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Reevaluation of Minimum Levels for Lake Denton in Highlands County, Florida

July 18, 2025

Southwest Florida Water Management District

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Executive Summary

The Southwest Florida Water Management District (District) is directed by the Florida Legislature to establish minimum levels for lakes within its boundaries. Minimum levels are defined in Section 373.042(1) of the Florida Statutes as “the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.” Once adopted into District rules, minimum levels can be used for water supply planning, water use permitting, and environmental resource regulation.

This report identifies minimum levels that were developed as part of a reevaluation of minimum levels currently adopted within the District’s Water Level and Rates of Flow rules (Chapter 40D-8, Florida Administrative Code) for Lake Denton in Highlands County. The reevaluation was conducted to support an ongoing assessment of the implementation of the Southern Water Use Caution Area Recovery Strategy in a region of the District where recovery of minimum flows and minimum water levels has been necessary.

For the reevaluation, the physical setting of Lake Denton and other relevant information, including regional physiography and hydrogeology, water level and bathymetric data for the basin, land-use and area water use information, and currently established minimum levels and their status were reviewed and summarized. The reevaluation also included development and use of a new water budget model for simulating lake water levels, and use of newly developed criteria and screening procedures, including the use of a Xeric Wetland Offset and other best available information, for development of proposed minimum levels that address all relevant environmental values identified in the Florida Water Resource Implementation Rule (specifically, Rule 62-40.473, Florida Administrative Code) for consideration when setting minimum levels.

Two minimum water levels were developed as a result of the reevaluation of currently established levels for the lake. A Minimum Lake Level of 108.8 ft above the National Geodetic Vertical Datum of 1929 (NGVD29) is proposed as a water surface elevation that must be equaled or exceeded 50% of the time, on a long-term basis. A High Minimum Lake Level of 112.4 ft NGVD29 is proposed as a water surface elevation that must be equaled or exceeded 10% of the time, on a long-term basis.

Assessment of long-term water levels in Lake Denton indicates the proposed Minimum Lake Level and High Minimum Lake Level are both currently met, and adoption or modification of an existing recovery strategy would, therefore, not be required in association with adoption of the proposed minimum levels. Additionally, projected data indicate that the Minimum Lake Level and High Minimum Lake Level will continue to be met during the next two decades, so implementation of a prevention strategy is similarly not required. If the lake’s levels fall below, or are projected to fall below an applicable minimum level, the District will expeditiously adopt or modify and implement a recovery or prevention strategy in accordance with Section 373.042(2), F.S. Additionally, the District will continue to implement a general, three-pronged approach that includes monitoring, annual status assessment of established minimum levels, and regional water supply planning, to ensure that the adopted minimum levels for the lake continue to be met. The District will also

continue to monitor levels in Lake Denton and other lakes to further understanding of lake hydrology and ecology and to support as-necessary, future refinements to District minimum levels methods.

CHAPTER 1 – INTRODUCTION

The Southwest Florida Water Management District (District or SWFWMD) is directed by the Florida Legislature to establish minimum water levels for priority water bodies within its boundaries. Minimum levels are defined for surface waters in Section 373.042(1) of the Florida Statutes (F.S.) as "the level of surface water at which further withdrawals would be significantly harmful to the water resources or ecology of the area." Once established, i.e., adopted into the District's Water Levels and Rates of Flow rules (Chapter 40D-8, Florida Administrative Code or F.A.C.), minimum levels are used for water resource regulation and management.

Minimum water levels were last established in 2008 for Lake Denton in Highlands County, replacing management levels that included minimum levels established for the lake in 1982. Reevaluation of the currently established minimum levels is scheduled for completion in 2025 to support the ongoing assessment of recovery needs in the Southern Water Use Caution Area, a region of the District where a recovery strategy is being implemented to help achieve minimum flows and minimum water levels that are currently not being met (see Rule 40D-80.074, F.A.C., and SWFWMD 2006, 2023b).

In support of the reevaluation, information on the physical setting and other relevant characteristics of Lake Denton are summarized in this document. Regional physiography and hydrogeology are described, as are water level and bathymetric data for the basin, land-use and area water use information, and the currently established minimum levels for the lake. Application of an updated approach for modeling lake water levels and new and updated lake-level standards and screening criteria for minimum levels establishment are also described.

Using this best available information, revised minimum water levels for Lake Denton were developed in accordance with all relevant statutory and rule requirements pertaining to minimum levels establishment. In addition, a status assessment that indicated the recommended, revised minimum levels are currently met and are projected to be met during the next 20 years was completed. Based on these findings, an update of the minimum water levels established for Lake Denton in Rule 40D-8.624, F.A.C., with the revised minimum levels described in this document is recommended.

1.1 Legal Directives

Section 373.042 of the F.S. requires the Florida Department of Environmental Protection (FDEP) or the state water management districts to establish minimum water levels, which are defined 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 water levels are to be calculated using the "best information available" and when appropriate, "may be calculated to reflect seasonal variations."

When establishing minimum water levels, the "department and the governing board shall consider, and at their discretion may provide for, the protection of nonconsumptive uses in the establishment of minimum flows and minimum water levels." In addition, "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", must be considered when establishing minimum water levels, with the caveat that these considerations shall not allow significant harm caused by withdrawals (Section 373.0421, F.S.).

Minimum water levels are adopted into the District's Water Levels and Rates of Flow Rules (Chapter 40D-8, F.A.C.) and used for water supply 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.

Emphasizing the importance of minimum water levels (and minimum flows) for water resource protection and management, Section 373.0421(2), F.S., requires 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 established pursuant to S. 373.042." Necessary recovery or prevention strategies are 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." Further supporting the adaptive management aspect of minimum levels establishment and implementation, Section 373.0421(3), F.S., requires the periodic reevaluation and, as necessary, revision of established minimum levels.

The District's Recovery and Prevention Strategies for Minimum Flows and Levels Rules (Chapter 40D-80, F.A.C.) describe the regulatory portions of the recovery or prevention strategies to achieve or protect, as applicable, minimum flows and levels established within the District.

The Florida Water Resource Implementation Rule (Chapter 62- 40.473, Florida Administrative Code; hereafter F.A.C.) provides additional guidance for the establishment of minimum flows and levels, requiring that "consideration shall be given to the protection of water resources, natural seasonal fluctuations in water flows, and environmental values associated with coastal, estuarine, aquatic and wetland 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." The Water Resource Implementation Rule 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".

The Central Florida Water Initiative Area Uniform Process for Setting Minimum Flows and Minimum Water Levels and Water Reservations Rule 62-41.304, F.A.C., within the Regulation of the Consumptive Use of Water Rules of the DEP (Chapter 62-41, F.A.C.) identifies additional requirements for minimum flow and level prioritization, establishment, and status assessments for certain waterbodies. These water bodies include those within the Central Florida Water Initiative (CFWI) area, which as defined in Section 373.0465, F.S., includes all of Orange, Osceola, Polk and Seminole counties and southern Lake County. The CFWI is a collaborative water supply planning effort among the St. Johns River, South Florida and Southwest Florida water management districts, the FDEP, the Florida Department of Agriculture and Consumer

Services, regional utilities, business organizations, environmental groups, agricultural interests, and other stakeholders (CFWI 2020). Rule 62-41.304, F.A.C., requires the FDEP, St. Johns River Water Management District, Southwest Florida Water Management District, and the South Florida Water Management District to meet prior to the annual submission of each District's MFLs priority list to FDEP for approval to discuss CFWI-area waterbodies proposed for inclusion on the priority lists. The annual noticing and facilitation of a joint public workshop within the CFWI Area by the three districts for discussion of each district's proposed priority list applicable to the CFWI is also required. In addition, the sharing of information supporting any proposed MFL between the three water management districts and the FDEP is required prior to a district seeking independent scientific peer review of the proposed MFL or prior to publishing a Notice of Proposed Rule associated with the proposed MFL, whichever comes first.

Although Lake Denton is not located within the CFWI area, it is near the Highlands County border with Polk County and withdrawals from within the CFWI, including those from within the Southwest Florida Water Management District and those from adjacent water management districts have the potential to affect the lake's water levels. Accordingly, these potential effects have been identified for the prioritized reevaluation of minimum levels established for Lake Denton included on the District's Priority List and Schedule for the Establishment of Minimum Flows and Levels and Reservations, and coordination with the South Florida Water Management District and St. Johns River Water Management District for the reevaluation has been conducted as part of the minimum level reevaluation described in this report.

1.2 Minimum Levels: Background Information

To address relevant legislative mandates and rule requirements within its boundaries, the District has developed, and as appropriate, updated specific methodologies for establishing minimum levels for lakes, wetlands, and aquifers. Methods that have been used by the District for minimum level establishment for lakes and wetlands are described in Campbell et al. (2020), Cameron (2022), Cameron et al. (2022a, b, c), GPI & SWFWMD (2022), Leeper (2006), Leeper et al. (2001), and SWFWMD (1999a, b, 2022). Bedient et al. (1999), Dierberg & Wagner (2001), Emery et al. (2022a, b), and Wagner & Dierberg (2006) include peer-review findings for the methods. Minimum aquifer levels are not further discussed in this reevaluation document for Lake Denton; information on their development and use can be found in documents available from the District's Minimum Flows and Levels Documents and Reports web page[1].

Once a minimum level is developed and approved by the Governing Board, rulemaking is initiated to adopt the level into District rules. Minimum levels, including Minimum Wetland Levels, High Minimum Lake Levels, Minimum Lake Level and Minimum Aquifer Levels established by the District are defined in Rule 40D-8.021(7), F.A.C., as "the Long-term level of surface water, water table, or potentiometric surface at which further withdrawals would be significantly harmful to the water resources of the area and which may provide for the protection of nonconsumptive uses."

For minimum level purposes, "'Long-term' means an evaluation period used to establish Minimum Flows and Minimum Water Levels, determine compliance with established Minimum Flows and

[1] Southwest Florida Water Management District Minimum Flows and Levels Documents and reports web page is available at https://www.swfwmd.state.fl.us/projects/mfl/documents-and-reports.

Minimum Water Levels, and assess withdrawal impacts on established Minimum Flows and Minimum Water Levels that represents a period which spans the range of hydrologic conditions which can be expected to occur based upon historical records, ranging from high water levels to low water levels. In the context of an average water level, the average will be based upon the historic expected range and frequency of levels. Relative to Minimum Flow and Level establishment and compliance, the best available information, selected through application of reasonable scientific judgement, that is sufficiently representative of Long-term conditions will be used" (Rule 40D-8.021(5), F.A.C.).

Two minimum levels, a Minimum Lake Level and a High Minimum Lake Level are established for lakes. The Minimum Lake Level is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time (P50) on a long-term basis (Rule 40D-8.624(4), F.A.C.).
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 (P10) on a long-term basis (Rule 40D-8.624(3), F.A.C.).
Several terms relevant to and necessary for understanding the development and implementation of minimum levels by the District are defined in Rule 40D-8.021, F.A.C. These terms include "Current", which "means a recent Long-term period during which Structural Alterations and hydrologic stresses are stable" and "Historic", which "means a Long-term period when there are no measurable impacts due to withdrawals and Structural Alterations are similar to current conditions." For these definitions, "Structural Alteration" "means human alteration of an inlet or outlet of a lake or wetland that affects water levels." Also, for minimum level purposes, ""P50"" means the percentile ranking represented by the elevation of the water surface of a lake or wetland that is equaled or exceeded 50 percent of the time as determined from a Long-term stage frequency analysis", and "P10" and "P90" are similarly defined as percentile rankings associated with water levels equaled or exceeded ten and ninety percent of the time.

1.3 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 minimum water levels originated, and following subsequent modifications to this directive and adoption of relevant requirements in the Water Resource Implementation Rule and District rules, 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 Flows and Levels (MFLs) program addresses all relevant requirements expressed in the Florida Water Resources Act, the Water Resource Implementation Rule and within its own rules.

A substantial portion of the District's organizational resources has been dedicated to its MFLs Program, which logistically addresses six major tasks: 1) development and reassessment of methods for establishing MFLs; 2) adoption of MFLs for priority water bodies (including the prioritization of water bodies and facilitation of public and independent scientific review of proposed MFLs and methods used for their development); 3) monitoring and MFLs status assessments, i.e., compliance evaluations; 4) development and implementation of recovery strategies; 5) MFLs 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.

The District's MFLs Program is implemented based on three fundamental assumptions. First, it is assumed that many water resource values and associated attributes 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 minimum flows and minimum water levels. 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.

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, minimum flows and levels may represent minimum acceptable rather than historic or potentially optimal hydrologic conditions.

Support for the assumptions inherent in the District's establishment of minimum flows and minimum water levels 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 information 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 minimum water levels for hundreds of 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).

1.4 Consideration of Changes and Structural Alterations and Environmental Values

As noted in Section 1.1, 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…" when establishing minimum flows and levels. Also, as required by statute, the District does not establish minimum flows or 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; and
- evaluate the status of water bodies with proposed or established minimum flows or levels (i.e., determine whether the current flow and/or water level are below, or are projected to fall below the applicable minimum flow or level).

As indicated in Section 1.2, the District has developed specific methodologies for establishing minimum flows or levels for lakes, wetlands, rivers, estuaries and aquifers, and subjected the methodologies to independent, scientific peer-review.

In 2022, the District finalized a multiyear effort to review and update criteria and methods used to support development of minimum levels for lakes. Details regarding the updated criteria and methods are summarized in Cameron and Ellison (2019), Cameron (2020), Cameron et al. (2022a, b, 2023), GPI and SWFWMD (2022), and SWFWMD (2022a). Because of the review effort, lake categories and methods associated with minimum lake levels were removed from District rules in 2021 (SWFWMD 2021b). Lakes had previously been divided into three categories, with methods identified for each (SWFWMD 1999a, 1999b; Leeper et al., 2001, SWFWMD 2021b). These rule changes supported further methods refinement and are expected to enhance flexibility regarding future methods development and application to better address each lake's unique characteristics during the development of minimum levels.

Currently, the environmental criteria and associated methods used for minimum lake level development are classified as "standards" or "screenings" (SWFWMD 2022). A standard identifies a lake-specific water surface elevation which is considered with other standards for identification of a recommended Minimum Lake Level that is based on the most sensitive, appropriate standard, i.e., standard associated with the highest water surface elevation. A recommended High Minimum Lake Level is subsequently developed using the recommended Minimum Lake Level and lake-specific water level fluctuations. Screening criteria are then used to assess lake-specific sensitivity for a given environmental value associated with the recommended minimum levels. If the screening indicates potential sensitivity, additional analyses are completed, and as necessary, the standard-based, recommended minimum levels are revised.

The approach involves assigning the greatest initial weight to the highest-confidence criteria/methods, while allowing for use of additional criteria/methods on a site-specific basis, as needed, to ensure sufficient protection against significant harm for all relevant environmental values. Collectively, the District's updated criteria and methods for the establishment of minimum lake levels address all the environmental values identified in the Water Resource Implementation Rule for consideration in when developing minimum flows and levels (Table 1-1).

Table 1-1: Environmental values from the Water Resource Implementation Rule (62-40.473, F.A.C.), associated significant change standards and screening criteria considered when establishing minimum lake levels.

Environmental Value	Associated Significant Change Standards and Screening Criteria
Recreation in and on the water	Basin Connectivity, Aesthetics, Species Richness, Dock Use, Aquatic Habitat Zone, Wetland Offsets
Fish and wildlife habitats and the passage of fish	Wetland Offsets, Basin Connectivity, Species Richness, Aquatic Habitat Zone
Estuarine resources	NA
Transfer of detrital material	Wetland Offsets, Basin Connectivity, Aquatic Habitat Zone
Maintenance of freshwater storage and supply	All
Aesthetic and scenic attributes	Wetland Offsets, Dock Use, Aesthetics, Species Richness, Aquatic Habitat Zone
Filtration and absorption of nutrients and other pollutants	Wetland Offsets, Aquatic Habitat Zone
Sediment loads	NA
Water quality	Wetland Offsets, Aquatic Habitat Zone, Basin Connectivity
Navigation	Basin Connectivity, Aquatic Habitat Zone, Dock Use

NA = Not applicable for consideration for most priority lakes.

Many of the standards and screenings rely on estimates of historic lake water levels, i.e., water levels in the absence of withdrawal impacts but with current structural alterations in place. The modeling procedures used to develop Historic records were evaluated as part of the lake methods review and the resulting updated processes are described in Cameron and Ellison (2019), Cameron (2020), Cameron (2022), and Cameron et al. (2022a). Status assessment, a separate but necessary process for minimum levels development and implementation was also updated as part of the District's recent minimum level methods review and is described in Cameron et al. (2023).

Each minimum levels evaluation or reevaluation incorporates the best available information and involves professional scientific judgement. On a lake-specific basis, individual standards, screenings, or methods may be deemed inappropriate or in need of refinement, or additional assessments or adjustments may be found necessary to address factors such as flooding concerns.

1.5 Currently Established Minimum Levels for Lake Denton

Minimum levels for Lake Denton (Table 1-2) were established by the District in 2008 and are currently included in Table 8-2 within Rule 40D-8.624(6), F.A.C. The Minimum Lake Level of 112.8 ft above the National Geodetic Vertical Datum of 1929 (NGVD29) and the High Minimum Lake Level of 114.1 ft NGVD29 were developed using best available information at that time, which included historic water surface elevation exceedance percentiles identified for characterizing expected water levels in the absence of withdrawal impacts, given the existing structural conditions at the lake and significant harm standards that were previously used for minimum lake level development, as described in SWFWMD (2007).

The levels established in 2008 replaced management levels that had been adopted for Lake Denton in 1982, including those which had initially been established as minimum levels (see Gant 1996, SWFWMD 2007, SWFWMD 2023a). The 2008 levels also included a High Guidance Level of 114.9 ft NGVD29 and a Low Guidance Level of 112.4 ft NGVD29, which corresponded with the Historic P10 and Historic P90 elevations, respectively. These guidance levels were, however, removed from District rules in 2021.

Table 1-2. Currently established minimum levels for Lake Denton.

Minimum Levels	Stage Elevation (ft NGVD29)	Stage Elevation (ft NAVD88)
High Minimum Lake Level	114.1	113.1
Minimum Lake Level	112.8	111.8

To be considered met or achieved, the established minimum levels for Lake Denton must be equaled or exceeded fifty (Minimum Lake Level) and ten (High Minimum Lake Level) percent of the time, respectively, on a Long-term basis. A status assessment completed in 2007 to support development of the currently established minimum levels indicated they were not being met. Subsequent annual status assessments completed through 2023 indicated the minimum levels established for the lake have continued to not be met (Leeper 2023). Based on its location in Highlands County, the recovery strategy outlined in Rule 40D-80.074, F.A.C. for the Southern Use Water Caution Area would be applicable.

Because the District has recently completed a multi-year process of migrating all vertical elevation data from NGVD 29 to the North American Vertical Datum of 1988 (NAVD 88), tables in this report include elevation data values in both NGVD 29 and NAVD 88. Elevation data values shown on graphs and the topographic contours on the bathymetric map are presented using NGVD 29. In some circumstances within this document, elevation data that were collected or reported relative to mean sea level or relative to NGVD 29 are converted to elevations relative to NAVD 88. All datum conversions were derived using the Corpscon 6.0 software distributed by the United States Army Corps of Engineers or based on elevations provided by professional surveyors.

CHAPTER 2 – PHYSICAL SYSTEM

2.1 Location

Lake Denton is a 66-acre lake located in the City of Avon Park in northwestern Highlands County, Florida (latitude 27.556319, longitude -81.489379) (Figure 2-1). The shoreline is mostly made up of residential developments. A concrete slab public boat ramp is located on the northeast shore and is accessible from Lake Denton Dr. The District staff gage (Station Identification Number, SID, 23816) is located on the dock of a private residence on the eastern shore.

Figure 2-1. Location of Lake Denton in Highlands County, Florida.

2.2 Watershed and Structural Control

With a drainage area of approximately 169 acres (Ardaman and Associates, 2013), Lake Denton lies within the Kissimmee River watershed (USGS 2004a, b) (Figure 2-2). Rainfall that does not immediately infiltrate into the soils in the contributing watershed could potentially run off into the lake. Overall runoff volumes to the lake are expected to be low due to the relatively small size of the drainage area, well-drained soils prevalent within the watershed (discussed in Section 2.5), and generally deep water-table in the area. However, residential development and a rather steep topographic gradient (discussed in Section 2.4) within the watershed serves to increase local runoff to the lake. Based on review of one-foot contour interval maps and field survey data, Lake Denton does not have an outlet conveyance system. The lake is therefore considered a closed-basin system and there is no Control Point elevation.

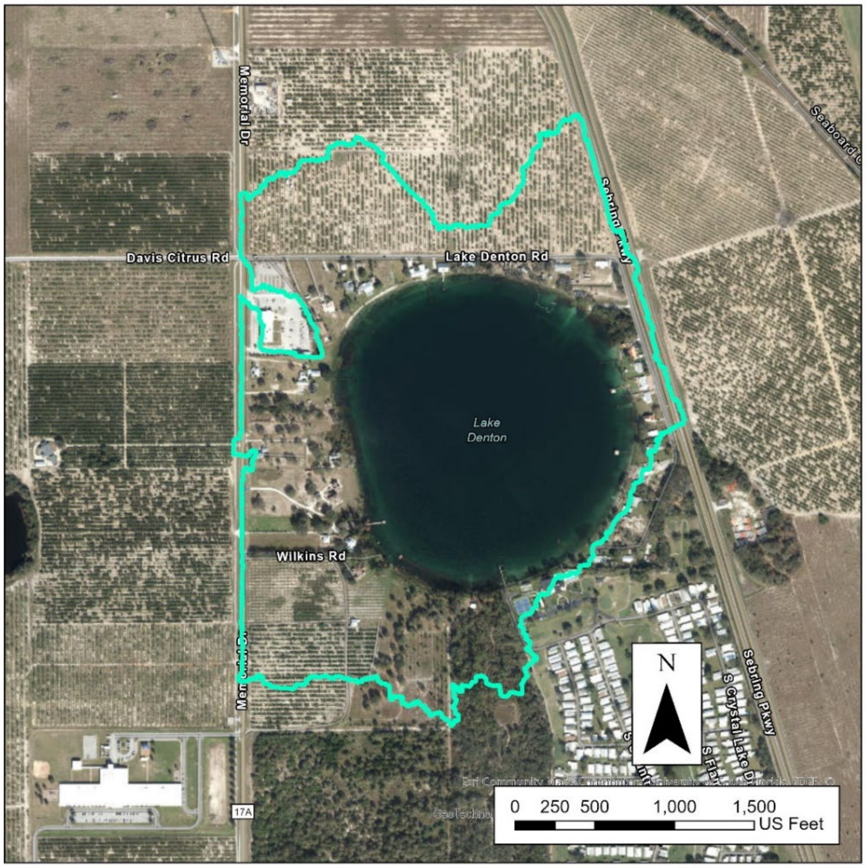


Figure 2-2. Lake Denton watershed.

2.3 Stage History

The 1952 USGS 1:24,000 Lake Arbuckle SW, Fla. quadrangle map shows Lake Denton with a water surface elevation of 110 feet NGVD29 (equivalent to 108.95 feet NAVD88). Surface water elevation data for Lake Denton (SWFWMD Station No. 23816) is available from the District's Environmental Data Portal, covering the period from February 3, 1982 to present (Figure 2-3).

The highest recorded lake level during this period was 115.6 feet NGVD29 (114.55 feet NAVD88) on October 24, 2017, while the lowest was 104.1 feet NGVD29 (103.05 feet NAVD88) on April 27, 1982. The data record for Lake Denton is not continuous, i.e., there are some months during the period of record when lake surface elevations were not recorded.

Based on the period of record data from February 1982 through December 2024, the calculated P10 (10^{th} exceedance percentile), P50 (median), and P90 (90^{th} percentage exceedance) elevations for Lake Denton are 112.7, 109.16, and 107.1 feet NGVD29, respectively (111.65, 108.11, and 106.05 feet NAVD88). This results in a P10–P50 range of 3.54 feet and a P10–P90 range of 5.6 feet. These ranges are several times greater than those observed in mesic, shallow water-table lakes such as those in the Tampa Bay region (SWFWMD, 1999; Cameron et al., 2022).

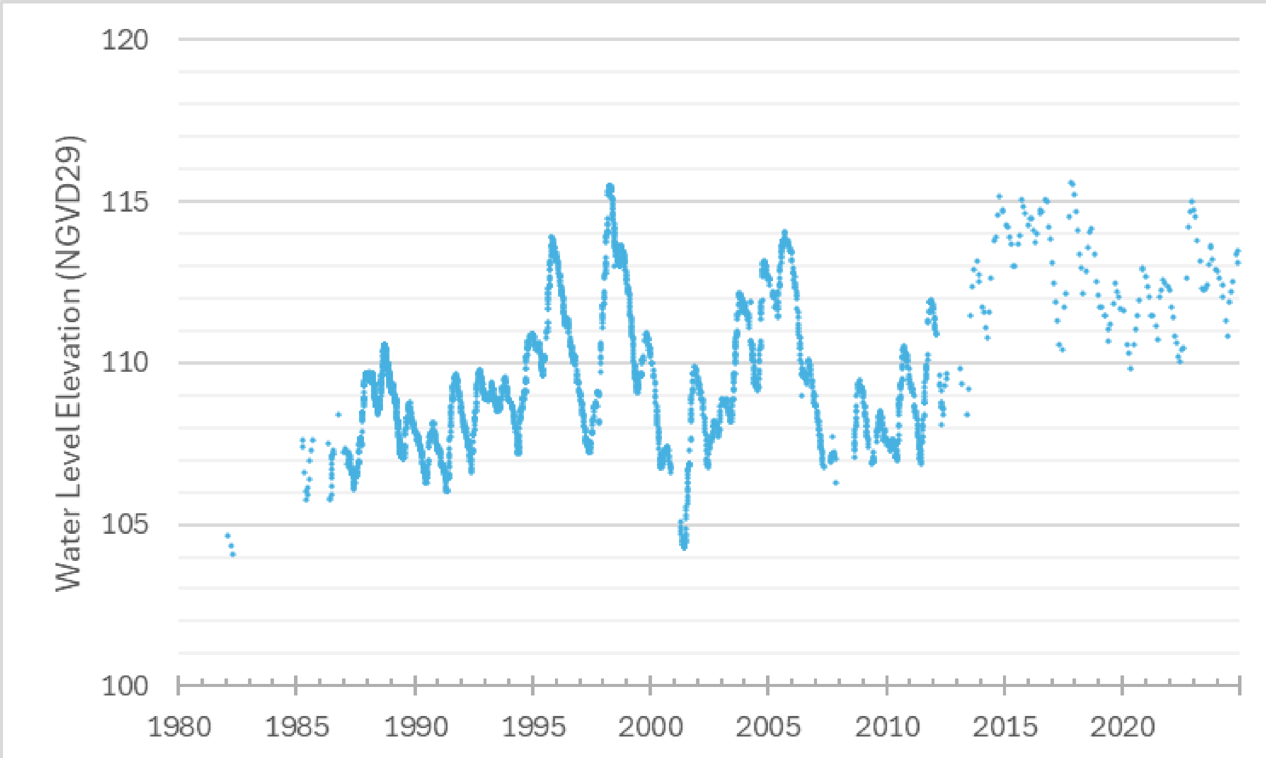


Figure 2-3. Lake Denton water level elevation (stage) observations (ft NGVD29) from February 3, 1982 through December 31, 2024.

2.4 Bathymetry

The relationship between water surface elevation (i.e., stage), inundated area, and total volume can be used to evaluate expected fluctuations in water body size that may occur in response to climate, other natural factors, and anthropogenic impacts (such as structural alterations or water withdrawals). Because long term reductions in stage, inundated area, and total volume can be detrimental to the environmental values associated with establishing minimum water levels, accurate stage-area-volume data are necessary for minimum level development and assessment. This information is also needed for development of the lake water budget models that are used for estimating the lake-level response to rainfall, evaporation, runoff, outflow, leakance, and groundwater withdrawals.

Stage-area-volume relationships for Lake Denton were previously developed by the District (SWFWMD 2007) to support minimum levels development. For this reevaluation of the minimum levels, lake bottom and land surface elevation data were used with ESRI® ArcGIS Pro software (3D Analyst ArcGIS Pro Extension) and Python to build a new model for estimating stage-area-volume relationships. The process involved merging the terrain morphology of the drainage basin in the vicinity of Lake Denton with the basin morphology to develop a single continuous 3D digital elevation model (DEM).

Two elevation data sets were used to develop a merged DEM of lake bathymetry and the surrounding uplands. Light Detection and Ranging (LiDAR) data from the USGS Florida

Peninsular Lidar project (Dewberry 2021) was merged with recently collected bathymetric data from the lake bottom. Bathymetric data was collected with multi-beam sonar technology and traditional (manual) survey methods. The bathymetric data collection process is outlined in SurvTech, Inc. 2021.

The combined elevation data sets were used to create a DEM, that was then used to develop a stage-area-volume relationship by using a Python script file to iteratively run the Surface Volume tool in the Functional Surface toolset of the ESRI® 3D Analyst toolbox at one-tenth of a foot elevation change increments from a peak or flood-stage elevation downward to a base elevation associated with the deepest portion of the lake. The DEM was also used to develop topographic contours of the lake (Figure 2-4).

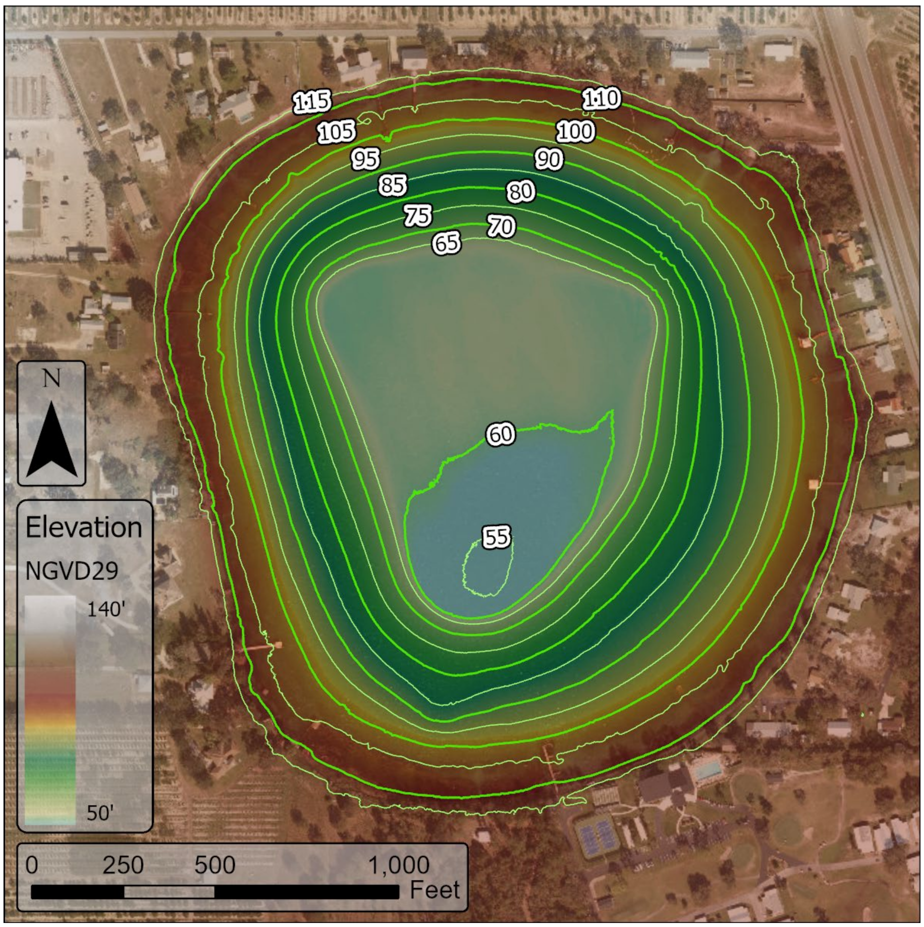


Figure 2-4. Topographic and lake bottom elevations (NGVD29) of Lake Denton.

Lake Denton is a sandhill lake with a steeply sloped bottom that descends toward its deepest point, located in the south-central portion of the basin at an elevation of 55.2 feet NGVD29 (Figure 2-4). Like many lakes on the Lake Wales Ridge, Lake Denton likely formed as a solution sinkhole, where slightly acidic rainwater and groundwater gradually dissolved the underlying limestone bedrock. Over time, this process formed the steep-sided, circular basin typical of Ridge lakes, as the overlying sediments collapsed into the resulting void. The bathymetric contours represent a nearly symmetrical and sharply sloping basin, with elevations ranging from approximately 55 feet

NGVD 29 at the lake bottom to 150 feet NGVD 29 at the adjacent surrounding uplands. Notably, a prominent hill is located northwest of the lake.

At the period-of-record median (P50) stage of 109.16 ft NGVD29, Lake Denton extends 63.7 acres. From the period-of-record P90 (107.1 ft NGVD29) to P10 (112.7 ft NGVD29) stages, the lake area varies from 59.5 to 70.6 acres. Surface area, maximum depth, mean depth, and volume relationships with lake stage are shown in Figure 2-5.

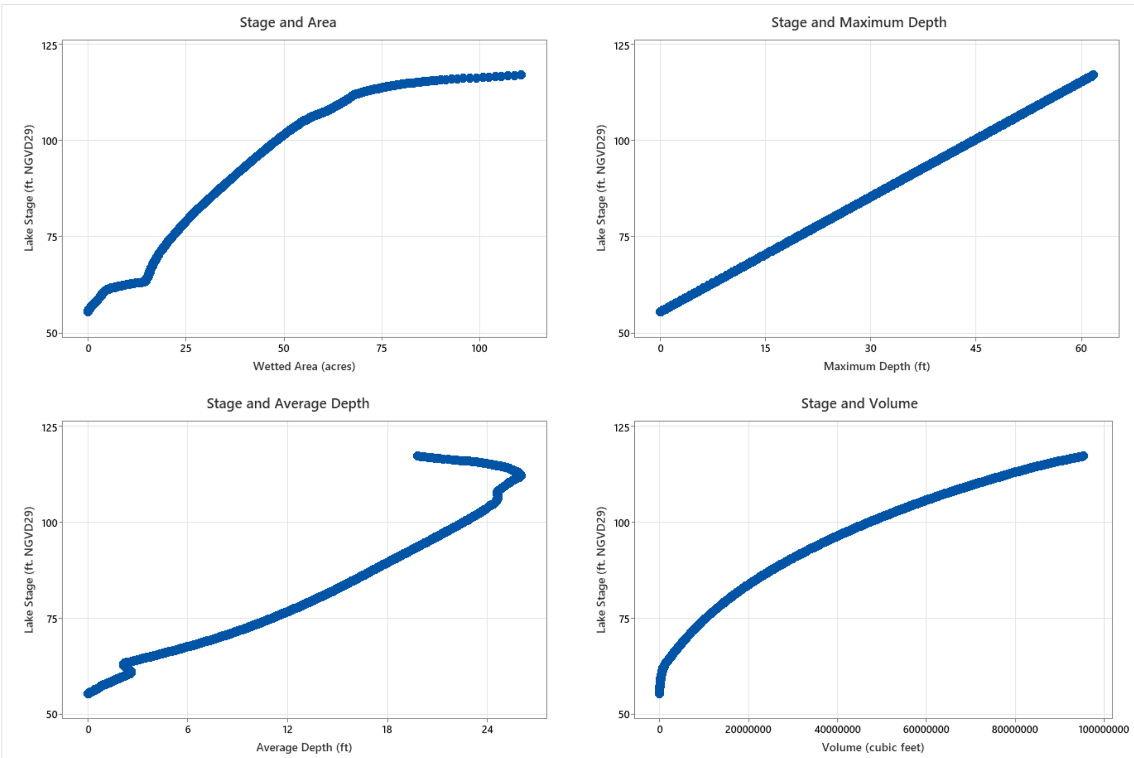


Figure 2-5. Surface area, maximum depth, mean depth, and volume versus lake stage for Lake Denton.

2.5 Physiography and Soils

Lake Denton is located near Avon Park within the Central Highlands of the Mid-peninsular physiographic zone of Florida, a region defined by a series of north-south trending ridges that are remnants of ancient beach and dune systems associated with Miocene, Pliocene, or Pleistocene shorelines (White, 1970; Arthur et al., 2008). Landforms in the surrounding area include xeric sandhills, dune fields, and sinkhole basins formed by the dissolution of underlying limestone bedrock. White (1970) identified this region as part of the Intraridge Valley, a karst-dominated area situated between the ridges of the southern Lake Wales Ridge physiographic region (Figure 2-6). The Lake Wales Ridge is the highest and most prominent of Florida’s central ridges, reaching elevations up to 305 feet NGVD29 (Spechler and Kroening, 2007). Within a few miles of Lake Denton, land surface elevations typically range from approximately 100 to 150 feet NGVD29 (Figure 2-6).

Soils in the Lake Denton area are part of a xeric upland system, consistent with the broader regional pattern of "yellow sands" and "white sands", which support distinct vegetative communities (Weekley et al., 2008). In support of the District's minimum levels evaluations, GPI (2021a, 2021b) classified Lake Denton as a xeric-associated system based on the characteristics of the surrounding soils. Dominant soil types around the lake include Group A Astatula series, which are very deep, excessively drained, and rapidly permeable sands found on uplands within the South-Central Florida Ridge (MLRA 154) and Southern Florida Flatwoods (MLRA 155) regions (USDA-NRCS, 2023a).

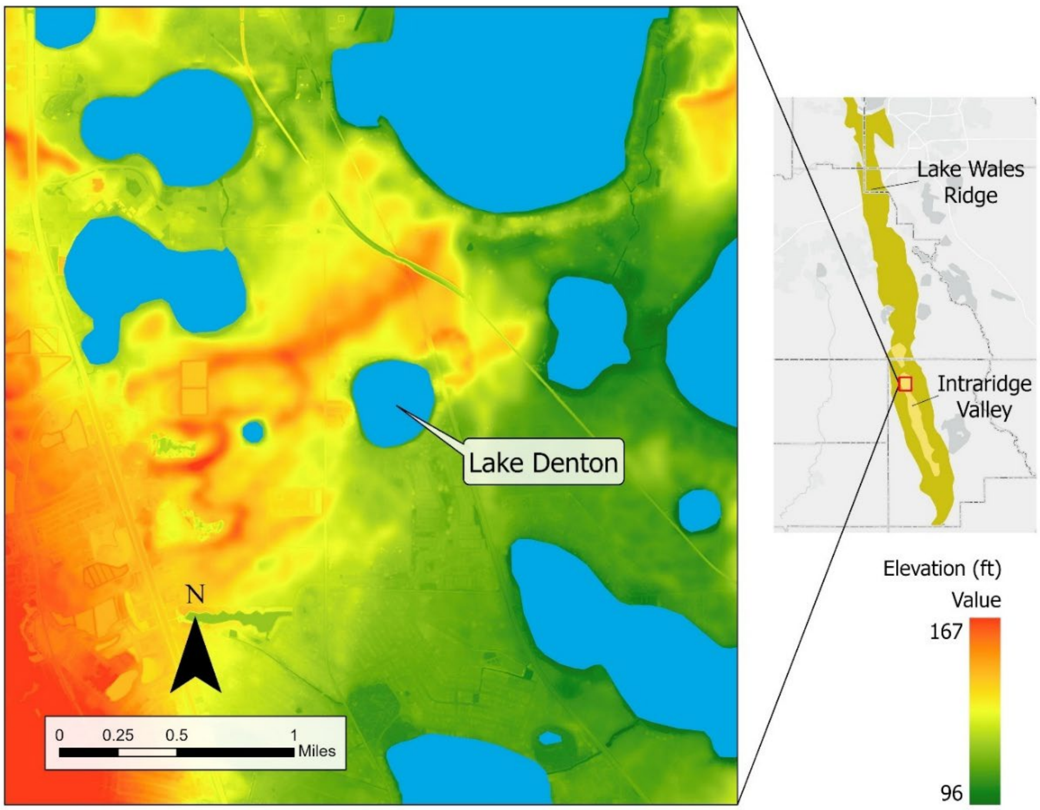


Figure 2-6. Land surface elevation (ft NGVD 29) near Lake Denton within the Intraridge valley in Highlands County.

2.6 Land Use and Cover and Additional Wetlands Information

Uplands immediately surrounding Lake Denton are used primarily for residential development (see Figures 2-7 and 2-8). Several homes are sited directly on the lake with the largest residential development existing on the southeast side of the lake. Two road easements (including the public boat ramp) end on the lake shoreline, but the remainder of the shoreline is privately owned. The area beyond the parcels directly on the shoreline is primarily used for agricultural production.

Land use/land cover (LULC) information for the area within the Lake Denton watershed in 2020 and 1990 are provided in Table 2-1 and Figure 2-7. Agriculture is the primary form of land use and includes citrus groves, dairies, pasture, sod, and vegetable farms (Spechler, 2010), with citrus groves being the most common. Agricultural lands comprised 30 percent of the watershed in 2020, a significant decrease from 40 percent in 1990. This change can be attributed to citrus greening and urban development. Urban and built-up lands in the watershed have expanded from approximately 23 percent in 1990 to 26 percent in 2020. Historical imagery around Lake Denton (Figure 2-8) shows an increase in tree cover on the south side of the lake from pre- to post-1990 conditions, but LULC data shows a disappearance of forest cover from 1990 to 2020. Figure 2-7 shows this area was re-classified as wetlands and rangeland, suggesting that land use data is classified differently in present day compared to the 1990s.

Table 2-1. Land Use Land Cover in the Lake Denton watershed in 1990 and 2020.

	1990 LULC (acres)	% of total acreage	2020 LULC (acres)	% of total acreage
Urban and Built-Up	40	23.4	44	26.2
Agriculture	67	39.5	51	30.0
Rangeland	0	0	1	0.6
Upland Forests	7	4.5	0	0
Water	55	32.6	64	37.7
Wetlands	0	0	7	4.0
Transportation, Communication and Utilities	0	0	2	1.4

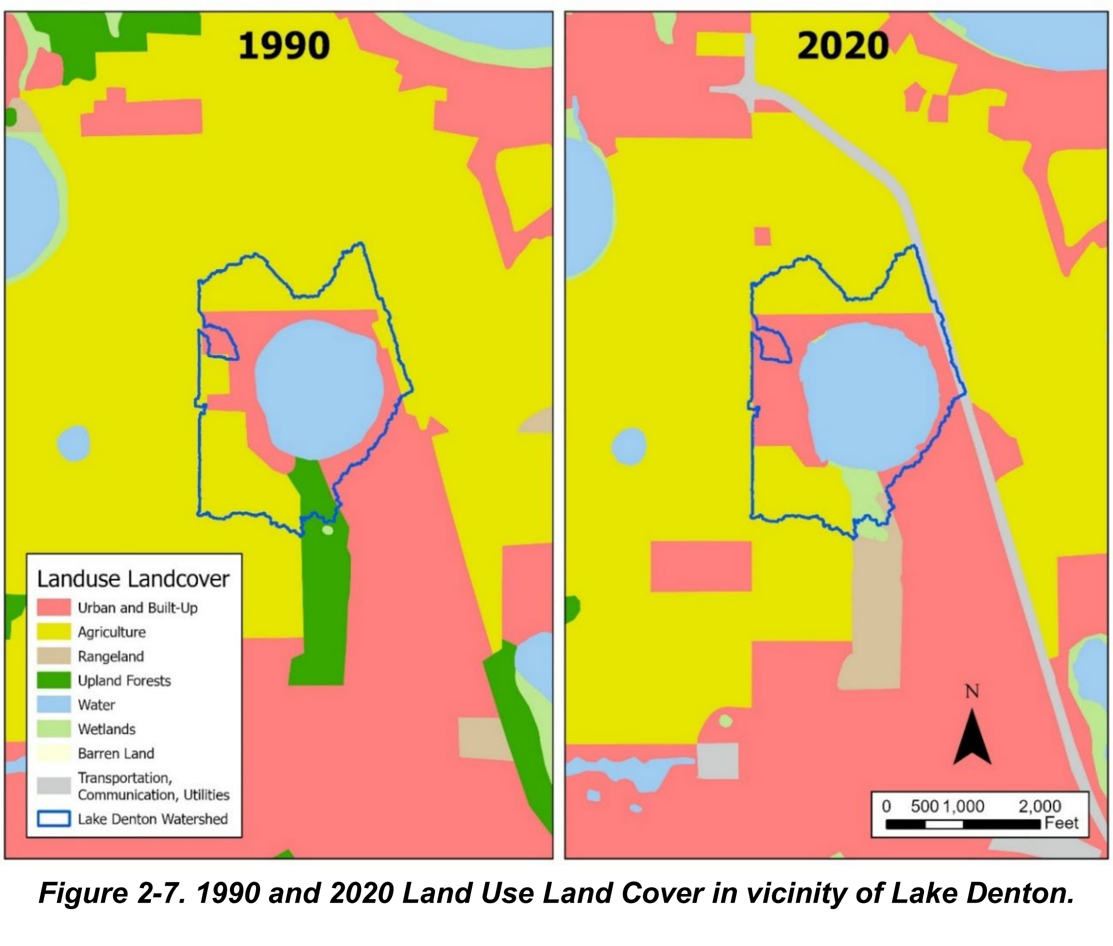


Figure 2-7. 1990 and 2020 Land Use Land Cover in vicinity of Lake Denton.

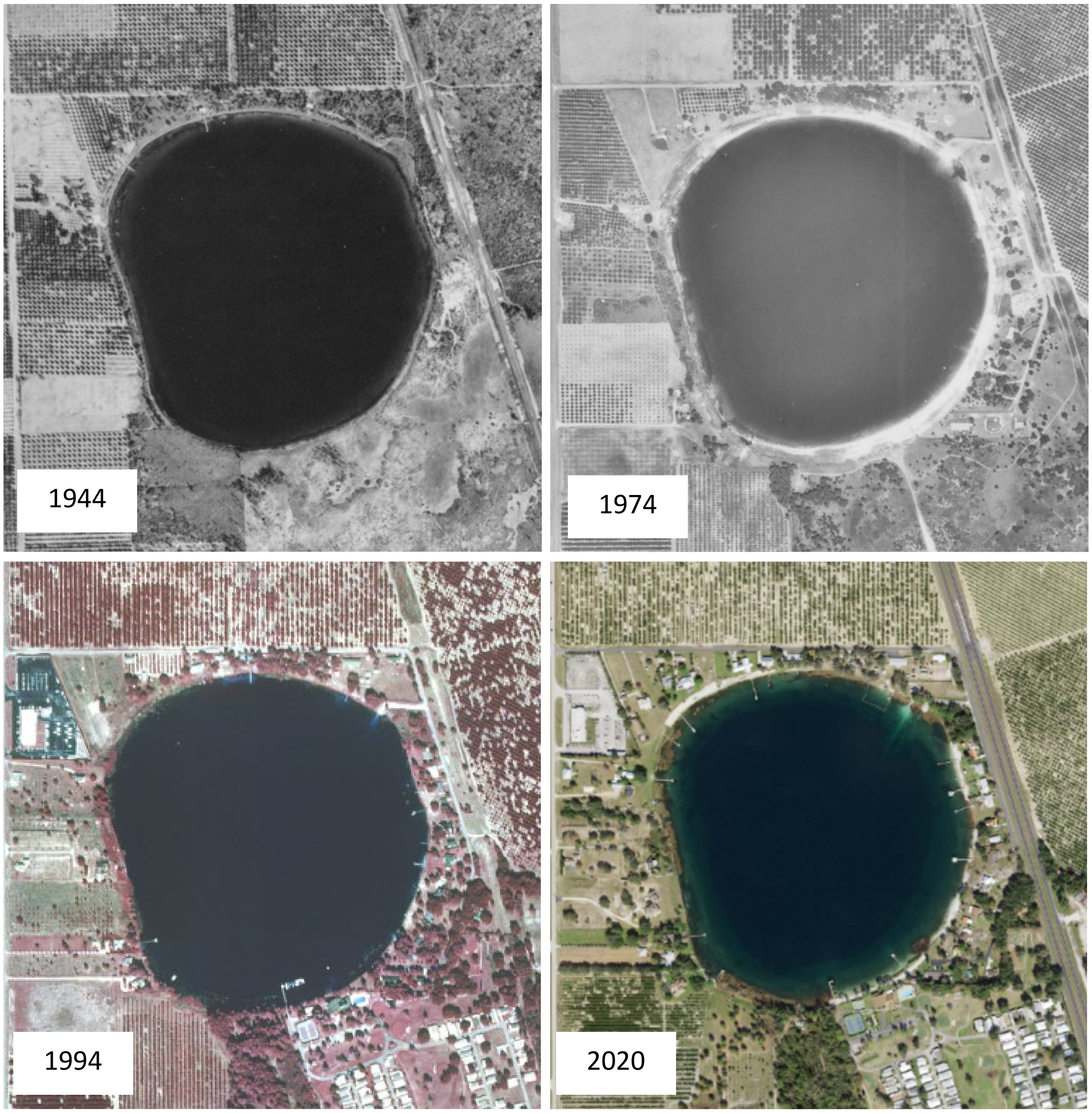


Figure 2-8. 1944, 1974, 1994 (infrared), and 2020 Aerial photographs of Lake Denton.

A 2020 Lake Vegetation Index assessment (FDEP, unpublished data) based on methods described by Fore (2007) and FDEP (2011, 2017), indicates torpedo grass (*Panicum repens*) and southern slim spikerush (*Eleocharis elongata*) are co-dominants in Lake Denton. Other species common in the emergent marsh zone include false daisy (*Eclipta alba*), Mexican primrose willow (*Ludwigia octovalvis*), dog fennel (*Eupatorium capillifolium*) and water pennyworts (*Hydrocotyle sp.*). Of all vegetative wetland species observed, 75% were native with a total of 24 species observed during the effort.

The area available for aquatic plant growth was estimated for Lake Denton based on a relationship of light attenuation as measured with Secchi depth (*SD*) and maximum depth of plant colonization. Maximum depth of plant colonization (*MDC*) refers to the average depth at which rooted aquatic vegetation is found in a lake and serves as an indicator of factors like light availability, water clarity, and habitat extent. Caffrey et al. (2007) developed a framework for using plant colonization depth and bathymetric relationships to inform MFL development in Florida lakes. The concept emphasizes the importance of maintaining adequate water levels to preserve littoral vegetation zones that support fish and wildlife habitat. This approach is particularly relevant for sandhill lakes like Lake Denton, where steep-sided basins and clear water can strongly influence the depth and extent of aquatic plant growth. Using data from 2006 through 2022 for Lake Denton (n = 21) obtained through the Florida LakeWatch monitoring program, the mean *SD* was 4.4 meters. Use of this Secchi depth with Equation 2-1 below (where *MDC* and *SD* are in meters) from Caffrey et al. (2007) yielded an *MDC* value of 5.33 meters or 17.5 feet.

(Equation 2-1) $\log MDC = 0.66 \log SD + 0.3$

Based on a 17.5 ft *MDC* and stage-area information developed in support of the reevaluation of minimum levels for Lake Denton (described in Section 2.4.2 of this document), the area available for aquatic plant colonization would range from 20.9 to 42.9 acres at water surface elevations from 104.1 (POR low) to 115.6 (POR high) ft NGVD29 in the Lake Denton basin (Figure 2-9).

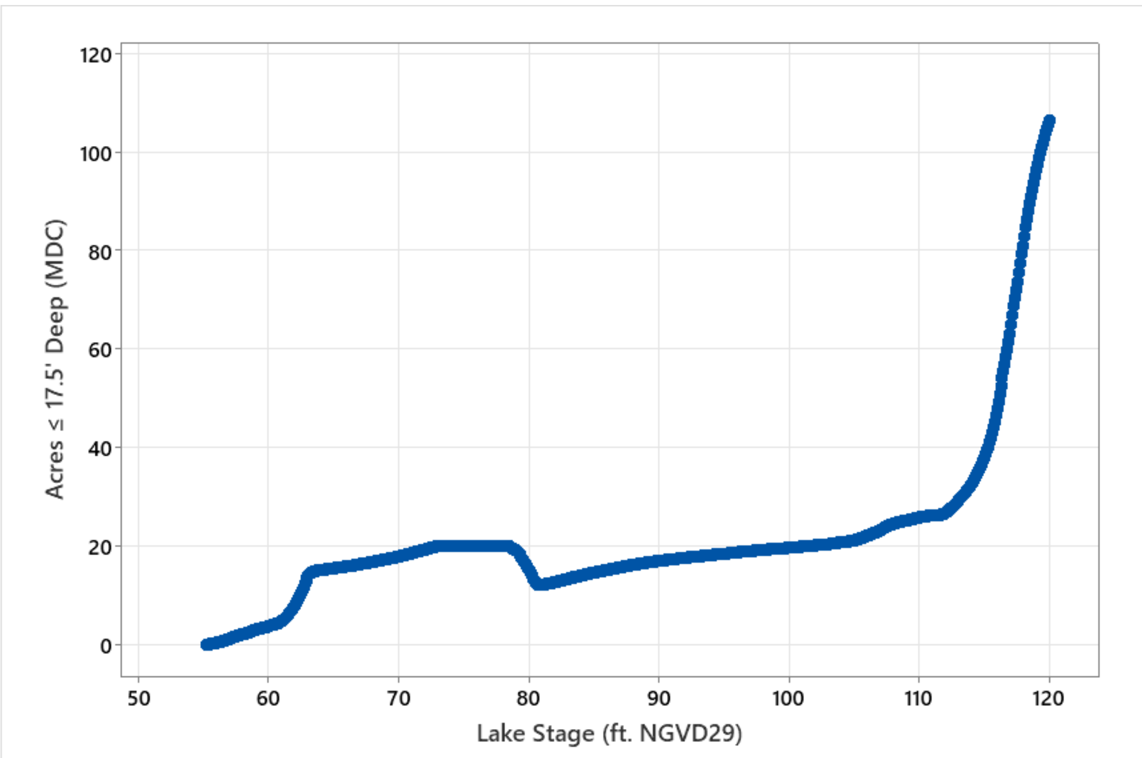


Figure 2-9: Lake stage and area available for aquatic plant colonization in Lake Denton.

2.7 Climate and Rainfall

2.7.1 Climate

Highlands County lies within a humid subtropical zone that is influenced by the Gulf of America and Atlantic Ocean. The area experiences hot, humid summers with mean temperatures in the low 80s (ºF) and mild to cool winters with mean temperatures in the upper 50s (ºF). The annual mean daily temperature is approximately 72ºF (21ºC). Wet season rainfall occurs during the summer from June through October, with remaining months considered “dry season” months. Tropical storms and hurricanes mostly occur between August and the first half of October, which can lead to greater rainfall totals during the late summer and early fall.

Long-term rainfall in Florida is affected by an oscillation of North Atlantic sea surface temperatures known as Atlantic Multidecadal Oscillation (AMO) (Enfield 2001, Kelly 2004, Kelly and Gore 2008). AMO consists of a cool phase that leads to lower average rainfall and a warm phase that leads to higher average rainfall in Florida. In turn, water bodies within the District experience long-term periods of relatively high flows and levels that switch to periods of relatively low flows and levels. Because a full AMO cycle lasts 60-80 years (Enfield 2001), evaluations of water bodies in the District consider a time period of at least 60 years to best represent all climactic conditions.

2.7.2 Rainfall near Lake Denton

Local rainfall near Lake Denton for the period January 1995 through December 2022 was characterized using radar-estimated (NEXRAD) rainfall available for a grid (square 2 km cells) that includes and extends beyond the District boundaries. Portions of this rainfall dataset were also used as an input to the lake’s water budget model (see Chapter 3).

Based on estimates from the dataset for Pixel ID Nos. 87580 and 87581, which were area-weighted to Lake Denton, annual rainfall for the period from January 1995 through December 2022 averaged 51.5 in/yr. This average is slightly below the long-term average (1915-2022) rainfall recorded in Highlands County of 52.1 in/yr derived from the District’s annual hydrologic data. Using the NEXRAD data over Lake Denton, annual rainfall departure from the Highlands County long term mean is shown in Figure 2-10. For the 1995 through 2022 period, the localized NEXRAD rainfall estimates resulted in a cumulative departure of -16.3 in from the long term mean of 52.1 in/yr. This estimated departure indicates conditions were 0.6 in/yr drier than normal for 1995-2022.

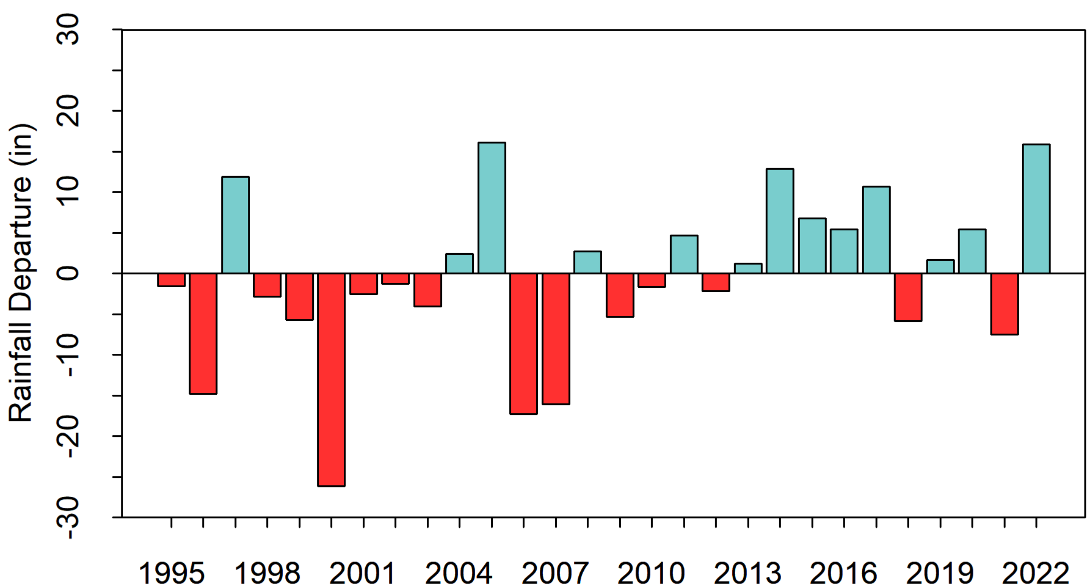


Figure 2-10. Annual rainfall departure at Lake Denton from 1995 through 2022.

2.8 Hydrogeologic Setting

The hydrogeologic framework of the Lake Wales Ridge area includes a relatively thick unconfined surficial aquifer (SA), a variable thickness Hawthorn confining unit (HCU) and a thick carbonate upper Floridan aquifer (UFA). Lake Wales Ridge can provide high rates of recharge to the UFA depending primarily on the thickness and hydraulic conductivity of the overlying SA and HCU. Estimates of UFA recharge in the region range from 1 inch per year up to 20 inches per year (Yobbi, 1986), typically with higher rates of recharge in the northern portion of Lake Wales Ridge (Aucott, 1988).

The SA thickness along the Lake Wales Ridge varies from 40 to 380 ft, with average thickness of nearly 200 ft. It is generally comprised of fine-to-medium grained quartz sands that grade into clayey sand just above the interface with the underlying HCU.

The HCU is a clay layer of varying thickness, ranging between 0 and 233 ft, indicating discontinuous confinement. Thin, isolated permeable zones of limestone, shell, gravel, or sand that form local aquifers may be imbedded in some portions of the HCU. Withdrawals from the aquifers embedded in the HCU are primarily associated with household water use.

All of Highlands County is underlain by the UFA, which is composed of a thick sequence of carbonate rocks that include the upper half of the Avon Park Formation, the Ocala Limestone, and (where present) the Suwannee Limestone. The total thickness of the UFA ranges from about 1,150 to 1,500 ft in Highlands County (Clayton, 1998; DeWitt, 1998; Mallams and Lee, 2005; Arthur et al., 2008). Most groundwater withdrawals within Highlands County come from the UFA. Lake Denton and the other lakes in the Lake Wales Ridge area of Highlands County provide recharge to the UFA through their subsidence features (Sacks et al., 1998). These lakes overlie a potentiometric high that separates two regional groundwater basins. The orientation and shape of the Lake Wales Ridge potentiometric high has changed little since predevelopment, i.e., prior to significant groundwater withdrawals, which began around 1930 (Figure 2-11).

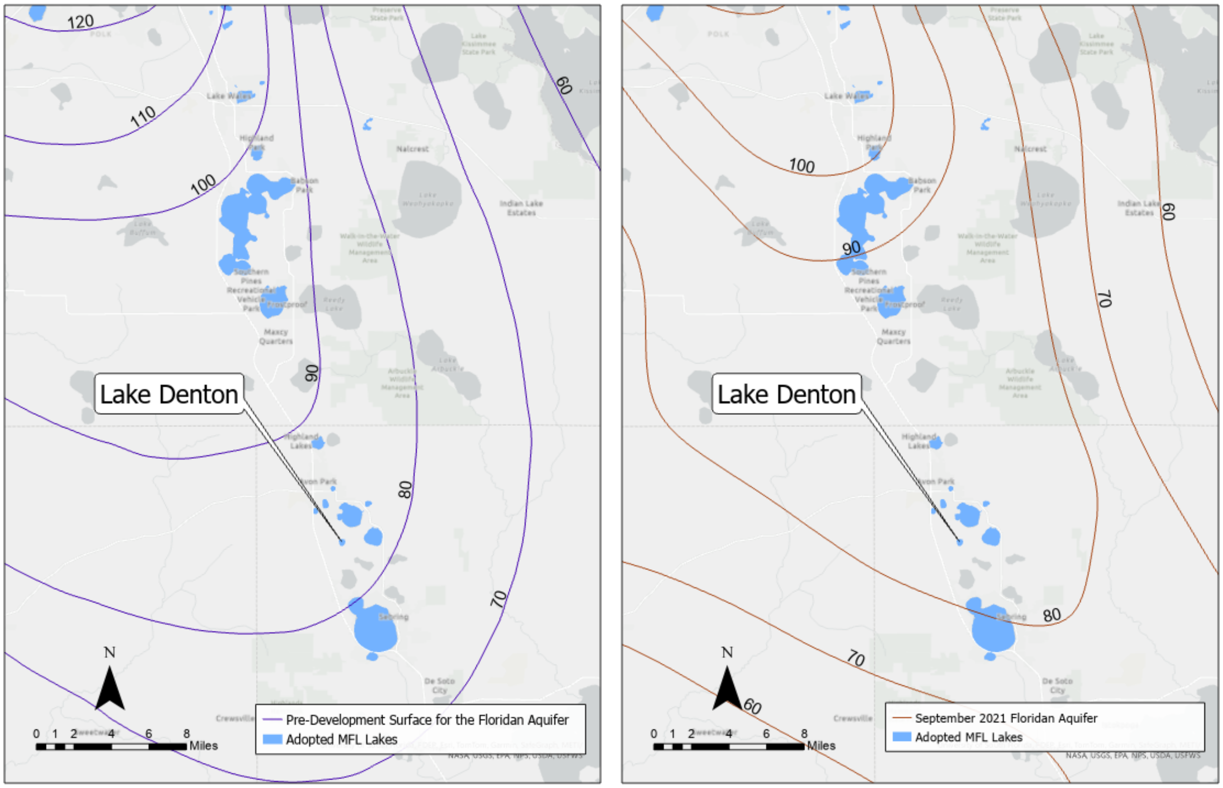


Figure 2-11. Pre-development upper Floridan aquifer (UFA) potentiometric surface (left panel) and September 2021 UFA (right panel) near lakes in Lake Wales Ridge.

2.9 Water Withdrawals

Ground water withdrawal permits near Lake Denton result in 15-20 million gallons per day (mgd) of withdrawals within five miles of the lake (Figures 2-12 and 2-13). This estimate comes from the District's database containing geospatially distributed monthly groundwater and surface water withdrawal data and estimates for all permits extending back to 1992. The database is updated each year typically two-to-three years after the withdrawals occur (e.g., 2021 geospatial data became available in 2023). Estimated annual pumping for domestic self-supply (household) wells across the District is provided in another database that is updated concurrently with the permitted water use database. Lastly, there are no permitted surface water withdrawals from Lake Denton.

Nearly all groundwater withdrawals within five miles of Lake Denton are used for public supply, agriculture, and recreation (Figure 2-12). Within this area, 18.2 mgd were withdrawn in an average year in the period 1992-2021, and total withdrawals have been relatively stable (varying from 13.6 to 20.5 mgd) since the mid-2000s (Figure 2-13). Year-to-year variation is driven by agriculture while the remaining uses have accounted for an approximately constant 5.7 mgd over the 30-year period. In 2021, agricultural groundwater use comprised 67 percent of the total groundwater withdrawn within 5 miles of Lake Denton. Public supply accounted for 27 percent of the total, while 6 percent was withdrawn for recreational use. Groundwater use for mining and industrial/commercial purposes was less than 0.04 percent of the total use.

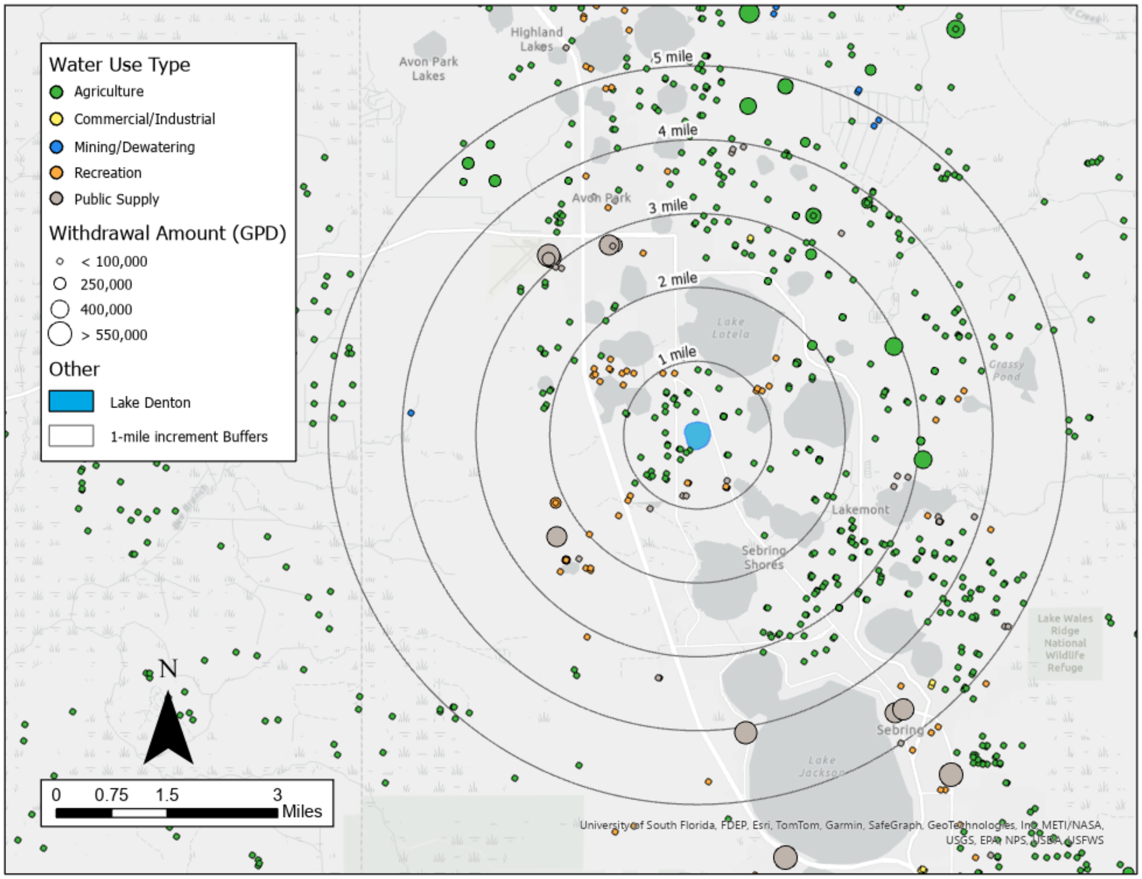


Figure 2-12. Permitted groundwater withdrawals in gallons per day (GPD) around Lake Denton.

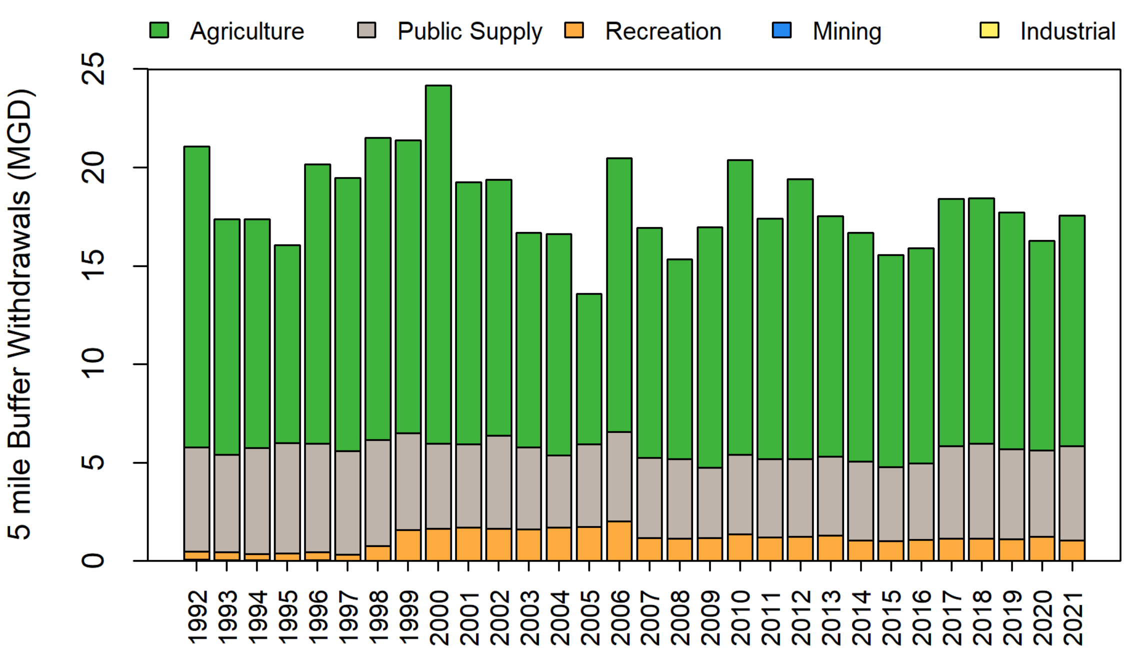


Figure 2-13. Annual average withdrawals within five miles of Lake Denton.

Spechler (2010) provides historical estimates of groundwater use in all of Highlands County, noting that groundwater withdrawals were approximately 37 mgd in 1965 and had risen to approximately 157 mgd by 2000. This increase was primarily due to increased water use for agricultural purposes and secondarily to increased use for public supply. Spechler (2010) reported withdrawals decreased to approximately 107 mgd in 2005, attributing the reduction to above average rainfall.

Annual average groundwater use within 5 miles of Lake Denton has declined from 19.8 mgd for the period of 1992-2001 to 17.3 mgd for the period of 2012-2021 (Figure 2-12). The declines in groundwater use have occurred due to water conservation, higher rainfall, land use change, and increased use of reclaimed water. This long-term decreasing trend in water use near Lake Denton is congruent with the implementation of Southern Water Use Caution Area (SWUCA) I rules in the early 2000s (Figure 2-14) that address conservation measures, alternative water supply development, and water use permitting requirements (SWFWMD 2023a, b). As part of the SWUCA Recovery Strategy, the District continues to work with users to develop alternative water supplies to meet water demands while reducing groundwater withdrawals when possible.

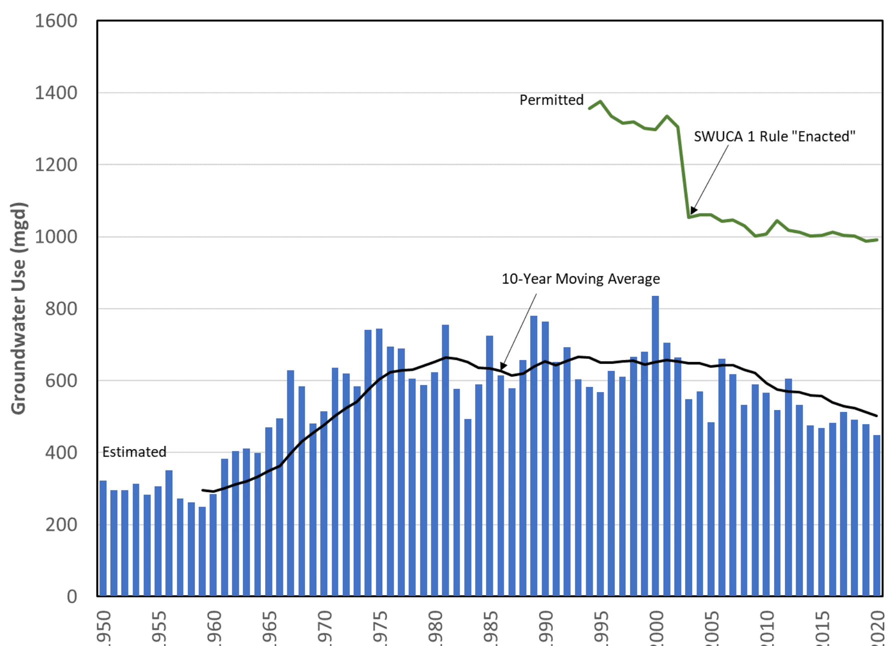


Figure 2-14. Groundwater withdrawals in the Southern Water Use Caution Area and permitted withdrawals for the area.

CHAPTER 3 – WATER BUDGET MODEL FOR LAKE DENTON

3.1 Water Budget Models

Water budgets (also called water balances) are widely used to represent hydrologic fluxes for lakes and other waterbodies (e.g., Healey et al., 2007). The change in lake stage or volume in a water budget is estimated as the difference between summed inflows and summed outflows over a specified time-period. Calibrated water budget models can be used to develop predictive scenarios, such as to estimate lake levels if groundwater levels increase. These models can also be used to estimate expected lake levels under historic conditions, i.e., in the absence of withdrawal impacts, given current structural alterations.

The water budget model implemented by the District for minimum lake level development is a calibrated spreadsheet model that tracks lake water inputs and outputs on a daily timestep to estimate lake water levels. The model developed specifically for Lake Denton includes precipitation, evaporation, surficial aquifer fluxes, upper Floridan aquifer fluxes, overland flow, and directly connected impervious area (DCIA) runoff. Since Lake Denton is a closed basin lake, surface outflow was not included in the model.

3.2 General Model Structure

The technical approach for lake water budget models at the District is summarized by Equations 3-1 and 3-2, where *LS* is the lake stage, ΔS is the change in storage, *R* is rainfall directly onto the lake, *E* is evaporation directly from the lake, UFA_{net} is the net exchange between the lake and upper Floridan aquifer, SA_{net} is the net exchange between the lake and surficial aquifer, *O* is overland flow into the lake from its watershed, and *DCIA* is runoff from impervious surfaces directly connected to the lake. Change in storage is added to the prior day's lake stage (LS_{n-1}) to estimate lake stage for the current day (LS_n).

(Equation 3-1) $LS_n = LS_{n-1} + \Delta S_n$

(Equation 3-2) $\Delta S_n = R_n - E_n + UFA_{net,n} + SA_{net,n} + O_n + DCIA_n$

Both *R* and *E* in Equation 3-2 were estimated using only the input data, where rainfall data was collected daily. Monthly evaporation data was available from two studies at Lake Starr (i.e., Swancar et al., 2000, and Swancar, 2015) for the period of August 1996 through July 2011. Swancar (2015) showed that evaporation rates in central Florida lakes can be nearly identical to each other even when the lakes are 60 miles apart, and Lake Denton is 28 miles south of Lake Starr. Thus, evaporation data from Lake Starr was considered appropriate for the Lake Denton water budget from August 1996 through July 2011, and monthly normal evaporation rates from this dataset were used for all other months in the water budget model.

Lake Denton was determined to have flow-through groundwater conditions based on local topography and SA water levels ($SA_{in,lev}$ and $SA_{out,lev}$) that were modeled using the ECFTX regional groundwater model (see Chapter 4 for details on this model). Thus, SA inflow and outflow were estimated separately as $SA_{in,n}$ and $SA_{out,n}$ using different data sources for each, with $SA_{net,n}$ being the difference between the two variables (Equations 3-3 through 3-5). The leakance coefficient between the lake and the SA (L_{SA}) is a calibrated parameter used in this estimation of SA flux.

(Equation 3-3) $SA_{net,n} = SA_{in,n} - SA_{out,n}$
(Equation 3-4) $SA_{in,n} = L_{SA}(SA_{in,lev} - LS_n)$
(Equation 3-5) $SA_{out,n} = L_{SA}(SA_{out,lev} - LS_n)$

Fluxes between Lake Denton and the UFA were estimated similarly to SA flux using a calibrated leakance coefficient, L_{UFA}, shown in Equation 3-6 below, where UFA_{lev} is the water level in the UFA.

(Equation 3-6) $UFA_{net,n} = L_{UFA}(UFA_{lev,n} - LS_n)$

Both runoff variables, *DCIA* and *O*, were estimated using the SCS curve number methodology (NRCS, 1986). The percentage of the Lake Denton basin that contributes DCIA runoff (*pDCIA*) and the curve number (*CN*) are calibrated parameters used in the estimation of *DCIA* and *O*. Harper and Baker (2007) outlined a procedure for estimating runoff in Florida based on seasonal rainfall patterns and vegetation conditions. Using this procedure (outlined in Chapter 4 of Harper and Baker, 2007) *DCIA* was estimated assuming an initial abstraction of 0.1 inches, and *O* was estimated using antecedent soil moisture conditions that vary between the growing (Mar-Sept) and dormant seasons (Oct-Feb). Both *DCIA* and *O* were estimated daily in the Lake Denton water budget model and multiplied by the ratio of the watershed's land surface area (A_{WL}) to the area of Lake Denton (A_L, which was estimated daily with the stage-area-volume relationship described in Chapter 2).

3.3 Lake Denton Water Budget Model

3.3.1 Calibration Period

The calibration period for the Lake Denton water budget model was May 1995 through December 2021. This period was selected based on available pumping data and well data for the surficial aquifer. Additionally, there was no structural alteration to the hydrology of the lake during this period. The average annual rainfall, using District rainfall data, from January 1915 to December 2021 was 52.1 in/yr, versus 50.7 in/yr for the water budget model time-period of May 1995 to December 2021. Thus, the water budget model calibration period represents slightly drier than normal conditions at the lake.

3.3.2 Input Data

The water budget model input data were obtained from the District's Environmental Data Portal (EDP) as indicated in Table 3-1 with locations shown in Figure 3-1. All water level data used in the model is shown in Figure 3-2. Lake stage data were obtained from the Lake Denton staff gage (SID 23816), with records from 1982 to present. Data collection frequency has varied through the period of record but has generally been sampled monthly.

SA water levels were obtained from three monitoring sites: Ridge WRAP H-2 Surf (SID 25524) located approximately 4.3 miles northwest of Lake Denton, ROMP 43XX Surf Aq Monitor (SID 25529) approximately 3.6 miles northeast of Lake Denton, and Lake Letta water level (SID 23798) approximately 1.2 miles east of Lake Denton. ROMP 43XX Surf Aq Monitor was used as SA inflow for most of the calibration period with Ridge WRAP H-2 Surf being used for the periods May 1995 to December 1999 and January 2008 to December 2013. The average difference between these two wells for the calibration period was subtracted from the Ridge WRAP H-2 level for the periods this well was used for. Data collection for these wells began in 1995, with various gaps and frequency. Lake Letta water levels were used for SA outflows. Data collection at the Lake Letta gage began in 1983, and water level recording has generally occurred monthly. Missing dates were linearly interpolated to produce a daily time series for use in the model.

UFA water levels were obtained from the ROMP 43XX U Fldn Aq Monitor well (SID 25532), located approximately 3.6 miles northeast of Lake Denton. Between the USGS and the District, data for this well are available from 1982 to present. Well water levels have been recorded daily since 1992. Missing dates were linearly interpolated to produce a daily time series for use in the model.

Rainfall data was obtained from an area-weighted average of NEXRAD pixels 87580 and 87581 which intersect the lake's watershed (Figure 3-1). Daily rainfall totals are available without gaps from 1995 to the present and were used for most of the period January 2001 to December 2021. Rainfall data from ROMP 43X (SID 25188) and ROMP43XX (SID 25189) rain gages in Avon Park were used for May 1995 to December 2000 and for 17 months in the 2001-2021 period.

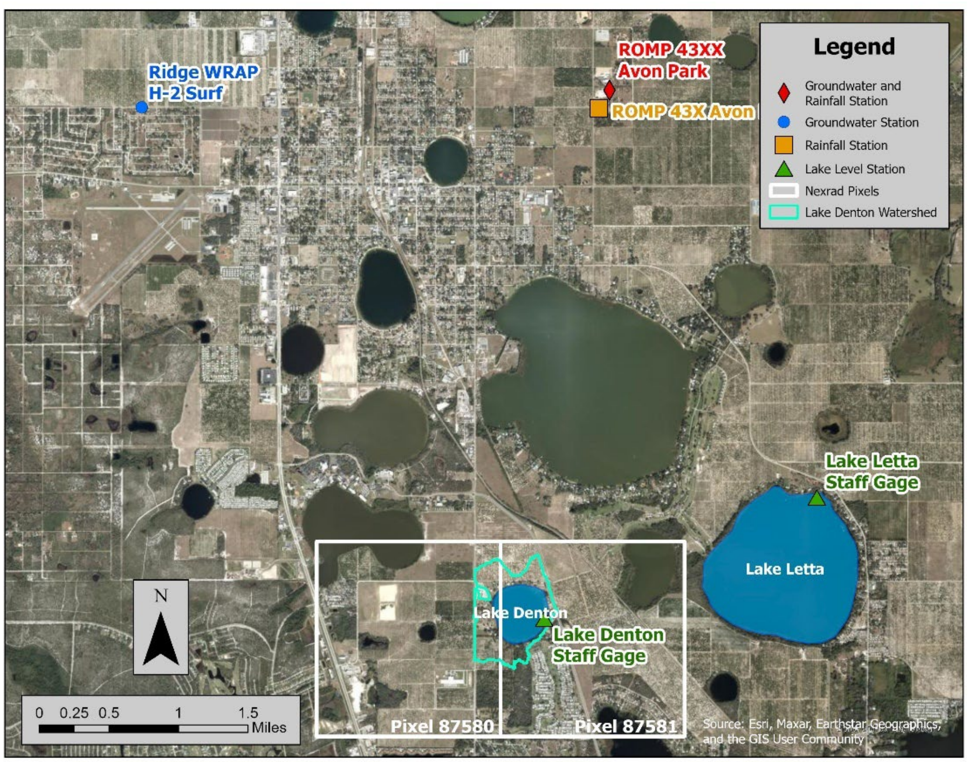


Figure 3-1. Locations of the input data collection sites around Lake Denton.

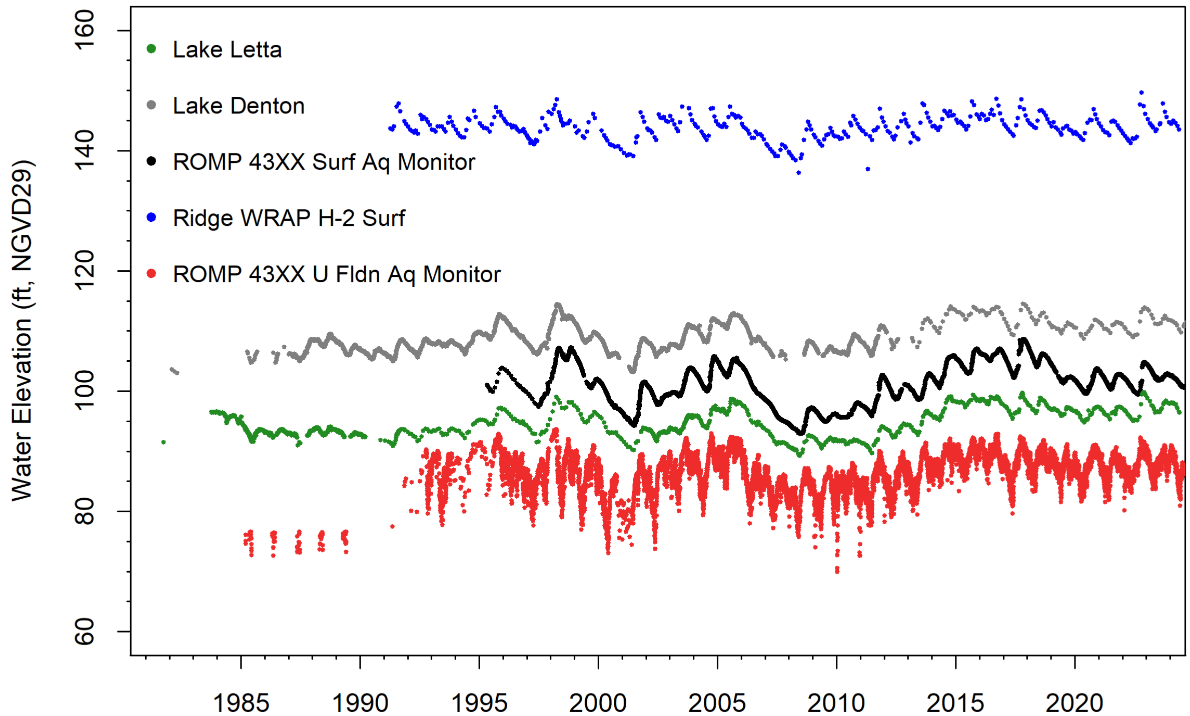


Figure 3-2. Observed water level data from the sites shown in Figure 3-1.

Table 3-1. Time series data input sources for the Lake Denton water budget model.

Input Type	Station/Pixel ID(s)	Station Name(s)
Lake Water Level	23816	Lake Denton
SA In Water Level	25524, 25529	Ridge WRAP H-2 Surf, ROMP 43XX Surf Aq Monitor
SA Out Water Level	23798	Lake Letta
UFA Water Level	25532	ROMP 43XX U Fldn Aq Monitor
Rainfall pixels	87580, 87581	NEXRAD (Radar Rainfall)
Rainfall gage	25188, 25189	ROMP 43X Avon Park, ROMP 43XX Avon Park

3.3.3 Model Calibration

3.3.3.1 Calibration Approach

The objective of water budget model calibration is to minimize residuals between pairwise model and observation data by modifying calibration parameters. During calibration, model parameters and outputs must remain within an expected or realistic range of values given the physical setting of the lake. Model calibration is non-unique and there may be many combinations of parameter values that produce acceptable calibrations. However, the best match of simulated and observed lake stages may not best represent the physical system. Unrealistic parameterizations and fluxes should not be accepted even if they result in ostensible improvements in model performance relative to a more realistic parameterization.

3.3.3.2 Runoff and Channel Fluxes

The lake's watershed area, A_W, was determined to be 169 acres using a subbasin delineation available from a regional floodplain study (Ardaman and Associates, 2013). This delineation is consistent with digital elevation data and a stage-area-volume relationship developed from survey data (Figures 2-5, 2-6).

The curve number, *CN*, was calibrated to a value of 60. This value was guided by site visits and review of soils and land use geospatial data (Figure 2-7). This curve number is relatively high for the thick, well-drained, sandy soils in a deep water-table setting that characterize the Lake Wales Ridge (Basso, 2019) but is close to an area-weighted estimate of soil and land use geospatial data and reflects the steep topography within the basin (Figure 2-6). Steep topography has been shown to increase *CN* in various watersheds (Ajmal et al., 2020).

The portion of the watershed which is directly connected impervious area, *pDCIA*, was calibrated to a value of 0.035. This value was guided by site visits and National Land Cover Database (NLCD) data for 2021 suggesting that approximately 10% of the lake watershed is impervious (Dewitz, 2021). Most of these impervious surfaces are not directly connected to the lake. Areas contributing to *pDCIA* are structures and/or residences on the lakeshore.

Information available in floodplain studies (Ardaman and Associates, 2013) led to Lake Denton being classified as a closed basin. Although surface outflow can occur when water levels exceed 119 ft NGVD29, this exceeds the observed maximum lake water level and the modeled 100-year, 24-hour flood elevation of approximately 115 ft NGVD29 (Ardaman and Associates, 2013). Therefore, no channel outflow occurs in the model, nor does the lake have channel inflow from another waterbody.

3.3.3.3 Groundwater Fluxes

SA inflows were modeled by using water levels of both ROMP 43XX Surf Aq Monitor and Ridge WRAP H-2 Surf and applying a constant adjustment of 10.2 ft, i.e., a 10.2- ft increase, for inflows. SA outflows were modeled by using water levels of Lake Letta and a constant adjustment of 12.5 ft for outflows. These shifts were guided by expected flow-through conditions at the lake (Lee, 2002; Sacks, 2002), ECFTX-modeled SA water levels and water-table depths near the lake, and topographic differences between the well and the area around the lake (Figures 2-6 and 3-2). Additionally, the SA leakage coefficient, L_{SA}, was calibrated to a value of 1.1×10^{-2} ft/d/ft. Calibration of both L_{SA} and SA level adjustments considered the long-term SA influx, which remained consistent with isotope-derived groundwater flux estimates for Lake Denton of 94-107 in/yr provided by Sacks (2002).

Both the ROMP 43XX U Fldn Aq well and Lake Denton are near the 80-ft contour of the UFA potentiometric surface (Figures 2-11). Because both the well and the lake have similar proximity to this contour line, it was determined that no adjustment was necessary for the well to be representative of UFA water levels under the lake.

The UFA leakance coefficient, L_{UFA}, was calibrated to a value of 1.7x10^{-4} ft/d/ft. This value is consistent with observed lake-UFA and SA-UFA head differences, the lake's hydrogeologic province, and stratigraphic information in the vicinity of the lake (Basso, 2019). Additionally, the long-term UFA flux was assessed to ensure consistency with the typical values for central Florida lakes (e.g., Fellows & Brezonik, 1980; Deevey, 1988; Belanger & Kirkner, 1994; Grubbs, 1995; Katz et al., 1995; Lee & Swancar, 1997; Motz, 1998, Sacks et al., 1998; Swancar et al., 2000; Motz et al., 2001; Watson, 2001; Lee, 2002; Metz & Sacks, 2002; Sacks, 2002; Swancar, 2015; McBride et al., 2017).

3.3.3.4 Model Performance

Errors occur due to the model's inability to completely represent the physical system and due to uncertainties associated with inputs and parameters used in the models. Winter (1981) provides a summary of uncertainties and errors associated with lake water budgets. Because the MFL rules described in Chapter 1 are stated in terms of percentiles, the water budget model performance is graded on percentile error, while using model fit statistics (e.g., mean error, maximum/minimum error, R^2) as guidance. Ideally, residuals in the P10, P50, and P90 will be less than a tenth of a foot, though water budget errors may prevent this objective. The P50 residual is regarded as most important as the MLL is defined by the 50th percentile. Once the P50 residual is less than ±0.1 ft the P10 residual becomes the next objective, followed by the P90 residual. Both the P10 and P90 residuals may be greater than ±0.1 ft to avoid affecting the P50 residual while maintaining the objective of minimizing these residuals.

The final calibrated Lake Denton water budget model is acceptable for the purpose of characterizing long-term water level percentiles in support of minimum levels development for Lake Denton. The parameterization (Table 3-2) produced fluxes within expected values (Table 3-3) and met the percentile performance objectives described above (Table 3-4). Model-predicted water levels match the pattern and magnitude of observed water levels (Figure 3-3).

Table 3-2. Parameters for the calibrated Lake Denton water budget model.

Parameter	Value
SA Leakance Coefficient, L_{SA} (ft/d/ft)*	0.011
SA Inflow Water Level Adjustment (ft)*	10.2
SA Outflow Water Level Adjustment (ft)*	12.5
UFA Leakance Coefficient, L_{UFA} (ft/d/ft)*	0.00017
UFA Water Level Adjustment (ft)*	0
Curve Number, *CN**	60
DCIA Proportion of Watershed, *pDCIA**	0.035
Watershed Area (including lake), A_W (ft^2)	7359200
Outflow Efficiency Coefficient†	Not applicable
Control Point (Outflow) Elevation (ft)†	119

* Calibrated parameter.

† Lake Denton is a closed basin lake.

Table 3-3. Average annual water balance for the calibrated Lake Denton water budget model.

Flux	In (in/yr and percentage of total flux)	Out (in/yr and percentage of total flux)	Net (in/yr)
Atmosphere			-7.5
Rainfall	50.7 (30%)	-	
Evaporation	-	58.2 (35%)	
Groundwater			
Surficial Aquifer	109.9 (65%)	93.3 (55%)	16.7
Upper Floridan Aquifer	0 (0%)	17.1 (10%)	-17.1
Surface Water			8.6
Overland Flow	5.9 (3%)	-	
DCIA	2.8 (2%)	-	
Channel	-	0 (0%)	
Total	169.3 (100%)	168.6 (100%)	0.7

Table 3-4. Exceedance percentile residuals for the calibrated Lake Denton water budget model. Negative values indicate model underprediction.

Metric	Unit	Value
P10 Residual	feet	0.1
P50 Residual	feet	0.0
P90 Residual	feet	0.2

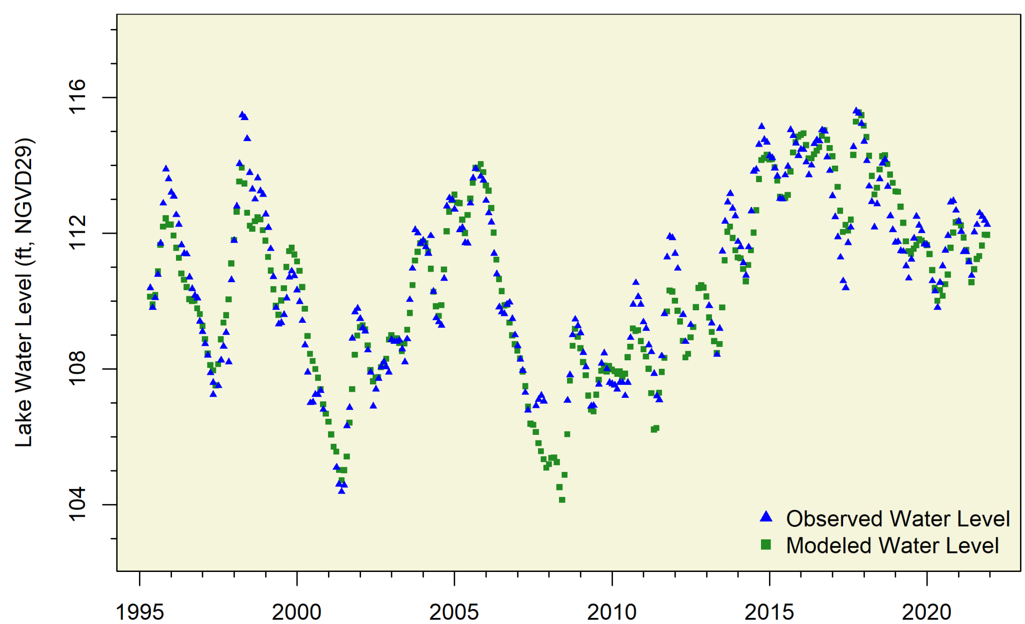


Figure 3-3. Observed and modeled lake water levels for the calibrated Lake Denton water budget model.

CHAPTER 4 – DEVELOPMENT OF HISTORIC LAKE STAGE PERCENTILES

The development of minimum lake levels requires an estimation of lake stage in the absence of withdrawals, given existing structural alterations. These historic water level records serve as a baseline hydrologic condition for use with the significant harm standards and minimum level screening criteria described in Chapter 5. The determination of historic lake levels is a three-step process:

1. First, the drawdown in both SA and UFA water levels is estimated. Drawdown is the change in aquifer water levels that has occurred due to pumping. Drawdown can be estimated from regional models by comparison of water levels simulated for "pumps-on" and "pumps-off" scenarios or through evaluation of reduced pumping scenarios, as well as through analysis of actual pumping rates and observed water level data.

2. A historic water budget model scenario is then simulated using the estimated drawdown information to increase SA and UFA water level inputs in a calibrated lake water budget model. With the adjusted groundwater level time series inputs, the lake water budget model calculates historic lake stage values.

3. The historic lake stage time series is then extended to 60 years by using a correlation between long term rainfall and historic lake stage values.

Implementation of these steps for development of a historic water level record for Lake Denton are described in this chapter.

4.1 Surficial and Upper Floridan Aquifer Water Level Change Due to Withdrawals

The East Central Florida Transient Expanded (ECFTX) model was used to predict long-term drawdown in the SA and UFA at Lake Denton. The ECFTX is an 11-layer regional groundwater flow model, which was constructed and calibrated for the years 2003-2014 by the Hydrologic Assessment Team (HAT) for the Central Florida Water Initiative (CFWI) in 2020. The model extends from the Gulf of America on the west to the Atlantic Ocean on the east and from southern Marion County in the north to the Highlands-Glades County line in the south, covering an approximate 24,000 square mile area (Figure 4-1). Version 1.0 of the model (CFWI-HAT 2020), which was peer-reviewed in 2020 (Andersen et al., 2020) simulates three-dimensional groundwater flow in the SA, intermediate aquifer system (IAS), UFA, LFA, and associated intermediate and middle confining units. The ECFTX version 2.0 model (CFWI-HAT 2022) was developed to improve the original model calibration, support water supply planning decisions, regulatory decisions, and help determine withdrawal impacts in areas where critical water bodies with established MFLs are located.

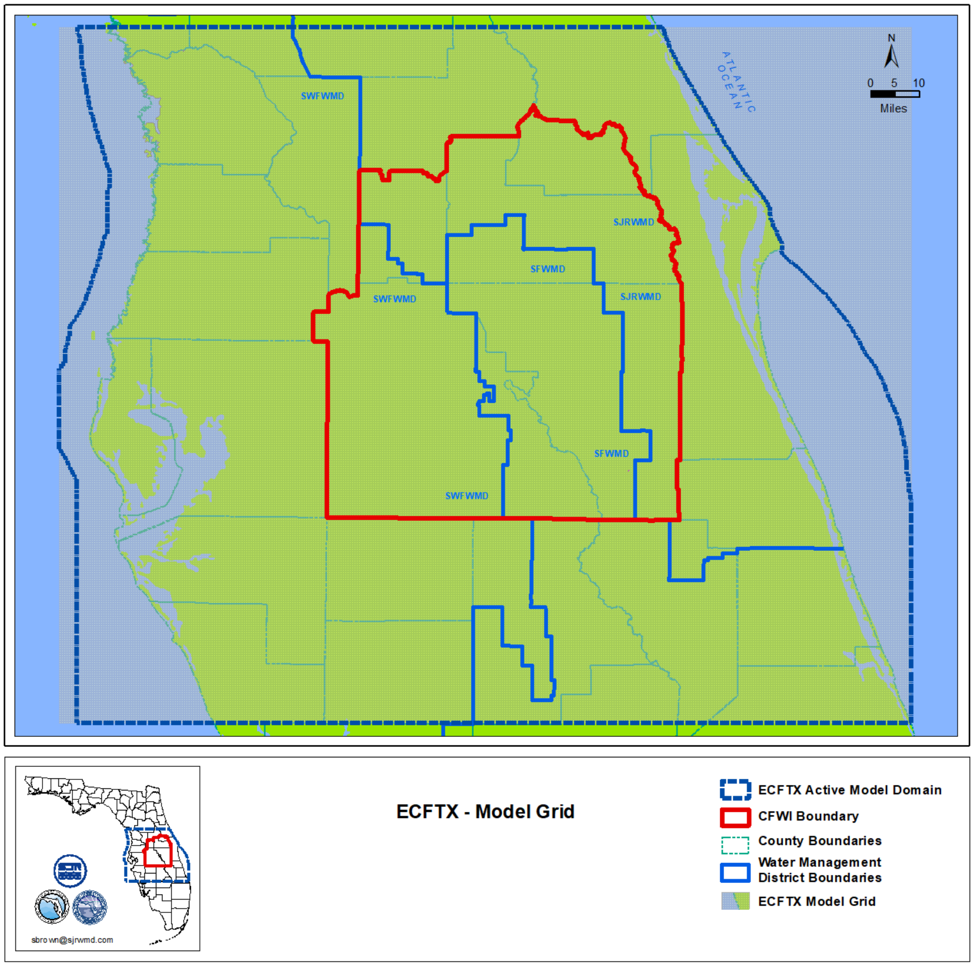


Figure 4-1. The ECFTX model domain in central Florida.

4.1.1 Monthly Drawdown

Monthly drawdown values for the UFA and SA were developed using data from ECFTX version 1.0 model for cells intersecting Lake Denton for the 2004 through 2014 time period. Drawdown was calculated by comparing reduced pumping and actual pumping scenario results. The reduced pumping scenario used a 50 percent reduction in groundwater withdrawals (including associated return water from the recharge package) across the model domain from 2003 through 2014. The difference between simulated heads in the UFA from this scenario and those from the calibrated model represent aquifer water level changes associated with a 50 percent reduction in withdrawals. This change in water level was then doubled to estimate UFA drawdown associated with a 100 percent reduction in withdrawals, which would approximate a "pumps-off" condition. This procedure had previously been used by the CFWI-HAT Team in 2020 and in 2025 to estimate current withdrawal impact to water bodies with established minimum flows and levels as part of the CFWI regional water supply planning process.

Drawdown in the SA is difficult to characterize due to high local variability. However, a lake-specific estimate of SA drawdown is necessary for characterizing fluxes between the lake and the SA in the Historic version of the lake's water budget model. Thus, an estimate of SA drawdown was developed for Lake Denton based on work conducted by Hancock and Basso (1999) for the northern Tampa Bay area, which indicates that given the leakance coefficient of the UFA in ft/d/ft (L_{UFA}), the ratio of SA to UFA drawdown (DD_{SA}/DD_{UFA}, ft/ft) can be calculated using Equation 4-1. This ratio can then be multiplied by the UFA drawdown to estimate SA drawdown. The ratio is an approximation developed using results from a regional groundwater flow model in the northern Tampa Bay area.

(Equation 4-1) $$\frac{DD_{SA}}{DD_{UFA}} = \frac{L_{UFA}}{8.3\times10^{-4}+0.98\times L_{UFA}}$$

Results from the ECFTX model are the most accurate source available for monthly drawdown estimates near Lake Denton, but these results capture less than half the period used for water budget model calibration. In previous District minimum lake level investigations (e.g., Campbell & Patterson, 2020; Campbell & Sealy, 2020; Venning & Cameron, 2020; Hurst et al., 2019; Sutherland et al., 2021; Campbell et al., 2021), linear relationships between drawdowns and pumping in the UFA have been identified to extend drawdown records beyond time periods or scenarios currently available from groundwater models. The approach recommended by the CFWI-HAT for calculating drawdown using the ECFTX model also assumes a linear response of UFA drawdown to pumping changes. Thus, to extend available monthly drawdown estimates from the 2004-2014 period to the 1995-2021 water budget model period for Lake Denton, a linear relationship was developed between modeled monthly UFA drawdown in ECFTX model cells that underlie the lake and average monthly pumping within a 6-mile radius of the lake (Figure 4-2). Monthly pumping data used for the regressions were obtained from the District's estimated and metered groundwater withdrawals database described in Section 2.9 of this report. Domestic self-supply (DSS) withdrawals were not included in the water use estimates due to their relatively small contributions to overall withdrawals.

The 6-mile radial distance gives a localized regional representation of the pumping-drawdown relationship in the UFA. Pumping limited to shorter radial distances may not include larger withdrawal permits that could have a strong influence on the drawdown at the lake, and of the inclusion of pumping within longer radial distances may include withdrawals in areas of different hydrogeology from the area around the lake. The use of withdrawal data within both a 5-mile and a 7-mile radius was tested in the Historic water budget model (see Section 4.2) and produced Historic P50 lake stages identical to that developed from the 6-mile radius.

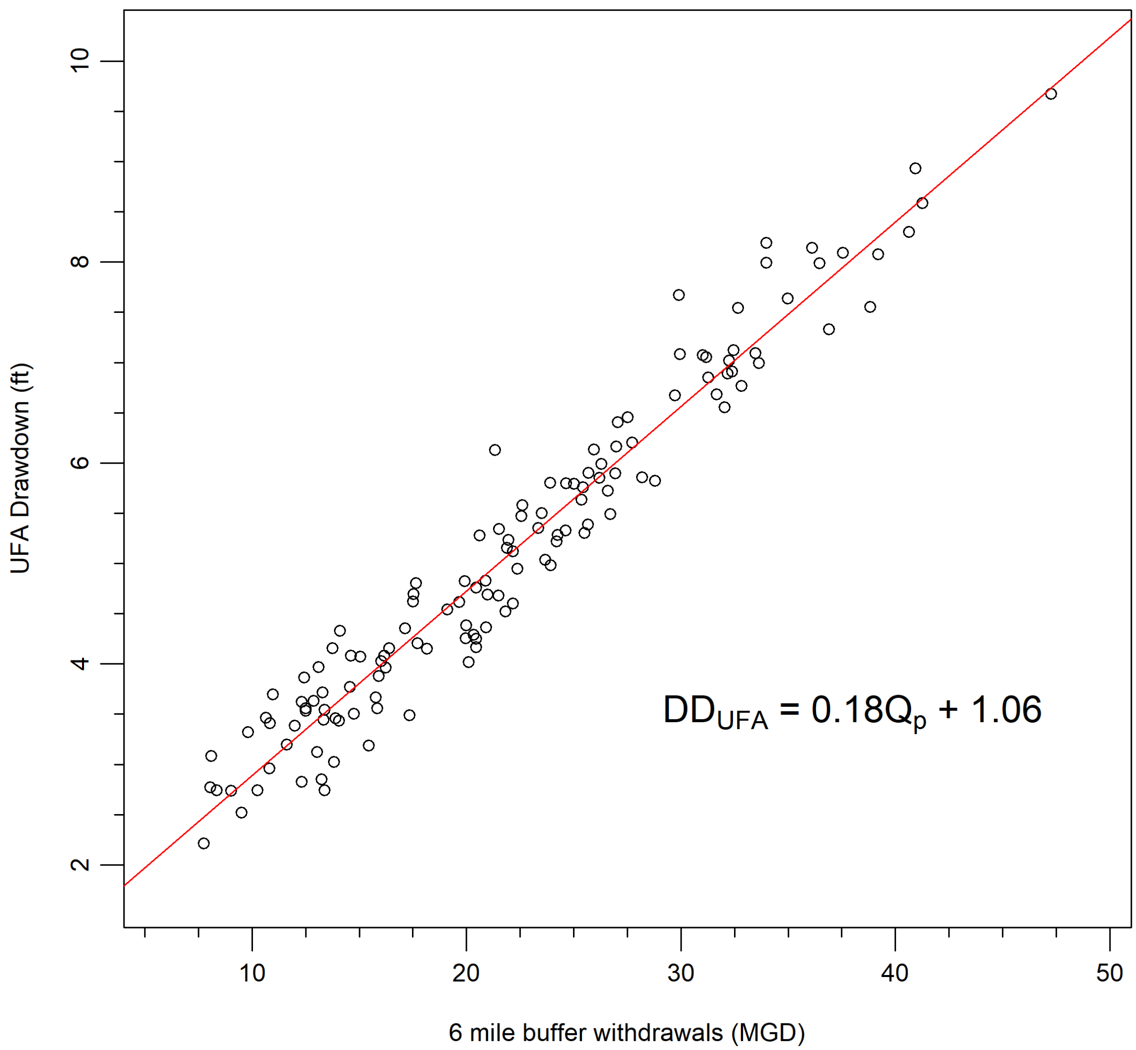
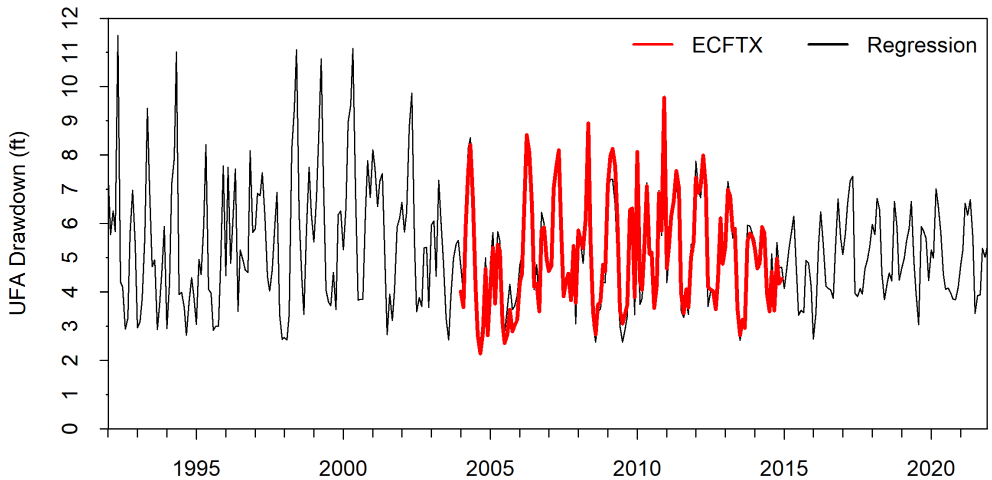


Figure 4-2. Linear regression between monthly drawdown in the UFA (DD_{UFA}) and monthly pumping (Q_p) in million gallons per day (MGD) within 6 miles of Lake Denton.

The 6-mile pumping regression was used with 1995-2021 6-mile estimated/metered monthly pumping data to estimate monthly UFA drawdown for the 1995-2021 period used in the Lake Denton water budget model (Figure 4-3, top panel). Equation 4-1 was used with inputs of the monthly UFA drawdown estimates from the ECFTX model and the calibrated value of 1.7×10^{-4} ft/d/ft for Lake Denton to estimate monthly SA drawdown for the 1995-2021 period (Figure 4-3, bottom panel). The regression-predicted drawdown values for the periods from 1995-2003 and 2015-2021 were then combined with ECFTX-derived monthly drawdown values available for the 2004 through 2014 simulations to create monthly time-series of UFA and SA drawdown for the 1995-2021 for use in the Lake Denton water budget model to simulate Historic water levels, as described in Section 4.2.



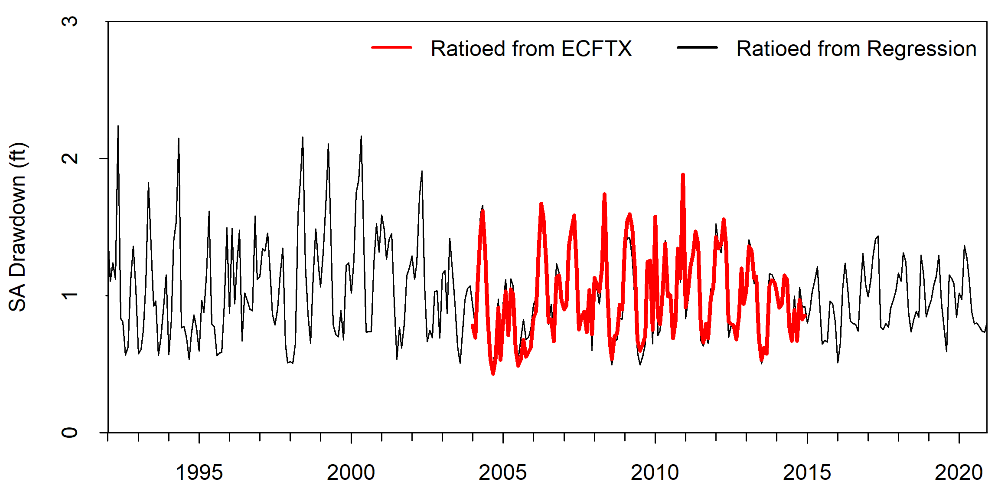


Figure 4-3. Monthly UFA (top panel) and SA (bottom panel) drawdowns for Lake Denton (red line) and a pumping-drawdown regression using pumping within a 6-mile buffer of the lake (black line).

4.2 Historic Lake Denton Scenario and Historic Stage Records

4.2.1 Historic Water Budget Model Development

The calibrated Lake Denton water budget model, described in Chapter 3, represents current conditions at the lake and can simulate lake levels for the period from May 1995 through December 2021. Groundwater level inputs used for model calibration include water level data that were impacted by withdrawals at the time of data collection. These impacts must be removed to represent the Historic condition. Thus, SA and UFA groundwater level time series inputs were adjusted upwards in the calibrated water budget model to offset drawdown in each aquifer. This

Historic scenario provided a means to estimate water levels expected in the absence of withdrawals, given existing or similar structural alterations.

The UFA and SA monthly drawdown estimates for Lake Denton (described in Section 4.1) minimize bias in the stage exceedance percentiles associated with water level higher than the Historic P50, as a constant long-term average drawdown would overpredict drawdown during periods of higher-than-average water levels. Usage of monthly drawdowns is also supported by the acceptable calibration of the ECFTX near Lake Denton and the strength of the pumping-drawdown relationship for the UFA developed for the lake.

To produce the Historic scenario for use in the water budget model, SA and UFA water levels were increased using the average monthly drawdown estimates described in Section 4.1.1, which were disaggregated into daily time series, assuming a uniform distribution (e.g., all days within January 2019 repeat the average January 2019 value, all days within February 2019 repeat the average February 2019 value, and so on). Then, the water budget is recalculated using the calibrated parameters (Table 3-2), and lake water levels are predicted in the absence of groundwater withdrawals.

4.2.2 Historic Water Budget Model Results

Results of the Historic scenario along with those for the calibrated model and observed lake stage record for the period from May 1995 through December 2021, are provided in Figure 4-4 and Table 4-1. In the absence of withdrawals, the P10, P50, and P90 for Lake Denton would increase 0.8, 0.9, and 1.0 ft respectively, relative to comparable percentiles predicted for the model calibration condition. The Historic P10, P50, and P90 were predicted to be 0.9, 0.9, and 1.2 ft higher than the observed P10, P50, and P90 respectively.

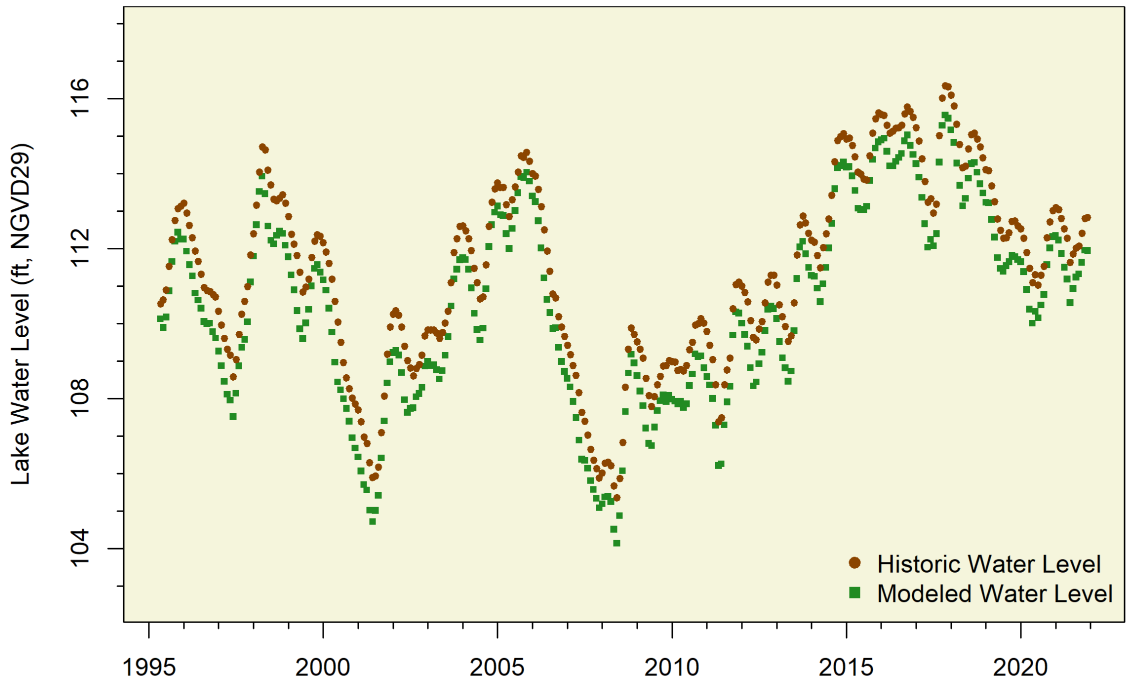


Figure 4-4. Lake Denton water levels from calibrated and Historic water budget model scenarios.

Table 4-1. Comparison of exceedance percentiles for observed water levels and water levels from water budget model scenarios.

Percentile	Observed (ft NGVD29)	Calibrated (ft NGVD29)	Historic (ft NGVD29)
P10	114.1	114.2	115.0
P50	111.0	111.0	111.9
P90	107.6	107.8	108.8

4.2.3 Historic Water Budget Model Limitations

The difference between calibrated and Historic lake water levels depends on the magnitude of the leakance coefficients and drawdown estimates, with higher values for either increasing estimated Historic lake water levels. Also, for lakes with structures, structure efficiency dampens inflow/outflow for water levels above structure elevation. Uncertainty in calibrated leakance coefficients and groundwater level adjustments in the water budget model limit the accuracy of the estimated Historic lake water levels because the modeled lake stage percentiles are sensitive to changes in these parameters (Qi et al., 2022). Additionally, removing the effects of pumping (i.e., drawdown, which is limited by the accuracy of ECFTX) from the water budget model changes the hydraulic gradients used for the SA and UFA around the lake, and the availability of predevelopment hydraulic gradients in these units is low, which limits the accuracy of groundwater fluxes in the Historic water budget model. However, the drawdown estimates and calibrated water budget model parameters represent the best information available near Lake Denton.

4.3 Long-term Historic Percentiles

The results of the Historic water budget model and long-term rainfall were used in a line of organic correlation (LOC) to derive a long-term (60 year) Historic water level record for Lake Denton. This long-term Historic record served as a basis for identifying Historic lake stage percentiles as part of minimum lake levels development. 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 et al., 2020). LOC is preferable for this application since it produces a result that best retains the variance of the original data.

For the water-level data set extension, Historic lake stages were correlated with Long-term rainfall. The Long-term rainfall data set was developed starting with the ROMP 43XX Avon Park rain gage (SID 25189) for the May 1995 – December 2021 calibration period used in the water budget model. Records from the Avon Park 2 W NWS rain gage (SID 25508) with a gap filled with the DeSoto City 8 SW NWS rain gage (SID 25554) were used to extend rainfall records back to 1963. The Avon Park gage is approximately 3.5 miles northwest of Lake Denton, and the DeSoto City rain gage is approximately 14 miles south of Lake Denton. In addition, NEXRAD data were used to extend the rainfall time series to December 2022.

The rainfall data were correlated to the Historic lake stage 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. For this application, weighted sums varying from 6 months to 10 years were separately used, the results compared, and the correlation with the highest Nash-Sutcliffe Efficiency (NSE) chosen as the best model. For Lake Denton, the 7-year weighted model had the highest NSE of 0.76.

Historic water budget model results (i.e., water levels) from May 1995 to December 2021 were correlated with the weighted rainfall values using the LOC procedure (Figure 4-5). Daily lake water surface elevations from January 1963 to December 2022 (60 years) were then derived using the resulting stage-rainfall relationship (the LOC model). The lake's predicted behavior in the absence of withdrawals, i.e., the predicted Historic water level record, is presented in Figure 4-6. Historic percentiles (P10, P50 and P90) for the Lake Denton Historic water level record are included in Table 4-2.

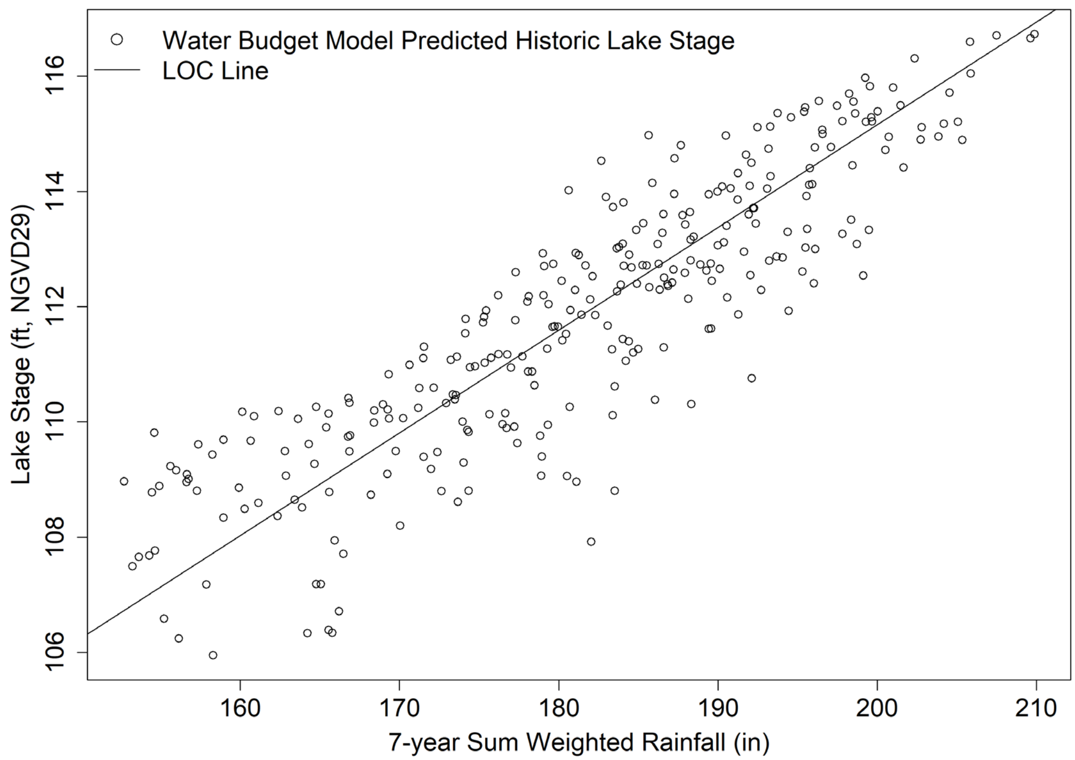


Figure 4-5. Lake Denton water levels from Historic water budget model correlated with 7-year weighted sum rainfall using LOC method.

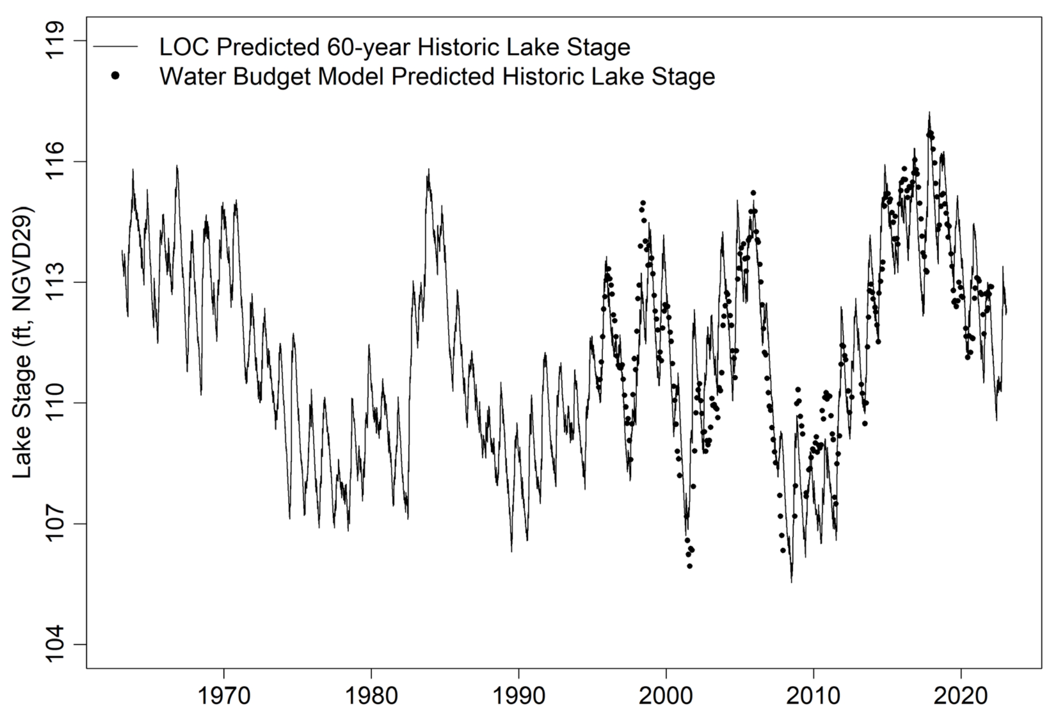


Figure 4-6. LOC predicted 60-year Historic Lake Denton water levels from January 1963 to December 2022 and Water Budget Model predicted Historic Lake Denton water levels from May 1995 to December 2021.

Table 4-2. Lake Denton P10, P50 and P90 water level elevations predicted from May 1995 to December 2021 with the Historic water budget model and from January 1963 to December 2022 using the Historic LOC method.

Percentile	Historic Water Budget Model (ft NGVD29)	Historic LOC Model (ft NGVD29)
P10	115.0	114.2
P50	111.9	110.9
P90	108.8	107.8

4.4 Summary

Best available information was used to develop a Historic scenario for Lake Denton using a calibrated water budget model. Lake minimum levels most heavily rely on the estimate of the Historic P50, which is the highest confidence percentile derived for the Historic scenario. The modeled Historic P50 is associated with some uncertainty but represents the best estimate available. The Historic scenario results were considered acceptable for supporting minimum levels development for Lake Denton.

CHAPTER 5 – ENVIRONMENTAL CRITERIA METHODS, RESULTS AND DISCUSSION

Revised minimum levels were developed for Lake Denton using lake-specific significant change standards and environmental screening methods (SWFWMD 2022a). The standards were used to identify a provisional Minimum Lake Level. The screening methods were used to evaluate the provisional Minimum Lake Level and determine whether any modification of the provisional level was necessary based on consideration of all relevant environmental values associated with the lake. Based on results from these screenings, a need for modification of the provisional Minimum Lake Level was identified, and the preservation of water levels that support emergent marsh habitat (Table 4-2) was used to identify a proposed Minimum Lake Level.

5.1 Normal Pool Elevation and Other Hydrologic Indicators of Sustained Inundation

The Normal Pool elevation, a reference elevation used for development of minimum wetland and lake levels, is established based on the elevation of hydrologic indicators of sustained inundation. Inflection points, i.e. buttress swelling, and moss collars on the trunks of cypress trees have been shown to be reliable indicators of Normal Pool (Carr et al. 2006). Because Lake Denton does not have sufficient cypress trees with adequate hydrologic indicators, a Normal Pool elevation was not determined.

As was the case for Normal Pool determination for Lake Denton, other useful hydrologic indicators of sustained inundation were similarly not identified for the lake.

5.2 Structural Alterations and Other Information for Consideration

Additional information to consider in establishing minimum levels are the Control Point elevation and elevations associated with the lowest building floor/slab elevation and other relevant features such as low roads, within the lake basin.

As discussed in Sections 1.1, 1.2 and 1.4, the Control Point elevation is the elevation of the highest stable point along the outlet profile of a surface water conveyance system that can principally control the lake water level fluctuations. Because Lake Denton does not have an outlet conveyance system and is considered a closed basin lake, a control point elevation was not identified for the lake (see Section 2.2).

A low floor slab elevation, based on survey reports (Survtech 2021), was established at 118.7 ft NGVD29 for the Lake Denton basin.

5.3 Significant Change Standards

Two significant change standards, the Xeric Wetland Offset and the Species Richness Standard, were established for Lake Denton based on historic lake stage percentiles and stage-area-volume relationships for the lake. The Xeric Wetland Offset was used for Lake Denton based on its characterization as a xeric lake (GPI 2021a; see also Sections 2.3, 2.5 and 5.4.1).

5.3.1 Xeric Wetland Offset

The Xeric Wetland Offset is developed to protect lake fringing wetlands in xeric settings that are not dominated by cypress. Xeric waterbodies are geographically isolated lakes and wetlands in landscapes dominated by xeric soils and are typically associated with deep water-table conditions and sand pine scrub or longleaf pine–turkey oak hills ecosystems (GPI 2016; GPI 2021b; Nowicki 2019; Nowicki et al. 2021, 2022). Xeric soils contrast with mesic and hydric soils by having low moisture content, typically with a hydric rating below 3.5% (CFWI-EMT 2013; GPI 2016, 2021b). Water levels at xeric waterbodies frequently display high range and low symmetry (Epting et al. 2008; GPI 2016; Schmutz 2019). Additionally, xeric waterbodies are usually internally drained, such that maximum elevations are not typically controlled by surface outflows (GPI 2016, Basso 2019).

The Xeric Wetland Offset was developed using hydrologic data and stress-status determinations for xeric wetland sites in the Lake Wales Ridge and northern Tampa Bay areas (GPI & SWFWMD 2022). The standard is applied as an offset from the Historic P50 elevation and is based on the finding that significant harm is likely to occur at a xeric wetland when the P50 is lowered by more than 2.2 feet relative to Historic conditions.

The Xeric Wetland Offset for Lake Denton was, therefore, established at 108.7 ft NGVD29, an elevation 2.2 ft. below the Historic P50 elevation of 110.9 ft NGVD29.

5.3.2 Species Richness Standard

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 a lake, the standard is established at the lowest elevation associated with less than a fifteen percent reduction in lake surface area relative to the lake area at the Historic P50 elevation (SWFWMD 2001; Emery et al. 2009).

For Lake Denton, the Species Richness Standard was established at 106.0 ft NGVD29, based on a 15% reduction in lake surface area from that at the Historic P50 elevation (Figure 5-1).

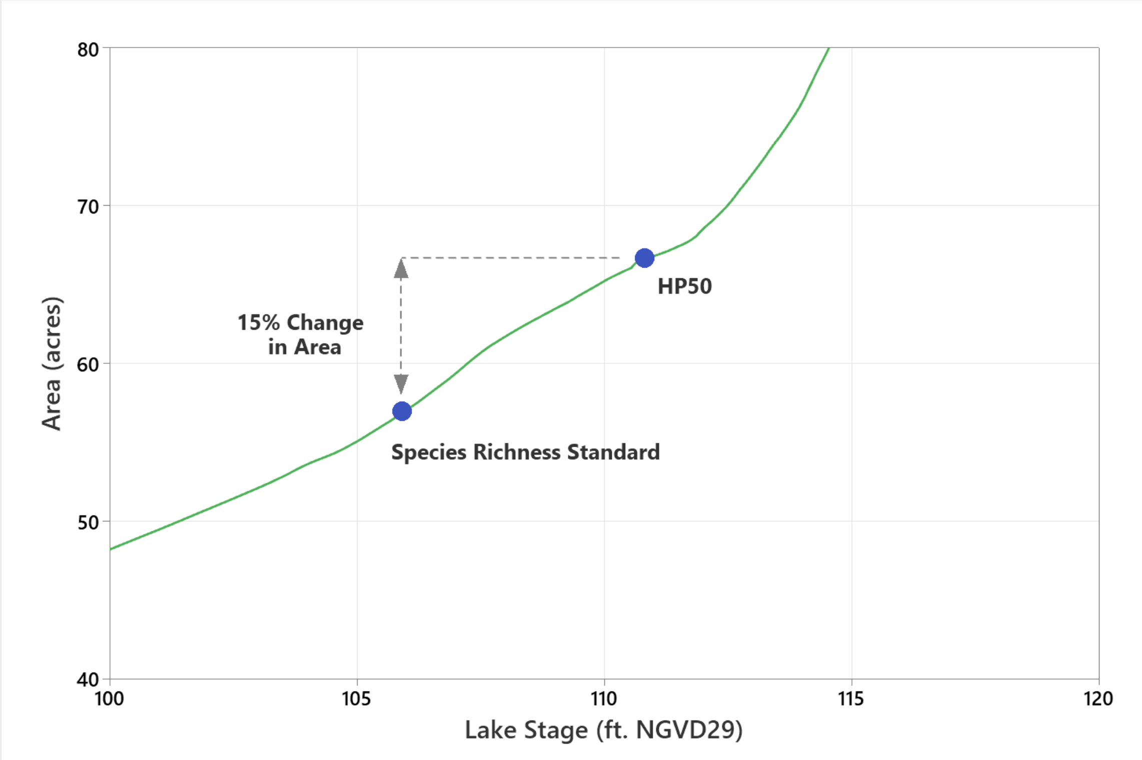


Figure 5-1: Species Richness Standard for Lake Denton compared to the Historic P50 (HP50) elevation.

5.4 Provisional Minimum Lake Level and MFL Condition Time Series

For Lake Denton, the Xeric Wetland Offset elevation of 108.7 ft NGVD29 was higher, i.e., more sensitive to stage reductions, than Species Richness standard of 106 ft NGVD29. The Xeric Wetland Offset was therefore used to identify a provisional Minimum Lake Level for the lake, which was used to develop an “MFL Condition” water level timeseries for use in the screening methods described in the following section.

The MFL Condition water level records were developed using the Lake Denton water budget model and a LOC rainfall regression, similar to the development of the historic water level time series. Model simulations involving incremental reductions in UFA and SA inputs from those associated with the historic condition were iteratively conducted to identify a time series associated with the least change in aquifer inputs that would yield a P50 elevation of 108.7 ft NGVD29, the elevation associated with a provisional Minimum Lake Level based on the Xeric Wetland Offset.

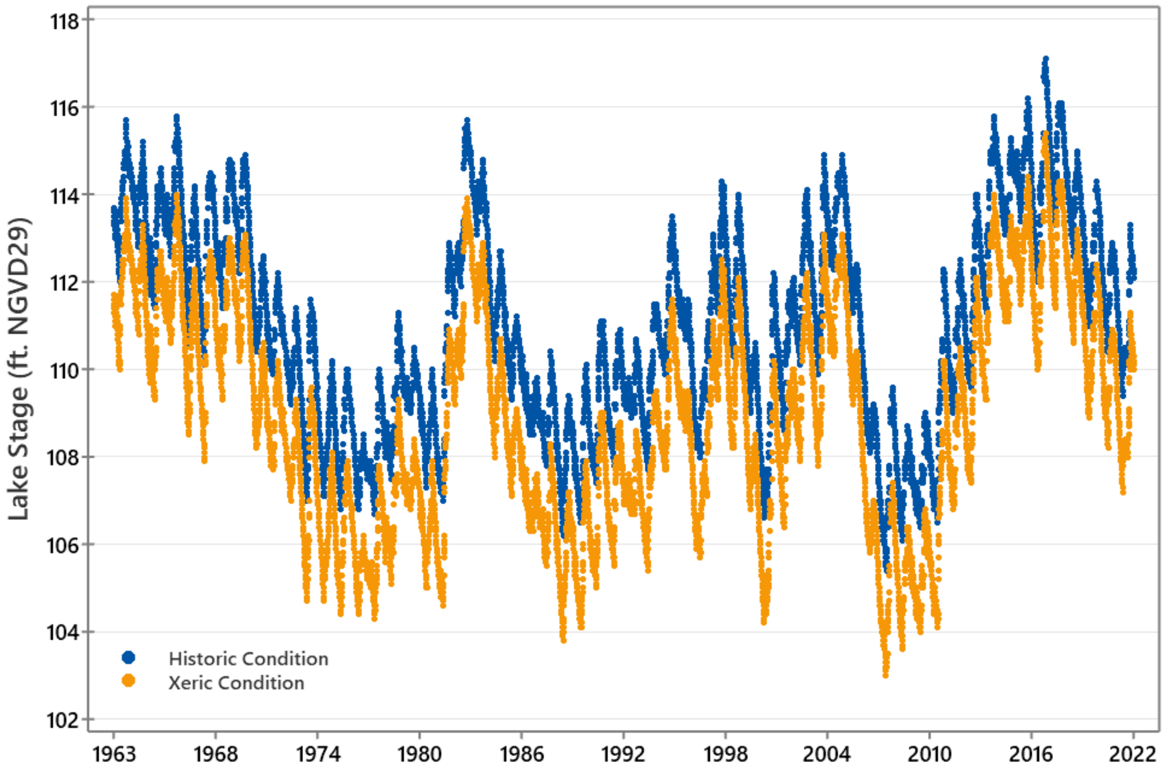


Figure 5-2. Historic and MFL Condition water levels simulated with the Lake Denton water budget model from January 1963 to December 2022.

5.5 Screening of Provisional Minimum Lake Level

Additional information associated with four screening processes was evaluated and considered for development of minimum levels for Lake Denton. This information, associated with aquatic habitat zones, basin connectivity, dock-use, and aesthetics, was evaluated to ensure all relevant environmental values associated with Lake Denton would be protected with implementation of the provisional Minimum Lake Level, and to identify the need for additional analyses prior to identification of proposed minimum levels. A summary of the methods associated with these screenings can be found in SWFWMD 2022a.

5.5.1 Aquatic Habitat Zone Screening

The aquatic habitat zone screening ensures that fish and wildlife habitats, natural system functions, and human-use values are protected when assessing minimum lake levels. The method evaluates potential changes in the areal extent of key aquatic habitats under simulated water level conditions, using bathymetric data and water level time-series analysis.

The District applies a 15% change threshold, a standard commonly used in Florida minimum flows and levels assessments (Sutherland et al. 2021; HSW Engineering, Inc. 2016), to identify whether proposed minimum levels sufficiently protect critical habitat areas. Habitat zones evaluated include littoral and deep-water areas, each defined by specific depth ranges linked to ecological and recreational functions.

The aquatic habitat zone screening for Lake Denton evaluates potential impacts of proposed minimum lake levels on six key habitat zones: small wading bird forage (0–0.5 ft), sandhill crane nesting (0.5–1.0 ft), large wading bird forage (0–1.0 ft), game fish spawning (1.0–4.0 ft), emergent marsh (0–6.0 ft), and deep-water habitat (>5.0 ft). Using stage-area-volume relationships derived from bathymetric data, average habitat areas under historic and simulated MFL conditions were compared.

Stage-area-volume relationships, derived from digital elevation models, are used to calculate average habitat areas across historic and minimum flow condition time series. If the average habitat area under the proposed minimum level condition is within 15% of the historic condition, the level is considered protective. When this threshold is exceeded, additional modeling is performed to identify protective conditions.

Initial screening of the proposed MFL condition using the xeric wetland offset showed that two of the six habitat zones—game fish spawning and deep-water habitat—remained within the District's 15% change threshold, which is used to ensure ecological protection. However, small wading bird forage habitat, large wading bird forage habitat, sandhill crane nesting habitat, and emergent marsh habitat all exceeded this threshold (see Table 5-1).

Table 5-1. Modeled historic and xeric offset MFL condition habitat area, and percentage change between the historic and xeric offset MFL condition for Lake Denton.

Habitat	Historic Average Habitat Area (acres)	MFL Condition Average Habitat Area (acres)	% of Historic Average Under MFL Condition
Small Wading Bird	1.5	1.04	70.7
Large Wading Bird	2.8	2.0	72.5
Sandhill Crane	1.3	0.98	74.5
Game Fish	6.2	5.4	86.4
Emergent Marsh	12.6	10.7	84.6
Deep Water Habitat	57.5	53.7	93.5

To reduce impacts to emergent marsh habitat, the water budget model was adjusted by modifying drawdown assumptions, resulting in a revised MFL scenario that brought impacts to this habitat below the 15% threshold. The other three habitat types - small and large wading bird forage areas and sandhill crane nesting habitat - were allowed to exceed the threshold because of their limited size and low regional ecological significance, as confirmed in an official letter of support by FWC (Appendix A). These habitats are naturally limited at this lake due to its steep bathymetry and trophic state, especially when compared to nearby lakes like Istokpoga and Kissimmee, which offer large areas of high-quality shallow water habitat. FWC staff agree that allowing more than a 15% reduction in these zones would not result in significant harm to fish and wildlife, as the total loss represents less than one acre of habitat across these zones.

A newly proposed MFL condition was generated resulting in a P50 and proposed minimum lake level of 108.8 ft NGVD29. The results of the aquatic habitat screening using this proposed MFL condition time series is included in Table 5-2 and Figure 5-3.

Table 5-2. Modeled historic and proposed MFL condition habitat area, and percentage change between the historic and proposed MFL condition for Lake Denton.

Habitat	Historic Average Habitat Area (acres)	MFL Condition Average Habitat Area (acres)	% of Historic Average Under MFL Condition
Small Wading Bird	1.5	1.1	71.7
Large Wading Bird	2.8	2.1	73.4
Sandhill Crane	1.3	1.0	75.3
Game Fish	6.2	5.4	86.9
Emergent Marsh	12.6	10.8	85.2
Deep Water Habitat	57.5	54.0	93.8

Small wading bird forage habitat (SWB) shows a general increase in area with stage, with a sharp expansion and contraction occurring at 60 feet NGVD29 and then expansion at elevations above approximately 108 ft NGVD29. This expansion continues beyond the Historic P50 elevation (110.9 ft NGVD29), peaking near the upper range of the hydrograph. Under the proposed MFL condition, the SWB habitat expands more slowly, and maximum habitat area is not maintained as consistently at higher stages. Average habitat area under the MFL condition is visibly lower than historic conditions across much of the relevant elevation range, particularly above 108.5 ft NGVD29. Horizontal reference lines show that the MFL condition results in a slight but persistent reduction in habitat relative to the historic average.

Large wading bird forage habitat (LWB) generally increases in area with rising water levels, with a sharp expansion and contraction in acreage occurring at 60 feet NGVD29 and then expansion above approximately 107.5 ft NGVD29. The habitat reaches and sustains its peak near and beyond the Historic P50 elevation (110.9 ft NGVD29). Average habitat area under the MFL condition is visibly lower than historic conditions across much of the relevant elevation range, particularly above 108.5 ft NGVD29. Horizontal reference lines show that the MFL condition results in a slight but persistent reduction in habitat relative to the historic average.

The sandhill crane nesting (SHC) habitat similarly demonstrated an early sharp increase and decrease in area with rising water levels just above 60 feet NGVD29, with another increase in area beyond water levels of approximately 105.0 ft NGVD29.

Game fish spawning habitat follows an upward trend with increasing stage similar to the previous three habitats. Following the sharp expansion and contraction of habitat around 60 feet NGVD29, the curve begins a modest rise around 106 ft NGVD29 before slightly contracting. The gradual curve suggests a broadening habitat area that becomes progressively more available as water levels rise.

Emergent marsh habitat displays a distinct two-phase pattern. An increase and subsequent decrease occurs at lower elevations around 60 ft NGVD29, followed by a gradual increasing section through 105 feet NGVD29. A second, much steeper rise begins near 105 ft and continues sharply upward, reaching a peak near the upper end of the elevation range. The increase of emergent marsh and all previous habitats at 60 feet NGVD29 is indicative of the basin shape, where the deepest areas of the lake (<60 feet NGVD29) existing in a singular area, followed by a larger, mostly-flat bottom existing from 60 – 65 feet NGVD29 before the bathymetry becomes more steep towards the surface.

Deep water habitat increases in a nearly linear fashion with elevation across the full range of the plot. The curve shows a consistent and proportional gain in habitat area as stage increases, with no significant inflection points or abrupt changes. This pattern reflects a predictable and direct relationship between water level and deep habitat extent.

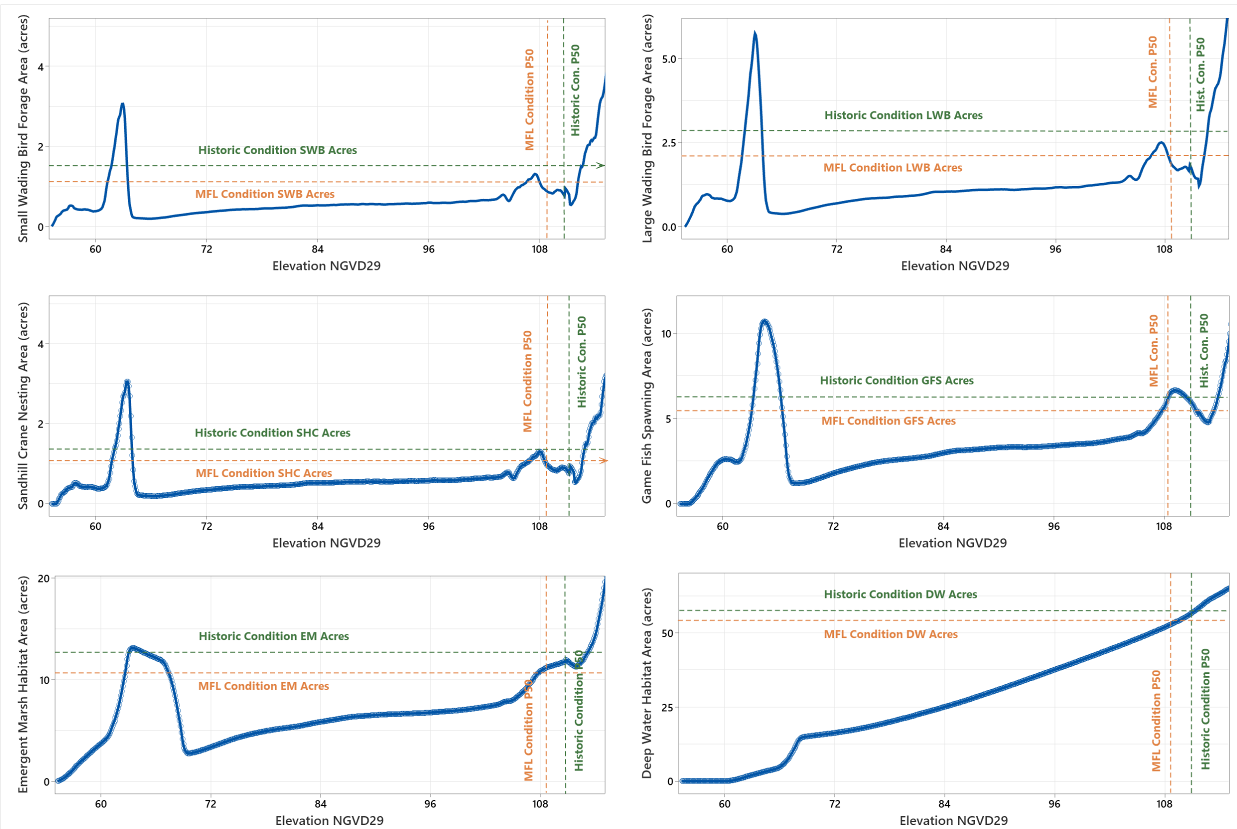


Figure 5-3. Stage/area relationship for assessed habitats simulated for MFL condition at Lake Angelo.

5.5.2 Basin Connectivity Screening

Basin Connectivity Screening is applied to lakes with sub-basins and in some cases at lakes connected to other lakes or waterbodies for the purpose of protecting surface water connections between lake basins or among sub-basins within lake basins. These surface water connections allow for movement of aquatic biota, such as fish, and support recreational uses. Basin connectivity is evaluated by determining high-spot elevations for all areas of connectivity between relevant lake sub-basins and between the lake and other waterbodies. A high-spot elevation is the lowest elevation at which surface water connection between any two given sub-basins or two waterbodies occurs. A critical fish passage elevation is then determined by adding 0.6 feet to the critical high-spot elevation and this elevation is evaluated to determine if it is inundated at minimum 80% of the time.

Lake Denton can be characterized as not having sub-basins and is not connected to other waterbodies. The basin connectivity screening was determined to be not applicable for Lake Denton.

5.5.3 Dock Use Screening

Dock Use Screening is conducted for lakes with functional, fixed-platform docks. Floating docks which may move up and down in response to water level variation are typically not considered in the screening process, nor are dilapidated docks or those that can be moved up or down the lakeshore in response to changing water levels. The screening process involves determining the mean elevation of sediments at the ends of existing docks, which is referred to as the mean dock sediment elevation (MDSE), and characterizing dock use by relating the MDSE to water-depth percentiles for various scenarios including observed (i.e., measured) period of record (POR) water levels, historic water levels, and water levels associated with achieving proposed minimum lake levels, i.e., an MFL condition scenario. Typically, P10, P50 and P90 water-level percentiles are used for comparison with the MDSE.

Fourteen functioning (not dilapidated), non-floating docks exist on Lake Denton (Figure 5-4), so a MDSE was calculated. The MDSE of the 14 docks on Lake Denton is 96.8 feet NGVD29.

Water level data collected through 2022 (Figure 2-3) show that, on average, the depth at the end of the dock was approximately 9.2 feet, 5.8 feet, and 3.7 feet at P10, P50, and P90 of recorded stages, respectively (Table 5-3).

Simulated historic water levels from the Lake Denton water budget model (Figure 5-2) indicate estimated depths of 11.1 feet at the P10 stage, 7.8 feet on average at the P50 stage, and 4.6 feet at the P90 stage.

Under the modeled MFL condition, water depths at the docks are projected to be approximately 8.8 feet, 5.3 feet, and 2.1 feet on average at the P10, P50, and P90 stages, respectively (Table 5-3).

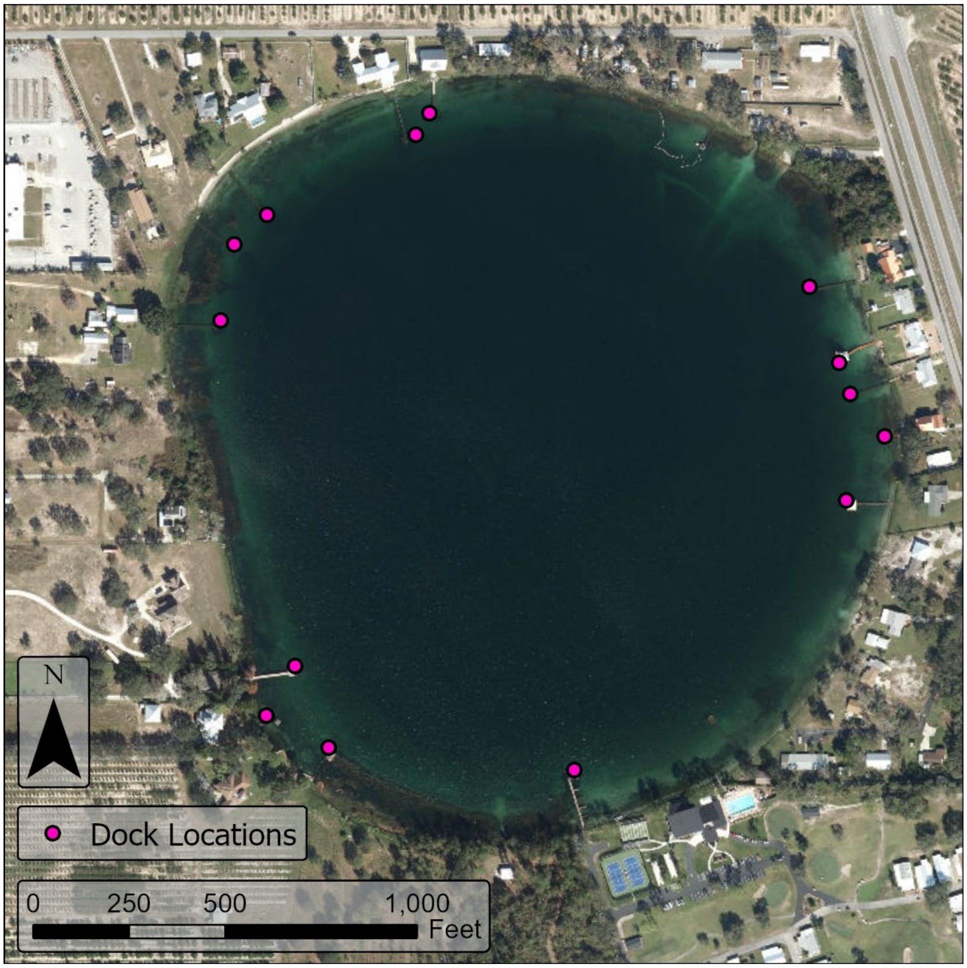


Figure 5-4. Dock locations on Lake Denton.

Table 5-3. Average water depths at the end of 14 docks on Lake Denton for Period of record (POR) and Historic and MFL Condition water level records simulated with a water budget model.

Stage Percentiles	Water Depths at End of Dock (ft)		
	POR	Historic	MFL Condition
P10	9.2	11.1	8.8
P50	5.8	7.8	5.3
P90	3.7	4.6	2.1

Dock platform heights were also evaluated to assess the vertical distance between dock surfaces and the water under each scenario. Based on period-of-record (POR) water level data, the 14 docks had an average distance of 1.74 feet between the platform and the water at the P10 level, 5.14 feet at the P50 level, and 7.24 feet at the P90 level (Table 5-4).

Under the historic condition simulated by the water budget model, the average distance from the dock platform to the water surface was 0.04 feet at the P10 level, 3.44 feet at the P50 level, and 6.54 feet at the P90 level (Table 5-4).

Under the MFL condition, model results indicate that the average platform-to-water distance would be 1.94 feet at the P10 level, 5.54 feet at the P50 level, and 8.84 feet at the P90 level (Table 5-4).

Table 5-4. Average distance from dock platform to water surface for 14 docks on Lake Denton for POR, Historic, and MFL water level records.

Stage Percentiles	Distance from Dock Platform to Water (ft)		
	POR	Historic	MFL Condition
P10	1.74	0.04	1.94
P50	5.14	3.44	5.54
P90	7.24	6.54	8.84

Based on the characterization of water depths at the end of the two existing docks on Lake Denton for the simulated MFL Conditions, as well as consideration of expected distances between the dock platforms and the lake surface, implementation of the provisional Minimum Lake Level is not expected to adversely affect dock-use and associated environmental values.

5.5.4 Aesthetics Screening

Aesthetics screening is completed to address and protect aesthetic values associated with lake basin inundation. The screening is used to help prevent unacceptable changes to lake aesthetic attributes that may be associated with the lowering of lake water levels by withdrawals. The screening is based on a lake-user survey that indicates those in Florida prefer water level conditions between the P80 and P10. The screening presumes that aesthetic values are protected if the Minimum Lake Level equals or exceeds the Historic P80.

The provisional Minimum Lake Level of 108.8 ft NGVD29 for Lake Denton is 0.1 feet higher than the Historic P80 of 108.7 ft NGVD29 developed using the lake water budget model. Since the provisional Minimum Lake Level is not lower than the HP80 elevation, the minimum level was deemed sufficiently protective of aesthetic and scenic attributes.

CHAPTER 6 – PROPOSED MINIMUM LEVELS AND CONSIDERATION OF ENVIRONMENTAL VALUES

6.1 Proposed Minimum Levels

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. The Minimum Lake Level is developed using a process that considers applying professional experience and judgement, and the standards and screenings described in Chapter 5. For Lake Denton a MLL of 108.8 ft NGVD29 was identified at the elevation developed to prevent greater than 15% change in average area to emergent marsh habitat.

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. The High Minimum Lake Level is established at the elevation corresponding to the Minimum Lake Level plus the difference between the Historic P10 and the Historic P50, or alternatively, the HMLL is established at the elevation corresponding to the MLL plus a Reference Lake Water Regime statistic. Based on the availability of Historic percentiles, the proposed HMLL for Lake Denton was set at 112.4 ft NGVD29 by adding the Historic P50 to Historic P10 difference to the proposed MLL.

The current vertical datum used by many federal, state, and local agencies for the contiguous United States is NAVD88. The proposed minimum levels for Lake Denton were therefore converted from elevations relative to NGVD29 to those relative to NAVD88 (Table 6-1). The datum shift was calculated based on third-order leveling ties from vertical survey control stations with known elevations above NAVD88. The NGVD29 datum conversion to NAVD88 is -1.05 ft. for the District water-level gaging station no. 25507 at Lake Denton.

Table 6-1. Proposed Minimum Levels for Lake Denton.

Minimum Levels	Elevation (ft NGVD29)	Elevation (ft NAVD88)
High Minimum Lake Level	112.4	111.4
Minimum Lake Level	108.8	107.8

Proposed minimum levels for Lake Denton are plotted in Figure 6-1 along with the observed water level record for the lake. The approximate locations of the lake margin when water levels equal the proposed minimum levels are shown in Figure 6-2.

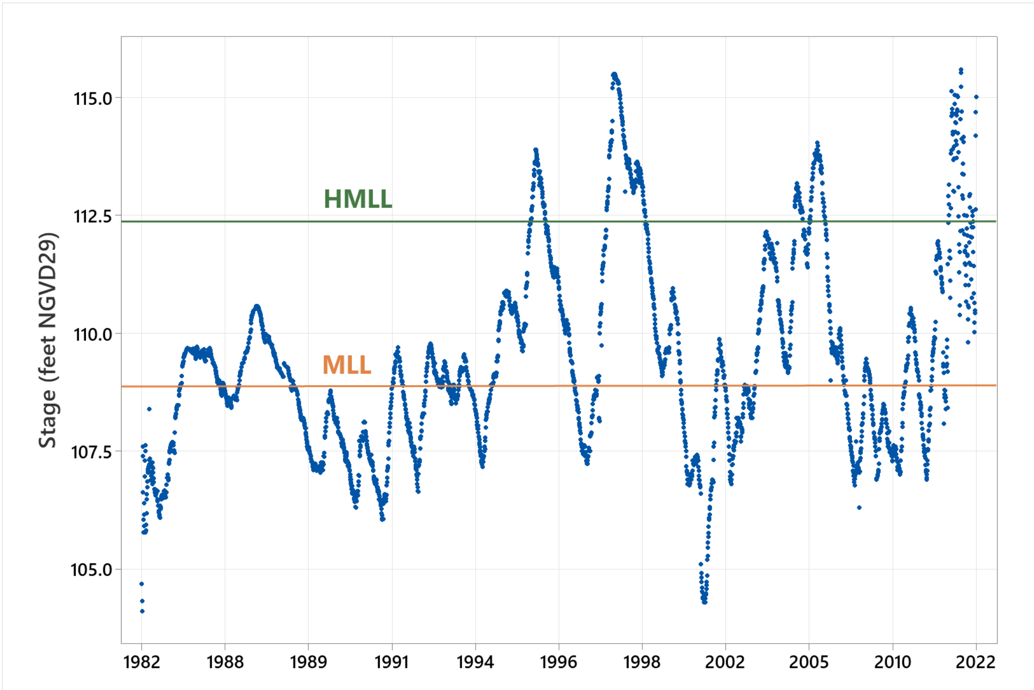


Figure 6-1. Proposed Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for Lake Denton and water level records for the lake from 1982 through 2022.

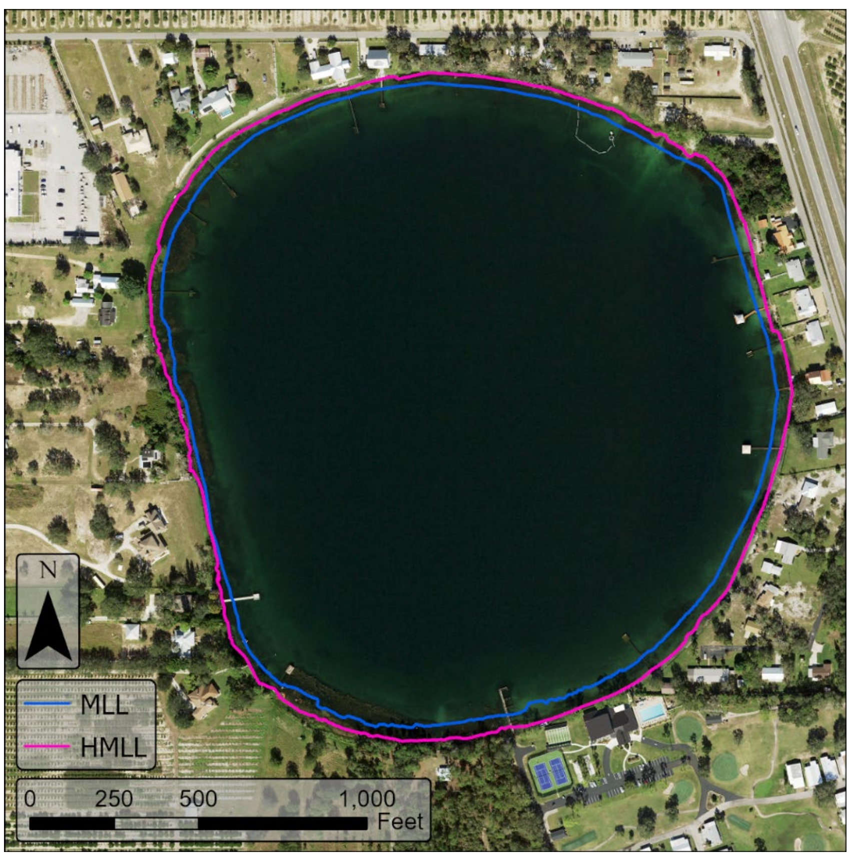


Figure 6-2. Proposed Minimum Lake Level and High Minimum Lake Level for Lake Denton overlayed on a 2023 aerial photograph.

6.2 Consideration of Environmental Values

The minimum levels for Lake Denton 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.). As described in Chapter 5, the District evaluated and considered significant change standards and other available information for the lake that could potentially exhibit sensitivity to long-term changes in lake water levels.

The proposed minimum level for Lake Denton was developed based on the aquatic habitat screening process, with a specific focus on ensuring protection of the emergent marsh habitat zone. This process was designed to prevent reductions exceeding 15% in the average area of emergent marsh habitat relative to historic conditions. The adopted approach aligns with protection of several environmental values identified in Rule 62-40.473, F.A.C., including: recreation in and on the water, relevant 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, water quality, and navigation (summarized in Table 1-1).

Consultation with the Florida Fish and Wildlife Conservation Commission (FWC) was conducted to support the selection of habitat criteria used in establishing the minimum level. Additional documentation, including an official letter of support from FWC and related correspondence, is provided in Appendix A.

In addition, the environmental value of maintenance of freshwater storage and supply is also expected to be protected by the proposed minimum levels based on inclusion of conditions in water use permits that stipulate permitted withdrawals will not lead to violation of adopted minimum flows and levels. Additionally, the cumulative impact analysis that occurs for new water use permits or increased allocations for existing permits must demonstrate that existing legal users and established minimum flows or levels are protected, further linking minimum flows and levels with the protection of freshwater storage and supply. Also, reasonable assurance that construction activities addressed in environmental resource permits will not adversely impact the maintenance of surface or groundwater levels or surface water flows associated with established minimum flows and levels is required.

Two environmental values identified in the Water Resource Implementation Rule were not considered relevant to development of the minimum levels proposed for Lake Denton. Estuarine resources were not considered relevant because Lake Denton is a closed-basin lake that is not connected to an estuarine resource. 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 process typically associated with flowing water systems.

6.3 Comparison of Proposed and Currently Adopted Minimum Levels

The proposed minimum levels identified in this report differ from those currently adopted for Lake Denton (Table 6-2). The proposed High Minimum Lake Level is 1.7 ft lower than the currently adopted High Minimum Lake Level, and the proposed Minimum Lake Level is 4 ft lower than the adopted Minimum Lake Level. These differences are associated with application of a differing modeling approach for characterizing Historic water level fluctuations within the lake, as well as use of additional hydrologic information that has become available since the previous evaluation. The use of updated lake-level methods which differ from those used previously also contributed to differences between the proposed and currently adopted minimum levels. In particular, the use of lake-specific habitat screening, including evaluation of emergent marsh habitat to ensure no greater than 15% reduction in average area relative to historic conditions, contributed to differences between the proposed and currently adopted minimum levels.

Table 6-2. Proposed and existing minimum levels for Lake Denton.

Minimum Levels	Proposed Elevations (ft NGVD29)	Currently Adopted Elevations (ft NGVD29)
High Minimum Lake Level	112.4	114.1
Minimum Lake Level	108.8	112.8

Chapter 7 - MINIMUM LEVELS STATUS ASSESSMENT AND MINIMUM LEVELS RECOMMENDATION

7.1 Status Assessment

To assess the current status and the projected 2045 status of the proposed minimum levels for Lake Denton, P10 and P50 water elevations were calculated by extending recent measured stage data to long-term (1963 to 2022) lake stage using a method similar to the method described in Section 4.3.

The current status used stage data measured at the lake (SID 23816) from 2003 through 2022 (SWFWMD, 2022b). The timeframe was selected based on data availability and regional groundwater use trend (Figure 2-13). This recent measured stage data was then extended to long-term lake stage based on long-term rainfall, using the LOC method. The current P10 is 0.8 ft higher than the proposed High Minimum Lake Level and the current P50 is 1.5 ft higher than the proposed Minimum Lake Level (Table 7-1). These results indicate the proposed minimum levels for Lake Denton are currently being met and development and adoption of a recovery strategy for the lake would not be required in association with adoption of the proposed levels into District rules.

Based on results from ECFTX regional groundwater model (CFWI-HAT, 2022) scenario simulations, UFA drawdown at Lake Denton is estimated to decrease by 5 feet between recent representative (2014) and 2045 withdrawal conditions. This equates to an aquifer recovery of 0.5 ft relative to the water budget model period (see Figure 4-2), and this information was used for a projected 2045 status assessment for the proposed minimum levels for Lake Denton.

Projected water levels from the 2045 withdrawals condition scenario of ECFTX were used in the Lake Denton water budget model to assess the 2045 status. Lake water levels predicted for the 2045 condition with the water budget model were then extended to long-term lake stage values based on long-term rainfall, using the LOC method. The P10 and P50 water surface elevations were then calculated from the resulting long-term lake stages for the projected 2045 condition. The P10 simulated for the 2045 conditions scenario was 1.1 ft higher than the proposed High Minimum Lake Level and the P50 for the scenario results was 1.3 ft higher than the proposed Minimum Lake Level (Table 7-1). These results indicate the proposed minimum levels are projected to be met during the coming approximately 20-year planning horizon and indicate that development and adoption of a specific prevention strategy for Lake Denton would not be necessary or required in association with adoption of the proposed levels.

As the lake is meeting its minimum levels, no recovery strategy is required at this time. However, the lake lies within the region of the District covered by an existing recovery strategy for the Southern Water Use Caution Area (Rule 40D-80.074, F.A.C.).

Table 7-1. Proposed minimum levels and current and projected P10 and 50 water levels used to assess the status of the proposed minimum levels for Lake Denton.

Percentile	Minimum Levels (ft NGVD29)*	Current Water Levels (ft NGVD29)	Projected 2045 Water Levels (ft NGVD29)
P10	112.4	113.2	113.5
P50	108.8	110.3	110.1

* The High Minimum Lake Level is the P10 and Minimum Lake Levels is the P50 that must, respectively, be equaled or exceeded on a long-term basis.

7.2 Minimum Levels Recommendation

Based on results of the reevaluation described in this document, removal of the minimum lake levels established for Lake Denton from the District's Water Levels and Rates of Flow rules (Chapter 40D-8, F.A.C.) and their replacement with a Minimum Lake Level of 108.8 ft NGVD29 and High Minimum Lake Level of 112.4 ft NGVD29 within the rule is recommended.

A status assessment of the recommended minimum levels indicates the levels are being met and are projected to be met during the next 20 years, so there is no need for development and implementation of a water-body specific recovery or prevention strategy. The District will continue to implement its general, three-pronged approach that includes monitoring, annual status assessment of established minimum levels, and regional water supply planning to ensure that the adopted minimum levels for the lake continue to be met. In addition, the District will continue to monitor levels in Lake Denton, other lakes and surface water bodies, and relevant groundwater systems to further our understanding of lakes and as necessary, to refine our minimum level methods.

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Appendix A: Lakes Angelo and Denton FWC Technical Assistance

FWC Letter

May 14, 2025

TJ Venning
Southwest Florida Water Management District
2379 Broad Street
Brooksville, FL 34604
TJ.Venning@swfwmd.state.fl.us

RE: Lakes Denton and Angelo Minimum Flows and Levels Technical Assistance Request, Southwest Florida Water Management District, Highlands County

Dear Mr. Venning:

Florida Fish and Wildlife Conservation Commission (FWC) staff received a request for technical assistance for the above-referenced project. The following comments and recommendations are provided as technical assistance to assist with future project planning and in accordance with FWC's authorities under Chapter 379, Florida Statutes.

Project Description

The Southwest Florida Water Management District (SWFWMD) is in the reevaluation process of the minimum lake levels (MLL) for Lakes Denton and Angelo in Highlands County. Lake Denton is a 66-acre spring filled, closed system lake. The lake is deep and clear with little vegetation or littoral zones. The public can access the lake via a boat ramp on the northeast shore. Lake Angelo is a 56-acre clear-water, closed system lake with no public access. The reevaluation for these lakes includes analyses of fish and wildlife habitat that may be affected by the MLL. The SWFWMD is evaluating the lakes utilizing a metric called the xeric offset standard. This standard will indicate if significant harm is likely to occur when the PE50 elevation (the water level equaled or exceeded 50% of the time) is lowered more than 2.2 feet (ft) below the Historic PE50 elevation (the water level equaled or exceeded 50% of the time associated with current structural alterations but in the total absence of withdrawals).

Comments and Recommendations

On January 23, 2025, FWC and SWFWMD staff met to discuss the application of the xeric offset standard in the analysis of the MLL for Lakes Denton and Angelo. Also discussed was the application of habitat screenings which are used to further evaluate aquatic habitat zones supported by fish and wildlife (and recreation) by using a presumptive standard of no more than a 15% change in average area, relative to historic conditions. The habitat screenings (and water depth ranges associated with each) applied to Lakes Denton and Angelo included:

- Small wading bird foraging habitat (0-0.5 ft),
- Sandhill crane nesting habitat (0.5-1.0 ft),
- Large wading bird foraging habitat (0-1.0 ft),
- Game fish spawning habitat (1.0-4.0 ft),
- Emergent marsh (0-6.0 ft), and
- Open-Water (i.e., deep-water) habitat (>5.0 ft).

FWC staff agrees that evaluating the potential changes in lake habitat zones associated with water level changes is a reasonable approach for protecting ecosystem function, and that the presumptive standard of no more than a 15% change in area relative to historic conditions within

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each zone should therefore be protective of fish and wildlife. The emergent marsh and open water zones broadly encompass the littoral and limnetic portions of the lakes, which functionally represents the entire lake area and volume, as well as the fish and wildlife that depend on those habitats. Habitat zones that support critical life history needs from Florida's iconic and economically important fish and wildlife were also considered to provide a more thorough understanding of potential impacts to those habitats with water level changes.

At Lake Angelo, the xeric offset standard resulted in a MLL of 95.9 ft (NGVD29), and the most limiting habitat zone screening was deep water habitat at a MLL of 96.2 ft (NGVD29), below which the acreage in deep water habitat is expected to be reduced by greater than 15%. At 96.2 ft, 85% of the average historic deepwater habitat is protected, in addition to 93-97% of the average historic habitat acreage from all other habitat zones. FWC staff support the proposed MLL at Lake Angelo of 96.2 ft as it is expected to be protective of ecosystem function and habitats that support fish and wildlife.

Lake Angelo				
Habitat zones	Historic Average Habitat Area (acres)	MLL Average Habitat Area (acres)	% of Historic Average Under MLL Condition	Reduction from historic average (acres)
Small Wading Bird	1.67	1.58	94	0.09
Large Wading Bird	3.34	3.14	94	0.21
Sandhill Crane nesting	1.67	1.56	93	0.11
Game Fish spawning	9.45	9.16	97	0.30
Emergent Marsh	18.88	18.30	97	0.60
Deep Water Habitat	39.95	34.09	85	6.15

At Lake Denton, the xeric offset standard resulted in a MLL of 108.7 ft (NGVD29), and the habitat zone screenings detected limitations for small/large wading bird foraging habitat and sandhill crane nesting habitat. These habitats required a MLL of more than 110 ft NGVD to avoid habitat reductions of greater than 15% within these zones. While the FWC supports the SWFWMD's policy of using the most limiting water resources values to recommend a MLL, in this instance, a MLL of approximately 110 ft NGVD protects negligibly more habitat than a MLL that is about one foot lower due to the lake's topography and limited amount of shallow water habitat. Lake Denton is an unproductive (chlorophyll <2 microgram/liter), deep (maximum depth = 51 ft.) lake with a steep gradient bathymetry. As such, the lake is composed of narrow bands of shallow water habitat, after which the depth drops off rapidly into the profundal zone of the lake. Due to the lake's trophic state and bathymetry, the quality of wading bird foraging habitat and sandhill crane nesting habitat is naturally low relative to other nearby lakes with productive and gentle gradient bathymetry (i.e., Lakes Istokpoga and Kissimmee) that offer vast acreages of shallow water habitat. FWC staff agrees that exceeding the presumptive standard of greater than 15% habitat loss in this instance (approximately 28% reduction in wading bird foraging habitat and 25% reduction in sandhill crane nesting habitat) will not cause significant harm to fish and wildlife given that the reduction from the historic average area to the MLL condition of 108.8 ft (NGVD29) will only amount to a reduction of approximately 1/3 to 3/4 acres in these zones.

Lake Denton				
Habitat zones	Historic Average Habitat Area (acres)	MLL Average Habitat Area (acres)	% of Historic Average Under MLL Condition	Reduction from historic average (acres)
Small Wading Bird	1.48	1.06	72	0.42
Large Wading Bird	2.8	2.05	73	0.75
Sandhill Crane nesting	1.32	0.99	75	0.33
Game Fish spawning	6.24	5.42	87	0.82
Emergent Marsh	12.63	10.76	85	1.87
Deep Water Habitat	57.49	53.92	94	3.57

FWC staff appreciates the opportunity to coordinate early on this project and looks forward to working with SWFWMD staff throughout the final approval process. For specific technical questions regarding the content of this letter, please contact Eric Nagid at (352) 273-3651 or by email at Eric.Nagid@MyFWC.com. All other inquiries may be sent to ConservationPlanningServices@MyFWC.com.

Sincerely,

Josh Cucinella

Josh Cucinella
Land Use Planning Program Administrator
Office of Conservation Planning Services

jc/ms
Denton and Angelo MFL_61807_05142025