P10, P50, and P90 are depicted as horizontal solid (P50) and dotted lines.

Normal Pool Elevation, Control Point Elevation and Structural Alteration Status

The **Normal Pool** elevation, a reference elevation used for development of minimum lake and wetland levels, is established based on the elevation of Hydrologic Indicators of sustained inundation. For development of Minimum Lake Levels, the Normal pool elevation is considered an approximation of the Historic P10. Based on the elevations of *Taxodium* sp. buttress inflection points measured in March 2012 along the east and west shores of the lake, (see Figures 4 and 12, Table 5), the Normal Pool elevation was established at 61.9 NGVD.

For development of minimum and guidance levels, lakes are classified as open or closed basin lakes. Open basin lakes are systems that are connected to, or are part of an ordered surface water conveyance system, *i.e.,* they have outlets or inlets for conveyance of surface water. Closed basin lakes are those that are not part of an ordered conveyance system. Lake Hanna is considered an open basin lake since it is part of the Thirteen Mile Run and has both an inlet canal and two outlets canals (see Figure 3).

The **Control Point** elevation is the elevation of the highest stable point along the outlet profile of a surface water conveyance system (*e.g.,* weir, ditch, culvert, or pipe) that is the principal control of water level fluctuations in the lake. 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 elevation is the lowest point on the portion of a water control structure that provides for conveyance of water across or through the structure. Two outfall structures are located on Lake Hanna (see Figure 3). The primary control structure is located on the east side of the lake with a crest elevation of 60.28 NGVD. This structure has an 18 inch flashboard capacity and a corresponding peak structure level of 61.78 NGVD. The secondary control structure on the west side of the lake is currently fixed at an elevation of 61.75 NGVD. The Control Point elevation for Lake Hanna was established at 60.28 NGVD, the invert elevation of the primary operable structure on the east side of the lake.

Structural Alteration Status is determined to support development of Minimum and Guidance Levels. In addition to identification of outlet conveyance system modifications, comparison of the Control point elevation with the Normal Pool is typically used to determine if a lake has been structurally altered. If the Control Point elevation is below the Normal Pool, the lake is classified as a structurally altered system. If the Control Point elevation is above the Normal Pool or the lake has no outlet, then the lake is not considered to be structurally altered. Based on the existence of the outlet canals and structures and given that the Normal Pool elevation (61.9 NGVD) is higher than the Control point elevation (60.28 NGVD), Lake Hanna was classified as a structurally altered lake.

Guidance Levels

The Ten Year Flood Guidance Level has historically been provided as advisory information for lakeshore development and is the level of flooding expected on a frequency of not less than the ten-year recurring interval, or on a frequency of not greater than a ten percent probability of occurrence in any given year. For Lake Hanna, a Ten Year Flood Guidance Level of 63.50 feet NGVD was adopted into Chapter 40D-8, F.A.C. in April 1980. Recent work completed in support of the District's Watershed Management Program has yielded a new ten-year recurrence flood stage for Lake Hanna. Results from the study, which involved floodplain analyses for the portion of the Cypress Creek basin in Pasco County, indicate a ten-year flood level of 62.31 feet above the North American Vertical Datum of 1988 for Lake Hanna (Parsons 2011). This provisional flood level corresponds to an elevation of 63.14 feet above NGVD, based on use of a 0.83 foot datum-conversion factor, and is 1.04 feet lower than the original flood level proposed in 1980.

In October 2007, the District Governing Board approved rule amendments to remove all adopted Ten Year Flood Guidance Levels from Chapter 40D-8, F.A.C. The intent of this action was not to discontinue development of regional and site-specific flood stage information, but rather to promote organizational efficiency by eliminating unnecessary rules. Flood stage levels continue to be developed under the District's Watershed Management Program, but ten year flood recurrence levels are not incorporated into Chapter 40D-8, F.A.C. In accordance with this policy, Chapter 40D-8, F.A.C. does not currently include a Ten Year Flood Guidance Level for Lake Hanna.

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 the Current P10, the control point, and the normal pool elevation. Based on the availability of the modeled long term Historic data record for Lake Hanna, the High Guidance Level for Lake Hanna was established at **62.0 NGVD 29** (Figure 11, Table 3).

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 established using Historic or Current lake stage data, and in some cases, the Reference Lake Water Regime (RLWR) statistics. Based on the availability of the long term modeled Historic data set for Lake Hanna, the Low Guidance Level for Lake Hanna was established at **58.1 NGVD 29** (Figure 11, Table 3).

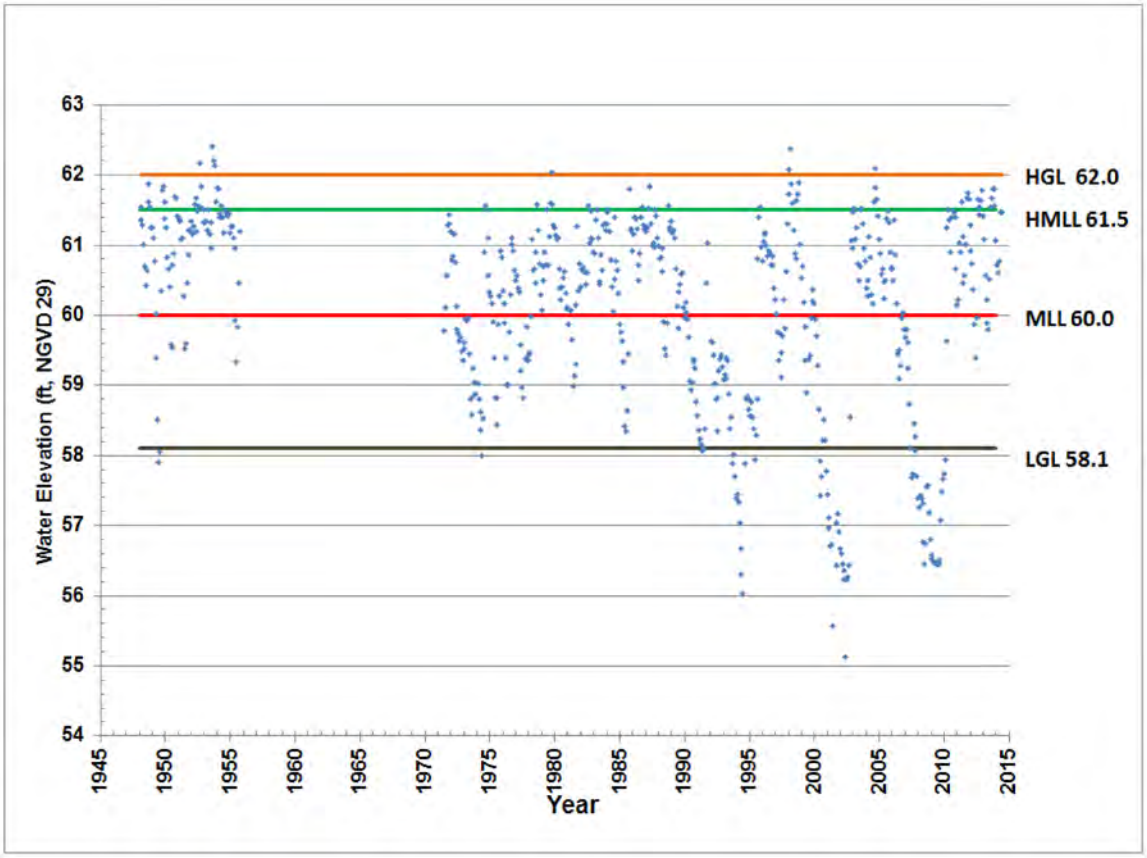

Figure 11. Mean monthly lake stage for Lake Hanna of the period of record; and Minimum and Guidance Levels for Lake Hanna (ft as NGVD 29). The levels include the High Guidance Level (HGL), High Minimum Lake Level (HMLL), Minimum Lake Level (MLL), and the Low Guidance Level (LGL).

Lake Classification

Lakes are classified as Category 1, 2, or 3 for the purpose of Minimum Levels development. Those with fringing cypress wetlands greater than 0.5 acres in size where water levels currently rise to an elevation expected to fully maintain the integrity of the wetlands (*i.e.*, the Historic P50 is equal to or higher than an elevation 1.8 feet below the Normal Pool elevation) are classified as Category 1 Lakes. Category 2 lakes are also lakes with fringing cypress wetlands greater than 0.5 acres in size, but where structural alterations have prevented the Historic P50 from equaling or rising above an elevation that is equal to an elevation 1.8 ft below normal pool. Despite the structural alterations the lake-fringing cypress swamp(s) remain viable and perform functions beneficial to the lake. Lakes without fringing cypress wetlands or with cypress wetlands less than 0.5 acres in size are classified as Category 3 Lakes.

Based on the presence of lake-fringing cypress wetlands of 0.5 acres or more in size within the lake basin, and because the Historic P50 nearly equals the 1.8 feet below the Normal Pool elevation, Lake Hanna was classified as a Category 1 Lake. The Historic P50 and Cypress Standard for Lake Hanna was 60.0 and 60.06 (NGVD), respectively and were nearly equal (Table 3). Both the elevation of Current P10 and Historic P10 were similar to the normal pool elevation indicating that the lake reaches the necessary high levels needed to sustain the fringing cypress wetlands (Table 3). Field assessments also indicated that the cypress wetlands have remained viable (see Figure 12).

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 (Rule 62-40.473, F.A.C.). Other information taken into consideration includes potential changes in the coverage of herbaceous wetland vegetation and submersed aquatic plants.

For Category 1 or 2 Lakes, a significant change standard is established 1.8 feet below the normal pool elevation. This standard identifies a desired median lake stage that if achieved, may be expected to preserve the ecological integrity of lake-fringing wetlands. Although not identified by name in the District's Minimum Flows and Levels rule, the elevation 1.8 feet below normal pool is typically referred to as the Cypress Standard in District documents pertaining to minimum levels development. For Lake Hanna, the Cypress Standard was established at 60.06 NGVD. Based on the Historic composite water level record, the standard was equaled or exceeded forty-nine percent of the time, *i.e.*, the standard elevation corresponds to the Historic P49. Based on observed monthly data for the Current period (1971-2014) the standard was equaled or exceeded 56.2 % of the time.

For Category 3 lakes, six significant change standards, including a Dock-Use Standard, a Basin Connectivity Standard, an Aesthetics Standard, a Recreation/Ski Standard, a Species Richness Standard, and a Lake Mixing Standard are developed. These standards identify desired median lake stages that if achieved, are intended to preserve various natural system and human-use lake values. Although Lake Hanna is a Category 1 Lake, Category 3 Lake standards were developed for comparative purposes. These standards were not, however, used to establish the Minimum Levels.

The **Dock-Use Standard** is developed to provide for sufficient water depth at the end of existing docks to permit mooring of boats and prevent adverse impacts to bottom-dwelling plants and animals caused by boat operation. The standard is based on the elevation of lake sediments at the end of existing docks, a clearance value for boat mooring, and use of Historic lake stage data or region-specific reference lake water

regime statistics. The Dock-Use Standard for Lake Hanna was established at **62.0** feet above NGVD, based on the elevation of sediments at the end of ninety percent of the **22** docks within the lake (**58.1** feet above NGVD, **Table 4**), a two-foot water depth based on use of powerboats in the lake, and the **1.9** foot difference between the Historic P50 and Historic P90. The sediment elevations were measured in March of 2012 with a corresponding water level of **60.6** NGVD. Based on the Historic water level record, the Dock-Use Standard was equaled or exceeded 10 percent of the time, i.e., the standard elevation corresponds to the Historic P10. The elevation of the dock use standard was equivalent to the elevation of the High Guidance Level. The dock-use standard was determined not to be appropriate for the establishment of a minimum level since the elevation is significantly higher than the Historic P50.

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 the lake area at the Historic P50 elevation (see Figure 13) for a plot of lake surface area versus lake stage. For Lake Hanna, the Species Richness Standard was established at **57.3** NGVD 29. The Species Richness Standard was equaled or exceeded 96.9 percent of the time, based on the long term composite Historic water level record. The standard elevation therefore corresponds to the Historic P96.9.

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 Hanna is 58.1 NGVD 29. Because the Low Guidance Level was established at the Historic P90 elevation, water levels equaled or exceeded the Aesthetics Standard ninety percent of the time during the Historic long term period (1946 to 2012, Figure 10).

The **Lake Mixing Standard** is developed to prevent significant changes in patterns of wind-driven mixing of the lake water column and sediment resuspension. 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 of <0.8. A shift in the dynamic ratio occurs at an elevation of 51.0 (Figure 13), indicating the elevation at which the lake depth and bottom slope becomes susceptible to resuspension of bottom sediments. Because the dynamic ratio does not shift across the 0.8 threshold as the stage of Lake Hanna changes from approximately 64 NGVD to low level conditions (Figure 13), a Mixing Standard was not developed for the lake.

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 lake-use. The standard is based

on the elevation of lake sediments at a critical high-spot between lake basins or lake, clearance values for movement of aquatic biota or powerboats and other watercraft, and use of Historic lake stage data or region-specific reference lake water regime statistics. A review of the historical imagery indicated that the lake remains one continuous basin over various stages and time periods. Because lake-basin depth measurements indicate that Lake Hanna does not contain separate sub-basins, the Basin Connectivity Standard was not considered applicable for the lake. Lake Hanna is comprised of a single main basin which does not separate into disconnected pools at elevations down to 51 ft NGVD 29, an elevation 7 ft below the Historic P90 (see Figure 5).

The **Recreation/Ski Standard** is developed to identify the lowest elevation within the lake basin that will contain an area suitable for safe water skiing. The standard is based on the lowest elevation (the Ski Elevation) within the basin that can contain a five-foot deep ski corridor delineated as a circular area with a radius of 418 ft, or a rectangular ski area 200 ft in width and 2,000 ft in length, and use of Historic lake stage data or region-specific reference lake water regime statistics. Lake Hanna did not meet the minimum size requirements for safe skiing practices and therefore the Recreational/Ski Standard was not considered applicable for the lake.

Information on herbaceous wetlands is taken into consideration when determining the elevation at which changes in lake stage would result in substantial changes in potential wetland area within the lake basin (*i.e*., basin area with a water depth of four or less 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 (*i.e*., basin area with a water depth of 7.5 feet or less feet). Review of changes in potential herbaceous wetland area or area available for submersed aquatic plant colonization in relation to change in lake stage did not indicate that of use of any of the significant change standards would be inappropriate for establishment of the Minimum Lake Level (Figure 14).

Because herbaceous wetlands are common within the Lake Hanna basin, it was determined that an additional measure of wetland change should be considered for minimum levels development. Based on a 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 (or Wetland Offset) 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 59.2 NGVD was therefore established for Lake Hanna by subtracting 0.8 feet from the Historic P50 elevation. The standard elevation was equaled or exceeded 74.4 percent of the time during the Historic period and therefore corresponds to the Historic P74.4.

Table 4. Summary statistics and elevations associated with docks in Lake Hanna as based on measurements made by District staff in March 2012. Percentiles (10th, 50th and 90th) represent the percentage of docks at or below the corresponding elevation.

Summary Statistics	Statistic Value (N) or Elevation (feet above NGVD) of Sediments at Waterward End of Docks	Statistic Value (N) or Elevation (feet above NGVD) of Dock Platforms
N (number of docks)	22	22
Mean	56.6	62.6
10th Percentile (P90)	55.6	61.9
50th Percentile	56.6	62.8
90th Percentile (P10)	58.1	63.6
Maximum	58.8	64.2
Minimum	52.9	57.8

Table 5. Summary statistics for hydrologic indicator measurements (elevations of the buttress inflection points base of lakeshore *Taxodium* sp.) used for establishing the Normal Pool Elevation for Lake Hanna.

Statistic	Statistic Value (N) or Elevation (feet above NGVD)
N	6
Median	61.91
Mean (Standard Deviation)	61.9 (0.24)
Minimum	61.6
Maximum	62.3

Figure 12. Stand of mature lakeshore cypress *(Taxodium* sp.) located along central west shore with several used as a normal pool reference.

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 fifty percent of the time on a long-term basis. For Category 1 Lakes, the Minimum Level is established at the Cypress Standard, which is 1.8 feet below the Normal Pool. Category 2 lakes are lakes with structural alterations that have prevented the Historic P50 from equaling or rising above an elevation that is equal to an elevation 1.8 ft below normal pool and the lake-fringing cypress swamp(s) remain viable and perform functions beneficial to the lake in spite of the structural alterations. For Category 2 Lakes the Minimum Level is established at the Historic P50.

For Lake Hanna, the Historic P50 and Cypress Standard are nearly equal (60.0 and 60.1 NGVD), indicating that the structural alterations are not significant enough to prevent the Historic P50 from equaling an elevation 1.8 ft below the normal pool. The 0.1 foot difference between the Historic P50 and Cypress Standard is below the threshold of expected error in measuring elevations of normal pool and modeling of the Historic P50. The Minimum Lake Level for Lake Hanna was therefore established at HP 50 (60.0 NGVD) the lowest of the two elevations. This level is expected to provide protection of both the cypress wetlands occurring within the basin and human-use values associated with the identified significant change standards.

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 1 lakes, the High Minimum Lake Level is established 0.4 feet below the Normal Pool elevation. The High Minimum Lake Level for Lake Hanna was therefore established at 61.5 NGVD. The High Minimum Lake Level at 61.5 NGVD was equaled or exceeded 15 percent of the time, based on the term modeled Historic water level record, and corresponds to the Historic P15.

The Minimum and Guidance levels for Lake Hanna are shown in Figure 11 along with monthly mean water surface elevations based on period of record water level measurements. Staging of the lake at Minimum levels (Figure 15 and 16) would not be expected to flood any man-made features within the immediate lake basin. The High Minimum Lake Level (61.5 NGVD 29) is approximately **2.7 feet** lower than the lowest residential floor slab (64.2 NGVD 29) within the lake basin (Table 6). The High Minimum Lake Level is also approximately **1.0 ft lower** than the lowest spot on the paved roads (62.5 NGVD 29) encircling the lake.

Table 6. Elevations of the lowest roadway and floor slab in the immediate Lake Hanna basin (Xynides 2011) as NGVD 29

Lake Basin Features	Elevation in Feet NGVD 29
Lowest roadway elevation	**62.52**
Low floor slab – residential	**64.20**

Consideration of Environmental Values

The minimum levels for Lake Hanna are protective of all relevant environmental values identified for consideration in the Water Resource Implementation Rule when establishing minimum flows and levels (see Rule 62-40.473, F. A. C.). 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. A Cypress Standard was used for developing Minimum Levels for Lake Hanna based on its classification as a Category 1 Lake. This standard is associated with protection of several environmental values identified in Rule 62-40.473, F. A. C., including: fish and wildlife habitats and the passage of fish, transfer of detrital material, aesthetic and scenic attributes, filtration and absorption of nutrients and other pollutants, sediment loads and water quality (refer to Table 1).

Two additional environmental value identified in Rule 62-40.473, F. A. C., are also protected by the minimum levels for Lake Hanna. The environmental value, recreation in and on the water is associated with the Aesthetic Standard developed for the lake. This standard is associated with an elevation lower than the Cypress Standard elevation indicating that it will be achieved at a higher frequency than the Cypress Standard. 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.

Two environmental values identified in Rule 62-40.473, F. A. C., were not considered relevant to development of minimum levels for Lake Hanna. 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. Sediment loads were similarly not considered relevant for minimum levels development for the lake, because the transport of sediments as bedload or suspended load is a phenomenon associated with flowing water systems.

Assessment of the Lake Hanna Minimum Level Condition

The minimum level developed for Lake Hanna was assessed to determine if lake levels are fluctuating relative to the minimum level in an appropriate manner. The methods used included using the prediction interval of the rainfall regression model developed to model the historic data; and evaluating the cumulative median relative to the minimum level (Ellison 2014). Both methods indicated that the lake is at or above the minimum low level of 60.0 NGVD 29.

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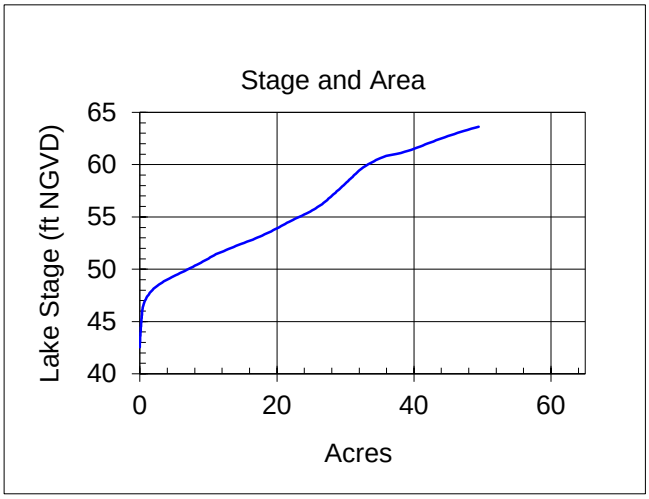
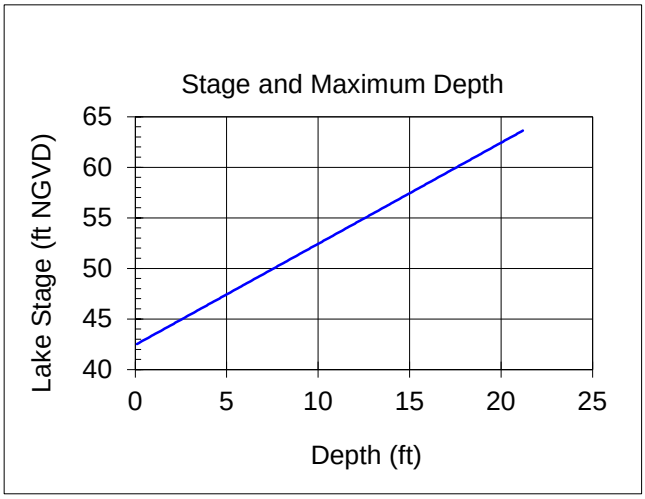
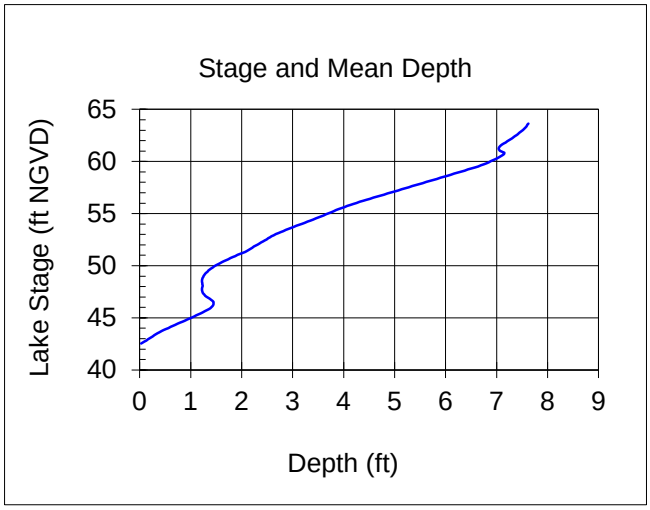
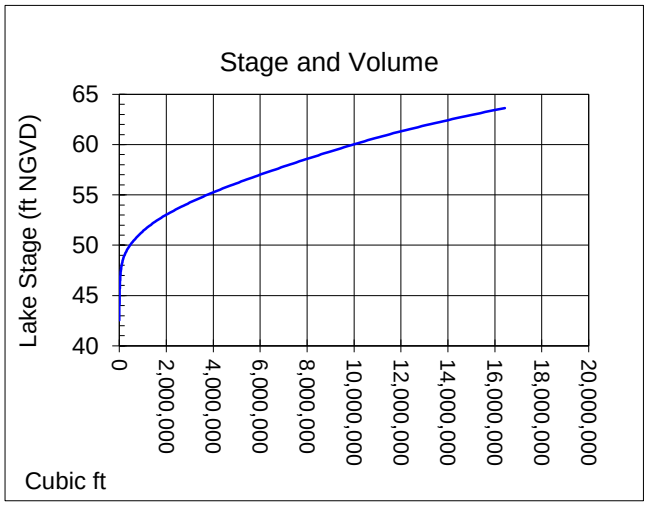








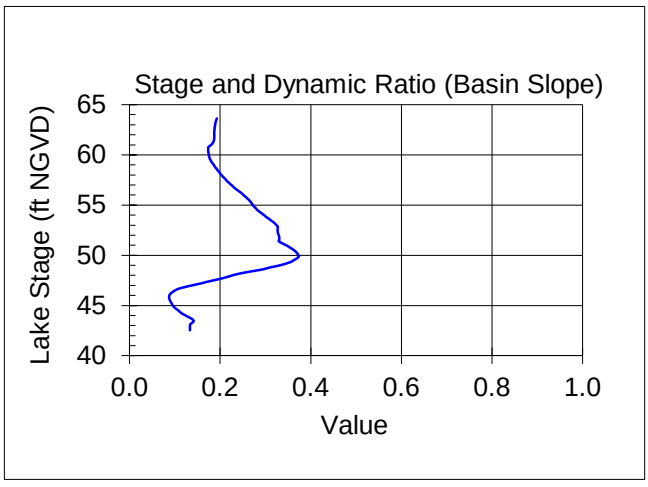
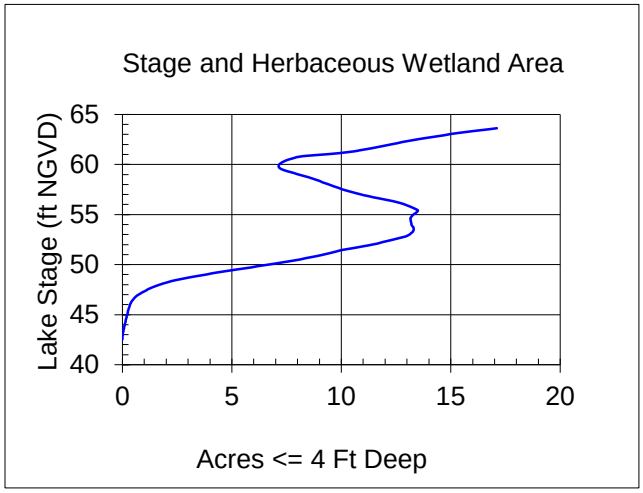


Figure 13. Surface area, maximum depth, mean depth, volume, dynamic ratio (basin slope) in feet above NGVD 29 for Lake Hanna.



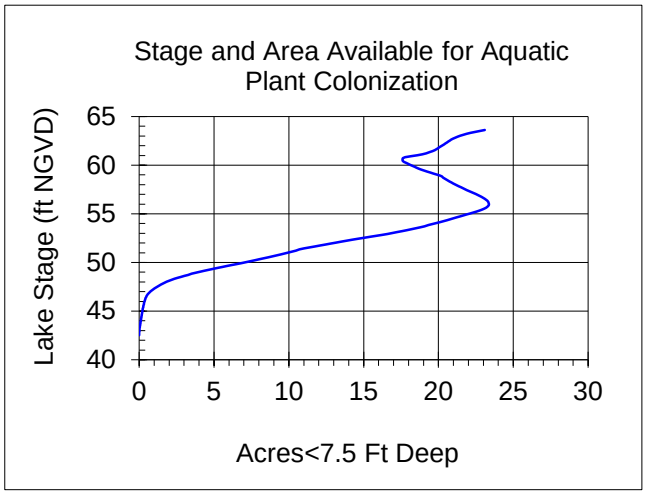


Figure 14. Potential herbaceous wetland area and area available for submersed macrophyte colonization in Lake Hanna as a function of lake stage (water surface elevation).

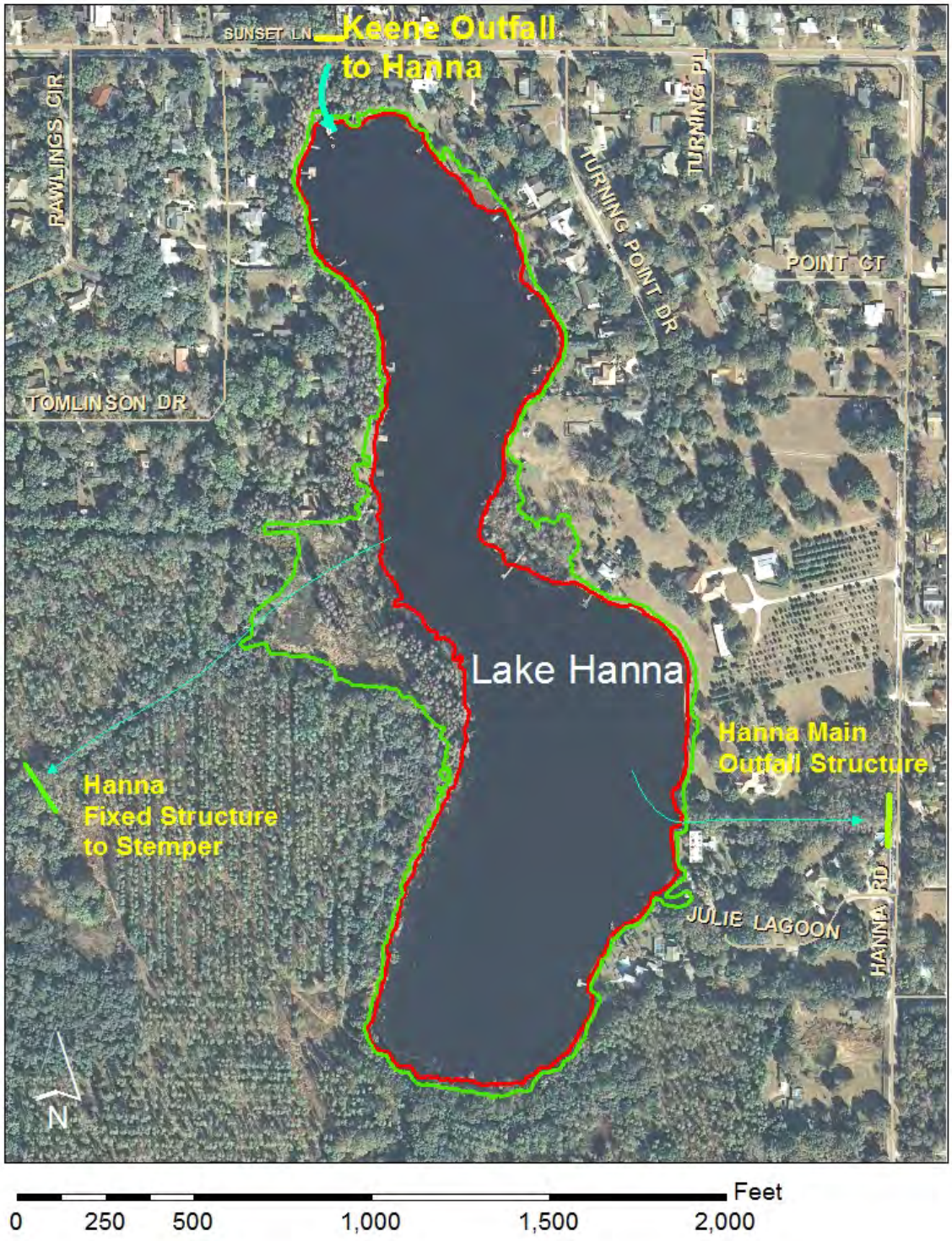


Figure 15. Recent (January 12, 2011) aerial view of Lake Hanna with contour lines representing the Minimum Lake Level (60.0 NGVD) and High Minimum Lake Level (61.5 NGVD).

Figure 16. Recent (January 12, 2011) aerial view of Lake Hanna with orange contour line representing the High Guidance Level (62.0 NGVD).

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