Minimum and Guidance Levels for North Lake Wales in Polk County, Florida







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Ecologic Evaluation and Hydrologic Evaluation Sections Resource Projects Department

Southwest Florida Water Management District

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Cover: 1970 and 2006 aerial views of North Lake Wales as captured in black and white imagery collected in March 1970 by the Florida Dept of Transportation) and by true color digital ortho imagery collected on 01/07/2006 by the District.

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Minimum and Guidance Levels for North Lake Wales

State law (Section 373.042, Florida Statutes; hereafter F.S.) directs the Department of Environmental Protection or the water management districts to establish minimum flows and levels for lakes, wetlands, rivers and aquifers. As currently defined by statute, the minimum flow for a given watercourse "shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area", and the minimum level of an aquifer or surface water body is "the level of groundwater in the aquifer and the level of surface water at which further withdrawals would be significantly harmful to the area". Minimum flows and levels are established and used by the Southwest Florida Water Management District (SWFWMD) for water resource planning, as one of the criteria used for evaluating water use permit applications, and for the design, construction and use of surface water management systems.

Development of a minimum flow or level does not in itself protect a water body from significant harm; however, resource protection, recovery and regulatory compliance can be supported once the flow or level standards are established. State law governing implementation of minimum flows and levels (Chapter 373.0421, 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". Recovery or prevention strategies are developed to: "(a) achieve recovery to the established minimum flow or level as soon as practicable; or (b) prevent the existing flow or level from falling below the established minimum flow or level." Periodic re-evaluation and as necessary, revision of established minimum flows and levels are also required by state law.

Minimum flows and levels are to be established based upon the best available information with consideration given to "...changes and structural alterations to watersheds, surface waters and aquifers, and the effects such changes or alterations have had, and the constraints such changes or alterations have placed on the hydrology of the affected watershed, surface water, or aquifer...", with the caveat that these considerations shall not allow significant harm caused by withdrawals (Section 373.0421, F.S.). The Florida Water Resources 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 Southwest Florida Water Management District has developed specific methodologies for establishing minimum flows or levels for lakes, wetlands, rivers and aguifers, subjected the methodologies to independent, scientific peer-review, and in some instances incorporated the methods into its Water Level and Rates of Flow Rule (Chapter 40D-8, F.A.C). For lakes, methodologies have been developed for establishing Minimum Levels for systems with fringing cypress-dominated wetlands greater than 0.5 acre in size, and for those without fringing cypress wetlands. Lakes with fringing cypress wetlands where water levels currently rise to an elevation expected to fully maintain the integrity of the wetlands are classified as Category 1 Lakes. Lakes with fringing cypress wetlands that have been structurally altered such that lake water levels do not rise to levels expected to fully maintain the integrity of the wetlands are classified as Category 2 Lakes. Lakes without at least 0.5 acre of fringing cypress wetlands are classified as Category 3 Lakes. Chapter 40D-8, F.A.C. also provides for the establishment of Guidance Levels, which serve as advisory information for the District, lakeshore residents and local governments, or to aid in the management or control of adjustable water level structures. Information regarding the development of adopted methods for establishing Minimum and Guidance lake levels is provided in Southwest Florida Water Management District (1999a, b), Leeper et al. (2001) and Leeper (2006). Peer-review findings regarding the lake level methods are available in Bedient et al. (1999), Dierberg and Wagner (2001) and Wagner and Dierberg (2006).

Two Minimum Levels and two Guidance Levels have typically been established for lakes, and upon adoption by the District Governing Board, incorporated into Chapter 40D-8, F.A.C. The levels, which are expressed as elevations in feet above the National Geodetic Vertical Datum of 1929 (NGVD), are described below.

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

water levels are expected to equal or exceed ninety percent of the time on a long-term basis.

In accordance with Chapter 40D-8, F.A.C., Minimum and Guidance Levels were developed for North Lake Wales, a Category 3 Lake located in Polk County, Florida. The levels were established using best available information, including field data that were obtained specifically for the purpose of minimum levels development. Following a public input process, which could result in revision of the levels, the District Governing Board approved the levels (Table 1) for adoption and incorporation into Chapter 40D-8, F.A.C on December 14, 2010. Staff prepared amendments to Rule 40D-8.624, F.A.C. that replace the original or previously adopted minimum and guidance levels established in 1991 with the revised or updated minimum and guidance levels described in this report and approved by the District Governing Board. The amendments will become effective once the rulemaking process is completed which is anticipated to occur within the next few months. The data and analyses used for development of the updated levels are described in the remainder of this report.

All elevation data values shown within this report on graphs, bathymetric maps, and within tables are presented relative to National Geodetic Vertical Datum of 1929 (NGVD 29) with feet as the standard unit. In some circumstances notations are made for data that was collected as North American Vertical Datum of 1988 (NAVD 88) (also as feet) and converted to NGVD 29. All datum conversions were derived using Corpscon 6.0, a computer software program developed by the United States Army Corps of Engineers.

Minimum and Guidance Levels	Elevation in Feet		
	NGVD 29		
High Guidance Level	109.8		
High Minimum Lake Level	109.2		
Minimum Lake Level	105.7		
Low Guidance Level	103.8		

 Table 1. Minimum and Guidance Levels for North Lake Wales.

Data and Analyses Supporting Development of Minimum and Guidance Levels for North Lake Wales

Lake Setting and Description

North Lake Wales is located in Polk County, Florida (Section 01 Township 30 South, Range 27 East), in the Peace River Basin of the Southwest Florida Water Management District (Figure 1). The area surrounding the lake is categorized as the Iron Mountains subdivision of the Lake Wales Ridge in the Central Lake Physiographic District (Brooks 1981); a region of residual sand hills underlain by sand, gravel, and clayey sand. As part of the Florida Department of Environmental Protection's Lake Bioassessment / Regionalization Initiative, the area has been identified as the Northern Lake Wales Ridge lake region and described as an area of alkaline, low to moderate nutrient, clearwater lakes (Griffith *et al.* 1997).

The lake is located in the Tiger Creek sub-basin of the Kissimmee River watershed. The lake has a drainage area of 243 acres and is identified as sub-basin M0030 within the City of Lake Wales Watershed Management Plan (SWFWMD 2007). Surface water inflow to North Lake Wales consists of stormwater drainage and overland flow from the residential areas surrounding the lake. There are no major, natural surface water systems draining into the basin, although at least two stormwater systems discharge directly into the lake. The lake has a high level discharge or overflow to the south through an underground stormwater conveyance system to Lake Wales (Figure 2) (SWFWMD 2007).

A topographic map of the lake basin generated in support of Minimum Levels development (Figure 3) indicates that the lake size is approximately 19.4 acres at an elevation of 113 feet above NGVD 29 and 4.9 acres at an elevation of 103 feet above NGVD 29. Data used for production of the topographic map and bathymetric maps were obtained from field surveys completed in 2006 and from Light Detection and Ranging (LiDAR) data collected in 2005.

The landscape of the surrounding lake area is primarily comprised of residential land use, public park land, and schools (Figure 2). Although most of the lake watershed is dominated by residential land use, few homes are located directly on the lake (Figure 2) and the lake is surrounded by a fringe of undeveloped land owned by the City of Lake Wales. The City permits passive recreation and foot traffic within the maintained portions of the lakeshore

The shallow nature of the lake and low water levels occurring during drought periods have allowed for the expansion of emergent wetland vegetation throughout the lake basin. Thick vegetation extends up to an elevation of approximately 105 feet above NGVD, as seen in the 2010 aerial imagery (Figure 3). The dominant plant species observed along the shoreline are primarily Willow (*Salix spp.*), Primrose Willow (*Ludwigia peruviana*), Dog Fennel (*Eupatorium capillofolium*), torpedo grass (*Panicum repens*), and pennywort (*Hydrocotyle spp*). Approximately four young Cypress trees are located at along the west side of the lake an elevation of 104 to 105 ft above NGVD; however, these trees were recently planted during a landscaping project (personal communication with City staff) and cannot be used as natural hydrologic indicators specific to establishing Minimum Levels. The heavy growth of plants within the lake basin is likely to contribute to high evapotranspiration rates and uptake of water within this shallow lake basin.

There are permitted ground water withdrawals within the surrounding lake area, but there are no surface water withdrawals from the lake currently permitted by the District.

Figure 1. Regional and General Location of North Lake Wales in Polk County, Florida.





Figure 2. Location of the lake water level gage, outlet, and control point for **North Lake Wales**



Figure 3. Two-foot contours within the Lake North Wales basin. Values shown are elevations in NGVD 29.



The contours shown (as NGVD) were prepared using a combination of LIDAR data and spot elevation data. LIDAR was collected in 2005 by EarthData International, and spot elevation data was collected by D.C. Johnson and Associates in 2006. The background imagery is true color digital ortho photography collected in 2010.

0	125	250	500	750	1,000
					Feet

Previously Adopted Guidance Levels

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

Based on work conducted in the 1970s (see SWFWMD 1996), the District Governing Board adopted management levels (currently referred to as Guidance Levels) for North Lake Wales in August 1991(Table 2). These levels have been incorporated into Chapter 40D-8, F.A.C. The Guidance Levels adopted included a High Level of 115.0 NGVD 29, a Low Level of 112.00 NGVD 29, and an Extreme Low Level of 110.0 NGVD 29. A Maximum Desirable Level of 114.50 feet above NGVD 29 was also developed, but was not adopted. The previously adopted Guidance Levels and Maximum Desirable Level were developed using a methodology that differs from the current District approach for establishing Minimum and Guidance Levels. The levels do not, therefore, necessarily correspond with levels developed using current methods. Minimum and Guidance Levels developed using current methods will replace existing Guidance Levels upon adoption by the District Governing Board into Chapter 40D-8, F.A.C.

Annually since 1991, a list of stressed lakes has been developed to support the District's consumptive water use permitting program. As described in the District's Consumptive Use of Water Rule (Chapter 40D-2, F.A.C.), "a stressed condition for a lake is defined to be chronic fluctuation below the normal range of lake level fluctuations". For lakes with adopted Guidance Levels, chronic fluctuation below the Low Level is considered a stressed condition. For lakes without adopted levels, evaluation of stressed condition is conducted on a case-by-case basis. North Lake Wales was included on the Stressed Lakes List for 2008, 2009, and 2010 (Gant *et al.* 2008, 2009, 2010).

Guidanaa Lavala	Elevation in Feet		
Guidance Leveis	NGVD 29		
High Level	115.00		
Low Level	112.00		
Extreme Low Level	110.00		

Table 2. Previously Adopted Guidance Levels for North Lake Wales.

Summary Data Used for Development of Minimum and Guidance Levels

Minimum and Guidance Levels for North Lake Wales were developed using the methodology for Category 3 Lakes described in Chapter 40D-8, F.A.C. The levels and additional information used for their development are listed in Table 3. Detailed descriptions of the development and use of these data are provided in the remainder of this report.

Table 3.	Minimum and Guidance Levels, lake stage percentiles, control point
elevation	, significant change standards, and associated surface areas for North
Lake Wal	es.

Levels	Elevation in Feet	Lake Area (acres)	
	NGVD 29		
Lake Stage Percentiles			
Current P10	109.5	16.3	
Current P50	104.8	7.6	
Current P90	100.0	1.0	
Historic P10	109.8	16.7	
Historic P50	106.3	10.3	
Historic P90	103.8	5.9	
Normal Pool and Control Point			
Normal Pool	NA	NA	
Control Point	114.83*	20.5	
Significant Change Standards			
Species Richness Standard	105.7	9.1	
Wetland Offset Elevation	105.5	8.7	
Aesthetics Standard	103.8	5.9	
Lake Mixing Standard	100	1.0	
Recreation/Ski Standard	NA	NA	
Dock-Use Standard	NA	NA	
Basin Connectivity Standard	NA	NA	
Minimum and Guidance Levels			
High Guidance Level	109.8	16.7	
High Minimum Lake Level	109.2	15.5	
Minimum Lake Level	105.7	9.1	
Low Guidance Level	103.8	5.9	

NA = not available/not appropriate

*= control point surveyed as NAVD88 and converted to NGVD 29 using Corpscon v. 6.0

Lake Stage Data and Exceedance Percentiles

Lake stage data, *i.e.*, surface water elevations for North Lake Wales were obtained from the District's Water Management Information System (WMIS) data base (Site Identification Number 25353). Lake stage data in the WMIS data base for North Lake Wales are recorded in NGVD 29. The period of record for the data extends from October 1990 through the present date (Figure 4, see Figure 2 for current location of the SWFWMD lake water level gage), with one water level recorded in August of 1981. The highest surface water elevation for North Lake Wales recorded in WMIS was 112.44 NGVD 29 and occurred on November 08, 2005. The low of record, 100.00 NGVD 29, occurred on multiple dates in 1990, 1991, and in 2001. Although it is likely that the lake level dropped below 100.00 NGVD 29 during this time period the lake gage was not within the water column when the lake surface was below 100.0 feet and actual lake surface elevations were not recorded. Based on available lake stage data, monthly mean lake surface elevations were calculated and graphed (Figure 4). The data record for North Lake Wales from 1990 to present is not continuous, *i.e.*, there are some months during the period of record when lake surface elevations were not recorded.





For the purpose of Minimum Levels determination, lake stage data are classified as "Historic" for periods when there were no measurable impacts due to water withdrawals, and impacts due to structural alterations were similar to existing conditions. In the context of Minimum Levels development, "structural alterations" means man's physical alteration of the control point, or highest stable point along the outlet conveyance system of a lake, to the degree that water level fluctuations are affected. Lake stage data are classified as "Current" for periods when there were measurable, stable impacts due to water withdrawals, and impacts due to structural alterations were stable. Lake stage data from January 1966 through the present date are classified as Current data for lakes affected by the drawdown effects of water withdrawals within the region where North Lake Wales is located (Ellison 2002). The available water level record for the lake was therefore classified as Current data since the continuous period of record starts in 1990.

Because Historic lake stage data are not available for North Lake Wales, a Historic data set of monthly mean lake surface elevations (Figures 5a and 5b) was developed using a 64-year record of modeled lake surface elevations for the period from January 1946 through February 2010. The 64-year period was considered sufficient for incorporating the range of lake-stage fluctuations that would be expected based on long-term climatic cycles that have been shown to be associated with changes in regional hydrology (Enfield *et al.* 2001, Basso and Schultz 2003, Kelly 2004).

Modeled monthly mean lake stage values for the Historic data set were developed using a linear fitting procedure known as the line or organic correlation (see Helsel and Hirsch 1992). The procedure was used initially to describe the linear relationship between available monthly mean lake stage data for North Lake Wales and Crooked Lake (District WMIS Site ID 23857), a large lake located about five miles south of North Lake Wales in Polk County with a long-term stage record that includes water levels that predate the onset of withdrawal impacts to lakes of the region. Crooked Lake was selected because it was subjected to similar drawdown effects at the time of peak withdrawals (SWFWMD 2010 Draft Report). This "initial" line of organic correlation equation was developed based on lake stage data collected in August 1981 and from October 1990 through February 2010, and was used to estimate Historic monthly water surface elevations for North Lake Wales for the period from January 1946 through December 1965 (Ellison and Said 2010, draft report).

A second line of organic correlation equation was then developed to describe the relationship between the Historic monthly water surface elevations for North Lake Wales derived from the initial regression analyses and regional rainfall, as measured at the Mountain Lake rainfall station (District WMIS Site Identification Number 25147) a long-term rainfall gaging station located about 3 miles northwest of the lake in Polk County. Rainfall values used for the analysis consisted of weighted 48-month cumulative totals that were derived using a linear-decay series to weight monthly rainfall values for the forty-eight month periods. The line of organic correlation equation developed for the modeled Historic lake stage and rainfall data collected from January 1946 through December 1965 was used to estimate water surface elevation values for North Lake Wales for the period from January 1966 through May 2000 using cumulative, weighted

rainfall records from the Mountain Lake station, and for the period from July 2000 through February 2010 using similarly weighted rainfall records from the Romp 58 rain gage (District WMIS Site Identification Number 25146). A Historic, composite data set of monthly mean water surface elevations for North Lake Wales for the period from January 1946 through February 2010 was then developed using the modeled water surface elevations derived from the initial and second regression analyses. For comparison, both the modeled Historic monthly lake stage and measured monthly lake stage are shown in Figures 5a.

The Historic data set of modeled monthly mean lake stage values was used to calculate the **Historic P10**, **P50**, and **P90** lake stage percentile elevations (Figure 5b). The Historic P10 elevation, the elevation the lake water surface equaled or exceeded ten percent of the time during the historic period, was **109.8 NGVD 29**. The Historic P50 elevation, the elevation the lake water surface equaled or exceeded fifty percent of the time during the historic period, was **106.3 NGVD 29**. The Historic P90 elevation, the elevation the lake water surface equaled or exceeded fifty percent of the time during the historic period, was **106.3 NGVD 29**. The Historic P90 elevation, the elevation the lake water surface equaled or exceeded 90 percent of the time during the historic period, was **103.8 NGVD 29**.

Figures 5a and 5b: a. Modeled Historic monthly lake stage (blue line) versus measured monthly mean lake stage (red line) for North Lake Wales. b. Modeled Historic monthly lake stage and Historic P10, P50, and P90 lake stage percentile for North Lake Wales for the period from January 1946 through February 2010. All elevations are in feet above NGVD 29.



5a. North Lake Wales Modeled Historic and Measured Lake Stage (as monthly means)



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

The **Normal Pool** elevation, a reference elevation used for development of minimum lake and wetland levels, is established based on the elevation of Hydrologic Indicators of sustained inundation. Because Hydrologic Indicators of Normal Pool were not observed at North Lake Wales, establishment of the Normal Pool elevation was not possible.

The **Control Point** elevation is the elevation of the highest stable point along the outlet profile of a surface water conveyance system (*e.g.*, structure, ditch, culvert, or pipe) that is the principal control of water level fluctuation in the lake. For North Lake Wales, the Control Point was established at the lake outlet pipe which discharges into an underground stormwater conveyance system that flows into Lake Wales (Figure 2). The elevation of the outlet pipe invert was measured at 114.83 NGVD 29 (Figure 2). This elevation is approximately 2.39 feet higher than the highest level recorded for period of record which occurred at 112.44 NGVD 29 on November 8, 2005, and suggests that no discharge from the basin occurred during the period of record.

Structural Alteration Status is determined to support development of Minimum and Guidance Levels. Because of known modifications to the outlet of the lake, North Lake Wales is considered to be Structurally Altered.

Guidance Levels

The **High Guidance Level** is provided as an advisory guideline for construction of lakeshore development, water dependent structures, and operation of water management structures. The High Guidance Level is the expected Historic P10 of the lake and is established using historic lake stage data if it is available, or is estimated using the Current P10, the Control Point and the Normal Pool elevation. The High Guidance Level for North Lake Wales was established at **109.8 NGVD 29** (Figures 6 and 8), based on the Historic P10 elevation derived from the modeled historic water level record.

The **Low Guidance Level** is provided as an advisory guideline for water dependent structures, information for lake shore residents, and operation of water management structures. The Low Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ninety percent of the time (P90) on a long-term basis. The level is established using Historic data, or Current data and reference lake water regime statistics if Historic data are not available. Based on the availability of the modeled Historic water level record, the Low Guidance Level was established at the elevation corresponding to the Historic P90 or **103.8 NGVD 29** (Figures 6 and 8).

Lake Classification

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

Significant Change Standards and Other Information for Consideration

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

Six significant change standards are developed for Category 3 Lakes, including a Species Richness Standard, an Aesthetics Standard, a Lake Mixing Standard, a Recreation/Ski Standard, a Dock-Use Standard, and a Basin Connectivity Standard. A Wetland Offset Elevation is also developed and used along with the significant change standards to identify desired median lake stage elevations that if achieved, are intended to preserve various natural system and human-use lake values.

The **Species Richness Standard** is developed to prevent a decline in the number of bird species that may be expected to occur at or utilize a lake. Based on an empirical relationship between lake surface area and the number of birds expected to occur at Florida lakes, the standard is established at the lowest elevation associated with less than a 15 percent reduction in lake surface area (Figure 7) relative to the lake area at the Historic P50 elevation. For North Lake Wales, the Species Richness Standard was established at **105.7 NGVD 29**. The Species Richness Standard was equaled or exceeded 63 percent of the time, based on the Historic water level record. The standard therefore corresponds to the Historic P63.

Because herbaceous wetland vegetation is common within the North Lake Wales basin, it was determined that an additional measure of wetland change should be considered for minimum levels development. Based on a recent review (Hancock 2006) of the development of minimum level methods for cypress-dominated wetlands, it was

determined that up to an 0.8 foot decrease in the Historic P50 elevation would not likely be associated with significant changes in the herbaceous wetlands occurring within lake basins. A **Wetland Offset elevation of 105.5 NGVD 29** was therefore established for North Lake Wales by subtracting 0.8 feet from the Historic P50 elevation. The standard elevation was equaled or exceeded 67.5 percent of the time, based on the Historic water level record. The standard elevation therefore corresponds to the Historic P67.5.

The **Aesthetics Standard** is developed to protect aesthetic values associated with the inundation of lake basins. The standard is intended to protect aesthetic values associated with the median lake stage from becoming degraded below the values associated with the lake when it is staged at the Low Guidance Level. The Aesthetic Standard for North Lake Wales was established at the Low Guidance Level , which is **103.8 NGVD 29.** The Low Guidance Level was set at the Historic P90. Because the Low Guidance Level was established at the Historic P90 elevation, water levels equaled or exceeded the Aesthetics Standard ninety percent of the time during the Historic period represented by the modeled Historic water level record.

The Lake Mixing Standard is developed to prevent significant changes in patterns of wind-driven mixing of the lake water column and sediment resuspension. The standard is established at the highest elevation at or below the Historic P50 elevation where the dynamic ratio (see Bachmann *et al.* 2000) shifts from a value of <0.8 to a value >0.8, or from a value >0.8 to a value <0.8. The Lake Mixing Standard for North Lake Wales was established at **100.0 NGVD 29** (Figure 7). This elevation is well below the Species Richness Standard. Review of the stage-area information (Figure 7) indicates that the lake size would only be one acre at the elevation corresponding to the Lake Mixing Standard.

Information on herbaceous wetlands is taken into consideration when determining the elevation at which changes in lake stage would result in substantial changes in potential wetland area within the lake basin (*i.e.*, basin area with a water depth of four or less feet). Review of changes in potential herbaceous wetland area in relation to change in lake stage indicated that of use of the Lake Mixing Standard would be inappropriate for establishment of the Minimum Lake Level (Figure 7). A 40% reduction in potential herbaceous wetland area is estimated to occur between the lower elevation associated with the Lake Mixing Standard to the higher water surface was at the Historic P50 elevation. Changes in lake stage associated with changes in lake area available for colonization by rooted submersed or floating-leaved macrophytes are also typically evaluated when establishing minimum lake levels, although sufficient water transparency data were not available for the North Lake Wales for this purpose.

Review of changes in potential wetland area in relation to change in lake stage indicated there would not be a substantial increase or decrease in potential wetland area within the lake basin at the Species Richness Standard relative to the potential wetland area at the Historic P50 elevation. The wetland area would increase from 60.2% of the basin to 63.0% of the basin (2.8% increase). Similarly there would not be a substantial increase or decrease in potential wetland area within the lake basin at the Wetland Offset Standard relative to the potential wetland area at the Historic P50

elevation. The wetland area would increase from 60.2% of the basin to 64.3% of the basin (4.1% increase).

The Recreation/Ski Standard, Dock-Use Standard, and the Basin Connectivity Standard, were not applicable to North Lake Wales. The Recreation/Ski Standard is developed to identify the lowest elevation within the lake basin that will contain an area suitable for safe water skiing. The lake does not meet the minimum lake size or lake depth requirements for establishing a ski standard. The Dock-Use Standard is developed to provide for sufficient water depth at the end of existing docks to permit mooring of boats and prevent adverse impacts to bottom-dwelling plants and animals caused by boat operation. Since there are no docks on North Lake Wales, a dock standard is not applicable. The Basin Connectivity Standard is developed to protect surface water connections between lake basins or among sub-basins within lake basins to allow for movement of aquatic biota, such as fish, and support recreational uses. Because the lake basin depth measurements indicate North Lake Wales does not contain sub-basins, a Basin Connectivity Standard is also not applicable for the lake.

Minimum Levels

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

The **Minimum Lake Level (MLL)** is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis. For Category 3 lakes the Minimum Lake Level is established at the elevation corresponding to the most conservative significant change standard, *i.e.*, the standard with the highest elevation, except where that elevation is above the Historic P50 elevation, in which case, the Minimum Lake Level is established at the Historic P50 elevation. Because all appropriate significant change standards were below the Historic P50 elevation, the Minimum Level for North Lake Wales was established at **105.7 NGVD 29**, the elevation corresponding to the highest of the standards, *i.e.*, the Species Richness Standard.

The **High Minimum Lake Level** (HMLL) is the elevation that a lake's water levels are required to equal or exceed ten percent of the time on a long-term basis. For Category 3 lakes, the High Minimum Lake Level is developed using the Minimum Lake Level, Historic data or reference lake water regime statistics. Based on the availability of Historic data for North Lake Wales, the High Minimum Lake Level was established at **109.2 NGVD 29**, by adding the difference between the Historic P50 and Historic P10 (3.5 feet) to the Minimum Lake Level. The Minimum and Guidance levels for North

Lake Wales are shown in Figure 6 along with monthly mean water surface elevations based on period of record water level measurements

Staging of the lake at Minimum levels would not be expected to flood any man-made structures within the immediate lake basin (see Figures 9, 10, and 11). The High Minimum Lake Level (109.2 NGVD 29) is approximately 5.3 feet lower than the lowest floor slab of a residential storage shed (114.55 NGVD 29, see Table 4) and 10.1 ft below the lowest floor slab of a house (119.26 NGVD 29, see Table 4) within the lake basin. The High Minimum Lake Level is also approximately 10.4 ft lower than the lowest spot on the paved roads (119.64 NGVD 29, see Table 4) encircling the lake. The lowest spot road elevation was measured within the same vicinity of the lowest floor slabs. The High Minimum Lake Level (109.2 NGVD 29) is also approximately 4.2 feet lower than the elevation of the City's sanitary sewer collection system located northerly shoreline areas that has a estimated elevation of 113.4 NGVD 29 based on information published within the City of Lake Wales Watershed Management Plan (SWFWMD 2007).

Water discharges from North Lake Wales to Lake Wales during extreme highs. Although the lake reached its highest recorded elevation for the period of record (112.44 NGVD 29 on November 8, 2005) after the 2004 hurricanes, the lake level remained below the invert elevation of the outfall pipe to Lake Wales (Control point 114.83 NGVD 29) and discharge to Lake Wales was unlikely. The period of record high (112.44 NGVD 29) remained below the lowest floor elevation (114.55 NGVD 29 for shed elevation). It should be noted that the elevation of the lowest floor elevation (shed elevation) is approximately 0.28 feet below the elevation of the invert of the outfall pipe control point (114.83 NGVD 29) so the potential for flooding of this structure exists. The High Guidance Level adopted for North Lakes in 1991 was established at 115.0 NGVD 29 and conflicts with the elevation of the shed that was likely to have been constructed after the levels were adopted in 1991.

Approximate elevation contour locations for the **Minimum Lake Level (MLL)** and **High Minimum Lake Level (HMLL)** are shown for different time periods and various lake stages in Figures 8, 9, and 10. Figure 8 depicts the lake stage observed on January 4, 2010; Figures 9 depicts the lake stage observed on 01/07/2006 and 01/09/2009; and Figure 10 depicts the lake stage observed during March 1970.

Table 4.	Elevations of	ake basin	features	in the imi	nediate l	North	Wales	Basin
	(Xynides 2010))						

Lake Basin Features	Elevation as Feet (NGVD 29)
Low floor slab – Lowest residential structure	119.26
Low floor slab – lowest lake side structure (residential shed)	114.55
Low spot on the paved roads near the lake	119.64

Figure 6. Monthly mean lake stage through February 2010 and Minimum and Guidance Levels for North Lake Wales. The High Guidance Level (HGL) is shown in green, Low Guidance Level (LGL) as brown, High Minimum Lake Level (HMLL) as orange, and Minimum Lake Level (MLL) as red. All elevations shown are NGVD 29.



North Wales, Polk County, City of Lake Wales SWFWMD WMIS SITE ID 25353



Figure 7. Surface area, maximum depth, mean depth, volume, dynamic ratio (basin slope), and potential herbaceous wetland area versus lake stage (NGVD 29) for Lake North Wales.

Figure 8. Approximate location of the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for North Lake Wales during recent basin conditions as documented by aerial imagery collected on 01/04/2010. The estimated lake stage was 101.9 NGVD 29 on the date of the imagery.



Legend

North Wales Minimum Levels Elevation NGVD 29 — 109.2 = HMLL — 105.7 = MLL The contours shown were prepared using a combination of LIDAR data and spot elevation data. LIDAR was collected in 2005 by EarthData International, and spot elevation data was collected by D.C. Johnson and Associates in 2006. The background imagery is true color digital ortho photography collected in 2010.



Approximate location of the Minimum Lake Level (MLL) and High Figure 9. Minimum Lake Level (HMLL) for North Lake Wales as associated with conditions observed on 01/09/2009 (top) and on 01/07/2006 (bottom). The lake stage was 105.94 NGVD 29 on 01/09/2009 and was 112.31 NGVD 29 on 01/07/2006.



Elevation NGVD 29 - 109.2 = HMLL - 105.7 = MLL

in 2006. The background imagery was collected on 01/09/2009. The elevation of the lake was 105.94 NGVD on the date of the imagery. 260 390 65 130 520

Feet



0

Legend - 109.2 = HMLL 105.7 = MLL

The contours shown were prepared using a combination of
 Legend
 The contours shown were prepared using a combination of LIDAR data and spot elevation data. LIDAR was collected in 2005 by EarthData International, and bathymetric spot elevation data was collected by D.C. Johnson and Associates in 2006. The background imagery was collected on 01/07/2006. The elevation of the lake was 112.31 NGVD on the date
 of the imagery. 0 65 130 260 390 520 0

Feet

Figure 10. Approximate location of the Minimum Lake Level (MLL) and High Minimum Lake Level (HMLL) for North Lake Wales as associated with conditions observed in March 1970. Lake stage records are not available during this period; however, the estimated elevation was 104.5 NGVD 29 based on the lake basin contours.



Legend North Wales Minimum Levels Elevation NGVD 29 — 109.2 = HMLL — 105.7 = MLL The contours shown were prepared using a combination of LIDAR data and spot elevation data. LIDAR was collected in 2005 by EarthData International, and spot elevation data was collected by D.C. Johnson and Associates in 2006. The background imagery was collected in the 1970s.



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