# SJRWMD Responses to Peer Review Comments Regarding the Draft MFLs for Lakes Brooklyn and Geneva, Clay and Bradford Counties, Florida

February 8, 2021

## Introduction

Independent scientific peer review was conducted for the draft Lakes Brooklyn and Geneva MFLs Report by two firms: Cardno and HSW Engineering. In addition, the revised environmental criteria were reviewed by Brown and Caldwell. Peer review comments on environmental criteria, minimum level and hydrological dataset development were based on review of the following documents and files:

- *Minimum Levels Reevaluation for Lakes Brooklyn and Geneva, Clay and Bradford Counties, Florida (Draft SJRWMD Report; Sutherland et al., 2018);*
- *Revised Environmental Criteria for Establishing Minimum Levels for Lakes Brooklyn and Geneva, Clay and Bradford Counties, FL (SJRWMD Technical Memorandum; June 8, 2019);*
- *A draft presentation summarizing the methodology used to determine and assess the proposed MFLs for Lakes Brooklyn and Geneva; and*
- *Spreadsheets including details of hydrologic analyses.*

This resolution document provides responses to peer review comments submitted by Cardno on June 12, 2018, and HSW on June 5, 2018, and peer review comments regarding revised environmental criteria submitted by Brown and Caldwell on September 13, 2019; *see attached for peer review documents*.

## Cardno Comments

***Comment #1 [ES pg. vi]:*** *Regarding the multi-decadal periods of high and low lake levels, the Panel is concerned about applying standards across the entire period of record. In particular, the Panel does not believe the dock standard is appropriate when applied across the entire period of record.*

**Response:**
We agree with the concerns regarding this metric and have removed it from the MFLs determination.

***Comment #2 [ES pg. vi]:*** *The Panel questions the appropriateness of using the aesthetic standard.*

**Response:**
The District agrees with concerns about the applicability of results from the Hoyer et al. (2006) survey to an aesthetics standard/threshold for Lakes Brooklyn and Geneva. As noted by Cardno, the respondents to the survey lived on lakes with very different characteristics from Lakes Brooklyn and Geneva. The majority lived on shallow lakes with low bank slopes, such that even small changes in water levels would have large effects on exposed shoreline and pool area. Because none of the lakes in the survey are similar to Lakes Brooklyn and Geneva, we agree that using this study is not appropriate. As such, the aesthetics standard as described (20% reduction in P50 exceedance under

the No-Pumping condition) is also not appropriate; therefore, this metric was not considered in the final MFL determination.

However, we agree that incorporating some threshold of change for pool size would protect multiple functions and values, including aesthetics. As is noted later in this document, the open water metric suggested by Cardno would be a better tool for protecting aesthetics and scenic values. The open water metric is detailed below.

***Comment #3 [pg. 2-10]:*** *Regarding the use of SWF's Lake Mixing Standard:*
*Given the Panel's concern regarding the significant differences likely to occur between the prolonged "wet" and "dry" period as discussed above, we wonder if the lake mixing standard would come into to play during the "dry" period.*

***Recommendation:*** *We recommend SJRWMD investigate this possibility.*

**Response:**
The District agrees with Cardno's suggestion that water quality (and other functions and values) could be addressed and protected with an open water metric. We used the suggested open water metric in lieu of using the SWFWMD's mixing standard. By providing a threshold of change for open water, depths sufficient for stratification or maintaining natural nutrient processing will also be protected. The open water metric is discussed below.

***Comment #4 [pgs. 2-11, 2-12]:*** *Regarding fish and wildlife criteria developed using the hydroperiod tool: "… is game fish spawning a seasonal occurrence, or is it assumed that spawning occurs throughout the year?"*

**Response:**
As stated in the report the water depth range used is meant to protect both spawning habitat and general forage and refugial habitat for small-bodied fish (i.e., non-game species and young-of-the-year of game species).

***Comment #5 [pg. 2-2]:*** *Part of [protecting a hydrological] regime included incorporation of an infrequent flood (IH) based on preventing a downward shift in the upland boundary at either Lake Brooklyn or Lake Geneva. The return interval, however, for meeting this criterion is so long (25 years) that it would not be protective of other water resource values that require protection in intervening years. This is analogous to protecting high flows in lotic systems but would not be protective of intermediate or low flows. Analogously, intermediate lake levels (e.g., the P50) and lower lake levels (e.g., <P50) would not necessarily be protected.*

**Response:**
We agree. Protecting lower water levels (e.g., P50 or lower percentiles) is the rationale behind evaluating other metrics beyond our standard event-based criteria. As discussed below, this is also the

rationale for assessing metrics with no specific critical elevation (e.g., the new open water metric) at multiple percentiles (i.e., the P25, P50 and P75).

***Comment #6 [pgs. 2-6, 2-7]:*** *Some environmental values that are applicable to the lakes do not appear to have been explicitly evaluated. For instance, water quality and filtration and absorption of nutrients are not listed in Table E-1.*

**Response:**

While not evaluated as a primary criterion, water quality was explicitly evaluated as part of the consideration of environmental values, per 62-40.473, F.A.C. (pages 81 – 92 of draft MFLs report reviewed). The MFLs condition, based on the most constraining criterion for each lake, was used for this assessment. Filtration and absorption of nutrients (environmental value #7) and water quality (environmental value #9) were both evaluated by comparing the exceedance of critical elevations associated with state standards between the no-pumping condition and MFLs conditions, for each lake.

***Comment #7 [pgs. 2-8, 2-9]:*** *Regarding SWF's Species Richness Standard:*

***1.*** *The types of habitats around [Brooklyn and Geneva] are very different from the habitats around lakes sampled in the previous studies. In particular, while the Emery et al. study focused on lake area, the study strongly emphasized lake edges. Lake edges…generally included bands of cypress trees and sometimes areas of marsh, some of them extensive, and for some lakes, suburban lawns. By contrast, at most water levels, the lake edge for Lake Brooklyn is best described as bare, white sand. The edge for Lake Geneva is generally low grasses / forbs generally those associated with rapid (weedy) growth. The assumption that bird species diversity will change within an individual lake if lake surface area is permanently reduced from some average condition must be accepted. There may be technical issues with the sampling design used in the SWFWMD study. The survey results were assumed to represent species richness, yet no analysis was done of sample adequacy for determining richness, especially on the smaller lakes in the study. The larger a lake is the more species it is likely to support because (all things being equal) it provides more niches. However, we are unsure if the greater number of species encountered with increasing lake area was due to the greater area or to the greater sampling effort that appears was used on large lakes. The lakes assessed in the SWFWMD study that were used to develop the criterion varied substantially in diversity (and lack thereof) of shoreline environments among lakes of similar size. A component of the study suggested that there was a significant reduction in species diversity for lakes surrounded by development, and that the change in species richness with change in lake size was significantly different for lakes surrounded by urbanization than those not surrounded by urban areas. This suggests that even among lakes of similar size, the predictive relationship may change, although we support the assumption that all things being equal, larger lakes would exhibit greater diversity than smaller. Chiefly on the basis of observation #3 above that deals with the adequacy of sampling effort per lake in the two studies, the Panel recommends that this criterion not be used.*

**Response:**

We agree with the concerns regarding applying this metric to Lakes Brooklyn and Geneva, and for these reasons have removed this metric from the MFLs determination.

***Comment #8 [pg. 2-9, 2-10]:*** *Regarding SJRWMD not using SWF's Mixing Standard:*
*The Panel, notes that this criterion would relate to water quality and filtration and absorption of nutrients and other pollutants. The Panel believes that there are other criteria which could be developed based on available data. Nutrient processing and retention in lakes and ponds is dependent on depth, vegetation, area, and time, among others.*

***Recommendation:*** *The Panel suggests that SJRWMD consider standards that have been developed for treatment wetlands, and consider developing a criterion, much like the habitat criteria used by SJRWMD for fish and wildlife, based on depth ranges at which key nutrient processing is efficient. Given the Panel's concern regarding the significant differences likely to occur between the prolonged "wet" and "dry" period as discussed above, we wonder if the lake mixing standard would come into to play during the "dry" period. We recommend SJRWMD investigate this possibility.*

**Response:**
As discussed above (response to Comment #3), we agree with Cardno's suggestion that water quality (and other functions and values) could be addressed and protected with an open water metric. We developed the suggested open water metric in lieu of using the SWFWMD's mixing standard. By providing a threshold of change for open water, depths sufficient for stratification or maintaining natural nutrient processing will also be protected.

To address the "wet vs dry" issue, the District has decided to assess metrics using the entire POR, and for area-based metrics to set an allowable change (15% reduction from no-pumping condition) to the average condition. By doing this, 1) all elevations, with their differing sensitivity to pumping impact, are considered; 2) small elevation-specific differences in freeboard/deficit are averaged over the entire lake level regime; 3) functions and values at high, low and average water conditions are protected; the subjectivity of determining specific high (wet) and low (dry) periods is avoided, as both wet and dry conditions are included in the analyses; and 4) multiple percentiles, spanning the entire regime, are used in the analyses; the average across the regime is the central tendency, instead of a median.

***Comment #9 [pg. 2-12]:*** *Regarding emergent marsh metric:*
*This section would benefit by citing literature supporting the choice of the outward extent of the marsh (i.e., 6 feet at outside edge); although, it is the opinion of the Panel that six (6) feet is a reasonable figure.*

**Response:**
We agree that the depth range is reasonable. The waterward extent is based on the species present at both lakes, and their depth tolerances. Depth tolerance data is based on scientific literature and data collected at numerous sites across the District.

***Comment #10 [pg. 2-12]:*** *Regarding small and large wading bird metrics:*
*…habitat definition appears to be reasonably supported but might be strengthened by citing other literature dealing with habitat suitability analyses.*

**Response:**
We agree. Additional citations have been added.

***Comment #11 [pg. 2-13]:*** *SJRWMD evaluated gain or loss of the various habitats as defined above using changes in area of each respective habitat type at three percentiles (P25, P50 and P75). In more stable lake environments (those varying over a much smaller range of elevations), one would only need to assess gain or loss of habitats at percentiles representative of higher elevations (e.g., P75 or greater), since wetlands occur at lake edges. However, given the wide range of lake level fluctuation at Lakes Brooklyn and Geneva, even in the absence of withdrawals, it is appropriate to evaluate these habitats over a range of percentiles. Overall, the Panel supports the use of these habitat metrics as reasonable criteria protective of certain fish and wildlife values.*

**Response:**
Instead of selecting specific percentiles, the District has decided to protect the entire MFLs curve by assessing metrics using the entire POR. By doing this, 1) all elevations, that may have differing sensitivity to pumping impact, are considered; 2) small elevation-specific differences in freeboard/deficit are averaged over the entire lake level regime; 3) functions and values at high, low and average water conditions are protected; the subjectivity of determining specific high (wet) and low (dry) periods is avoided, as both wet and dry conditions are included in the analyses; and 4) multiple percentiles, spanning the entire regime, are used in the analyses; the average across the regime is the central tendency, instead of a median.

***Comment #12 [pgs. 2-14]:*** *SJRWMD dock standard: A large proportion of the permanent docks in the Property Appraiser's database appear to have been built during or shortly after the end of the period of high rainfall that characterized the 1960s and early 1970s with a few additional docks built during and after more recent brief high-water events. As a result, we have concerns with the use of a mean end-of-dock elevation in the methodology used to develop the criterion.*

**Response:**
To address these concerns, the District evaluated whether the assessment of the dock access metric would yield significantly different results (i.e., allowable lake level reduction) for docks built at different times (i.e., under wetter, drier or average conditions). A sensitivity analysis was conducted to determine if the allowable shift (15% reduction in exceedance) varies significantly from the mean dock elevation to +/- 1 standard deviation (SD) above/below mean elevation. The standard deviation for dock elevations (waterward dock piling elevations) at Lake Brooklyn and Lake Geneva is 1.7 ft and 3.7 ft, respectively (i.e., a range of 5.4 feet). The sensitivity analysis, based on draft hydrological data, showed that the freeboard/deficit calculation varied significantly from the mean elevation minus 1 SD to the

mean elevation plus 1 SD; there was an approximate doubling of freeboard/deficit, based on draft hydrological data. Therefore, the District agrees with the concerns raised by Cardno about using the mean dock elevation for such a highly fluctuating system, where freeboard/deficit calculations are very sensitive to small changes in elevation.

The District also agrees that the critical elevation for this metric (i.e., dock elevation) is subject to when the homeowners happened to build their dock, and the resulting allowable water level reduction varies significantly based on whether docks were built during wet or dry periods.

For these reasons the District did not use this the dock access metric in the final MFL determination.

***Comment #13 [pgs. 2-14]:*** *Assuming that most docks, especially the ones with permanent pilings, were constructed primarily under "wet conditions" such as occurred from the late 1950s to the early 1970s, the waterward dock piling elevation would be located relatively high in the landscape compared to what might have occurred under "dry conditions." If this hypothetical were true, the standard could be viewed as protecting an artificially high condition.*

**Response:**
See response to Comment #12.

***Comment #14 [pgs. 2-14]:*** *Based on the docks for which construction dates are available, it appears that "permanent" docks were constructed during generally wet conditions.*

**Response:**
See response to Comment #12.

***Comment #15 [pgs. 2-15]:*** *The Panel's initial reaction to the dock standard was that it was seeking to protect access that would simply not exist much of the time, and we questioned the applicability of the standard to these lakes. However, the standard as proposed by SJRWMD would likely protect access from these docks under wet climatic conditions, but not all conditions.*

**Response:**
See response to Comment #12.

***Comment #16 [pgs. 2-15]:*** *Lack of access from docks for long periods of times cannot simply be attributable to groundwater withdrawal impacts and the complete cessation of groundwater withdrawals will not substantially improve access for much of the time. This is especially true for Lake Geneva, because it appears that docks located on this lake would not have water under them during multi-decadal dry periods. In Lake Brooklyn, access might be improved slightly during dry periods.*

**Response:**
See response to Comment #12.

***Comment #17 [pgs. 2-16]:*** *Some members on this panel (Jones et al. 2017) and others (Neubauer et al. 2007) have been critical of using exceedance probability curves because they can obscure seasonal and even decadal trends in the data. This approach would explicitly address the climatic variability so evident in the data. Using the dock standard for Lake Brooklyn as an example, there were short periods of time where it appears there would technically have been dock access during the dry period, and these days added to the count of the number of days of access, even when it might be argued the docks were essentially not useable because the period of access was small.*

**Response:**

Based on comment #1, the District is no longer using the dock access metric. However, we do not concur that relevant parts of the hydrologic regime are "obscured" by using an exceedance curve approach for the dock access metric. Neubauer et al. (2008, *not 2007*) advocates against the use of exceedance (or duration) curves for ecological metrics that require hydrological events that are tied to specific life-history requirements, plant physiology, recruitment dynamics, etc.

***Comment #18 [pg. 2-16]:*** *The Panel also wonders if SJRWMD has given any thought to evaluating all its proposed criteria under essentially two different elevation regimes by segregating the no-pumping record (1957 to 2015) into a "wet" and a "dry" period.*

**Response:**

We agree that, given the highly fluctuating nature of these lakes, it is appropriate to assess metrics under different conditions. This is done in two ways:

- For metrics with a specific critical elevation, our approach already divides the entire POR into periods when the elevation is exceeded (i.e., non-continuous "wet" portions of the POR) and periods when not exceeded (i.e., non-continuous "dry" portions of the POR).
- For area-based metrics, the District has decided to assess these using the entire POR. By doing this, 1) all elevations, with their differing sensitivity to pumping impact, are considered; 2) small elevation-specific differences in freeboard/deficit are averaged over the entire lake level regime; 3) functions and values at high, low and average water conditions are protected; the subjectivity of determining specific high (wet) and low (dry) periods is avoided, as both wet and dry conditions are included in the analyses; and 4) multiple percentiles, spanning the entire regime, are used in the analyses; the average across the regime is the central tendency, instead of a median.

***Comment #19 [pgs. 2-17]:*** *As illustrated in Figure 4, panel C, to construct a dock in Lake Brooklyn or Lake Geneva that would allow access under most conditions, the height of the most waterward piling would need to be extremely high, and the length of the dock excessively long. Such a dock seems impractical for a number of reasons (e.g., cost, safety, and aesthetics). The Panel does understand how the dock standard works as applied by SJRWMD, but wonders if a dock standard is to be used, should it be applied to a hypothetical dock as shown in panel C (which seems impractical) or evaluated only for access during wet periods.*

**Response:**
See responses to Comments #1 and #12

***Comment #20 [pg. 2-17, 2-18]:*** *Regarding Alternative Recreational Standards: The Panel is in agreement with SJRWMD that SWFWMD's ski standard does not appear applicable to these lakes; however, a similar type of recreational standard might be considered based on the discussion that SWFWMD provided, "Certain recreational activities such as water skiing are dependent on open water, free of emergent, floating or near surface submerged vegetation." Leeper et al. (2007) cites work done by Wagner (1991) related not only to the open area of water required for water skiing but also the amount of depth needed for safe operation of power boats (see also Table 1 in Mosisch and Arthington (1998)). As an example, a standard might consider the amount of open water in the lake with at least 4 feet of water depth. If, for discussion purposes, 20 acres of open water are required per boat, the carrying capacity for boats at the no pumping P50 elevation might be determined. Supposing the lake is able to support 20 boats at this elevation, then the standard might be no more than a 15 percent reduction in the lake's carrying capacity. In this example, the lake's recreational boating potential is protected by allowing the P50 elevation to decline to the point where boat carrying capacity is 17 boats (i.e., 20 * 0.85 = 17). We believe that open water has ecological value, and this criterion could also be considered protective of the fish and wildlife water resource value, but supportive literature would need to be provided.*

**Response:**
We agree that it is appropriate to pursue alternative recreation standards. We also agree that developing a new open water metric is a good idea because it would serve to protect multiple important functions and values, including recreational activities, fish and wildlife habitat and water quality. One potential approach, suggested by Cardno, would be to consider an allowable change to open water when depth is at a minimum (e.g., based on the safe operation of power boats; they give 4 ft as an example). For Lakes Brooklyn and Geneva depths this low (in the main lobes of each lake) are below the P100 (i.e., not recorded in the observed POR). However, we agree that including an elevation with a minimum depth is appropriate for an open water metric; the depth used is 5 ft based on a range recommended by the U.S. Coast Guard for safe boating.

***Comment #21 [pg. 2-19]:*** *Boat ramps, may provide more tractable approaches to developing a recreational standard than docks. Rather than attempting to use the existing locations of docks, it may be possible to use boat ramp design standards to develop a standard that is based on design criteria for boat ramps as opposed to attempting to determine a suitable elevation for the end of a multitude of docks. Boat ramps always begin at or above the lake edge and extend outward to a depth where a boat will float with the propeller in adequate water depth for the prop to not cause erosion beyond the end of the ramp. The ramp then being closed when the water depth is inadequate. Unlike residential docks, multiple governmental entities have design standards, most of them quite similar, for determining the amount of water needed at the bottom of a ramp such that boat propellers will not wash out the bottom, usually on the order of 3 to 4 ft. If the boat ramp is designed to be used 90 percent of the time under no-pumping conditions, then the allowable time of inadequate depth, increased by 15 percent, could become a criterion for recreational use.*

**Response:**

Regarding assessing any metric relative to the elevation of man-made structures (i.e., public boat ramps, docks, etc.), the District considers it inappropriate to assess criteria based on man-made structures that were located based on the climatic conditions occurring at time of construction. This is in agreement with Cardno's concerns regarding subjectivity of using dock access elevations for MFLs metrics.

The elevations of boat ramps, docks and other man-made structures are largely a function of the climatic conditions under which they were built. Also, sensitivity analyses of dock elevations at Lake Brooklyn demonstrated that small differences in elevation result in meaningful differences in freeboard/deficit. Therefore, criteria based on dock or boat ramp elevations were determined to be inappropriate for such highly fluctuating lakes.

***Comment #22 [pg. 2-20]:*** *Lake Connectivity Elevation Standard: "The purpose of this criterion is to prevent a significant change due to water withdrawal, relative to historical conditions, in the duration of continuous surface-water connections between lake lobes. The metric is based on the minimum water depth required for lake lobe connectivity . . . to which an offset (boat final) is added to provide sufficient depth for boating or other forms of recreation" (Sutherland et al. 2018). The panel would add that this metric is also protective of fish passage between lake lobes and thus addresses, in part, at least two water resource values. We believe that this metric protects water quality especially in more shallow lobes by allowing water exchange between lobes. Generally as water depth is decreased in lakes, water quality is negatively affected due to increased temperatures, lowered DO, potential for increased algal blooms as nutrients become concentrated, and negative effects resulting from resuspension of sediments (e.g., reduced clarity, introduction of potential sediment contaminants into the overlying water column). The Panel can think of no water quality positives that accrue as lake lobes are disconnected, and a number of obvious and potential negatives, as such this is a good metric even if connections occur at relatively high elevations under current conditions.*

**Response:**

We agree that maintaining lake connectivity has many benefits, including recreational, water quality and fish and wildlife benefits.

***Comment #23 [pg. 2-20]:*** *We did find one possible data issue that could affect results under low water connections. Once connections between various lobes are lost, it cannot necessarily be assumed that elevations within disconnected lobes will track one another due to differences in bathymetry between lobes and potentially different leakance rates. While it might be possible that below surface water transfer could maintain similar levels between pools, this is less likely under dry periods than wet periods. This would potentially affect any calculation for standards where the relevant exceedance percentiles are below the highest connectivity elevation for each lake (e.g., some of the fish and wildlife habitat metrics).*

**Response:**

We agree with the comment/concern but are also aware that the standard for MFLs is "best available data." Water level data does not exist for each individual lobe for either lake, and therefore we must use available data for our analyses. However, to address this concern the District conducted a sensitivity analysis using the hydroperiod tool (stage/area curve) and an analysis of historical aerial photographs to determine whether specific lobes seemed to track differently from the gaged primary lobe of Lake Brooklyn. We determined that the two smallest lake lobes did fluctuate slightly differently. We tested whether the most sensitive metric (i.e., the open water area) would be significantly more constraining if the two smallest lobes had a larger area than indicated by the gaged data and hydroperiod tool stage/area curve. We found that increasing the area in the two smallest lobes did not significantly change the deficit due to the open water area metric; the change was less than a tenth of a foot.

***Comment #24 [pg. 2-22]:*** *Except for a short period, Lake Geneva Lobe 3 is only connected to the main body of the lake during the "wet period" as demonstrated in Figure 6 (Figure 7 of the final MFL Report). The Panel wonders what the outcome of this analysis would have been if done for distinct wet and a dry periods.*

**Response:**

As noted above, our approach only applies the threshold to those time periods (non-continuous portions of the POR) when the lake connection elevation is exceeded. As such, we are not applying the standard to the entire POR. The non-continuous portions of the POR when water levels are below the critical elevation are not part of the analysis. Therefore, our current approach only involves the "wet" portions of the POR, and thus addresses Cardno's concern.

***Comment #25 [pg. 2-22]:*** *Although the SJRWMD devotes considerable space and effort in their report to significant climatic differences that persist for multi-decadal time periods, it is hard to understate this impact on the water budgets and the ecology of these lakes. Relying solely on exceedance probability curves, it is possible to lose touch with important seasonal, annual, and multi-decadal differences that can occur due to an averaging affect as discussed by Neubauer et al. (2008) regarding the use of flow duration curves (analogous to exceedance probability curves) on environmental flow assessments. Quoting, "Magnitude and duration are often presented graphically as traditional flow-duration curves (FDCs) that display the relationship between flow and percentage of time a particular flow is exceeded. . . Unfortunately, FDCs are not sufficient to characterize or implement SJRWMD MFLs because these are: period of record dependent, tend to oversimplify and essentially average the data. Extending this example to a lake with a water level that is exceeded 10 percent of the time during a 50-year period could be the result of stage data collected during five consecutive wet years (i.e., 1826 consecutive days above the 10 percent time exceeded water level) or yearly flood events that last for 36.5 days duration each."*

**Response:**

See response to Comment # 17.

***Comment #26 [pg. 2-23]:*** *SJRWMD Aesthetics – Lake User Perception*

*The Panel, however, has concerns about the applicability of the survey to Lakes Brooklyn and Geneva and to other high fluctuation lakes, primarily due to the wide natural fluctuation regimes in these lakes and the under-representation of such lakes in the survey. It appeared from the survey results that some of the most common uses of the lakes were likely dependent on aesthetics, for instance, sitting and enjoying the lake was the most common activity recorded in the survey. Bird and wildlife watching were also common activities reported in the survey. Hoyer et al. (2006) included in their survey a list of lakes that the respondents live on or use. The overwhelming majority of these lakes are described by respondents as relatively shallow lakes with gradually sloping shorelines, and to our knowledge, few, if any have natural fluctuations as broad as those found on Lakes Brooklyn and Geneva. The Panel is unaware of any studies of user preferences that would be more appropriate to these lakes and fully acknowledges that MFLs are to be based on best available information. The Hoyer et al. (2006) study did not address the area of the lake pool and the width of dry shoreline above the water, both of which could affect user perceptions of aesthetics on Lakes Brooklyn and Geneva. While clearly these opinions would also affect no pumping conditions, the Panel believes that incorporating some aspect of pool size into the criteria, or adding pool size as an additional criteria would be beneficial in protecting aesthetic values on these lakes.*

**Response:**
This metric has been removed.

***Comment #27 [pg.2-24]:*** *Aesthetics are more than a personal preference because they also affect property values. Given that property values can be evaluated numerically and objectively, the Panel suggests that SJRWMD consider adding an evaluation of effects of water level change on property value in any future effort.*

**Response:**
Because it is not part of the statutory mandate for MFLs to consider the economic (non-environmental) effects of withdrawal on priority water bodies, we are not evaluating the change in water level on property value.

***Comment #28 [pg. 2-24, 2-25]:*** *Regarding the adopted sandhill lakes comparison:*
*Although the mean percent reduction in mean depth for the 33 lakes allowable under their respective minimum levels was 5.6 percent; the allowable percent change in lake depth was 11.6 percent for SJRWMD lakes and 4.3 percent for SWFWMD lakes. All the minimum levels on the lakes in this analysis were set using separate methods from those used on Lakes Brooklyn and Geneva as discussed in the final MFLs report. The 6 SJRWMD minimum levels were set using their standard approach which required the presence of stable wetlands and wetland soils. The 27 SWFWMD lake minimum levels were set using one criterion from a suite of multiple criteria; criteria which were generally found unsuitable for application to Lakes Brooklyn and Geneva. In addition, while multiple criteria were evaluated for each lake, the vast majority of the minimum levels on SWFWMD lakes were set using a single criterion (i.e., "wetland offset", see Hancock 2007) that was not evaluated by SJRWMD. Had it been assessed, it would likely have been considered unsuitable for use, since it was based on protecting fringing lake wetlands. This single criterion is important, however, because it explains the mean allowable P50 change on SWFWMD lakes regardless*

*of lake depth. This criterion simply allows the P50 to be reduced by no more than a 0.8 from the historic P50. This was the criterion applied on 19 of the 27 SWFWMD lakes; hence the average of 0.77 feet for SWFWMD lakes as a group. As far as a test of reasonableness, we are not sure that the results support the claim of "an average (and range) of allowable change for sandhill lake minimum levels throughout Florida."*

**Response:**

We agree that, given the large variation in lake type, fluctuation and how the MFLs were established, that this comparison across districts does not represent an average allowable change for sandhill lakes.

***Comment #29 [pg. 2-26]:*** *The Panel explicitly addressed the use of the 15 percent change standard, and although it has been criticized by some, we find it acceptable and reasonable. We did suggest that SJRWMD consider applying their analysis to both a "wet" and a "dry period." This would not substantively change the methods or approach; however, it is possible, as explained in our narrative, that the use of single exceedance probability curves for each lake "essentially average the data." It is possible, however, that use of two periods rather a single period of record would lead to different recommended levels.*

**Response:**

Regarding the 15% threshold: we agree. Further, the District agrees with Cardno that, in the absence of statutory guidance and in the absence of a clear breakpoint (i.e., threshold) exhibited by empirical data, using professional judgement regarding significant harm is appropriate.

Regarding the issue of assessing during wet vs dry periods, see response to Comment #18; Regarding the use of exceedance curves for assessment, see response to Comment #17.

***Comment #30 [pg.2-26]:*** *The Panel strongly supports the use of multiple criteria and the concept of adopting the more conservative outcome; however, we have raised issues regarding specific methods (e.g., dock use, aesthetics), and these are addressed under the discussion of each. The reader will need to review the individual method discussions for each criterion for details of our particular concerns.*

**Response:**

We agree that using multiple metrics is appropriate, especially for systems with a high range of natural fluctuation.

***Comment #31 [pg. 2-27]:*** *Whether considered an assumption or not, we suggested consideration of minimum levels on the basis of two distinct periods based on multi-decadal differences in rainfall as clearly outlined by SJRWMD in the final MFLs Report.*

**Response:**

Regarding the issue of assessing metrics for wet vs dry periods, see response to #18.

***Comment #32 [pg. 2-27]:*** *We questioned the assumption, inherent in some analyses, that water levels in disconnected pools tracked each other exactly. However, since levels were not measured in disconnected pools, the analyses were done with "best information available."*

**Response:**
We agree.

***Comment #33 [pg. 2-27]:*** *The appropriateness of recommended minimum levels has been implicitly questioned by the Panel because we questioned the suitability/applicability of some of the criterion that were used to arrive at the proposed minimum levels. We also suggested that SJRWMD consider evaluating the criteria that were developed against benchmarks based on "wet" and "dry periods." Should SJRWMD follow our recommendations related to specific criterion and/or use an approach based on a "wet" and "dry periods", the proposed minimum levels are likely to change.*

**Response:**
Regarding the issue of assessing metrics for wet vs dry periods, see response to Comment #18.

***Comment #34:*** *Regarding the regressions to predict change in lake levels in response to pumping, the Panel would like to see validity of the linear relationship over a wider range of pumping.*

***Recommendation:*** *SJRWMD should consider performing additional pumping reduction scenarios with the 2001 and 2009 NFSEG models. This would enable quantification of lake level responses under different pumping amounts and two different rainfall/recharge conditions (2001 and 2009). For example, pumping can be reduced by half for each period. This would provide a total of four scenarios (4 data points): 330 mgd and 165 mgd with 2001 recharge, and also, 300 mgd and 150 mgd with 2009 recharge. In all cases, the modeled hydrologic responses need to be evaluated to ensure results are reasonable.*

**Response:**
As recommended by the review panel, additional pumping scenarios were completed to improve the regressions used in estimating the impact from groundwater pumping:

- 2009 pumping reduced by 25% w/ 2009 BCs
- 2001 pumping reduced by 25% w/ 2001 BCs
- 2009 pumping reduced by 50% w/ 2009 BCs
- 2001 pumping reduced by 50% w/ 2001 BCs
- 2009 pumping reduced by 75% w/ 2009 BCs
- 2001 pumping reduced by 75% w/ 2001 BCs
- 2009 pumping increased by 25% w/ 2009 BCs
- 2001 pumping increased by 25% w/ 2001 BCs

Besides additional pumping scenarios, the regressions were also improved by adding Lake Brooklyn levels as another variable (Please see details in Appendix B of the MFL report).

***Comment #35.*** *There are periods when the calculated lake drawdowns appear to be highly varied (e.g., 2003 and 2004) that should be evaluated.*

***Recommendation:*** *Potential changes discussed earlier might address these apparent, abrupt changes*

**Response:**

Both 2001 and 2009 pumps-off simulations indicates a sharp increase in drawdown (6 to 7 feet) in the second half of 2003. Our review of lake water budget in late 2003 revealed that there was substantial increase in surface water inflows to the lake during that time (approximately 500 million gallon) under 2001 pumps-off condition. The increase in groundwater levels under pumps-off condition also results in an increase in water levels of all the other lakes upstream of Lake Brooklyn. Therefore, it is not unexpected to see a significant increase in surface water flows from upstream lakes into Lake Brooklyn. In addition, a small change in lake volume can cause significant increase in lake elevation at low lake levels due to the bathymetry of the lake. For example, 100 million gallons of water can increase lake levels by about 7 feet at a lake level of 85 feet whereas the same amount of water could increase lake levels by only about 1 foot at lake level of 100 feet. In summary, a sharp increase in drawdown in late 2003 under pumps off conditions seems to be largely due to a substantial increase in surface flows from the upstream lakes into Lake Brooklyn during a period when lake levels were very low (87 to 89 feet).

***Comment #36.*** *When doing no-pumping model runs, the Panel wonders whether SJRWMD ensured that the response of the model was reasonable, i.e., water levels were not rising above ground surface, stream flows were not unreasonable, etc.*

***Recommendation:*** *SJRWMD should first make sure the response of the modeled hydrologic system to the removal of all pumping and recharge wells does not exceed reasonable bounds. For example, modeled surficial aquifer water levels should not rise significantly above land surface and streamflows should be reasonable. If the no-pumping scenario appears problematic, a series of pumping reduction scenarios as discussed below can be used to accomplish the same goal*

**Response:**

NFSEG pumps-off simulations were reviewed for reasonableness and documented (Durden et al., 2019). KHTM pumps-off simulations are reviewed for reasonableness per peer reviewer's recommendation. No significant anomalies were found.

## HSW Comments

***Comment #1 [pg. iii]*** *Consider revising Table E-1 to list freeboards determined.*

**Response**:

Freeboards are provided in tables in the assessment section. Because freeboards aren't adopted in rule, they are not included in the Recommended Minimum Level table. To be consistent with past MFLs reports we are not adding freeboards to Table E-1.

***Comment #2 [pg. iv]*** *Perhaps note in Table E-1 that SWFWMD and SJRWMD use different methods for docks, connectivity, aesthetics, etc.*

**Response:**
We will add "SJRWMD" to the name of our dock and lake connectivity metrics to distinguish them from SWFWMD metrics.

***Comment #3 [pg. 2]*** *While consistent with 373.042 F.S. language, there is little or no evidence that significant harm "would" occur if an MFL is exceeded. Rather, there is low risk that significant harm would occur if the MFL is not exceeded.*

**Response:**
A 15% reduction of habitat availability has been used by other water management districts as a significant harm threshold for MFLs (Munson and Delfino 2007). This threshold has been peer reviewed and has been the basis for numerous adopted MFLs (see SWFWMD MFLs for Crystal River, Gum Slough, Chassahowitzka River, and Homosassa River, among others). While many MFLs using this threshold are for flowing systems, a 15% reduction in habitat has also been used as a critical threshold for lakes (Hoyer and Canfield 1994, Leeper et al., 2001, Emery et al., 2009).

This threshold is also within the range (10 to 33%) of percent allowable change documented in other studies (as documented in Munson and Delfino 2007). Based on the best available information, the probability of significant harm occurring from impacts above the 15% threshold is such that it represents an unacceptable risk to fish and wildlife habitat. As noted by the peer reviewer of this MFL, this threshold has been supported by others, including Shaw et al. (2005) who states that "… changes in available habitat due…occur along a continuum with few inflections or breakpoints where the response dramatically shifts.", and therefore "…loss or reduction in a given metric occurs incrementally …and in the absence of any clear statutory guidance [they] believe that the use of a 15 percent for loss of habitat is reasonable and prudent."

***Comment #4 [pg. 2]*** *This is the first use of "historical". Consider describing that this is presumed to be a no-pumping regime.*

**Response:**
This has been removed.

***Comment #5 [pg. 3]*** *Consider revising or eliminating the parenthetical phrase that defines "constraining" as "most sensitive". MFLs identify a range of water flows and/or levels above which water might be*

*permitted for consumptive use. The constraint is the lower limit of the range. This report documents a robust and reasonable assessment of minimum levels for these sandhill lakes.*

**Response:**
We agree that there may be a metric that is very sensitive (because it is at a low lake elevation), but not most constraining (because the allowable threshold is high), so the two are not necessarily synonymous. We will use "most constraining" when discussing the difference between freeboard or deficit among metrics.

***Comment #6 [pg. 6]*** *How was bathymetry determined?*

**Response:**
The bathymetry section has been revised based on new data collected using acoustic doppler profiling equipment.

***Comment #7 [pg. 6]*** *The acreage (1,700) at 106.7' is inconsistent with page 42 acreage (1,719 at 100.7')*

**Response:**
This has been corrected.

***Comment #8 [pg. 20]*** *Consider elaborating on the wetland communities that were "previously mapped" or provide a reference.*

**Response:**
This referred to Figures 13 and 14. This was clarified in the text.

***Comment #9 [pg. 25]*** *What WQ parameter in Table 3 indicates poor buffering capacity? Suggest checking the geometric mean of 0.0 listed for TP.*

**Response:**
Alkalinity was not presented; this has been fixed in the text. The TP value has been corrected.

***Comment #10 [pg. 25]*** *Consider piece-wise linear plots in lieu of polynomial lines in Figures 17-22. Such plots are useful for identifying "knots" where there is a distinct change in slope. For example, Figures 17 and 18 indicate hinges at a Lake Brooklyn stage of about 98 feet for total nitrogen and total phosphorus.*

**Response:**
The key to this analysis was determining the elevation at which the constituent exceeded the state standard, not in determining the exact relationship with water level. When a polynomial or piecewise regression, the relevant elevation would not change significantly. This new analysis has not been conducted.

***Comment #11 [pg. 38]*** *Perhaps specify a pine species. Pond pine might not be killed.*

**Response:**
This change has been made.

***Comment #12 [pg. 40]*** *Consider alternative verbiage to "relatively insensitive" for the IH discussion. Modeling results presented in Appendix B indicate about a 2- to 4-foot difference between baseline and no-pumping lake stages at IH stages. These differences exceed the freeboards of 1.2 and 0.5 feet determined for the IH's (Figures 41 and 42).*

**Response:**
The reason for the difference is that the assessment of freeboard/deficit for the IH is not based simply on a difference in exceedance of an elevation (from No Pumping to current pumping [aka baseline]). Instead frequency analysis is conducted on event data that incorporates duration and return frequency. Therefore it is possible to have a difference in event frequency that yields a freeboard of 1.2 ft, and also have a 2 ft difference in exceedance between No Pumping and current pumping. "Relatively insensitive" means in relation to other metrics, The IH is relatively insensitive when compared to other metrics.

***Comment #13 [pg. 42]*** *Geneva acreage at 100.7' not consistent with page 6 acreage at 106.7'*

**Response:**
See response to Comment #7.

***Comment #14 [pg. 42]*** *Is information available to substantiate the appropriateness of the plots in Figure 29? The Lake Brooklyn and Geneva P50 no-pumping surface areas are 0.37 and 0.84 log10 (km2) units which translate to a water bird species richness of about 40-50 species based on the Emery (2009) study. Does the species richness seem reasonable for these lakes?*

**Response:**
Based on peer review comments (i.e., from Cardno), we have removed this metric from the final MFL determination.

***Comment #15 [pg. 42]*** *Consider noting that a 15% area reduction is equivalent to a decline of 1 species as added context for this metric.*

**Response:**
This metric is no longer being used.

***Comment #16 [pg. 42]*** *District might consider elaborating on the software (GIS version, programming languages) and its application of the Hydroperiod Tool to the lakes so reader has a better feel for potential uncertainty. What grid-cell size was used? How were bathymetric contour plots transformed to raster surface plots and what was the interval of the contours that were transformed? Were LiDAR topographic data used?*

**Response:**
The hydroperiod tool description has been revised.

***Comment #17 [pg. 44]*** *Consider extending the Lake Geneva stage-area plot to about elevation 107 to cover the range in lake stage depicted on the stage-duration curve (Figure 28).*

**Response:**
This change has been made.

***Comment #18 [pg. 44]*** *Consider adding a column with no-pumping P50 water levels so reader can more easily understand the difference in P50 no-pumping and 15%-reduce area stages.*

**Response:**
This change has been made.

***Comment #19 [pg. 45]*** *"fluctuations" or "decline"?*

**Response:**
It should be “decline.” This change has been made.

***Comment #20 [pg. 45]*** *Start new paragraph. The discussion of quartiles is a new subject, i.e., an indicator of hydrometeorological condition.*

**Response:**
This change has been made.

***Comment #21 [pg. 49]*** *Consider adding vertical lines depicting P25, P50, and P75 stages to Figures 35 and 36 so reader can more readily understand the stages listed in Table 6.*

**Response:**
This change has been made.

***Comment #22 [pg. 49]*** *consider adding P25 50 and 75 lines to figures 35 and 36. I think this will help clarify discussion.*

**Response:**
This change has been made.

***Comment #23 [pg. 54]*** *It is important for reader to understand this nomenclature. “shift” and “percentile shift” represent the numerical difference between two percentiles. A “relative shift” is what depends on the starting percentile. The 15% threshold criterion (exceedance threshold) used for a percent-of-time analysis is a relative shift in time. Care should be taken to use the nomenclature appropriately.*

**Response:**
This change has been made.

***Comment #24 [pg. 57]*** *Consider adding a clarifying footnote to Table 7 that MDA is the average dock piling elevation determined by survey.*

**Response:**
This metric is no longer being used.

***Comment #25 [pg. 57]*** *consider adding days per year, on average, as a way of explaining the percentiles and percentile changes. A 15% change from the median (P50) is 27.4 days from a no-pumping use dock access of 182.5 days. Maybe in the table?*

**Response:**
This metric is no longer being used.

***Comment #26 [pg. 61]*** *Consider adding acronym "MLA" for Minimum Lake Aesthetics. Check that the threshold criteria in column heading is consistent with text.*

**Response:**
This metric is no longer being used.

***Comment #27 [pg. 61]*** *District might consider using 15% for consistency with other criteria.*

**Response**:
We are removing the aesthetics standard; see above the response to Cardno Comment #2.

***Comment #28 [pg. 62]*** *The results in Table 10 conform with earlier narrative. Consider revising several criterion and ML descriptions for added clarification.*

**Response:**
Descriptions have been revised for clarification.

***Comment #29 [pg. 63]*** *The results in Table 11 conform with earlier narrative. Consider revising several criterion and ML descriptions for added clarification.*

**Response:**
Descriptions have been revised for clarification.

***Comment #30 [pg. 65]*** *Add a note to Figures 41 and 42 indicating the frequency curve is for baseline condition. Freeboard calculation appears correct.*

**Response:**
This change has been made.

***Comment #31 [pg. 67]*** *Consider adding a table similar to Table 12 to summarize the Bird Species Diversity results and facilitate reader understanding of the results.*

**Response:**
This metric is no longer being used.

***Comment #32 [pg. 69]*** *Consider inserting a column to the left for Baseline MDA elevation percentile to facilitate interpretation and cross-reference to Figure 43. Same for Tables 14 and 15. Freeboard calculations in all 3 tables appear correct.*

**Response:**

This metric is no longer being used.

***Comment #33 [pg. 72]*** *While not invalid, the approach for normalizing environmental criteria to P50 seems unnecessarily complex. It is complicated to follow and does not appear to change the overall conclusions regarding the most constraining criterion listed in Tables 16 and 17.*

**Response:**
This method for converting freeboard to P50 is no longer being used.

***Comment #34 [pg. 73]*** *In Table 17, the aesthetics factor is the only negative freeboard. If any other parameter is selected for the MFL, Geneva would not be in recovery. Aesthetics survey is more than a decade old.*

**Response:**
This is one of several reasons for removing the aesthetics standard. See above the response to Cardno Comment #2.

***Comment #35 [pg. 74]*** *District might consider pro-rating the recovery at the percentile associated with the constraining criterion for each lake. It could be simpler for reader to understand and should be similar to the MFLs conditions curves illustrated in Figures 50 and 51.*

**Response:**
The relationship between lake drawdown and aquifer drawdown (i.e., impact ratio) is no longer being used to calculate freeboards (or deficits).

***Comment #36 [pg. 74]*** *District might consider mentioning the date of aerial photo in Figures 44-49 and associated lake level and/or exceedance percentile. Appears to have been taken at about P50.*

**Response:**
These are no longer being used.

***Comment #37 [pg. 84]*** *Per earlier comment, consider using days reduction earlier in the text as a way of clarify % reduction.*

**Response:**
This change has been made.

***Comment #38 [pg. 87]*** *See comment on page 25, line 19 regarding piece-wise linear regression to determine a "knot" where there is a distinct change in slope. Should knots be determined for the various water quality parameters, then these analyses and conclusion relating to nutrients and other water parameters should be revisited.*

**Response:**
See response to Comment #10.

***Comment #39 [pg. 95]*** *While expressed as a median in Table E-2, isn't the MFL is really defined by Figures 50 and 51, which are developed using the equation on page 81? Other MFLs have been set like this (i.e., Lower Suwannee River) but it seems ambiguous without explicitly tying MFL in Table E-2 to method for generating curves in figures 50 and 51. There are infinite possibilities for achieving the medians in Table E-2.*

**Response:**

More detail has been added regarding the period of record used to calculate the minimum median. The minimum P25 and P75 are now being adopted as well. All three statistics must be met.

***Comment #40 [pg. 95]*** *The District might consider if it necessary to characterize the minimum P50 as "normal". Lake levels will continue to be very dynamic and influenced substantially by climatological factors in addition to anthropogenic stresses. If anything, "normal" for karstic lake systems such as these is characterized more by an interquartile (or decile) range of stage than a single percentile.*

**Response:**

See response to Comment #39.

***Comment #41 [pg. C-1]*** *The District might consider elaborating on the basis for a two-foot boat draft. A possible reference is HSW's WRV assessment of the lower Ocklawaha River (HSW 2012) that describes field observations and provides references for vessel draft and engine shaft length.*

**Response:**

More detail has been added about the rationale for the boat draft.

***Comment #42 [pg. C-4]*** *Consider revising the SWFMWD dock-use conclusion to indicate that a different metric was assessed.*

**Response:**

Both metrics used to assess dock access have been removed.

***Comment #43 [pg. C-4]*** *Consider revising to indicate that a different metric was assessed, similar to the preceding comment regarding dock access.*

**Response:**

This has been clarified.

***Comment #44 [pg. C-28]*** *In Table C.3-2, why is elevation 81 in red font.*

**Response:**

This was a typographical error and has been fixed.

***Comment #45:*** *Although not stated in the text, Step #4 (in Hydrological Appendix) appears to be an application of an assumed linearity in the groundwater model, in which a change in the independent variable (pumping) effects a proportional change in the dependent variable (water levels). Groundwater systems are frequently assumed to be linear or nearly so, and the response-function (impact ratio)*

*approach described on page B-29 uses monthly aquifer drawdown ($UFADD_k$) as a proxy for pumping ($Q_k$) and does not consider an intercept. Consider explaining what a non-zero intercept represents.*

***Recommendation:*** *The reviewers understand and concur with the overall adjustment approach but recommend using a lake-level adjustment equation that has a zero intercept. The recommended approach conforms with the simple concept that if there is no change in pumpage, then there would be no change in lake and aquifer water levels associated with pumpage. It also ensures that the month-to-month adjustments are interpolated values between pumpages of zero and 330.97 mgd instead of extrapolations outside the range of 330.37 and 330.97 mgd.*

**Response:**
See response to Cardno Comment #34.

## Brown and Caldwell Comments

The following comments were from Brown and Caldwell's peer review of changes made to the draft environmental criteria in response to the peer review by Cardno and HSW of the draft MFLs Report.

***Comment #1:*** *The Panel agrees with the District's decision to remove the minimum dock access, aesthetics, and species richness criteria due to their limited applicability to sandhill lakes like Lakes Brooklyn and Geneva.*

**Response:** No response required.

***Comment #2****: The Panel supports the decision to add the open water, surface area, and average depth criteria to better protect the aesthetic, recreational, and ecosystem values of Lakes Geneva and Brooklyn. These criteria address these values in a more straightforward way than the three criteria they replace.*

**Response:** No response required

***Comment #3:*** *The Panel supports the District's goal of finding a standard protection statistic that is more protective along the entire natural lake level regime for these lakes due to their large naturally occurring fluctuations. Unlike lakes with more stable water levels, these lakes can persist for long periods of time at water levels that are significantly different from average levels.*

**Response:**
The adoption of a P25, P50 and P75 will ensure the protection of the minimum hydrologic regime at low, average and high levels for Lakes Brooklyn and Geneva.

***Comment #4:*** *The Panel believes the District's proposed methodology – using the arithmetic average change from the no-pumping condition over the modeled period of record— does not necessarily achieve the goal of being protective across the entire natural lake-level regime. The Panel believes evaluating historical wet and dry conditions separately can supplement the District's proposed approach to improve applicability of minimum levels over the lakes natural range of lake level fluctuations. Explicitly allowing*

*a greater degree of change over the drier conditions would prevent the criteria from being significantly over-protective, while still placing limits on the degree of change acceptable during decades-long periods when water levels are naturally below average.*

**Response:**

Assessing MFLs differently during wet and dry periods presents several challenges and concerns, which would introduce significant subjectivity and uncertainty into the process.

Determining distinct wet and dry periods is one of the main challenges. Different methods such as Standard precipitation index (SPI), palmer hydrological drought index or cumulative departure from mean rainfall can be used. However, each method would probably yield different breakpoint between wet and dry, which would likely change the status of MFLs and amount of available water (i.e., freeboard or deficit).

This is further complicated by the fact that the MFLs period of record may not represent a complete hydrological cycle. Because of this, the POR may be biased with more dry data than would be included if one or more complete wet and dry cycles were used. Further, while the wet and dry periods delineated with a specific method (e.g., SPI) might be largely homogeneous, there would likely be some short wet times in the dry period and vice versa. As such, exceedance percentiles from each period may not accurately reflect only wet or dry conditions.

Finally, ensuring compliance with MFLs specific to wet or dry periods would be very challenging. Management implications include how to construct, issue or modify long-term consumptive use permits, not knowing whether the next extended period will be wet or dry.

For these reasons the District has decided to assess metrics using the entire POR, and for area-based metrics to set an allowable change (15% reduction from no-pumping condition) to the average condition. By doing this, 1) all elevations, with their differing sensitivity to pumping impact, are considered; 2) small elevation-specific differences in freeboard/deficit are averaged over the entire lake level regime; 3) functions and values at high, low and average water conditions are protected; the subjectivity of determining specific high (wet) and low (dry) periods is avoided, as both wet and dry conditions are included in the analyses; and 4) multiple percentiles, spanning the entire regime, are used in the analyses; the average across the regime is the central tendency, instead of a median.

***Comment #5:*** *The Panel suggests adding graphics that illustrate the differential impacts of groundwater withdrawals on the proposed criteria over the natural lake level regime and a summary table similar to Table 10, "Summary of Environmental Criteria and minimum levels" as found in the draft MFLs Report.*

**Response:**

See response to Comment #4; for these reasons, metrics will not be assessed at different elevations, or during wet vs dry periods.

# Peer Review of Minimum Levels Determination for Lakes Brooklyn and Geneva

June 2018

Cardno®

# Document Information

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|---|---|
| Prepared for | St. Johns River Water Management District |
| Project Name | Peer Review of Minimum Levels Determination for Lakes Brooklyn and Geneva |
| Project Number | E218101400 |
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# Executive Summary

The St Johns River Water Management District contracted Cardno to provide independent scientific peer review of the final Minimum Levels Determination for Lakes Brooklyn and Geneva (final MFLs report) and appendices. Cardno was directed to focus the review on:

- the environmental criteria, analyses and assumptions of the MFLs determination,
- the hydrological analyses conducted in support of the MFLs determination and assessment, and
- the appropriateness of the recommended minimum levels for these lakes.

Cardno assembled a Peer Review Panel (Panel) consisting of the following staff with expertise in hydrology, hydrogeology, groundwater modeling, limnology, and ecology.

Gregg Jones, PhD, PG, (Panel Chairman) - Karst Hydrogeology
Martin Kelly, PhD, Limnology, Hydrology
Shirley Denton, PhD, Ecology
Mark Barcelo, PE, Hydrogeology, Groundwater Modeling

As per the work order, the Panel has prepared a final Technical Memorandum of the findings and recommendations related to the peer review of the final MFLs report. The following is a summary of the Panel's major findings and responses to the questions posed by the SJRWMD that were part of the Panel's original charge.

**Major Findings**

1) The Panel acknowledges that setting minimum levels for these lakes is a very difficult undertaking for the following reasons:

   - Water levels in the lakes fluctuate as much as 31 feet for Lake Brooklyn and 26 feet for Lake Geneva, which are among the largest lake level fluctuations in Florida.
   - The natural condition of Lakes Brooklyn and Geneva is to have alternating multi-decadal periods of high and low water levels.
   - Each lake has a high degree of interconnection with the Upper Floridan Aquifer system.
   - Surface water inflow to Lake Brooklyn occurs during wet periods but is highly intermittent during dry periods.
   - There is minimal surface water inflow to Lake Geneva.
   - During high water periods, each lake is a single body of water. During low water periods, the lakes separate into isolated pools.

2) The Panel acknowledges that the District has provided a great deal of data to demonstrate that the natural condition of Lakes Brooklyn and Geneva is to have multi-decadal periods when levels are high and periods of when levels are low. Supporting information includes:

   - The median water level in Lake Brooklyn has declined by 12 feet and Lake Geneva by 18 feet over the past 30 years.
   - Lake levels are elevated during multi-decadal periods of high rainfall - 150 inches cumulative rainfall surplus from the early 1930s to the early 1970s.
   - Lake levels are much lower during multi-decadal periods of low rainfall - 105 inches cumulative rainfall deficit from early 1970s to 2012.
   - The final MFLs report states that lake level trends are cyclic in nature primarily in response to periods of high and low rainfall related to climate cycles.
   - The final MFLs report states there is a comprehensive body of literature that corroborates that there is a strong correlation between lake levels and rainfall with increasing levels correlated with above annual average rainfall and declining levels correlated with below average rainfall.
   - The final MFLs report states that the lakes are particularly sensitive to prolonged periods of below average rainfall because they are highly connected to the Upper Floridan Aquifer System.

3) The Panel agrees with the information provided by SJRWMD that indicates that the dominant factor that creates these multi-decadal periods of high and low lake levels is rainfall. While groundwater pumping influences lake levels, periods of deficit and surplus rainfall are the dominant factors.

   - The MFL report states that the impact of pumping during a dry period is higher than the impact of pumping on lake levels during a wet period for the same amount of pumping because of a lack of surface water inflows and runoff.
   - The MFL report states that although the amount of regional pumping in the 1960s was not negligible, the impact of pumping on both lakes was relatively low. The pumping impact had been largely offset by the amount of surface water flows coming from the upstream lakes during that period.
   - The MFL report states that for much of the period of record, Lake Brooklyn has received surface water flows from the upstream lakes. However, since 1973, the amount of surface flows coming from the upstream lakes to Lake Brooklyn has declined and varied due to rainfall deficit. Because of this, the groundwater impact to Lake Brooklyn has exhibited large variation and become more pronounced since 1973.

4) The Panel is in agreement with SJRWMD's application of a multiple standards approach and the selection of the most restrictive standard for the minimum lake levels.

5) In general, the Panel concurs with SJRWMD's consistent application of the 15 percent change criteria.

6) Regarding the multi-decadal periods of high and low lake levels, the Panel is concerned about applying standards across the entire period of record. In particular, the Panel does not believe the dock standard is appropriate when applied across the entire period of record. The Panel wonders if SJRWMD has considered applying the standards to the distinct wet and dry periods. The Panel is curious to see if the standards would work better when evaluated in this manner.
7) The Panel questions the appropriateness of using the aesthetic standard.
8) Regarding the regressions to predict change in lake levels in response to pumping, the Panel would like to see validity of the linear relationship over a wider range of pumping.
9) When doing no-pumping model runs, the Panel wonders whether SJRWMD ensured that the response of the model was reasonable, i.e., water levels were not rising above ground surface, stream flows were not unreasonable, etc.

**Validity and Appropriateness of Environmental Criteria**

Question 1. Are the environmental data used to develop criteria adequate and appropriate?

The environmental data used were essentially the no-pumping lake stage data which represented the "benchmark" against which significant harm was evaluated. The same data set was used for each criterion evaluated. They are "environmental data" in the sense that lake stage was related to various environmental or other water resource values to be protected. In most cases, a 15 percent significant change standard was used to determine when significant harm would occur. The Panel is in agreement that the data are adequate and appropriate.

Question 2. Are the methods and procedures used for environmental analyses appropriate?

The Panel reviewed each criterion in some depth and depending on the criterion, some issues were identified. However, there was consistency in the methods and procedures applied to each criterion. For example, the 15 percent significant change standard was generally applied as "a no more than a 15 percent reduction in time" that something would occur. In short, and making a distinction between "methods" versus "criterion", the Panel is in agreement that the methods and procedures used were consistently applied, reasonable, and appropriate.

The Panel explicitly addressed the use of the 15 percent change standard, and although it has been criticized by some, we find it acceptable and reasonable. We did suggest that SJRWMD consider applying their analysis to both a "wet" and a "dry period." This would not substantively change the methods or approach; however, it is possible, as explained in our narrative, that the use of single exceedance probability curves for each lake "*essentially average the data."* It is possible, however, that use of two periods rather than a single period of record would lead to different recommended levels.

Question 3. Are methods to evaluate the relevant environmental values and beneficial uses appropriate?

The Panel strongly supports the use of multiple criteria and the concept of adopting the more conservative outcome; however, we have raised issues regarding specific criteria (e.g., dock use, aesthetics), and these are addressed under the discussion of each.

Question 4. Have all relevant environmental values been evaluated?

To the extent possible, the Panel is in agreement that all relevant environmental values have been evaluated. The caveat is applied because there is inadequate data to explicitly address some of the environmental values as identified in rule 62-40.473, F.A.C. For example, it is difficult to find in the literature a study of the “transfer of detrital material” in a lake that could be readily transferred to Lakes Brooklyn and Geneva. In our view this value is likely protected because a number of different values were directly addressed, and the proposed minimum lake levels were based on the most conservative of these. Clearly some of the environmental values are not relevant to minimum levels on these lakes (e.g., estuarine resources).

Question 5. Are data appropriate for evaluations, selected criteria, and conclusions?

The appropriate data required for all evaluations and selected criteria was a benchmark water level time series. The benchmark used is the no pumping time series. The Panel presented four approaches that could and have been used to develop a benchmark, and we are in agreement that the modeling approach used by SJRWMD*, “overcomes what we believe are major limitations to the other approaches.”*

Question 6. Are assumptions reasonable and consistent given the "best information available”?

Whether considered an assumption or not, we suggested consideration of minimum levels on the basis of two distinct periods based on multi-decadal differences in rainfall as clearly outlined by SJRWMD in the final MFLs Report. The Panel is in agreement that the use of a 15 percent change standard is appropriate for determining “significant harm.”

We questioned the assumption, inherent in some analyses, that water levels in disconnected pools tracked each other exactly. However, since levels were not measured in disconnected pools, the analyses were done with “best information available.”

## Validity and Appropriateness of Hydrological Analyses

Question 1. Are the hydrologic data used to develop impact assessment methods appropriate?

The Panel believes this question was addressed during development and review of the groundwater models. Though more historic data would be desirable, it is believed that the data available to SJRWMD was sufficient for the analyses needed to determine minimum lake levels.

Question 2. Is the method used to assess the impact of local and regional groundwater pumping on MFL water bodies using KHTM appropriate and valid?

The Panel is in agreement that the overall process that was used to determine the response of Lakes Brooklyn and Geneva levels to pumping using the KHTM is appropriate and valid. However, the Panel had questions about some aspects of the process and has provided suggestions for additional analyses that could be performed to potentially improve overall results and/or improve their confidence.

Question 3. Are the analytical and statistical methods and procedures appropriate for – (1) Conducting groundwater pumping impact assessment and (2) developing baseline condition datasets?

The Panel is generally in agreement that the analytical and statistical methods and procedures used to develop the groundwater pumping impact assessment and developing baseline condition datasets are a resourceful and creative use of model output that attempts to address concerns such as the non-linear response of surficial processes to changes in stresses.

Question 4. Are assumptions reasonable and consistent given the “best available information?”

Overall, the basic approach used by SJRWMD seems reasonable. The Panel recognizes there are difficulties in separating effects of pumping from measured lake levels, and creating a lake levels dataset that is free of pumping influences but that incorporates effects of the actual climatic influences that occurred over the period of interest. It appears SJRWMD has used the best available information and tools available. However, the Panel has provided comments that could help to enhance and further refine the methodologies employed.

## Appropriateness of Recommended Minimum Levels

Question 1. The validity and appropriateness of assumptions used and conclusions made in the development of protective minimum levels, including identifying sources of uncertainty and their impact on development of protective minimum levels for these lakes.

The appropriateness of recommended minimum levels has been implicitly questioned by the Panel because we questioned the suitability/applicability of some of the criterion that were used to arrive at the proposed minimum levels. We also suggested that SJRWMD consider evaluating the criteria that were developed against benchmarks based on “wet” and “dry periods.” Should SJRWMD follow our recommendations related to specific criterion and/or use an approach based on a “wet” and “dry periods”, the proposed minimum levels will change.

Question 2. Adequacy of data to support conclusions and recommendations

The Panel is in agreement that the data presented in the final MFLs Report to support conclusions and recommendations are adequate.

# 1 Introduction

The St Johns Water Management District (SJRWMD) is mandated by Florida statutes to establish minimum flows and levels (MFLs) for priority surface waters and aquifers within its boundaries for the purpose of protecting the water resources and the ecology of the aquatic ecosystems from "significant harm" (Florida Statutes, 1972 as amended, Chapter 373, §373.042). In this report, minimum levels are proposed for two sandhill lakes, Lakes Brooklyn and Geneva.

Under the statutes, MFLs are defined as follows:

- A minimum flow is the flow of a watercourse below which further water withdrawals will cause significant harm to the water resources or ecology of the area; and
- A minimum level is the level of water in an aquifer or surface water body at which further water withdrawals will cause significant harm to the water resources of the area.

The statutes require SJRWMD annually develop and update a list of priority water bodies for which MFLs are to be established and identify those that will be subjected to a voluntarily independent scientific review. SJRWMD's Governing Board has continued to voluntarily submit MFLs determinations for independent scientific peer review.

The Statutes also provide for the MFLs to be established using the "best available information," for the MFLs "to reflect seasonal variations," and for SJRWMD's Board, at its discretion, to provide for "the protection of non-consumptive uses." In addition, §373.0421 of the Florida Statutes states that the SJRWMD's Board "shall consider 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….".

The State Water Resources Implementation Rule (Chapter 62-40.473, Florida Administrative Code) contains additional guidance for the establishment of MFLs, providing that "…consideration shall be given to the protection of water resources, natural seasonal fluctuations, in water flows or levels, and water resource values (WRV) associated with coastal, estuarine, aquatic and wetlands ecology, including:

1. Recreation in and on the water;
2. Fish and wildlife habitats and the passage of fish;
3. Estuarine resources;
4. Transfer of detrital material;
5. Maintenance of freshwater storage and supply;

6. Aesthetic and scenic attributes;
7. Filtration and absorption of nutrients and other pollutants;
8. Sediment loads;
9. Water quality; and
10. Navigation."

## 1.1 Charge for Peer Review Panel

SJRWMD provided the Peer Review Panel (Panel) with the following charge:

The Consultant shall provide the District with independent scientific peer review of the final Minimum Levels Determination for Lakes Brooklyn and Geneva (final MFLs Report). One focus of this review is on the environmental criteria, analyses and assumptions of the MFLs determination. Another focus of this review is the hydrological analyses conducted in support of the MFLs determination and assessment. Ultimately, this review is on the appropriateness of the recommended minimum levels for these lakes. This work order includes review of the main report and appendices.

Contractor shall prepare a final and final Technical Memorandum (TM) summarizing the findings and recommendations related to the peer review of the Lakes Brooklyn and Geneva MFLs report, and submit to the SJRWMD's Project Manager. Contractor shall include the following items in the review process and provide answers to the following questions in the TM.

Assess validity and appropriateness of environmental criteria

- Are the environmental data used to develop criteria adequate and appropriate?
- Are the methods and procedures used for environmental analyses appropriate?
- Are methods to evaluate the relevant environmental values and beneficial uses appropriate?
- Have all relevant environmental values been evaluated?
- Are data appropriate for evaluations selected criteria and conclusions?
- Are assumptions reasonable and consistent given the "best information available"?

Assess validity and appropriateness of hydrological analyses

- Are the hydrologic data used to develop impact assessment methods appropriate?
- Is the method used to assess the impact of local and regional groundwater pumping on MFL water bodies using KHTM appropriate and valid?
- Are the analytical and statistical methods and procedures appropriate for –
    a. Conducting groundwater pumping impact assessment
    b. Developing baseline condition dataset

- Are assumptions reasonable and consistent given the "best information available”?

Appropriateness of recommended minimum levels

- The validity and appropriateness of assumptions used and conclusions made in the development of protective minimum levels, including identifying sources of uncertainty and their impact on development of protective minimum levels for these lakes.
- Adequacy of data to support conclusions and recommendations

# 2 Validity and Appropriateness of Environmental Criteria

## 2.1 Introduction

As noted in the *Minimum Levels Determination for Lakes Brooklyn and Geneva, Clay and Bradford Counties, Florida (final MFLs Report)* (Sutherland et al. 2018) prior adopted minimum levels for Lakes Brooklyn and Geneva were based on a methodology designed to maintain the location of existing stable wetland and organic soils. However, it is now recognized that stable wetland and organic soils do not exist on these two sandhill lakes. As a result, a reevaluation of minimum levels was warranted. Further, it was realized that methods using additional environmental criteria were needed.

As stated in their report (Sutherland et al. 2018), the “overarching question” that MFLs attempt to answer is what hydrologic regime is needed to protect a subject waterbody from “significant harm.” The purpose of a minimum flow or level is not to ensure that historical levels unimpacted by withdrawals are maintained, but rather to establish a minimum regime that if maintained protects a given waterbody from significant harm due to withdrawals.

The MFLs methodology most often applied by SJRWMD was designed to maintain existing stable wetland and organic soils. This methodology has been applied to both running (rivers, streams, and springs) and standing waterbodies (lakes), and is described in Neubauer et al. (2008). Although, stable wetlands and organic soils do not exist on Lakes Brooklyn and Geneva, SJRWMD did identify an infrequent flooding criterion, Minimum Infrequent High (IH) that should be met in order to prevent a down gradient shift in the upland / wetland boundary of each lake. These boundaries are clearly visible on aerial photography. This criterion will be discussed further below.

After developing their IH, SJRWMD then sought to identify additional criteria that could be used to help protect lake water levels from significant harm due to withdrawals. SJRWMD was quick to appreciate and acknowledge that the scientific literature was little help in this regard. Although there is a considerable wealth of published information and guidance regarding the establishment of environmental flows on flowing waterbodies, there is a relative paucity of such information on natural lakes (see for example, Leira and Cantonati 2008 or Evtimova and Donohue 2016). The scientific literature that does exist for setting lake water-level regimes for regulatory purposes is more often concerned with regulated waterbodies, such as reservoirs used for hydropower generation, water supply, recreation, flood storage or multiple uses. Oftentimes regulations or release schedules are just as concerned with downstream values as with within waterbody values.

While we agree with SJRWMD that there is little scientific literature that explicitly addresses environmental levels, there are analogies with the literature on flowing waters and in terrestrial ecology that are helpful in identifying relevant criteria.

## 2.2 Analogies to Environmental Flows

As noted above, in comparison to work on environmental flow requirements and criteria, relatively little relevant science has been done on environmental levels needed for lakes. However, the literature on environmental flows is informative. It is well established, for example, that protection of environmental flows requires a consideration of the entire flow regime. The science has advanced from earlier efforts that focused on a single minimum flow criterion (Poff et al. 1997, Richter et al. 1997) to one that considers inter and intra-annual variation and even multi-decadal differences in flows that are likely to occur even in the absence of withdrawals. As a result a single metric or criterion is not likely to be protective of the entire regime. This logic is applicable to lakes and wetlands as well. This was explicitly acknowledged by SJRWMD; "*a protective minimum hydrologic regime is established based on a percentage of change allowable from a more natural (e.g., no-pumping impact) condition.*" Part of this regime included incorporation of an infrequent flood (IH) based on preventing a downward shift in the upland boundary at either Lake Brooklyn or Lake Geneva. The return interval, however, for meeting this criterion is so long (25 years) that it would not be protective of other water resource values that require protection in intervening years. This is analogous to protecting high flows in lotic systems, but would not be protective of intermediate or low flows. Analogously, intermediate lake levels (e.g., the P50) and lower lake levels (e.g., <P50) would not necessarily be protected.

Since environmental flow regimes typically include consideration of infrequent high flows, in-stream flows, and seasonally low flows (for example, see Richter et al. 1997), SJRWMD reviewed various metrics/criteria that might be useful in protecting water resource values under a potential range of elevations (i.e., levels). A distinction is made here between strictly environmental considerations and water resource values, since the state's water management districts are required to consider such things as aesthetics, navigation and recreational uses in addition to purely ecological concerns. There is, however, overlap in some of these values. For example, a consideration of water depth necessary for boating between lake basins would probably be protective of fish passage as well.

## 2.3 Analogies to SWFWMD Methodologies

A detailed discussion of SWFWMD methodolgies and considerations is not part of the scope of this review; however, some review is necessary to appropriately evaluate criteria use by SJRWMD.

It was recognized by SJRWMD that SWFWMD has been applying a number of different criteria to Category 3 lakes (i.e., those without fringing cypress wetlands) when developing minimum lake levels, and these were considered for possible incorporation by SJRWMD. As noted by SJRWMD, "to establish the minimum lake level for Category

3 lakes, SWFWMD typically develops one or more of the following six 'significant change standards' . . . aesthetics standard; lake mixing standard; dock-use standard; basin connectivity standard; species richness standard; and recreational/ski standard" (Sutherland et al. 2018).

Sutherland et al. (2018) concluded, "Of the six standards evaluated, only one was deemed appropriate for use at Lakes Brooklyn and Geneva; the Species Richness Standard. The remaining five metrics . . . "*were evaluated and found to not be appropriate for determining a minimum P50 for these lakes, due to results that suggested an extremely high level (i.e., well above historical P50 conditions) or an extremely low level for the minimum P50.*"

It is not surprising that that the majority of criteria developed by SWFWMD were not strictly applicable to Lakes Brooklyn or Geneva. SWFWMD initially developed and applied their criteria using statistics developed on a set of twenty-two reference lakes (see Leeper et al. 2001). As reported, the mean difference between the historic (unimpacted) P10 and P50 was 1.0 feet and the difference between the P10 and P90 was 2.1 feet. These differences are indicative of a group of lakes that fluctuate over a very narrow range in elevation. Lakes Brooklyn and Geneva, with P10 to P90 differences of approximately 20 and 15 feet, respectively, are clear outliers.

SJRWMD, in order to determine whether SWFWMD criteria could be applied to Lakes Brooklyn and Geneva (see Sutherland et al. 2018, Appendix C), did compute standard values for each of the criteria. Because the Species Richness Standard as used by SWFWMD simply allows no more than a 15 percent reduction in lake surface area from the historic P50 in order to generate a new P50, it would likely be applicable on any lake regardless of its fluctuation range. Unlike some of the other criteria assessed, as long as this standard is applied to an unimpacted P50, it could not generate a P50 higher than the unimpacted condition. However, depending on the unique morphology of a lake, it could allow for a substantial decrease in lake depth before a 15 percent reduction in lake area occurs (for example, consider a lake basin that is cylindrical for some depth). Presumably, however, the use of multiple standards would not allow an excessive change in lake depth to be proposed because some more restrictive standard would be used. This was the intent as described by SJRWMD.

## 2.4 The 15 Percent Significant Change Standard Used to Assess "Significant Harm"

SJRWMD has extended the use of a 15 percent significant change standard from rivers to lakes, and we believe that this is a reasonable. This significant change standard has been used by several of the state's water management districts in the establishment of environmental flows. This criterion was based on a recommendation by the peer review panel reviewing proposed minimum flows on the upper Peace River (Gore et al. 2002). That panel explicitly recommended a particular tool (PHABSIM) as a basis for establishing, "*acceptable flows to maintain the integrity of stream and river ecosystems*." They stated*, "In general, instream flow analysts consider a loss of more than 15 percent habitat, as compared to undisturbed, or current conditions, to be a significant impact on that population or assemblage."* The criterion has been both criticized and endorsed by

various peer review panels, but generally upheld as exemplified by Shaw et al. (2005), *"As previously described, we have repeatedly observed that changes in available habitat due to flow reduction occur along a continuum with few inflections or breakpoints where the response dramatically shifts. We have found that loss or reduction in a given metric occurs incrementally as flows decline, and in the absence of any clear statutory guidance, believe that the use of a 15 percent for loss of habitat is 'reasonable and prudent.'*

It is also this panel's observation, that there are two types of ecological relationships that could be used to assess "significant harm". One denotes a clear breakpoint such as shown in the left panel of Figure 1. In this example, fish species richness declined abruptly when dissolved oxygen dropped to 2 mg/l or less. These type of criteria require little judgement as to when "significant harm" has occurred. However, it has also been our experience that most ecological metrics respond less dramatically, typically increasing or decreasing along a continuum (right panel in Figure 1). In the absence of a clear breakpoint or bright line, a judgment must be made as to when significant harm has occurred. This decision is a matter of professional judgment or negotiation.

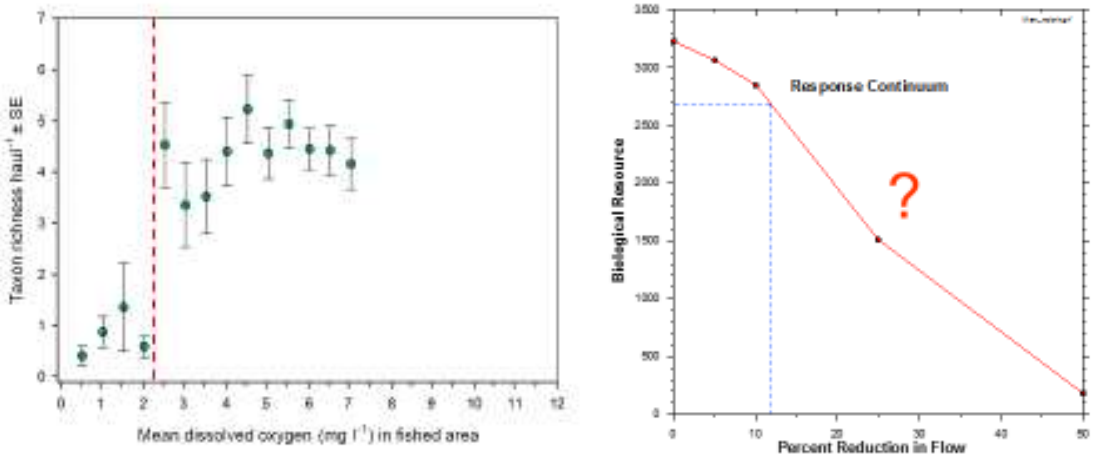


**Figure 1. Examples of two types of biological responses to environmental variables.**

The 15 percent loss criterion has been applied to standards other than fish habitat. For example, it has been applied to the river/floodplain connection and area of wetland habitat inundated, and to changes in salinity zones of estuaries as a result of increases or decreases of freshwater inflow. Reiterating Shaw et al. (2005), *"in the absence of any clear statutory guidance"* the extension of the 15 percent is reasonable and consistent with previous MFL efforts.

## 2.5 The Overall Approach

SJRWMD has developed a methodological approach for application to sandhill lakes and their approach is conceptually consistent with the process of an environmental flow determination as outlined by Beecher (1990). Steps in this process include: development of a goal (protection from significant harm); identification of resources to

be protected (various water resource values); a unit of measure (e.g., elevation); a benchmark period (e.g., no pumping condition); a protection standard statistic (e.g., P50, or median lake elevation).

## 2.6 The Benchmark Period

The Panel has identified four approaches that could be used to establish a "benchmark period", and these are discussed briefly because the "benchmark period" is the measure against which acceptable change is made. In the literature on environmental flows, the terms, benchmark, baseline and historical are likely to be encountered and are used somewhat interchangeably. We point this out, simply because SJRWMD uses the term "baseline" to refer to the more current impacted condition and their use of baseline should not be confused with "benchmark". The "no-pumping condition" is SJRWMD's equivalent of "benchmark" as used in this discussion.

In the environmental flows literature, the most typical approach probably used to obtain a "benchmark period" has simply been to take a portion of the flow record that would be considered unimpacted by withdrawals. For example, if there is a long flow record (e.g., 60 years), the early part of the record might be simply be selected (e.g., the first 20 years) that was judged to be relatively free of anthropogenic impacts. This type of record is routinely used when applying the Indicators of Hydrologic Alteration program (Richter et al. 1997) and has been used in many previous environmental flow studies. There was a time when a 20 year flow record would have been deemed acceptable, because it was assumed that such a period would encompass most of the climatic variability one would likely encounter in a long flow record (The Nature Conservancy 2009). In our view a multi-decadal period needs to be assessed.

A second approach likely to be used in the absence of a good historical record, would be the "reference approach." This is, at least initially, the approach that SWFWMD used in developing its Category 3 methodology (Leeper et al. 2007). This approach essentially develops a set of reference values for a set of lakes considered unimpacted by withdrawals for comparison against presumably impacted lakes.

Another approach is the "paired watersheds" approach. In this approach, statistical relationships are developed between metrics of interest, before an alteration occurs. One watershed is then altered, the other is not. The prior relationship is then used to predict what the condition of the altered watershed should be using the current condition in the unaltered watershed. We are not aware if this approach has been used anywhere except in manipulative or experimental situations (e.g., Clausen and Spooner 1993).

A fourth approach is a modeling approach such as used by SJRWMD in the analysis that is the subject of this peer review. This approach has been used in environmental flows that have recently been developed on flowing waterbodies in Florida and is a recommended approach in recent peer reviews (Graham et al. 2013, Jones et al. 2017). The modeling approach essentially produces a flow (in the case of rivers) or level (in case of lakes) record in which withdrawals are added back into the system. This approach is only as good as the models used and the assumptions made. However, it overcomes what we believe are major limitations to the other approaches. For example,

we now know that there are multi-decadal differences in rainfall and thus flows and levels that could substantially affect the use of a pre-impact flow or level record. With respect to the “reference approach”, reference regimes are not transferrable to waterbodies outside of the range of variability on which the references were developed (as demonstrated in this report), and finally the “paired watersheds” approach is only applicable in rare instances.

## 2.7 Discussion of Individual Criteria

The table below (E-1), taken from the final MFLs Report, lists the values to be considered as well as the Environmental Criteria Evaluated.

**Table E-1. Environmental criteria evaluated for Lakes Brooklyn and Geneva, Clay and Bradford counties, Florida. Check marks denote which criteria were ultimately assessed for each lake.**

| Environmental Criterion | Environmental Value(s) Protected | Lake Brooklyn | Lake Geneva |
|---|---|---|---|
| Minimum Infrequent High (SJRWMD) | Upland/wetland boundary | √ | √ |
| Dock Use Standard (SWFWMD) | Recreation / dock access | | |
| Basin Connectivity Standard (SWFWMD) | Boating / fishing | | |
| Species Richness Standard (SWFWMD) | Bird diversity | √ | √ |
| Recreation/Ski Standard (SWFWMD) | Recreation / water skiing | | |
| Lake Mixing Standard (SWFWMD) | Lake stratification | | |
| Aesthetics Standard (SWFWMD) | Aesthetics / scenic attributes | | |
| Minimum game fish habitat reduction | Fish and wildlife habitat | √ | |
| Minimum emergent marsh habitat reduction | Fish and wildlife habitat | √ | |
| Minimum large wading bird forage habitat reduction | Fish and wildlife habitat | | |
| Minimum small wading bird forage habitat reduction | Fish and wildlife habitat | | |
| Minimum sandhill crane nesting habitat reduction | Fish and wildlife habitat | | |
| Minimum Dock Access elevation exceedance | Recreation / dock access | √ | √ |
| Minimum Lake Connectivity elevation exceedance | Boating / fishing | √ | √ |
| Aesthetics – minimum P50 exceedance | Aesthetics / scenic attributes | √ | √ |

After reviewing the table, the Panel has a number of general comments. Some of the criteria appear to apply to more than one Environmental Value. Some environmental values that are applicable to the lakes do not appear to have been explicitly evaluated. For instance, water quality and filtration and absorption of nutrients are not listed in Table E-1. These values are known to be related to water levels in much the same ways that various types of fish and wildlife habitat are related to water levels. We realize

that they may be much more difficult to measure and/or require a number of assumptions that could not be overcome without detailed monitoring and analyses on a case by case basis. For example, pollution absorption and breakdown are related to water area, temperature, retention time, depth, and vegetation. While protecting water quality relative to pollutant inputs is not a function of the MFL process, maintaining a physical water fluctuation regime where the natural processing of natural nutrient inputs can be maintained is a function of water regime. This, plus maintaining aesthetics and recreation might lead to creation of an evaluation criterion based on reduction in area of open water. And reduction in open water could be used in lieu of adopting standards, which rely upon transfer of limits from lakes whose physical characteristics may not extend well to these high fluctuation systems. We consider that the "value protected" in Table E-1 as "Stratification" is applicable to or "Water Quality" and also for "Filtration and absorption of nutrients and other pollutants" as listed in the rule.

The Panel also considers that using the most restrictive criteria is an appropriate way to ensure that the proposed water level fluctuation regime will be fully protected. The panel is of the opinion that the SJRWMD's approach, where each criterion was evaluated and only the most limiting criterion was accepted, is appropriate.

### 2.7.1 SJRWMD Minimum Infrequent High

The methodology used by SJRWMD (Neubaur et al., 2008) has been previously reviewed. Although these lakes differ in many respects from most lakes in Florida, the upland boundary criterion is based on the flooding tolerance of individual species, primarily several upland oak species, and indirectly, on saw palmetto. Many studies of plant physiology support this at an even broader level. Most upland species do not have the necessary physiological adaptations to survive extended periods of inundation, especially during the growing season. The seasonality and duration of flooding determines how much inundation most upland trees can tolerate. Floods that occur in the active growing season kill upland trees more quickly than those that occur during the dormant season. (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5187438.pdf ).

The Panel is in agreement that this criterion is appropriate to both Lakes Brooklyn and Geneva. The specific methodology used to establish the level was developed by SJRWMD and has been used on multiple lakes with minimum levels and previously subject to peer review.

### 2.7.2 Southwest Florida Water Management District (SWFWMD) Standards

#### *2.7.2.1 SWFWMD Dock Use Standard*

As explained in Leeper et al. (2007), the primary requirement for regulations concerning dock construction and installation was "to prevent degradation of water quality or habitat destruction which may occur when watercraft come into contact with or disturb lake sediments or benthic biota." SWFWMD reviewed various regulations and ordinances related to dock construction in tidal and non-tidal systems. They essentially equated their Low Guidance Level (P90) to the elevation at the end of the dock labeled the

"waterward dock piling (lake sediment) elevation depicted in SJRWMD's dock figure in the final MFLs report (Sutherland et al. 2018 (Figure 3)).

SJRWMD considered the use of the previously developed dock criterion. However, due to the wide fluctuation ranges of Lakes Brooklyn and Geneva, application of SWFWMD's method resulted in minimum water levels for docks that would have exceeded no pumping water levels.

The Panel is in agreement with SJRWMD that SWFWMD's dock criterion should not be applied to Lakes Brooklyn and Geneva.

#### *2.7.2.2 SWFWMD Basin Connectivity*

SJRWMD considered the use of the previously developed basin connectivity criterion. However, due to the wide fluctuation ranges of Lakes Brooklyn and Geneva, application of the methodology resulted in minimum levels for basin connectivity that would have exceeded those under no-pumping conditions.

The Panel is in agreement that SWFWMD's basin connectivity criterion should not be applied to Lakes Brooklyn and Geneva.

#### *2.7.2.3 SWFWMD Species Richness Standard*

SJRWMD used a species richness criterion that was developed for use by SWFWMD. This criterion was based on a survey of lakes, primarily in west central Florida and was conducted by Emery et al. (2009). This study used a method developed by Hoyer and Canfield (1994) which was extended to more lakes and refined to improve ornithological aspects of the original study and to increase the breadth and intensity of seasonal sampling. Emery et al. (2009) then developed a linear regression model to relate the number of bird species observed during sampling to the lake area. The resultant model was used to estimate how much lake area could be reduced before loss of single bird species occurred. Based on the statistical relationship developed, it was concluded that a 15 percent change in lake area would result in a loss of one bird species.

The Panel reviewed both prior studies on which the standard was based and made the following observations:

1. The types of habitats around these lakes are very different from the habitats around lakes sampled in the previous studies. In particular, while the Emery et al. study focused on lake area, the study strongly emphasized lake edges. Lake edges in the SWFWMD study generally included bands of cypress trees and sometimes areas of marsh, some of them extensive, and for some lakes, suburban lawns. By contrast, at most water levels, the lake edge for Lake Brooklyn is best described as bare, white sand. The edge for Lake Geneva is generally low grasses/forbs generally those associated with rapid (weedy) growth.
2. The assumption that bird species diversity will change within an individual lake if lake surface area is permanently reduced from some average condition must be

accepted. SWFWMD was aware of this and included it in its own critique of using this study in the establishment of MFLs (Leeper et al., 2001).

3. There may be technical issues with the sampling design used in the SWFWMD study. The survey results were assumed to represent species richness, yet no analysis was done of sample adequacy for determining richness, especially on the smaller lakes in the study. Species accumulation curves should have been used to determine sample adequacy and to evaluate effects of a sampling design that allocated significantly more effort to the survey of large lakes than small ones. For instance, see discussions of determining species richness from samples in Moreno and Halffter (2000), Soberón and Llorente (1993) and Sutherland (1996). In short, the greater the sampling effort, the more species that are likely to be encountered on any given lake. The larger a lake is the more species it is likely to support because (all things being equal) it provides more niches. However, we are unsure if the greater number of species encountered with increasing lake area was due to the greater area or to the greater sampling effort that appears was used on large lakes.
4. The lakes assessed in the SWFWMD study that were used to develop the criterion varied substantially in diversity (and lack thereof) of shoreline environments among lakes of similar size. A component of the study suggested that there was a significant reduction in species diversity for lakes surrounded by development, and that the change in species richness with change in lake size was significantly different for lakes surrounded by urbanization than those not surrounded by urban areas. This suggests that even among lakes of similar size, the predictive relationship may change, although we support the assumption that all things being equal, larger lakes would exhibit greater diversity than smaller.

Chiefly on the basis of observation #3 above that deals with the adequacy of sampling effort per lake in the two studies, the Panel recommends that this criterion not be used.

#### *2.7.2.4 SWFWMD Lake Mixing Standard*

This standard is an elevation where the lake area/depth ratio changes, and where the lake switches from deep and stratified to shallow and well-mixed. The dynamic ratio (as described by Bachmann et al. (2000) is used to determine if a lake is susceptible to wind mixing due to changes in lake depth. The dynamic ratio is calculated as the square root of lake surface area divided by the mean depth, with the mean depth calculated as lake volume divided by lake surface area at the P50. The critical elevation for this standard occurs when the dynamic ratio (mixing threshold) is 0.8. SJRWMD concluded that it is not appropriate for use in minimum level development at Lakes Brooklyn and Geneva because these lakes are very deep relative to their respective surface areas, and it would require a very large reduction (~15 feet) in average depth to shift the dynamic ratio until it exceeds 0.8.

The Panel, notes that this criterion would relate to water quality and filtration and absorption of nutrients and other pollutants. The Panel believes that there are other

criteria which could be developed based on available data. Nutrient processing and retention in lakes and ponds is dependent on depth, vegetation, area, and time, among others.

The Panel suggests that SJRWMD consider standards that have been developed for treatment wetlands, and consider developing a criterion, much like the habitat criteria used by SJRWMD for fish and wildlife, based on depth ranges at which key nutrient processing is efficient. The Panel suggests a review of Treatment Wetlands by Kadlec and Wallace, 2007 for selection of appropriate depths, vegetation zones, and inundation durations. The Panel suspects that, depending on the nutrient, the depth ranges will correspond closely with one or more of the criteria for fish and wildlife, but might also suggest the need for a criterion based on a deeper zone or an open water zone.

Although considered inappropriate for Lakes Brooklyn and Geneva, it could be argued that there is some value in computing the lake mixing standard and presenting these results for any lake. The dynamic ratio (Bachmann et al. 2000, Leeper et al. 2007) is used to determine if a lake is susceptible to wind mixing due to changes in lake depth. By evaluating this standard one is considering the “water quality” resource value, since re-suspension of lake sediments or an increase in the likelihood that sediments would be re-suspended would suggest potential water quality problems.

The Panel believes there is value to applying the criteria developed in this report to lakes other than Lakes Brooklyn and Geneva, even to lakes with stable wetlands and organic soils. This is because a number of these criteria explicitly address specific water resource values, and their use would obviate the need to explain or assume that protection of stable wetlands and organic soils addresses certain water resource values implicitly. Using the lake mixing standard as a criterion and demonstrating that a substantial reduction in lake depth is required before it is violated demonstrates protection of water quality. However, if SJRWMD only intends to limit use of the criteria presented in this report to Lakes Brooklyn and Geneva, the point is moot. We do note that of the approximately 70 Category 3 lakes evaluated by SWFWMD, the criterion was only applicable in 28 cases because the shallow nature of most lakes rendered them susceptible to sediment resuspension without any further reductions in lake depth (i.e., dynamic ratios >0.8).

Given the Panel’s concern regarding the significant differences likely to occur between the prolonged “wet” and “dry” period as discussed above, we wonder if the lake mixing standard would come into to play during the “dry” period. We recommend SJRWMD investigate this possibility.

#### *2.7.2.5 SWFWMD Aesthetics Standard*

The SWFWMD aesthetics standard was reviewed and assessed using the P50 and P90 levels for Lakes Brooklyn and Geneva. Due to the large elevation difference between the P50 and the P90 in these high fluctuation lakes, the resulting shift in water levels between the P50 and P90 was deemed to be unacceptably low. The SWFWMD methodology was rejected for this reason. The Panel concurs with SJRWMD that this

criterion should not be used in the establishment of minimum levels for Lakes Brooklyn and Geneva.

#### *2.7.2.6 SWFWMD Recreation / Water Skiing*

SJRWMD reviewed a SWFWMD standard for water skiing and evaluated the concept for use at Lakes Brooklyn and Geneva. While the areas, and semi-linear lengths of open water may be applicable, SJRWMD concluded that since water levels, even in the absence of drawdowns would generally be below the elevations of public boat ramps and docks, that the standard would not be appropriate for use on Lakes Brooklyn and Geneva.

The Panel notes that a review of recent aerial photographs supports this conclusion. Most boats on and near the water appear to be small boats, mostly of the "john boat" variety, not ski boats. Ski boats and skiers are not evident on available aerials, though they could have been present at times other than when the aerial photos were taken. The aerial photographs support the concept that the lakes have recreational uses, but in the absence of contrary evidence, that use does not appear to be for water skiing.

Furthermore, based on the analysis of both Lakes Brooklyn and Geneva, and on SJRWMD's analysis of docks, plus the locations of boat ramps, there would be no obvious way to access the areas of adequate size for skiing at the minimum water levels for the ski areas. Hence, the Panel is in agreement with SJRWMD that a water skiing criterion should not be used in the establishment of minimum levels for Lakes Brooklyn and Geneva. Further, the Panel does not consider water skiing to be the only recreational activity of potential importance. Other forms of recreation should be considered (see below).

### *2.7.3 Summary of SWFWMD Standards*

SJRWMD chose to use only one of the SWFWMD standards, which was the Species Richness Criterion. As noted above, the Panel recommends not using this standard. For all of the other SWFWMD criteria, the panel is in agreement with SJRWMD that SJRWMD methods are more appropriate.

### 2.7.4 Fish and Wildlife Habitat Thresholds

SJRWMD developed a number of nearshore habitat standards consistent with direction given in Rule 62-40.473, F.A.C. One of the water resource values explicitly named in the rule was "fish and wildlife habitat and the passage of fish." Unfortunately, as with the other water resource values in the rule, there was no guidance given as to how these water resource values were to be addressed. It was only stated that, "consideration should be given."

By comparing elevations of surveyed wetlands in 1996 to observations made during the current reassessment, SJRWMD recognized that important wetland communities moved downslope due to long periods of lower than average rainfall; exacerbated by groundwater withdrawals. Further, it was recognized that the areal extent of these wetlands varied as a function of lake water level and bathymetry.

Using both SJRWMD's hydroperiod tool and a significant harm threshold of 15 percent change in areal extent for various defined habitats, SJRWMD determined the extent (coverage) of various habitats under various elevations (P25, P50, and P75). The habitats as defined by SJRWMD were: emergent marsh habitat, game fish spawning habitat, large wading bird habitat, small wading bird habitat, and sandhill crane nesting habitat. There may be refinements to this approach that could be made. For example, should sandhill crane nesting habitat by evaluated only for the nesting season? Similarly, is game fish spawning a seasonal occurrence, or is it assumed that spawning occurs throughout the year. In either case, some supporting evidence should be cited. Regardless, since water elevation and bathymetry do determine the areal extent of these habitat types and since groundwater (and surface water) withdrawals in addition to rainfall will affect lake levels, gain or loss of various habitat types are reasonable proxies for assessing harm to dependent biota.

#### *2.7.4.1 Emergent Marsh Habitat*

Emergent marsh habitat was defined as the littoral shelf that extended from the water's edge to a depth of 6 feet. It must also be assumed that marshes would develop in these areas regardless of sediment quality and that they would develop quickly. This section would benefit by citing literature supporting the choice of the outward extent of the marsh (i.e., 6 feet at outside edge); although, it is the opinion of the Panel that six (6) feet is a reasonable figure. We do note as with the other wildlife metrics, that there is unlikely to be any muck to protect. The likely absence of dense marsh vegetation plus frequent natural fluctuations are sufficiently great that muck is unlikely to accumulate (too much oxidation relative to accumulation).

#### *2.7.4.2 Game Fish Spawning Habitat*

Game fish spawning habitat was defined as an area with a depth range of 1 to 4 feet. This habitat definition appears to be reasonably supported; although it might be argued that different species of fish will have different spawning habitat requirements other than those encompassed by this metric.

#### *2.7.4.3 Large Wading Bird Habitat*

Large wading bird habitat was defined as littoral area with a depth of 0 to 1 feet to support foraging by long-legged wading birds such as great egrets and great blue herons. This habitat definition appears to be reasonably supported, but might be strengthened by citing other literature dealing with habitat suitability analyses.

#### *2.7.4.4 Small Wading Bird Habitat*

Small wading bird habitat was defined as littoral area with a depth of 0 to 0.5 feet to support foraging by short-legged wading birds such as little blue herons and snowy egrets. This habitat definition appears to be reasonably supported, but might be strengthened by citing other literature dealing with habitat suitability analyses.

#### *2.7.4.5 Sandhill Crane Habitat*

Sandhill cranes typically nest in shallow herbaceous wetlands in the type of vegetation observed on Lakes Brooklyn and Geneva, and a range of 0.5 to 1.0 feet was used as the depth criterion to define this habitat type. The Panel suspect this habitat is likely

more relevant to wintering greater sandhill cranes than to Florida sandhill cranes based on maps of the wintering ranges of the greater sandhill crane and breeding areas for the Florida sandhill crane. There are habitat suitability analyses for the greater sandhill crane, but so far as we are aware, not for the nesting areas for the Florida sandhill crane.

Data for all habitats evaluated was smoothed using local regression (LOESS). Consistent with evaluation of other standards proposed by SJRWMD, a 15 percent loss of habitat area was used to define significant harm.

The use of the various habitat areas as defined by SJRWMD is somewhat analogous to an important instream method routinely applied in riverine environments; the Physical Habitat Simulation (PHABSIM) model. The purpose of PHABSIM is to simulate a relationship between streamflow and physical habitat for various life stages of a species of fish or a recreational activity (Milhous and Waddle 2012). PHABSIM, using species and life stage specific habitat preferences for water depth, velocity, cover and substrate (habitat suitability curves), generates a measure of available habitat (weighted usable area) in a stream that is specific to the organism(s) being evaluated. Using the amount of habitat available, one is able to evaluate the gain or loss in habitat that occurs as flows are increased or decreased. Further, just as SJRWMD observed for Lakes Brooklyn and Geneva, habitat for some species or groups may actually increase as water is removed from the system.

SJRWMD evaluated gain or loss of the various habitats as defined above using changes in area of each respective habitat type at three percentiles (P25, P50 and P75). In more stable lake environments (those varying over a much smaller range of elevations), one would only need to assess gain or loss of habitats at percentiles representative of higher elevations (e.g., P75 or greater), since wetlands occur at lake edges. However, given the wide range of lake level fluctuation at Lakes Brooklyn and Geneva, even in the absence of withdrawals, it is appropriate to evaluate these habitats over a range of percentiles. Overall, the Panel supports the use of these habitat metrics as reasonable criteria protective of certain fish and wildlife values.

### 2.7.5 Recreational Uses

#### *2.7.5.1 SJRWMD Dock Access Standard*

Although SJRWMD determined that SWFWMD's dock use standard would not be appropriate for Lakes Brooklyn and Geneva as documented in the final MFLs report, it did develop a dock use standard specific to these lakes.

The primary goal of the dock standard as proposed by SJRWMD was to protect lake-user access by not allowing more than a 15 percent reduction in the amount of time that boat access would be possible under historic (no-pumping) conditions. As such, the SJRWMD standard is primarily a recreational water resource value protection standard rather than an ecological standard.

We are not certain when the docks on Lakes Brooklyn or Geneva were built and if there were any regulatory constraints on their construction; however, this would be important

to know. Review of aerial photographs of Lakes Brooklyn and Geneva, and a cursory review of dock installation dates on the Clay County Property Appraiser's website, suggest that the docks can be described either as "permanent" or "temporary". Permanent docks would be those with substantial, non-movable pilings. Installation dates for a subset of these permanent docks are in the Clay County Property appraiser's database. Temporary docks are smaller docks that appear to be moved up and down slope as water levels vary and are not in the Property Appraiser's database. A large proportion of the permanent docks in the Property Appraiser's database appear to have been built during or shortly after the end of the period of high rainfall that characterized the 1960s and early 1970s with a few additional docks built during and after more recent brief high water events. As a result, we have concerns with the use of a mean end-of-dock elevation in the methodology used to develop the criterion.

Figure 2, shows the mean waterward piling elevations (i.e., minimum dock access elevation less 2 feet) for both lakes superimposed on observed water level elevations for Lakes Brooklyn and Geneva. Assuming that most docks, especially the ones with permanent pilings, were constructed primarily under "wet conditions" such as occurred from the late 1950s to the early 1970s, the waterward dock piling elevation would be located relatively high in the landscape compared to what might have occurred under "dry conditions." If this hypothetical were true, the standard could be viewed as protecting an artificially high condition. On lakes with such a naturally wide range of level fluctuations, it is not surprising that docks could be rendered relatively useless for access under some conditions. If constructed under "wet conditions" the waterward dock piling may currently be located very near the water's edge or even out of water; conversely, if constructed under very dry conditions, docks may end up submerged and non-functional unless the most waterward dock piling is extremely tall. Based on the docks for which construction dates are available, it appears that "permanent" docks were constructed during generally wet conditions. It appears that "temporary" docks were constructed during dry periods and at least since 1994, many of those have been relocated at lower elevations as water levels fell.

For context, we surveyed minimum levels adopted by SWFWMD on their Category 3 lakes. None of their lakes exhibited the extreme natural (as defined by the historic P90 to historic P10 difference) water level fluctuations characteristic of Lakes Brooklyn and Geneva. Only three comparatively shallow lakes in Marion County (Lake Bonable, Little Lake Bonable and Tiger) had P90 to P10 differences that exceeded 10 feet.
The Panel notes that it is not only the elevation of the lakeward end of the dock and the amount of water under that waterward end that affects use of the dock. The vertical distance of the dock deck to the water affects use. The kayakers and canoeists on the

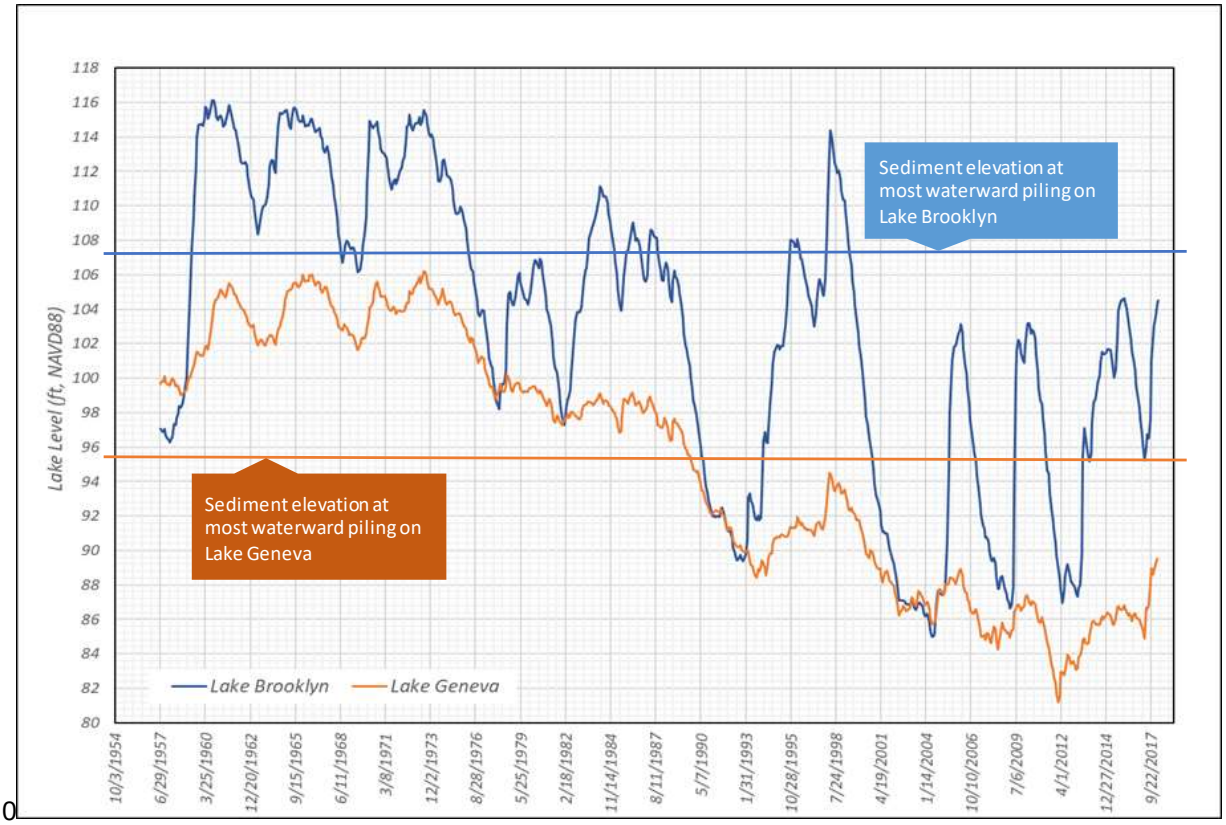


**Figure 2.** **The means of the most waterward dock piling elevations for Lake Brooklyn and Lake Geneva.**

Panel pointed out that they would not use a dock where they had to climb down a 6-ft (or taller) ladder to get into a boat (they would access the boat from the shore). The same Google Earth explorations suggest that most boats observed along the shores of these lakes are small boats (most appear to be john boats) that can be pulled onto the shoreline, but the availability of these photographs does not begin until 1994, which is well after the lakes had experienced years of reduced water levels.

Hoyer et al. (2006) conducted a survey of lake-user opinions regarding preferences in water levels. The most common use of docks in their survey was sitting on the dock and enjoying the view. A substantial majority (72 percent) of respondents indicated that water levels at or below the bottom of the dock reduced the scenic value of the lake. Respondents also indicated that having a large drop from the deck of the dock to the water was undesirable.

The Panel's initial reaction to the dock standard was that it was seeking to protect access that would simply not exist much of the time, and we questioned the applicability of the standard to these lakes. However, the standard as proposed by SJRWMD would likely protect access from these docks under wet climatic conditions, but not all conditions. Lack of access from docks for long periods of times cannot simply be attributable to groundwater withdrawal impacts and the complete cessation of groundwater withdrawals will not substantially improve access for much of the time. This is especially true for Lake Geneva, because it appears that docks located on this lake

would not have water under them during multi-decadal dry periods. In Lake Brooklyn, access might be improved slightly during dry periods.

From a purely editorial or presentation standpoint, we wonder if this standard and its application are likely to be misinterpreted by the lay reader as being more protective than it actually is. One interpretation would be that access will only be negatively impacted 15 percent of the time (which is actually true), so conversely there will be access 85 percent of the time (which is not true). The real interpretation should be that the minimum level standard would only allow access that would occur in the absence of pumping to be reduced by 15 percent, but this can be misleading as well, if the reader does not understand the implication of the "wet" and "dry" periods as discussed by SJRWMD in the final MFLs report. For example, the period of record from 1957 to 2015 is 58 years or 21,170 days long (not counting leap years). Docks on Lake Brooklyn using the criterion defined in the final MFLs report and under no-pumping conditions would have been accessible for 10,267 days or approximately 28 years or for less than half the time. The proposed minimum level would reduce this by 15 percent or to 8,722 days (approximately 23 years). Under current conditions, docks were accessible for only 5,822 days or about 16 years. Under the proposed minimum level, on average, docks would be accessible 4 out of 10 years. However, the years of accessibility are not scattered throughout the period of record, but rather concentrated in the wet period.

The Panel also wonders if SJRWMD has given any thought to evaluating all its proposed criteria under essentially two different elevation regimes by segregating the no-pumping record (1957 to 2015) into a "wet" and a "dry" period (Figure 3). If this strategy was adopted, SJRWMD could develop minimum levels for each period and adopt the more conservative of the two. We do realize this strategy has the potential to be over protective for some periods; however, the other strategy has the potential to be under protective for some periods. Some members on this panel (Jones et al. 2017) and others (Neubauer et al. 2007) have been critical of using exceedance probability curves because they can obscure seasonal and even decadal trends in the data. This approach would explicitly address the climatic variability so evident in the data. Using the dock standard for Lake Brooklyn as an example, there were short periods of time where it appears there would technically have been dock access during the dry period, and these days added to the count of the number of days of access, even when it might be argued the docks were essentially not useable because the period of access was small.

Although the following is not a significant concern, it is noted that the "wet" period for the period of record used (1957 to 2015) lasted from essentially 1957 to 1977, and the "dry" period from 1978 to 2015, in other words there are fewer "wet period" years than "dry period" years in the no-pumping hydrograph. We do acknowledge, however, that there is no reason why "wet" and "dry" periods should be of equal length, and it is quite likely, for example, that a 40 year wet period could be followed by either a shorter (e.g.,30 year) or longer (e.g., 50 year) dry period. It would be interesting, just as a proof of concept, to see one such analysis done this way. We know this would involve some additional work on the part of SJRWMD; however, no new data acquisition would be

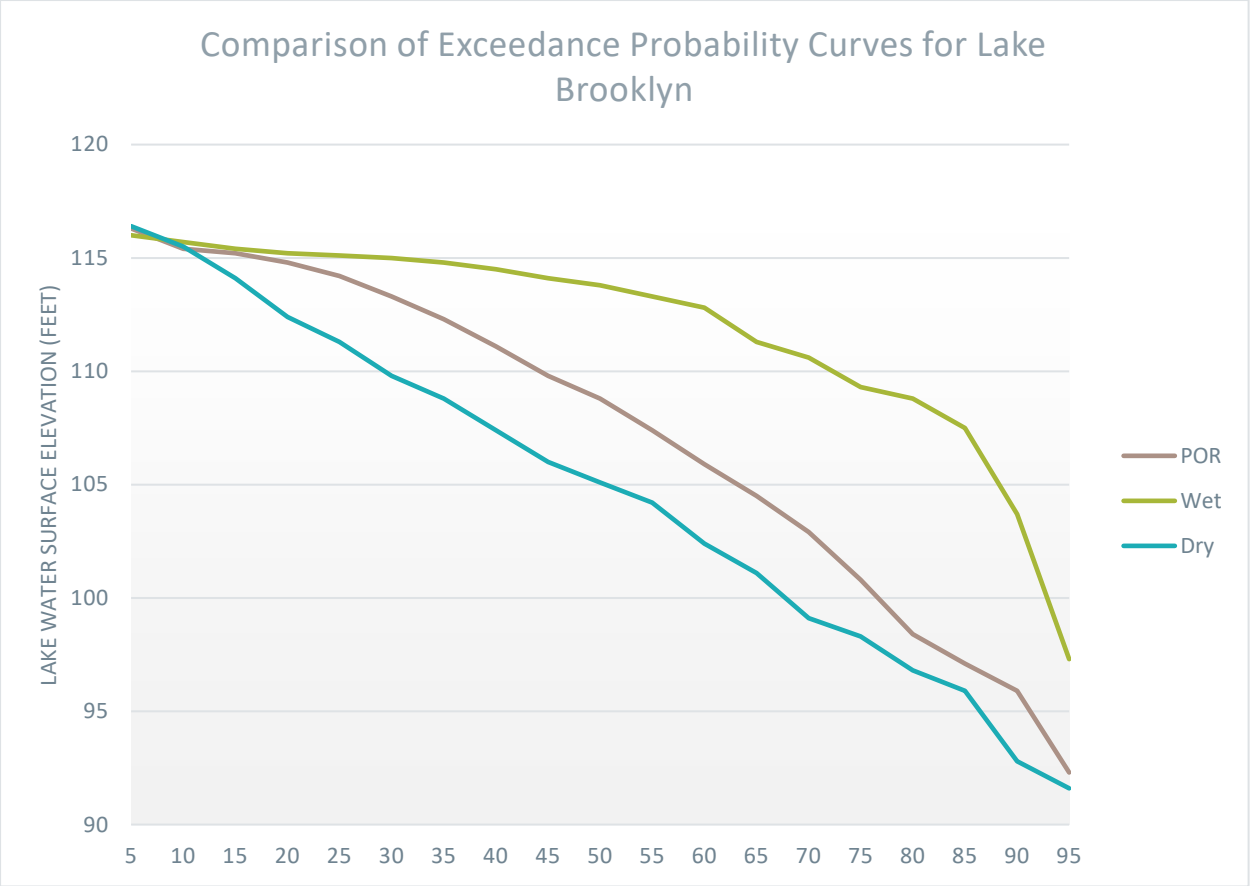


**Figure 3. Comparison of exceedance probability curves for the "wet period" (approximately 1957 to 1977), the "dry period" (1978 to 2015), and the period of record (1957 to 2015) for Lake Brooklyn.**

required. It would also be interesting to do this type of comparison for the fish and wildlife habitat thresholds that were evaluated.

The lake mixing standard was deemed unsuited for these lakes, but because lake depth is considerably diminished in the "dry period", we wonder if it might be relevant for the lakes, especially Lake Geneva, if analysis was restricted to the lake during the dry period. However, because the dynamic ratio is a function of both lake depth and area, it is possible that the effect of decreased lake depth on the ratio is offset by the concomitant decrease in surface area.

The Panel has vacillated on whether a dock standard should be applied to either Lakes Brooklyn or Geneva. For example, we acknowledge that the criterion used is somewhat protective of dock assess as discussed above; however, it does little or nothing to address access during the climatic "dry period." Using Lake Brooklyn as an example, it is believed that the surveyed docks were constructed during the wet period and for that period did allow access much of the time (Figure 4, panel A). It is unlikely that residents were aware of the extreme fluctuation range likely for this lake, since there was probably little or no experience with a preceding dry period. If one were to survey docks

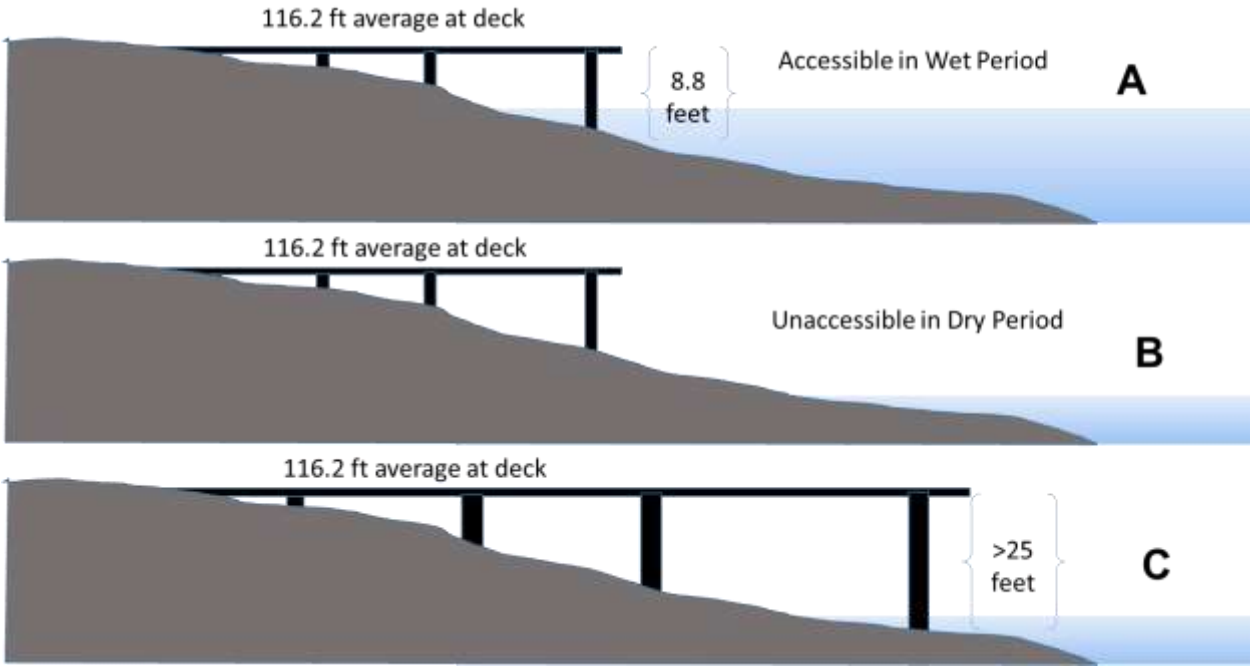


**Figure 4. Actual and hypothetical dock configurations on Lake Brooklyn highlighting the difficultly of constructing a dock that would be accessible in both extended wet and dry periods.**

on most lakes where fixed docks are used, we suspect that one would find that the deck is typically situated at the P10 elevation or greater (perhaps coinciding with the lake's outlet elevation) and that the elevation of the most waterward piling at the lake's sediment is located somewhere near the P90 elevation (plus or minus a foot or two). Such a placement would insure access 80 percent of the time; the deck would be under water no more than 10 percent of the time, and the dock unusable due to low water another 10 percent of the time. As illustrated in Figure 4, panel C, to construct a dock in Lake Brooklyn or Lake Geneva that would allow access under most conditions, the height of the most waterward piling would need to be extremely high, and the length of the dock excessively long. Such a dock seems impractical for a number of reasons (e.g., cost, safety, and aesthetics). The Panel does understand how the dock standard works as applied by SJRWMD, but wonders if a dock standard is to be used, should it be applied to a hypothetical dock as shown in panel C (which seems impractical) or evaluated only for access during wet periods.

### 2.7.6 Alternative Recreational Standards

The Panel is in agreement with SJRWMD that SWFWMD's ski standard does not appear applicable to these lakes; however, a similar type of recreational standard might be considered based on the discussion that SWFWMD provided, *"Certain recreational activities such as water skiing are dependent on open water, free of emergent, floating or near surface submerged vegetation."* Leeper et al. (2007) cites work done by Wagner (1991) related not only to the open area of water required for water skiing but also the amount of depth needed for safe operation of power boats (see also Table 1 in Mosisch and Arthington (1998)). As an example, a standard might consider the amount of open water in the lake with at least 4 feet of water depth. If, for discussion purposes,

20 acres of open water are required per boat, the carrying capacity for boats at the no-pumping P50 elevation might be determined. Supposing the lake is able to support 20 boats at this elevation, then the standard might be no more than a 15 percent reduction in the lake's carrying capacity. In this example, the lake's recreational boating potential is protected by allowing the P50 elevation to decline to the point where boat carrying capacity is 17 boats (i.e., 20 * 0.85 = 17). We believe that open water has ecological value, and this criterion could also be considered protective of the fish and wildlife water resource value but supportive literature would need to be provided.

Another alternative is to address other forms of recreation on the lakes and ways other than docks by which the lakes can and are accessed for recreation. For instance, there is a camp (YMCA Camp Immokalee) on the north side of Lake Brooklyn. Established in 1909, its website indicates that camp participants use the lake for canoeing, kayaking, and fishing. Some residents on Lake Brooklyn have small boats that can be seen along the lake fringe in Google Earth images. These look to be john boats (or equivalent) plus at least one canoe. Boat ramps exist on both lakes, two on Lake Geneva and one on Lake Brooklyn. The ramp on Lake Brooklyn and the ramp on Lake Geneva are closed due to low water. The town's ramp at Keystone Heights Beach Pavilion appears to have been replaced so that it is usable. A suspicion is that the ramps would be used for a range of recreational activities (fishing, boating, water skiing), if water levels were adequate for access both to the relevant lake, and in the case of the ramp at Lake Geneva, to the main lake pool. Few recreational activities will occur from these ramps if there is inadequate water to use them.

The Panel suspects that at least one of these ramps (the ramp on Lake Geneva) has likely never been consistently usable and would not be consistently usable under the no-pumping condition. Further, the ramp on Lake Geneva has the problem that it ends in a pool that appears not to have adequate or frequent connection to the main lake.

Boat ramps, may provide more tractable approaches to developing a recreational standard than docks. Rather than attempting to use the existing locations of docks, it may be possible to use boat ramp design standards to develop a standard that is based on design criteria for boat ramps as opposed to attempting to determine a suitable elevation for the end of a multitude of docks. Boat ramps always begin at or above the lake edge, and extend outward to a depth where a boat will float with the propeller in adequate water depth for the prop to not cause erosion beyond the end of the ramp. The ramp then being closed when the water depth is inadequate. Unlike residential docks, multiple governmental entities have design standards, most of them quite similar, for determining the amount of water needed at the bottom of a ramp such that boat propellers will not wash out the bottom, usually on the order of 3 to 4 ft. If the boat ramp is designed to be used 90 percent of the time under no-pumping conditions, then the allowable time of inadequate depth, increased by 15 percent, could become a criterion for recreational use. Using such a standard to evaluate the needed water regime for recreational boat access, in combination with a minimum that establishes an allowable change in the amount of time the ramp is usable, might be a potential approach for establishing a standard to protect public recreation on the lakes.

### 2.7.7 Lake Connectivity Elevation Standard

*"The purpose of this criterion is to prevent a significant change due to water withdrawal, relative to historical conditions, in the duration of continuous surface-water connections between lake lobes. The metric is based on the minimum water depth required for lake lobe connectivity . . . to which an offset (boat final) is added to provide sufficient depth for boating or other forms of recreation"* (Sutherland et al. 2018). The panel would add that this metric is also protective of fish passage between lake lobes and thus addresses, in part, at least two water resource values. We believe that this metric protects water quality especially in more shallow lobes by allowing water exchange between lobes. Generally as water depth is decreased in lakes, water quality is negatively affected due to increased temperatures, lowered DO, potential for increased algal blooms as nutrients become concentrated, and negative effects resulting from resuspension of sediments (e.g., reduced clarity, introduction of potential sediment contaminants into the overlying water column). The Panel can think of no water quality positives that accrue as lake lobes are disconnected, and a number of obvious and potential negatives, as such this is a good metric even if connections occur at relatively high elevations under current conditions.

Examination of hydrographs for Lakes Brooklyn and Geneva suggest that for long periods of time the lakes have been separated into multiple lobes. At times the lakes can be viewed as multiple lakes. This may create a problem when considering application of various standards.

Using Lake Geneva as an example, the upper panel of Figure 5 shows Lobe 3 of Lake Geneva and the connection with the main body of the lake. The control elevation in the connection between Lobe 3 and the main lake body occurs at elevation 96.5 feet. When the water surface elevation drops below 96.5 feet, the lake is separated into two distinct pools. Referring to the bottom panel of Figure 5, it can be seen that this separation is more than an intermittent occurrence that is only temporary or seasonal in nature. Lobe 3 has not been connected to the main body of the lake since about 1990, and as such has existed as a separate entity (it is acknowledged that the under the no-pumping condition, Lobe 3 would have been connected to the main body of the lake for a short period of time in 1999.) Based on the exceedance probability curves (EPCs) for Lake Geneva, the break into two lobes occurs below the P50 elevation (at approximately P63). The criterion developed actually added 2 feet to the highpoint elevation so the standard is based on elevation 98.5 feet for Lake Geneva.

The calculations presented by SJRWMD are correctly done. Text in the final MFL report under discussion of recreational uses states, ***"****Critical elevations for each metric were determined for each lake (Tables 7 and 8). A 15 percent reduction in time exceeded was calculated by multiplying the no-pumping percentile for each elevation times 0.15. The resulting percent . . . was subtracted from the no-pumping percentile to yield the MFLs condition percentile."*


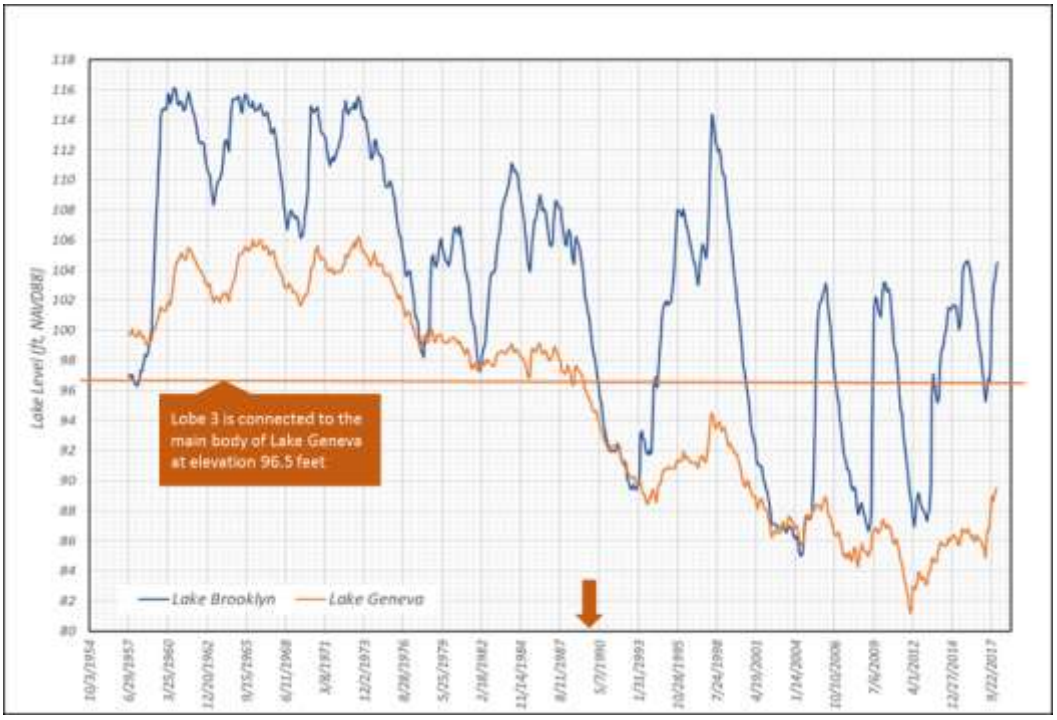


**Figure 5.** **Upper panel shows location of Lobe 3 with respect to Lake Geneva proper, and bottom panel shows the water elevation at which Lobe 3 has a surface connection to the main body of Lake Geneva.**

Since a 15 percent reduction in time is also another way of saying preserving 85 percent of the time exceeded, the same result is achieved by multiplying the no-pumping percentile by 0.85. This is the critical calculation for the recreational standards presented and needs to be clearly high-lighted.

Except for a short period, Lake Geneva Lobe 3 is only connected to the main body of the lake during the "wet period" as demonstrated in Figure 6 (Figure 7 of the final MFL Report). The Panel wonders what the outcome of this analysis would have been if done for distinct wet and a dry periods. Essentially for Lake Geneva, there would have been no connection between Lobe 3 and the lake during the dry period, and there would be no expectation that the connection would need to be preserved. On the other hand, inspection of Figure 5 suggests that the main lake and lobe connection was always maintained under wet conditions. The statistics and standards as calculated by SJRWMD work because the no-pumping condition encompasses both a "wet period" and a "dry period".

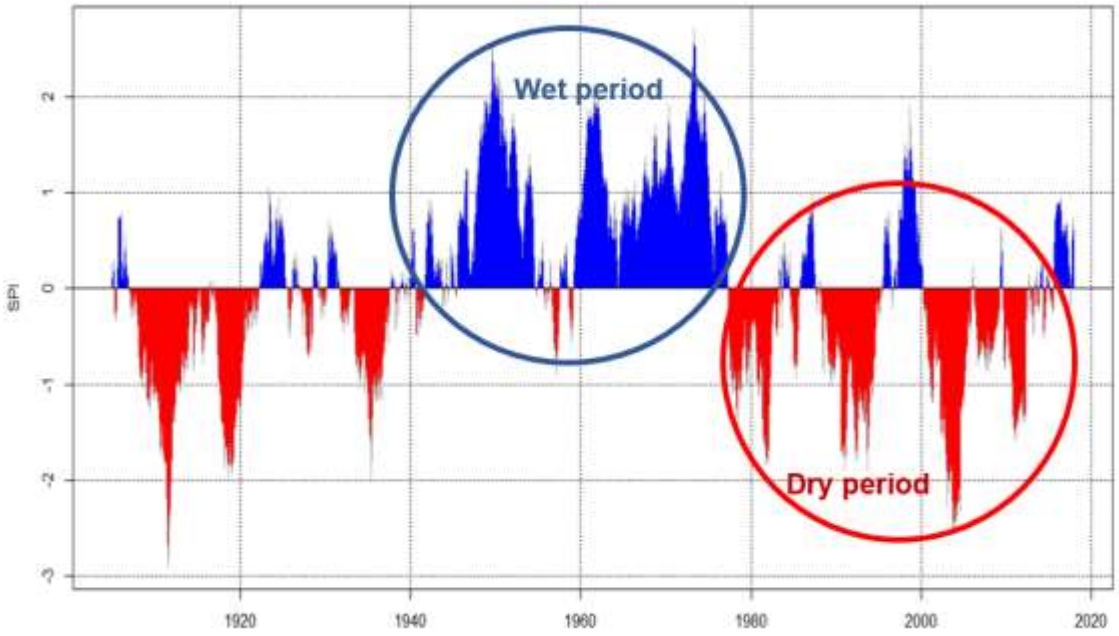


**Figure 6. Long-term 60-month standard precipitation index of composite rainfall (Gainesville and Local Keystone Heights rainfall stations).**

While the Panel is certain that SJRWMD scientists understand this, it must be appreciated that high lake elevations are rarely achieved under dry conditions especially in Lake Geneva which receives very little surface inflow during such times. Although the SJRWMD devotes considerable space and effort in their report to significant climatic differences that persist for multi-decadal time periods, it is hard to understate this impact on the water budgets and the ecology of these lakes. Relying solely on exceedance probability curves, it is possible to lose touch with important seasonal, annual, and multi-decadal differences that can occur due to an averaging affect as discussed by Neubauer et al. (2008) regarding the use of flow duration curves (analogous to exceedance probability curves) on environmental flow assessments. Quoting, *"Magnitude and duration are often presented graphically as traditional flow-duration*

*curves (FDCs) that display the relationship between flow and percentage of time a particular flow is exceeded. . . Unfortunately, FDCs are not sufficient to characterize or implement SJRWMD MFLs because these are: period of record dependent, tend to oversimplify and essentially average the data. Extending this example to a lake with a water level that is exceeded 10 percent of the time during a 50-year period could be the result of stage data collected during five consecutive wet years (i.e., 1826 consecutive days above the 10 percent time exceeded water level) or yearly flood events that last for 36.5 days duration each."*

We did find one possible data issue that could affect results under low water connections. Once connections between various lobes are lost, it cannot necessarily be assumed that elevations within disconnected lobes will track one another due to differences in bathymetry between lobes and potentially different leakance rates. While it might be possible that below surface water transfer could maintain similar levels between pools, this is less likely under dry periods than wet periods. This would potentially affect any calculation for standards where the relevant exceedance percentiles are below the highest connectivity elevation for each lake (e.g., some of the fish and wildlife habitat metrics).

### 2.7.8 SJRWMD Aesthetics – Lake User Perception

Per Rule 62-40.473, F.A.C., the District is required to consider "aesthetics and scenic attributes," which are to protect from significant harm passive beneficial uses such as bird-watching, sightseeing, photography, contemplation, and other forms of relaxation. SJRWMD used a survey by Hoyer et al. (2006), to assess the acceptability of a shift in the time that the P50 elevation is exceeded, under the no-pumping condition, by 20 percent. The resulting shift in the P50 equals a percentile shift of 10 percent (shift = percentile * 20 percent; = 50 * 0.20 = 0.10 = 10 percent). The aesthetics metric was assessed by comparing the allowable shift with the baseline condition.

User questionnaires have been used by others when assessing lake aesthetics (Tallar and Jian-Ping Suen, 2017) and has also been used for rivers (Pflüger et al., 2010). These studies consider many of the same factors used by Hoyer et al. (2006) but are appropriately unique to their particular situations. The use of the Hoyer et al. (2006) study as a major basis for aesthetics of lakes in Florida appears to be appropriate, in general.

The Panel, however, has concerns about the applicability of the survey to Lakes Brooklyn and Geneva and to other high fluctuation lakes, primarily due to the wide natural fluctuation regimes in these lakes and the under-representation of such lakes in the survey. It appeared from the survey results that some of the most common uses of the lakes were likely dependent on aesthetics, for instance, sitting and enjoying the lake was the most common activity recorded in the survey. Bird and wildlife watching were also common activities reported in the survey.

Hoyer et al. (2006) included in their survey a list of lakes that the respondents live on or use. The overwhelming majority of these lakes are described by respondents as relatively shallow lakes with gradually sloping shorelines, and to our knowledge, few, if

any have natural fluctuations as broad as those found on Lakes Brooklyn and Geneva. The Panel is unaware of any studies of user preferences that would be more appropriate to these lakes and fully acknowledges that MFLs are to be based on best available information.

The Hoyer et al. (2006) study did not address the area of the lake pool and the width of dry shoreline above the water, both of which could affect user perceptions of aesthetics on Lakes Brooklyn and Geneva. While clearly these opinions would also affect no-pumping conditions, the Panel believes that incorporating some aspect of pool size into the criteria, or adding pool size as an additional criteria would be beneficial in protecting aesthetic values on these lakes.

There are other approaches to assessing aesthetics that might be appropriate for use to the extent that they provide objective ways of valuing aesthetics. While not feasible based on existing data, SJRWMD might want to consider looking into one or more metrics based on changes in the value of property and/or recreation prior to future reviews of the minimum level.

Aesthetics are more than a personal preference because they also affect property values. Given that property values can be evaluated numerically and objectively, the Panel suggests that SJRWMD consider adding an evaluation of effects of water level change on property value in any future effort.

In recent years, a number of studies have looked at the effect of water level reduction on value of property. The changes in water levels assessed range greatly, but some of the more recent studies assess changes in the range of the reduction in water levels from pre-pumping conditions being proposed for Lakes Brooklyn and Geneva. There are several studies that include duration of change and season of change. In brief summary, both reduction in level and reduction in length of shoreline appear to be important. Water quality also affects value. A good recent summary can be found in Kashian et al. (2016). This paper also gives details on how the analyses were conducted. Given that the existing studies with data were conducted in widely different parts of the U.S. and over a wide range of time, using percent change in value would likely be useful to making these studies appropriate.

### 2.7.9 Adopted Sandhill Lakes MFLs Comparison

SJRWMD also conducted an analysis to evaluate whether the proposed minimum levels for Lakes Brooklyn and Geneva are within the range of change (from historical / no-pumping condition) allowed for other sandhill lake minimum levels in Florida. To evaluate this, SJRWMD obtained data on established minimum levels in SJRWMD and SWFWMD, and created a metric with which to compare the proposed minimum levels for Lakes Brooklyn and Geneva with those for other sandhill lakes with established minimum levels in Florida. This assessment was based on percent change in median lake depth allowed under the adopted minimum levels.

A total of 33 lakes were used for this comparison; 27 lakes from SWFWMD and 6 lakes from SJRWMD. The Panel had several observations/comments relative to this

assessment. First, no definition for a “sandhill lake” was given, so we do not know on what basis the lakes were selected for inclusion in this analysis. We understand how the math was done, and how the lakes were “standardized” to evaluate the range of change in percent of lake depth that could be lost under each lake’s adopted minimum level. We do make the following observations keeping in mind that most lakes in the analysis were SWFWMD lakes. The mean (i.e., average) depth for the 33 lakes was 24 feet; however, the mean lake depth of the SJRWMD lakes was 18 feet, while SWFWMD lakes averaged 26 feet in depth. The minimum level allowable change in the P50 was approximately 1 foot for the 33 lakes assessed; however, the mean change in P50 elevation for SJRWMD lakes was 2.35 while that of SWFWMD lakes was 0.76 feet. Although the mean percent reduction in mean depth for the 33 lakes allowable under their respective minimum levels was 5.6 percent; the allowable percent change in lake depth was 11.6 percent for SJRWMD lakes and 4.3 percent for SWFWMD lakes.

All the minimum levels on the lakes in this analysis were set using separate methods from those used on Lakes Brooklyn and Geneva as discussed in the final MFLs report. The 6 SJRWMD minimum levels were set using their standard approach which required the presence of stable wetlands and wetland soils. The 27 SWFWMD lake minimum levels were set using one criterion from a suite of multiple criteria; criteria which were generally found unsuitable for application to Lakes Brooklyn and Geneva. In addition, while multiple criteria were evaluated for each lake, the vast majority of the minimum levels on SWFWMD lakes were set using a single criterion (i.e., “wetland offset”, see Hancock 2007) that was not evaluated by SJRWMD. Had it been assessed, it would likely have been considered unsuitable for use, since it was based on protecting fringing lake wetlands. This single criterion is important, however, because it explains the mean allowable P50 change on SWFWMD lakes regardless of lake depth. This criterion simply allows the P50 to be reduced by no more than a 0.8 from the historic P50. This was the criterion applied on 19 of the 27 SWFWMD lakes; hence the average of 0.77 feet for SWFWMD lakes as a group. As far as a test of reasonableness, we are not sure that the results support the claim of “an average (and range) of allowable change for sandhill lake minimum levels throughout Florida.”

## 2.8 General Observations and Conclusions

In the subsections of Section 2 above, the Panel discussed the environmental criteria individually to highlight our observations, questions and concerns. In this subsection, the Panel discusses the validity and appropriateness of the environmental criteria we were asked to specifically address as part of our charge. The specific charge and related questions and our responses to them are included below.

### 2.8.1 Assess Validity and Appropriateness of Environmental Criteria

Question 1. Are the environmental data used to develop criteria adequate and appropriate?

The environmental data used were essentially the no-pumping lake stage data which represented the “benchmark” against which significant harm was evaluated. The same data set were used for each criterion evaluated. They are “environmental data” in the

sense that lake stage was related to various environmental or other water resource values to be protected. In most cases, a 15 percent significant change standard was used to determine when significant harm would occur. The Panel is in agreement that the data are adequate and appropriate.

Question 2. Are the methods and procedures used for environmental analyses appropriate?

The Panel reviewed each criterion in some depth as discussed above and depending on the criterion we did identify some issues (e.g., bird species richness); however, there was consistency in the methods and procedures applied to each criterion. For example, the 15 percent significant change standard was generally applied as “a no more than a 15 percent reduction in time” that something would occur. Exceptions were the aesthetics standard (where a 20 percent shift was used rather than a 15 percent shift) and the species richness standard where a 15 percent reduction in lake surface area was justified on the basis of losing a single species from the population of species likely to occur. In short, and making a distinction between “methods” versus “criterion”, the Panel is in agreement that the methods and procedures used were consistently applied, reasonable, and appropriate.

The Panel explicitly addressed the use of the 15 percent change standard, and although it has been criticized by some, we find it acceptable and reasonable. We did suggest that SJRWMD consider applying their analysis to both a “wet” and a “dry period.” This would not substantively change the methods or approach; however, it is possible, as explained in our narrative, that the use of single exceedance probability curves for each lake “*essentially average the data.”* It is possible, however, that use of two periods rather a single period of record would lead to different recommended levels.

Question 3. Are methods to evaluate the relevant environmental values and beneficial uses appropriate?

The Panel strongly supports the use of multiple criteria and the concept of adopting the more conservative outcome; however, we have raised issues regarding specific methods (e.g., dock use, aesthetics), and these are addressed under the discussion of each. The reader will need to review the individual method discussions for each criterion for details of our particular concerns.

Question 4. Have all relevant environmental values been evaluated?

To the extent possible, the Panel is in agreement that all relevant environmental values have been evaluated. The caveat is applied because there is inadequate data to explicitly address some of the environmental values as identified in rule 62-40.473, F.A.C. For example, it is difficult to find in the literature a study of the “transfer of detrital material” in a lake that could be readily transferred to Lakes Brooklyn and Geneva. In our view this value is likely protected because a number of different values were directly addressed, and the proposed minimum lake levels were based on the most

conservative of these. Clearly some of the environmental values are not relevant to minimum levels on these lakes (e.g., estuarine resources).

Question 5. Are data appropriate for evaluations, selected criteria, and conclusions?

The appropriate data required for all evaluations and selected criteria was a benchmark water level time series. The benchmark used is the no pumping time series. We discussed four approaches that could and have been used to develop a benchmark, and the Panel is in agreement that the modeling approach used by SJRWMD*, "overcomes what we believe are major limitations to the other approaches."*

Question 6. Are assumptions reasonable and consistent given the "best information available"?

Whether considered an assumption or not, we suggested consideration of minimum levels on the basis of two distinct periods based on multi-decadal differences in rainfall as clearly outlined by SJRWMD in the final MFLs Report.

The Panel is in agreement that the use of a 15 percent change standard is appropriate for determining "significant harm."

We questioned the assumption, inherent in some analyses, that water levels in disconnected pools tracked each other exactly. However, since levels were not measured in disconnected pools, the analyses were done with "best information available."

### 2.8.2 Appropriateness of Recommended Minimum Levels

Question 1. The validity and appropriateness of assumptions used and conclusions made in the development of protective minimum levels, including identifying sources of uncertainty and their impact on development of protective minimum levels for these lakes.

The appropriateness of recommended minimum levels has been implicitly questioned by the Panel because we questioned the suitability/applicability of some of the criterion that were used to arrive at the proposed minimum levels. We also suggested that SJRWMD consider evaluating the criteria that were developed against benchmarks based on "wet" and "dry periods." Should SJRWMD follow our recommendations related to specific criterion and/or use an approach based on a "wet" and "dry periods", the proposed minimum levels are likely to change.

Question 2. Adequacy of data to support conclusions and recommendations

The Panel is in agreement that the data presented in the final MFLs Report to support conclusions and recommendations are adequate.

# 3 Lake Levels and Hydrology

## 3.1 Introduction

The Panel's charge is to "Assess validity and appropriateness of hydrologic analysis" used in the process for determining MFLs for lakes Brooklyn and Geneva. The focus of the Panel's review was on the appropriateness of methods used to develop the lake levels data that represented the "Benchmark Period" and that were used in determining the proposed minimum lake levels. The Panel was instructed to assume that the groundwater flow models used in the analysis (NFSEG, KHTM) are accurate, properly calibrated, and verified. Therefore, the focus of the panel was on the application of these modeling tools to establish the necessary lake levels for the Benchmark Period. As part of the review, the Panel has offered comments and suggestions regarding additional information that would be helpful to include in the final document to facilitate a better understanding of the physical system and complex relationships that exist.

As noted by SJRWMD in the final MFLs Report, Appendix B, ". . . *determining minimum flows and levels and assessing the status of waterbodies requires substantial hydrological analysis*." The process was summarized in five basic steps that included: 1) review of data, 2) long-term rainfall analysis, 3) historical groundwater pumping impact assessment, 4) development of lake level datasets representing no-pumping and baseline conditions, and 5) development of relationships between lake, and the Upper Floridan Aquifer levels. It is important that the lake levels data used to represent the Benchmark Period reflect long-term rainfall conditions, including both wet and dry periods, and the long-term fluctuation of the lakes in the absence of effects of groundwater withdrawals.

The Panel understands the hydrologic setting of the Keystone Heights area is complex due to the influence of sinkholes, stream flows, and long-term cyclic variations in rainfall. As noted by Clark et al. (1963), Lake Brooklyn declined more than 20 feet over a three year period in the 1950s due to a period of lower than normal rainfall. Lakes Brooklyn and Geneva are on the southern end of a chain of six lakes that are connected by the intermittently flowing Alligator Creek. Lakes in the upper portion of the chain generally have stable lake level fluctuations whereas Lakes Brooklyn and Geneva in the lower portion are considered to be among lakes in the State of Florida with the widest ranges of fluctuation.

The process to establish the necessary lake levels datasets involved the use of nested groundwater models and development of statistical relationships that related the monthly response of lake levels to total pumping in a six-county area over the period 1957 to 2015. Through this process, long-term lake levels datasets were developed that reflected the levels that would be expected to occur in the absence of groundwater pumping and under the influence of actual rainfall that occurred over the period. The period of record used corresponds to the period when regular water levels data

collection began and also to the availability of information related to groundwater withdrawals.

The pages that follow are a discussion of the validity and appropriateness of the hydrological analyses the Panel was tasked to address as part of our charge. The specific charge and related questions and our responses to them are included in the discussion.

The specific charge and related questions include:

## 3.2 Assess Validity and Appropriateness of Hydrological Analyses

Question 1. Are the hydrologic data used to develop impact assessment methods appropriate?

Rainfall. The rainfall data presented were a composite of data collected from several sites in the Gainesville and Keystone Heights areas and extend from 1900 to 2017. The data were sufficient to represent short and long term trends that likely occurred in the area. Based on the time series presented, it is evident that cyclic fluctuations occur and that the period from 1945 to 1965 was generally very wet and the periods from 1910 to 1920 and 1995 to 2005 were generally very dry. The collection of long-term water levels data in the Keystone Heights area began during the wetter period. The presentation of known climate cycles (AMO, PDO, and ENSO) supports the conclusion that rainfall in the area is cyclic and that the amount of rainfall received since the early-1970s is less the rainfall received over the period from the 1930s to the early 1970s.

Lake Levels. The period of available lake levels data for Lakes Brooklyn and Geneva extends from about 1957 to 2017. This period is sufficiently long to indicate lake levels will generally rise in response to rainfall and that there were periods when the lakes naturally fluctuated much higher than during recent decades given that the rainfall was significantly higher during those periods. To create a long term daily time series of lake levels, SJRWMD first calculated monthly average levels and then linearly interpolated between these values to estimate daily values. Though it may not make a difference, SJRWMD might consider comparing their approach for infilling missing daily values to simply performing linear interpolation between measured values.

Groundwater Withdrawals. Estimates of historical groundwater withdrawal quantities were provided on a county-wide basis for six counties surrounding the area. This was sufficient for understanding the historical development of groundwater in the region. It would be helpful to see maps that depict withdrawal quantities by location (e.g., using a model grid) as well as the change in withdrawals from the early to recent periods. Additionally, it would be beneficial to summarize the withdrawals by use type and county for the early and late periods to provide the reader with a better sense of the distribution of groundwater use. Although SJRWMD directed the reader to the NFSEG and KHTM documents for this information, we suggest providing it in an appendix to the final MFLs Report.

Groundwater Levels. Trends in historical groundwater levels in the Keystone Heights area and surrounding region were not presented. It would be helpful to see the relationship between measured groundwater and lake levels and to see how the relationships have changed over time.

Streamflow. Surface water inflows and outflows were generally discussed. Information on historical streamflows was referenced but not presented. It would be helpful to see a plot(s) of streamflows along with lake levels to better understand the relationships that exist. Measured and estimated flows used in the modeling effort would also be useful as long as they are labeled as such. This information would be helpful in terms of understanding the degree to which the response of lake levels to pumping is affected by the inflows.

Overall, the Panel believes the question regarding whether the hydrologic data used to develop impact assessment methods are appropriate was addressed during development and review of the groundwater models. Though more historic data would be desirable, it is believed that the data available to SJRWMD is sufficient for the analyses needed to determine minimum levels.

Question 2. Is the method used to assess the impact of local and regional groundwater pumping on MFL water bodies using KHTM appropriate and valid?

The Panel is in agreement that the overall process that was presented and used to determine the response of lakes to pumping is reasonable. The process uses nested groundwater models and regression analysis to address regional and local effects of pumping on lake levels. However, there are questions about some aspects of the process that would be helpful to understand. Based on the Panel's understanding of information presented, suggestions for additional analyses are provided that could be performed and potentially used to modify some aspects of the analysis to potentially improve overall results and/or improve confidence in the results that were presented.

It is very reasonable to use a nested model approach to separate effects of withdrawals from other factors influencing lake levels. The NFSEG model provides the regional response to pumping and the KHTM provides the more detailed response to pumping since it has a higher degree of spatial resolution and incorporates more detailed hydrologic processes. Regarding the assessment of historical pumping impacts, on page A-25 it is stated that potential impacts *". . . not only from local pumping but also from regional pumping were assessed."* However, more explanation would be beneficial to understand how the "no pumping" scenario was conducted using the KHTM with pumping in the KHTM area included in the model run. Based on the KHTM model document it appears pumping within the model area is on the order of 3 to 4 mgd and it is understood that this was included in the KHTM runs.

The NFSEG model was calibrated to steady-state hydrologic conditions for two different time periods, 2001 and 2009. The calibrated models for these periods were used as the basis for quantifying changes in groundwater levels (drawdowns/recovery) in response to ". . . *removing all the pumping and human-induced recharge wells* . . . " (pg A-27).

Pumping and recharge wells in the two NFSEG “no pumping” runs were removed and results were compared to the respective base calibration run. In this way, modeled changes reflected the response due to removal of the pumping and recharge wells since the rainfall/recharge in the respective, paired simulations was the same. Changes in groundwater levels along the locations of the KHTM boundaries were obtained and used to adjust boundary elevations for the long-term “no-pumping” run to quantify the response of lake levels to removal of all pumping and recharge wells. Suggestions for further evaluation and clarification include the following.

Checking the Response of Models to Removal of All Pumping. Depending on how a model is conceptualized and implemented, it is possible that when all pumping is removed water levels and flows will respond in a manner that does not meet the expectation for a given hydrologic setting. For example, water levels in the surficial aquifer might rise well above land surface. These types of responses can unduly influence modeled groundwater levels and flows. The Panel wonders to what extent were the NFSEG model results evaluated to ensure levels and flows reflect pre-pumping conditions that would be expected to occur under the two different recharge conditions used (2001 and 2009)? Since the removal of all pumping can be considered somewhat arbitrary, the SJRWMD might consider running a series of pumping reduction scenarios to ensure the water level responses are reasonable and not the result of the model being unable to distribute excess water through a physical process that is not being explicitly represented. This information can also be used to help evaluate/demonstrate the overall linearity or non-linearity of the response.

Recharge Wells. The extent to which “human-induced recharge wells” (page A-26) affect groundwater levels along the KHTM boundaries was not discussed or presented. It seems reasonable that the lake levels for the Benchmark Period are free of effects of pumping and recharge wells. However, if the goal is to isolate the response of the system to just pumping, effects of recharge wells would need to be accounted for. This needs to be clarified in the overall goal statement for this task.

Rainfall/recharge. Based on review of the annual rainfall time series, it appears 2001 is close to the 30$^{th}$ percentile of rainfall (low) and 2009 is close to the 60$^{th}$ percentile of rainfall (high) for the period of record and also model period. It is positive that the events are generally near the center of the distribution and not representative of extreme conditions.

Adjusting Boundary Elevations. Effects of adjustments to boundary elevations in the KHTM “no-pumping” run needs to be evaluated. Though the adjustments varied spatially along the boundaries, they were constant at each boundary location throughout the KHTM simulation period (from 1957 to 2015). For months when the actual pumping amounts were much less than the 2001 and 2009 amounts, adjustments applied to the transient model could potentially result in water levels and flows that are higher than would be expected to have occurred prior to when pumping in the area began. For example, in 1960 estimated pumping in the six county area as shown in Figure B-14 in the final MFLs Report was about 180 mgd compared to 330 mgd in 2001 and 300 mgd in 2009. If the goal is to estimate a pre-pumping level in 1960, the observed heads

would need to be adjusted upwards based on the drawdown resulting from pumping 180 mgd. That drawdown amount would certainly be less than what occurs when pumping 330 mgd. The result is that by adding the drawdown resulting from 330 mgd to boundary elevations for periods when the pumping is much less, elevations that are higher than pre-pumping water levels may result. It's possible this would result in unanticipated responses in other parts of the system. Since the lake level response in the KHTM is a result of non-linear processes, allowing boundary heads to exceed "pre-pumping" levels could enable a modeled lake response that would not be expected to occur. Of particular interest is how streamflow and surficial aquifer levels changed and understanding their influence on the overall lake level responses. This information was not discussed in the documents that were provided.

Warm Up and Simulation Periods. The KHTM model was run using monthly stress periods for the period 1957 to 2014, with the period from 1957 to 1960 used as a "warm-up" period and "excluded from the analysis." However, In reference to Figures B-18 and B-19, a comment at the bottom of page A31 suggests that the entire period may have been used. A follow up question would be, it is possible to run the period 1957 to 1960 twice, where the first three years would serve as a warm-up period and the second three years would begin the simulation period? This would provide an additional three years of early data that could be useful.

Question 3. Are the analytical and statistical methods and procedures appropriate for – (1) Conducting groundwater pumping impact assessment and (2) developing baseline condition datasets?

The overall approach for developing the groundwater pumping impact assessment is a resourceful and creative use of model output and tries to address concerns such as the non-linear response of surficial processes to changes in stresses. The process was to create separate linear relationships ($LDD_k = A_kQ_k + B_k$) for each month over the entire period. The relationships were based on the modeled changes in lake levels from the KHTM no pumping runs that were based on the 2001 and 2009 NFSEG model runs.

Linear relationships. Each monthly relationship was based on only two data points that were obtained from results of the KHTM no pumping runs. As expressed by SJRWMD, concerns over the non-linear responses that occur are somewhat addressed by the fact that the relationships were developed separately for each month. When pumping the same amount, depending on the hydrologic conditions that exist in the model for that month, a different response will result. This seems reasonable when considering the different hydrologic factors that influence levels and depending on the stage/volume relationship that exists. However, the fact that only two data point are available to describe the relationships appears limiting. As is standard for regression analysis, the greatest confidence in results of the analysis will be for pumping amounts that are within the range of observed values. From review of the regressions that were provided (email from F. Gordu to G. Jones, May 11, 2018), it was noted that for some months the intercept term was very different from zero. For the month of August 2003, the calculated intercept was -34.79 and the calculated slope term was 0.132. Using these parameters, LDD (lake drawdown) is zero when pumping is 263 mgd. From a basic

physical perspective, it is expected that LDD would be zero when Q is zero. This should be analyzed further. It's possible that providing more data points by running additional pumping reduction scenarios would improve the determination of these relationships. The additional pumping reduction scenarios would also help demonstrate how linear or non-linear the responses are. It is possible more than one linear regression is needed for each month to capture a non-linear response. This can be addressed after completion of this exercise. Following completion of the final process, it would be helpful for SJRWMD to provide guidelines for how these relationships will be used.

Monthly Drawdown Response. When reviewing Figures B-18 and B-19 in the Appendix, there are periods when the calculated lake drawdowns appear to be highly varied (e.g., 2003 and 2004). The table below summarizes changes occurring in Lake Brooklyn for three months. Where these lakes fall on the stage-volume relationships might affect the response but not to the extent shown. Whereas, 295 mgd results in 3.4 feet of drawdown in July 2003, the addition of 31 mgd in January 2004 (total of 326 mgd) results in an additional 8.9 feet in January 2004. These two months have very different rainfall amounts and, July 2004 has similar rainfall to July 2003 but has much more drawdown response. Explaining these responses will be useful for understanding the regression responses.

| Month | Lake Level (ft) | Pumping (mgd) | Drawdown (ft) | Rainfall: Current Month (inches) | Rainfall: Previous Three Months (inches) | Streamflow (CFS) |
|---|---|---|---|---|---|---|
| July 2003 | 86.7 | 295 | 3.4 | 6.8 | 8.2 | 0 recorded |
| January 2004 | 86.2 | 326 | 12.3 | 1.42 | 3.5 | 0 recorded |
| July 2004 | 85.0 | 326 | 10.9 | 6.2 | 11.7 | 0 recorded |

No-Pumping and Baseline Conditions. The basic process proposed to determine "no-pumping condition" and "baseline condition" lake levels appears reasonable if the previous comments are considered and addressed. Following are general thoughts and comments regarding the information presented:

- The "No-pumping Condition" time series was developed by adding the "estimated impact of groundwater pumping" to observed lake levels. There are periods with fairly sharp changes (e.g., 2003 to 2004) that should be evaluated. Potential changes discussed earlier might address these apparent, abrupt changes. In the spreadsheet provided by SJRWMD, the monthly pumping value used to create these figures was a 12-month moving average versus the monthly pumping as indicated on page A-30 of the Appendix. This was not discussed in the document.

- Figures B-20 and B-21 illustrate the "estimated impact of current groundwater pumping." These changes were also calculated using the linear relationship

where pumping input to the regression was a constant 282 mgd, the average pumping over the period 2011 to 2015. This time series of lake level changes was added to observed lake levels to establish the "Baseline Condition." There are periods with fairly sharp changes (e.g., 2003 to 2004) that should be investigated. The fact that they occur when monthly pumping amounts are the same suggests that this variation is built into the linear relationships.

- Impact Ratios. The basic process for determining Impact Ratios, that is the ratio of modeled monthly lake level drawdown to monthly Upper Floridan aquifer drawdown, appears reasonable but, there are questions regarding the influence of surface water inflows on this ratio. Using the KHTM 2001 no pumping run and calibration run, the impact ratio for each month was calculated as the difference in modeled lake levels divided by the difference in modeled UFA levels. The same calculation was done using the 2009 no pumping run and calibration run. The average of these two impact ratios was then calculated to establish the impact ratio for each month. During periods of surface water inflow to Lake Brooklyn, changes in lake levels due to pumping will be mitigated by the additional input to the lake. As such, since the Impact Ratios only consider the responses of water levels, consideration should be given to excluding periods of surface water inflow to the lakes from the calculation of these ratios.

- There should be recognition that to some extent, the limited surface water inflow to Lake Geneva over the past several decades may be attributed to periods of no surface water outflow from Brooklyn. To the extent the lack of reduced surface water outflow from Brooklyn can be attributed to pumping, that would equate to a pumping impact on Lake Geneva.

Question 4. Are assumptions reasonable and consistent given the "best available information?"

Overall, the basic approach used by SJRWMD seems reasonable. It is recognized there are difficulties in separating effects of pumping from measured lake levels, and creating a lake levels dataset that is free of pumping influences but that incorporates effects of the actual climatic influences that occurred over the period of interest. It appears SJRWMD has used the best available information and tools available. However, the Panel has questions and comments that could help to enhance and further refine the methodologies employed. The comments are offered to assist in strengthening confidence in the final results.

No-Pumping Scenario: SJRWMD should first make sure the response of the modeled hydrologic system to the removal of all pumping and recharge wells does not exceed reasonable bounds. For example, modeled surficial aquifer water levels should not rise significantly above land surface and streamflows should be reasonable. If the no-pumping scenario appears problematic, a series of pumping reduction scenarios as discussed below can be used to accomplish the same goal. The goal is to be able to quantify the response of the hydrologic system (in particular lake levels) to pumping.

Additional Pumping Reduction Scenarios. SJRWMD should consider performing additional pumping reduction scenarios with the 2001 and 2009 NFSEG models. This would enable quantification of lake level responses under different pumping amounts and two different rainfall/recharge conditions (2001 and 2009). For example, pumping can be reduced by half for each period. This would provide a total of four scenarios (4 data points): 330 mgd and 165 mgd with 2001 recharge, and also, 300 mgd and 150 mgd with 2009 recharge. In all cases, the modeled hydrologic responses need to be evaluated to ensure results are reasonable.

Linearity. If it is determined through additional pumping reduction scenarios that the response over the desired range of pumping values is not linear, separate monthly regressions can possibly be performed on different portions of the response curve to approximate the response.

KHTM. A possible alternate approach to consider would be to construct a pre-pumping version of the KHTM and then modify the boundary elevations to simulate the effects of adding 2001 and 2009 pumping. Additional NFSEG model runs using different percent reductions in pumping could be run to establish the relationship between changes in water levels and pumping. KHTM boundary heads for each month could then be adjusted proportionally to the change in pumping that occurred in each month over the 1957 to 2014 period. It's understood that if a predevelopment model is not currently available, it could require considerable effort to perform this task. However, it is a possibility that can be considered.

Guidance. It would be helpful for SJRWMD to provide recommendations for use of the linear relationships that were developed.

## 3.3 Appropriateness of Recommended Minimum Levels

See discussion in Section 2, page 2-27.

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# MEMORANDUM

| | |
|---|---|
| **Date:** | June 5, 2018 |
| **To:** | Andrew Sutherland, Ph.D., SJRWMD |
| **From:** | Ken Water, Ph.D., PH<br>Scott Emery, Ph.D.<br>Dean Mades, P.E., D.WRE |
| **RE:** | Contract #32927 / Work Order #01 |
| **Project Title**: | Independent Technical Peer Review<br>Minimum Levels Determination for Lakes Brooklyn and Geneva<br>Clay and Bradford Counties, Florida |
| **HSW Project No.:** | 1BG900604 |

HSW Engineering, Inc. (HSW) is pleased to provide this scientific peer review of the referenced document. The discussion that follows relates to several key items in the report that directly impact the MFL. Specific comments are provided in the table and review-comment supplement following this discussion. The page and line numbers listed in the table are cross-referenced to line-numbered Word documents that will be provided as supplemental information to facilitate back-checks.

HSW's Drs. Ken Watson and Scott Emery, and Dean Mades reviewed the referenced document. The reviewer comments are consolidated in the table. A summary of the reviewer assessments and preliminary conclusions were discussed during a teleconference on May 24, 2018. A draft technical memorandum summarizing the findings and recommendations related to the peer review was submitted to the District on May 29th. Several points were clarified during a follow-up telephone call on May 30th.

A primary element of the minimum levels assessment is a hydrological analysis involving groundwater modeling performed by the District using regional and subregional groundwater models -- North Florida Southeast Georgia (NFSEG) and Keystone Heights Transient Model (KHTM), respectively. Results of a hydrologic analysis performed by the District using the KHTM are described in a draft technical memorandum (Gordu 2017) that has been peer reviewed by others. At the onset of the peer review, HSW's review team did not review the technical memorandum, because HSW was not tasked to do so. However, the District provided HSW a draft technical memorandum with the District's responses to the groundwater-modeling analysis peer-review comments (January 2018) which HSW inspected.

The District at HSW's request on May 24th provided four Excel spreadsheets and the Gordu 2017 draft technical memorandum that HSW subsequently inspected:

- Brooklyn_pumpsoff020318.xlsx and Geneva_pumpsoff020318.xlsx - data and formulas used to determine the intercept and slope coefficients; and
- Brook_ImpactRatioExceCurves023018.xlsx and Geneva_ImpactRatioExceCurves023018.xlsx - data and formulas used to determine the impact ratios.

The spreadsheets were very helpful and essential for understanding the approach. The draft technical memorandum (Gordu 2017) is similar to Appendix B that HSW received and reviewed.

The MFLs assessment report authors Dr. Andrew Sutherland, Mr. Fatih Gordu, Dr. Jennewein, and others unknown to the reviewer team are to be commended for the quality of the information provided for us to review. The report is appropriately technical, properly organized, and well written.

Summarizing the District's minimum levels determination memorandum, seven environmental criteria were assessed by the District for Lake Brooklyn, and five criteria were assessed for Lake Geneva (Table E-1). A minimum hydrologic regime (i.e., MFLs condition) was determined for each lake based on its most constraining (i.e., sensitive to withdrawal) criterion. The most constraining environmental criteria determined are a dock access metric for Lake Brooklyn and an aesthetics metric for Lake Geneva. The MFLs condition recommended by the authors for Lakes Brooklyn and Geneva is represented by the minimum median (P50) lake level for each lake. The authors assert that MFLs establish a minimum hydrologic regime and define the limits at which further consumptive use withdrawals would be significantly harmful to the water resources or ecology of an area. The MFLs are presumed to be protective of the other environmental criteria assessed for each lake.

Table E-1. Environmental criteria evaluated for Lakes Brooklyn and Geneva, Clay and Bradford Counties, Florida. Check marks denote which criteria were ultimately assessed for each lake.

| Environmental Criterion | Environmental value(s) protected | Lake Brooklyn | Lake Geneva |
|---|---|---|---|
| Minimum Infrequent High (SJRWMD) | Upland/wetland boundary | √ | √ |
| Dock Use Standard (SWFWMD) | Recreation / dock access | | |
| Basin Connectivity Standard (SWFWMD) | Boating / fishing | | |
| Species Richness Standard (SWFWMD) | Bird diversity | √ | √ |
| Recreation/Ski Standard (SWFWMD) | Recreation / water skiing | | |
| Lake Mixing Standard (SWFWMD) | Lake stratification | | |
| Aesthetics Standard (SWFWMD) | Aesthetics / scenic attributes | | |
| Minimum game fish habitat reduction | Fish and wildlife habitat | √ | |
| Minimum emergent marsh habitat reduction | Fish and wildlife habitat | √ | |
| Minimum large wading bird forage habitat reduction | Fish and wildlife habitat | | |
| Minimum small wading bird forage habitat reduction | Fish and wildlife habitat | | |
| Minimum sandhill crane nesting habitat reduction | Fish and wildlife habitat | | |
| Minimum Dock Access elevation exceedance | Recreation / dock access | √ | √ |
| Minimum Lake Connectivity elevation exceedance | Boating / fishing | √ | √ |
| Aesthetics – minimum P50 exceedance | Aesthetics / scenic attributes | √ | √ |

While the authors' assertion is consistent with Section 373.042(3), *Florida Statutes (F.S)),* we note that there is little or no evidence that significant harm "would" occur if an MFL is exceeded. Rather, there is low risk that significant harm would occur if the MFL is not exceeded. Our review is tempered with this concept in mind.

In addition to the afore-mentioned metrics for Recreation, Fish and Wildlife Habitat, and Aesthetics the District also considered whether seven other environmental values pursuant to Sections 373.042 and 373.0421, *F.S.*) would be protected by the MFLs. Four of the seven (Transfer of Detrital Material, Filtration/Absorption of Nutrients and Other Pollutants, Maintenance of Freshwater Storage and Supply, and Water Quality) were assessed and considered protected by the recommended MFLs. The three remaining values (Estuarine Resources, Sediment Loads, and Navigation) were deemed not particularly relevant, hence were not assessed.

Following are the primary comments regarding our collective peer review. The comments are organized along the lines of the questions listed under HSW's Work Order Task B.3 (Review Technical Memorandum) that the District requested the peer reviewers address. We concur with the District's choices of environmental values to assess (Table E-1), and our comments focus on those values.

**1. Assess validity and appropriateness of environmental criteria**

a. Are the environmental data <u>used to develop criteria</u> adequate and appropriate?

Yes; both adequate and appropriate. The primary environmental data used include:

| | | |
|---|---|---|
| Lake bathymetry | Land surface topography | Land cover |
| Hydrography | Lake stage | Groundwater level |
| Rainfall | Geology (regional and local) | Soil (type and distribution) |
| Dock piling and deck elevation* | Anecdotal recreation survey | Vegetation (type and distribution) |
| Select water quality parameters (e.g., TN, TP, chlorophyll *a*, etc.) | Bird species diversity | Boat draft |

Comments are offered regarding:

- Lake bathymetry (Field survey method and data density)
- An apparent inconsistency in the Lake Geneva area mentioned on pages 6 and 42
- Bird species diversity (Availability of lake-specific data to corroborate the literature data used)
- Boat draft (Basis for 2-foot boat draft, i.e. specific boat / engine type; a suggested reference is provided)
- Figure content (e.g., adding P25, P50, and P75 lines on Figures 35 and 46).

b. Are the methods and procedures <u>used for environmental analyses</u> appropriate?

Yes. The primary methods/procedures used include:

- Hydroperiod Tool (GIS)
- Topographic mapping (GIS)
- Groundwater modeling

- Statistical calculations
- Environmental criterion (EC) sensitivity measures (e.g., percent-of-area, percent-of-time, change-in-event-frequency)

Comments are offered regarding:

- Hydroperiod Tool and topographic mapping (Consider elaborating on the software, e.g. GIS version, programming language, etc.)
- Groundwater modeling (NFSEG and KHTM are appropriate groundwater models that are suitable for evaluating the sensitivity of lake hydrology to local and regional pumping and rainfall, and transient conditions)
- Statistical calculations (Consider describing the specific software/version(s) used)
- EC sensitivity measures (See the following response to review question 1.c.)

c. Are methods to evaluate the relevant environmental values and beneficial uses appropriate?

Yes.

The surrogates used to represent the value of the various environmental criteria assessed are relevant and appropriate measures of value. Examples include lake surface area and number of suitable days for recreating. The insufficiency of the original MFL, an infrequent high based on annual flooding frequency of high soils, is described. Multiple environmental criteria used by SWFWMD to establish MFLs for sandhill lakes were evaluated, and some methods were modified to be more appropriate for Lakes Brooklyn and Geneva. Percentile frequency statistics (e.g., lake stage duration curves) and translation functions (e.g., lake stage-area plots) were used.

Several different measures of environmental criterion (EC) sensitivity were used. Percent-of-area change was considered to evaluate bird diversity. Percent-of-time change in the annual number of days of suitable dock access was considered to evaluate recreation. The SJRWMD infrequent high (IH) change-in-event-frequency method was used to evaluate the downward shift in the upland boundary.

A legal basis and literature are described to justify the mathematical constructs used to characterize an allowable change in the EC value. All constructs applied in this assessment have been used previously by various Florida water management districts to establish MFLs for lakes and rivers.

d. Have all relevant environmental values been evaluated?

Until updated rules are adopted by the SJRWMD Board for these lakes, it would be premature to assert that “all” relevant values have been evaluated. However, all environmental values assessed and described in the report are relevant to local and regional stakeholders, ecosystem health, and beneficial use of these unique water resources.

e. Are data appropriate for evaluation (*sic*) selected criteria and conclusions?

Yes; the data collated for the assessment are appropriate for evaluating the selected environmental criteria, the results of which are the basis for the recommended MFLs. Key data such as lake bathymetry, and historical lake stage, local groundwater level, rainfall, and groundwater pumping are associated with data-collection procedures that are well documented. Monitoring locations appear close enough to the lakes to provide representative data.

Bird species diversity is based on surveys performed for SWFWMD that established empirical formulas for diversity as a function of lake surface area. A reviewer asked if the baseline condition diversity intimated by these formulas is reasonable for these two lakes.

Several comments pertain to aesthetics and lake-user perspective. The aesthetics survey is more than a decade old, and aesthetics is the constraining environmental criteria for Lake Geneva. It is the sole criterion that necessitates a recovery program for Lake Geneva. The impact threshold change prescribed for evaluating the criterion is 20% and based on responses to just two questions. The District might consider performing an updated survey that is specific to Lakes Brooklyn and Geneva and includes a more robust set of questions tailored to lake aesthetics. An impact threshold of 15% might also be considered for consistency with the thresholds prescribed to evaluate the other relevant environmental criteria.

f. Are assumptions reasonable and consistent given the "best information available"?

Yes; the assumptions are reasonable and consistent.

A fundamental assumption of SJRWMD's approach is that alternative hydrologic regimes exist that are lower than historical regimes but still protect the environmental functions and values of MFLs water bodies from significant harm caused by water withdrawals. Numerous MFLs have been adopted based on this assumption.

The District evaluated hydrologic regimes for two distinctly different conditions – no pumping and baseline. Each regime was evaluated consistently using regional and subregional groundwater models (NFSEG and KHTM). Each simulation period spanned a 59-year period from 1957 to 2015 during which rainfall and lake levels varied widely.

The no-pumping condition characterizes a historical regime that is relatively unimpacted by anthropogenic variables. It is a substantial backcast to a time when there is a paucity of data. Although there is an inherent uncertainty associated with the no-pumping condition, the approach for characterizing the historical regime is reasonable.

The baseline condition represents a reference hydrologic condition of the lakes in which the total regional groundwater pumping impacting the lakes is assumed to be constant from 1957 to 2015 at a rate of averaged regional pumping from 2011 to 2015 (~284 mgd). Estimated annual historical pumping ranged between about 155 and 370 mgd and averaged close to 284 mgd, so the assumption of constant pumping is reasonable.

Numerous MFLs have been adopted by SJRWMD and other districts assuming a 15% impact threshold, so there is a legal basis for its use in this assessment. The District might consider assuming 15% for the aesthetics evaluation for consistency.

**2. Assess validity and appropriateness of hydrological analyses**

a. Are the hydrologic data used to develop impact assessment methods appropriate?

Yes, although several comments were offered regarding data adequacy.

Additional information would be beneficial for addressing the adequacy of the rainfall amounts (page B-5). What was the reporting frequency of the collated rainfall data (i.e., daily or monthly)? How was missing rainfall record addressed?

Figures B-3 and B-4 indicate several years have a notably sparse amount of lake stage data (Brooklyn, 2002; Geneva, 1962-64). Were other methods (e.g. regression analysis of concurrent lake levels or lake/GW levels) considered to infill missing record? Figure B-5, stage hydrographs, and stage-duration curves may change somewhat if estimated daily stages for those years are revised.

b. Is the method used to assess the impact of local and regional groundwater pumping on MFL water bodies using KHTM appropriate and valid?

Yes. A considerable effort was made to understand the hydrological analyses and results presented in the report. Many comments were made on Appendix B and in the supplement provided for those comments regarding the groundwater modeling that is summarized in Appendix B.

Starting with page B-2 (and throughout) regarding surface water inflow being important and lake levels responding slowly: Rainfall drives the hillslope hydrology of the ridge, and topography and lithology have a pronounced effect on the magnitude and direction of surface- and groundwater runoff. Lateral exchanges of water between the lakes and the surficial aquifer may also be an important part of the lake water budget. The District might consider expanding a discussion on the topic or citing a technical report that describes KHTM development and calibration. Vertical discretization of the surficial aquifer could influence the calculated seepage rates which Merritt and Konikow (2000) describe in quite detail for karstic lakes such as Brooklyn and Geneva.

Starting with page B-17, the District might consider expanding the section by comparing the model dimensions, discretization, hydrologic features represented, hydraulic parameters, inputs, and calibration with NFSEG. For example, it is not known if the surficial aquifer system is represented by five layers as done in an earlier USGS study (Merritt 2001) or one layer, or whether sublake separation and coalescence (Merritt and Konikow 2000) is represented in the KHTM. The NFSEG v1.1 model is well documented, and a reference to similar documentation for the KTHM would be helpful.

Consider elaborating on the appropriateness of using NFSEG modeling results associated with two different climatological conditions (that existed in 2001 and 2009) to perform transient modeling for a much longer period and wider range of climatological conditions. The annual rainfall in 2001 and 2009 totaled about 46.5 and 53 inches, respectively (Figure B-9). In comparison, the annual amounts during the KHTM calibration and historical analysis periods ranged between about 33 and 67 inches, a range that is about 5 times the range for 2001 and 2009.

HSW inspected the District's responses to the groundwater modeling/hydrologic analysis memorandum peer-review comments (January 2018) and offers the following:

- Comment #1: Insufficient information is provided in the assessment report to clearly understand the modeling analysis. Insufficient information is provided in the two model-description sections (page B-17) for readers to truly understand the primary characteristics of these important analysis methods. Consider expanding the section by comparing the model dimensions, discretization, hydrologic features represented, hydraulic parameters, and inputs. For example, it is not known if the surficial aquifer system is represented by five layers as done in an earlier USGS study (Merritt 2001) or one layer, or whether sublake separation and coalescence (Merritt and Konikow 2000) is represented in the KHTM.
- Comments #2 and #3: Years 2001 and 2009 were reportedly selected for establishing KHTM lateral boundary conditions because "groundwater levels were generally stable over the entire year in critical parts of the model domain." Although the method for establishing the boundary conditions is appropriate, it is unclear to what degree different local and regional rainfall conditions during those two years might have influenced boundary conditions and potentially affected the validity of the modeling results.
- Comments #6 and #7: The method for determining the monthly impact ratios, associating them with lake stages, and plotting on the percentile plots (Figures B-26 and B-27) could be explained more clearly.

Regarding page B-21, an explanation should be provided for what the intercept ($B_k$) represents, or an alternative approach should be considered. See the review-comment supplement for page B-21, line 11 for additional information. The reviewers understand and concur with the overall adjustment approach but recommend using a lake-level adjustment equation that has a zero intercept. The recommended approach conforms with the simple concept that if there is no change in pumpage, then there would be no change in lake and aquifer water levels associated with pumpage. It also ensures that the month-to-month adjustments are interpolated values between pumpages of zero and 330.97 mgd instead of extrapolations outside the range of 330.37 and 330.97 mgd. Consider revising the definition of $Q_k$ to conform with the spreadsheet variable and explaining the rationale for a 12-month moving average.

c. Are the analytical and statistical methods and procedures appropriate for -
- Conducting groundwater pumping impact assessment?
- Developing baseline condition dataset?

Yes; see response to question 2.b.

d. Are assumptions reasonable and consistent given the "best information available"?

Yes; see response to question 2.b.

**3. Appropriateness of recommended minimum levels**

a. Does the report document the validity and appropriateness of assumptions used and conclusions made in the development of protective minimum levels, including identifying sources of uncertainty and their impact on development of protective minimum levels for these lakes?

Yes; the report authors have documented sufficiently the validity and appropriateness of assumptions used and conclusions. Many review comments are offered in the table and supplement to help clarify data presentations, method descriptions, and discussions of results.

Summarizing our comment to question 1.f, the District might consider an alternative to using a dated survey to evaluate lake aesthetics, particularly since recovery for Lake Geneva is associated with that metric.

The District might consider revising or eliminating the parenthetical phrase that defines the "constraining" criterion as the "most sensitive". Results of the various environmental criteria evaluations characterize a range of lake levels above which water might be permitted for consumptive use. The “constraint” is the lower limit of the range. An illustrative example is provided in the review-comment supplement explaining a reviewer’s perception of constraint and sensitivity.

Regarding page 64 and consistency between the various environmental criteria evaluated, what period of record is the minimum Infrequent High based on? Do the annual exceedance plots (Figures 41 and 42) encompass the groundwater modeling warm-up period (1957-1960)?

While not invalid, the approach for normalizing environmental criteria to P50 seems unnecessarily complex (page 72). It is complicated to follow and does not appear to change the overall conclusions regarding the most constraining criterion listed in Tables 16 and 17. An alternative format for the tables is provided in the review-comment supplement for the District to consider.

Regarding page 74, the District might consider pro-rating the recovery at the specific percentile associated with the constraining criterion for each lake. It could be simpler for readers to understand and should be like the MFLs condition curves illustrated in Figures 50 and 51. An alternative approach and sample graphics and table are provided in the review-comment supplement for the District to consider.

While expressed as a median in Table E-2, isn't the MFL really defined by Figures 50 and 51, which are developed using the equation on page 81? Other MFLs have been set like this (i.e., Lower Suwannee River), but it seems ambiguous without explicitly tying an MFL in Table E-2 to a method for generating curves in figures 50 and 51. There are infinite possibilities for achieving the medians in Table E-2.

b. Are the data adequate to support conclusions and recommendations?

Yes, very much so. Some climatological information may be superfluous.

Starting with pages 11 and B-11: The District might consider discussing climate patterns, SPI, and Figures B-8 and B-13 only in the main report as background information, unless the assessment relied upon an association between rainfall and other hydrologic variables that were evaluated. The climate patterns had no apparent effect on the MFLs assessment methodology, and their association with lake-level change was not evaluated analytically.

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# Technical Memorandum

Prepared for: St. Johns River Water Management District

Project Title: Independent Technical Peer Review Services of Revised Environmental Criteria for Draft MFLS for Lakes Brooklyn and Geneva, Clay and Bradford Counties

Project No: 153839

Subject: Lakes Brooklyn and Geneva Minimum Flows and Levels Peer Review

Date: September 13, 2019

To: Andrew Sutherland, MFLs Technical Program Manager,

From: Gregg Jones, Senior Expert, Hydrogeology

Prepared by: _____
Gregg W. Jones, PhD, PG

Matt Van De Bogert, PhD

Reviewed by: _____
Paul M. Leonard, Managing Principal, Water Resources

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# Section 1: Introduction

The St. Johns River Water Management District (District) is in the process of evaluating minimum flows and levels (MFLs) for Lakes Brooklyn and Geneva. Minimum levels for both lakes were adopted in January 1996 and were based on a methodology designed to maintain the location of existing stable wetlands and organic soils. However, because of naturally occurring large water-level fluctuations, stable wetlands and organic soils do not exist at these sandhill lakes. Therefore, a reevaluation was necessary to ensure that appropriate, protective minimum levels were developed. In revising the minimum levels for Lakes Brooklyn and Geneva, the District plans to set appropriate and protective limits to consumptive withdrawals based on the best available data and up-to-date methods (Sutherland et al. 2018).

The Districts' reevaluation of the minimum levels has benefited from improved understanding, additional data, and modeling. These include improved methods, long-term water budget models, a longer record of hydrologic data, and multiple rounds of review and solicitation of comments from stakeholder groups. The final minimum levels, when developed, will incorporate data from the available period of record (POR) for these lakes and define a minimum hydrologic regime based on the historical record of naturally occurring lake-level fluctuations (Sutherland 2019). The proposed minimum levels are not static water elevations, but rather a set of conditions and environmental criteria modeled over the period of record for a no-pumping condition, combined with pre-determined "impact thresholds" established to prevent significant harm. Assessment of the minimum levels is determined through comparison of modeled hydrological regimes with no withdrawals to modeled hydrological regimes that incorporate specified rates of withdrawals for the current condition or future scenarios (Sutherland et al. 2018).

The District released its first draft of the revised minimum levels in 2018 (Sutherland et al. 2018) and solicited reviews and comments from two consulting firms (Cardno, Inc. and HSW Engineering, Inc.) and several stakeholder groups. Based on these reviews and subsequent data analysis, the District revised the set of proposed environmental criteria for establishing minimum levels for Lakes Brooklyn and Geneva to address concerns and ensure the establishment of reasonable and protective minimum levels. The changes to the proposed criteria are summarized in an Environmental Criteria Technical Memorandum (Criteria Memo; Sutherland 2019). The Criteria Memo proposes removing three previously proposed criteria, adding three new criteria, and revising how several others are applied.

### Scope of Current Review

Brown and Caldwell has provided the District with a review of and responses to the Criteria Memo described above including assumptions and conclusions the District has made related to developing environmental criteria to be used to establish protective minimum levels for Lakes Brooklyn and Geneva. The signatories on the cover page of this Technical Memorandum comprise the Peer Review Panel (the Panel) for this evaluation.

This work has included the following:

- Review of the rationale and assumptions for removing existing criteria, based on stakeholder and peer review comments.
- Review of the revision of two existing criteria and the addition of several new criteria.
- Conclusions and/or recommendations related to proposed criteria and their appropriateness for developing protective minimum levels for Lakes Brooklyn and Geneva.
- A technical memo that documents whether and why Brown and Caldwell agrees or disagrees with the recommended environmental criteria to be used for the Lakes Brooklyn and Geneva minimum levels.

Where appropriate, this review may reference the initial draft MFLs report and subsequent peer review documents, but it does not aim to systematically reassess methods and assumptions that were supported by the previous peer review process including the hydrological modeling methods, the multiple criteria framework for assessment, or the selection of 15 percent as an appropriate impact threshold. These changes are evaluated in detail in the following sections.

# Section 2: Section 2: Criteria Proposed for Removal

The Criteria Memo proposes to remove three criteria as recommended by previous peer review panels. The Panel agrees that the removal of the following criteria by the SJRWMD appropriately address the concerns of the previous reviewers and believes that the proposed additions and revisions to the remaining criteria address the original intent of these removed criteria appropriately.

## 2.1 Minimum Dock Access

The District proposed a dock access standard to protect recreational lake user access by not allowing more than a 15 percent reduction in the amount of time that boat access would be possible from existing docks. However, as the reviewers pointed out and the District verified through analysis of existing dock elevations, the locations of the docks are dependent upon the conditions present at the time the dock was constructed and is not representative of an average condition or even an inherently optimal condition. Rather, the elevation of existing docks is simply a function of when the dock was installed relative to the naturally fluctuating water levels. To the extent that most of the docks were constructed during periods of high-water levels, the standard would be protective of an artificial and somewhat rare high-water condition. The removal of the proposed dock access standard is appropriate given the concerns raised and the Panel agrees that the newly proposed open water/boater safety criterion discussed below addresses the protection of recreational values for the lakes.

## 2.2 Aesthetics Criterion

To assess the impact of water level changes on “aesthetics and scenic attributes”, the District proposed using an analysis based on a lake user perception survey from users of other lakes to assess water level preferences and the perceived water level where the lakes’ scenic beauty is harmed. However, the reviewers noted that the survey did not include lakes with the degree of fluctuations observed in Lakes Geneva and Brooklyn; the majority of lakes included in the survey were more stable, shallow lakes with gradually sloping banks where small changes in lake level would result in large effects on exposed shoreline and lake surface area. As such, the survey results were dismissed as inappropriate for these lakes. Instead, the reviewers suggested that the aesthetic values of the lakes could be protected by incorporating pool size into the suite of assessed criteria.

The District agreed with the reviewers’ concerns and removed the aesthetics criterion. The District then proposed that a new lake surface area metric would be appropriate for protecting aesthetics and scenic values. The Panel agrees with the previous reviewers and finds that the District’s response appropriately addresses their concerns regarding the applicability of the survey data while still incorporating criteria which are protective of this important recreational use of the lakes.

## 2.3 Southwest Florida Water Management District (SWFWMD) Species Richness Standard

The District proposed a species richness standard that would prevent loss of bird species from the lake ecosystems. Assessments were also considered for fish and aquatic macrophyte communities, but a review of the scientific literature found that birds are the most sensitive to lake area and therefore were the focus of this criterion. The District used a standard that was developed for use by SWFWMD based on a survey of lakes primarily in west central Florida (Emery et al. 2009). Analysis of data from that survey suggested that a reduction in lake area of 15 percent would result in the loss of one bird species and therefore would constitute significant harm.

Several critiques of this standard were raised in the peer review process, including the concern that the lakes used to develop the criterion had very different and more heterogeneous shoreline habitats compared with Lakes Brooklyn and Geneva and therefore the statistical relationship derived from those lakes could not be extrapolated to Lakes Brooklyn and Geneva.

The Panel supports the District's conclusion that the application of statistical relationships from very different lakes makes the details of this metric inappropriate for use at Lakes Brooklyn and Geneva. Although described as a species richness criterion, the proposed criterion as implemented was a simple assessment of the change in lake surface area as a proxy for species richness. As described below, the District has now directly incorporated a lake surface area standard through the newly proposed Lake Surface Area criterion which has the same proposed impact threshold of 15 percent (Sutherland 2019).

# Section 3: Newly Proposed Criteria

Three new criteria have been proposed in the Criteria Memo to improve and simplify how aesthetic and recreational values are incorporated and two of the criteria are also protective of ecological values. Overall, the Panel believes that the inclusion of these criteria improves how recreation and aesthetic values are considered and appropriately addresses many of the concerns of the previous reviews. However, the Panel does have concerns about how these criteria will be applied to assure adequate levels of protection throughout the variable hydrologic regime of these lakes. These concerns are addressed in more detail in Section 4 (Revision of How Some Criteria Are Applied). As currently proposed, the application of these criteria may not be adequately protective across the natural lake level regime.

## 3.1 Open Water/Boater Safety

Given the concerns with the previously proposed aesthetics and dock access criteria (discussed in Section 2), previous reviewers suggested that an open water area criterion could be developed to be protective of both the aesthetics and recreational values of Lakes Brooklyn and Geneva. The open water criterion ensures that surface water area with sufficient depth (≥5 ft) to provide for safe boating is not harmfully reduced by withdrawals.

The Panel agrees with the District and previous reviewers that this is an important addition for the protection of recreational values. The Panel also agrees there are likely benefits to water quality and fish habitat as a result of protecting open water area.

The application of a 15 percent change threshold has already been evaluated in previous peer reviews and is generally well established. The Panel supports the application of 15percent as a change threshold for the *average* open water area under the no pumping criterion, but, as discussed in more detail in Section 4, the Panel is concerned that impacts during naturally occurring low level conditions (e.g. prolonged dry periods)

may be much greater than 15 percent. For lakes that do not have such highly fluctuating levels, low-level conditions are rare and short-lived; for Lakes Geneva and Brooklyn, however, these conditions are an expected part of the natural lake level regime and can persist for years or decades. Without explicit consideration of these naturally occurring periods of low water levels, impacts greater than 15 percent could likewise persist for extended periods of time. The Panel suggests that the District consider applying an additional impact threshold to ensure protection of the values addressed by the Open Water criterion over more of the natural lake level regime (see Section 4).

## 3.2 Lake Surface Area

While the open water standard is protective of the recreational uses of the lake, there is also aesthetic value to protecting lake surface area from significant changes (and therefore minimizing exposed areas along the shoreline). Lake surface area has also been correlated with species richness and was a key component of the species richness standard. The Panel agrees this is an important criterion for the protection of aesthetics and the ecosystem and the Panel supports the 15 percent change threshold for the *average* surface area over the entire no pumping regime. In addition to the impact threshold for the average condition, the Panel encourages the district to consider setting an additional threshold to ensure adequate protection over the lower levels of the natural lake level regime.

## 3.3 Average Lake Depth

The draft MFLs Report for Lakes Brooklyn and Geneva considered a lake mixing standard developed by the SWFWMD, of which lake depth was a component, but determined the standard was not applicable to sandhill lakes like Lakes Brooklyn and Geneva. The peer reviews of the draft MFLs Report pointed out that lake depth is important for maintaining the physical, chemical, and biological processes in lakes that regulate nutrient dynamics, water quality, and habitat, and although the lake mixing standard may not be appropriate, some other standard could be adopted that would be protective of these values. The Criteria Memo points out that reduction in water depth can increase wind-driven sediment resuspension, water temperatures, and light availability. All of these can increase algal growth. Subsequent senescence and decay of algae combined with increased temperatures can reduce dissolved oxygen concentrations, potentially to levels harmful to fish and other organisms.

The Panel supports the District's inclusion of an average lake depth criterion and supports the 15 percent impact threshold for the average impact over the entire no-pumping period. As discussed above, because pumping differentially impacts the lakes depending on water level elevation, the Panel recommends the District consider adding an additional impact threshold to ensure adequate protection over the lower levels of the natural lake level regime.

# Section 4: Revision of How Some Criteria Are Applied

The Criteria Memo includes a set of 10 criteria proposed for the Lakes Brooklyn and Geneva minimum levels (Table 1). Each of these criteria specifies (a) a value or resource to be protected, (b) a standard protection statistic, (c) an impact threshold, and (d) an assessment protocol.

The following section reviews the proposed criteria, protection statistics, impact thresholds, and assessment protocols for nine criteria that have either been added or revised based on the previous peer reviews. The minimum infrequent high criterion has not changed since the previous draft MFLs report and will not be reviewed here.

One of the more important changes proposed in the Criteria Memo relates to changing the "protection statistic" for most of the proposed criteria from single-value percentile statistics (such as the median or P75 values) to a new value determined through the District's newly proposed "natural lake level regime" framework. The revised protection statistics are reviewed in Section 4.1 and specific changes to individual criteria are evaluated in section 4.2.

**Table 1. Summary of criteria proposed for the Lakes Brooklyn and Geneva MFLs (Sutherland, 2019).**

| Criterion Type | Value / Resource | Protection Statistic | Impact Threshold | Assessment Protocol |
|---|---|---|---|---|
| Ecological | Minimum Infrequent High (MIH) | Minimum Return Interval | Min. return interval (RI) ≤ MFL RI | MFL RI versus current-pumping RI of MIH |
| | Emergent marsh area | Average habitat area for the benchmark period | Allowable reduction equals 15% from average no-pumping (NP) condition | Assessed by comparing the NP to current-pumping (CP) condition for the average of entire natural lake level regime (i.e., average of exceedance curve, calculated at 5% intervals) |
| | Gamefish spawning habitat area | | | |
| | Small wading-bird forage habitat area | | | |
| | Large wading-bird forage habitat area | | | |
| | Sandhill crane nesting habitat area | | | |
| Cultural / Human-use | Lake surface area (aesthetics, scenic value) | Average surface area for benchmark period | Allowable reduction equals 15% from average NP condition | |
| | Open-water / boater safety (recreation) | Average open-water area (area ≥ 5 ft deep) for benchmark period | Allowable reduction equals 15% from average NP condition | |
| Both Ecological and Cultural / Human-use | Average depth (water quality and fish refugia) | Average depth for benchmark period | Allowable reduction equals 15% from average NP condition | |
| | Lake connectivity (recreation and fish passage) | Exceedance percentile for critical lake lobe connection elevation | Allowable reduction equals 15% from NP exceedance | Comparison of NP and CP exceedance of critical elevation |

## 4.1 Evaluation of Revised Protection Statistics

In the draft MFLs Report, the standard protection statistics for most of the included criteria were set at a specific value on the exceedance curve such as the P50 (median) or P75 values. As a result of concerns raised during the review process, these statistics have been revised in the Criteria Memo for the criteria in

Table 1 (except for the minimum infrequent high and lake connectivity criteria). Rather than the median value, the new protection statistics use the average value of the metric over the entire benchmark period. For example, the standard protection statistic for surface area is defined as the average surface area over the period being assessed.

### 4.1.1 Single-value metrics and highly fluctuating lake levels

Reviewers, stakeholders, and District staff noted that the impact of groundwater withdrawals on some environmental metrics (such as water level, surface area, and mean depth) varies with lake elevation; the impact of withdrawals during high-water periods can be less pronounced than during low-water periods because of the contributions of surface water inflows and connectivity to the Upper Floridan aquifer. A defined withdrawal that may not be harmful under high-water conditions could very well meet the threshold of harm during naturally occurring periods of low-water.

Although single-value metrics such as the median or mean may be appropriate for lakes with stable water levels (low variance around the mean water level), reducing the period of record to a single summary value can over-simplify the implications of groundwater withdrawals and conceal the skewed relationship between the effects of withdrawals and lake elevation in highly variable systems. The Criteria Memo points out that there are decades-long periods in the period of record characterized by water levels near the extremes (below the 25$^{th}$ or above the 75$^{th}$ percentiles) of the full period of record; environmental criteria determined to be protective for the median (or mean) condition by keeping any shift in values to within 15 percent, may not be protective at these extremes. Given the long-term nature of some of the dry periods, this could result in decades-long periods of time during which the specified minimum levels are not specifically protective.

Given these concerns about variable effects of groundwater withdrawals with lake elevation and the difficulty of single-value metrics to adequately characterize impacts over the full range of hydrologic conditions, the Panel agrees with the District's choice of dropping single-value protection statistics based on the P50 or similar values for setting minimum levels for Lakes Brooklyn and Geneva.

The Panel accepts the claim that impacts of groundwater withdrawal vary with lake elevation, but it would be helpful to see graphics or data tables that illustrate how different these impacts would be over the period of record for potential withdrawal scenarios on each of the proposed criteria. Such graphics would better illustrate the need for considering impacts of withdrawal over the natural lake level regime.

### 4.1.2 Natural Lake Level Regime

Addressing the concerns raised above, the District acknowledged that it would be better to assess metrics throughout the entire range of fluctuation for Lakes Brooklyn and Geneva: "*Nutrient dynamics, plant and animal communities, and soil structure are organized around dynamic hydrology. Also, there are important ecological and socio-economic functions maintained by high and low (and average) water conditions. Therefore, it is important to prevent significant change from the entire natural lake level regime, not just a few elevations or exceedance percentiles*."

The Criteria Memo presents the natural lake level regime concept as a framework for guiding the development of multi-percentile evaluations. This framework asserts that maintaining the natural variability of a lake is fundamental to maintaining ecosystem structure and function.

The Panel supports the District's efforts to consider the natural fluctuations in developing the minimum levels and their goal of preventing significant change throughout the entire natural lake level regime. However, the Panel has concerns regarding how well the details of the proposed approach fulfill the goals presented.

The general approach presented in the Criteria Memo is as follows:

1) Define the measurement to be evaluated (e.g. water surface area)
2) Calculate values of the criteria for the no-pumping condition along 5 percent intervals of the elevation exceedance curve for the entire period of record.
3) Calculate the average value of the criteria using the arithmetic mean of the values obtained in step 2.
4) Apply the appropriate change threshold to the average value obtained in step 3 (e.g. allowance of a 15 percent reduction to the value obtained in step 3 over the entire period of record).

This approach can be simplified to simply calculating the average of the daily values over the period of record: the average value obtained in Step 3 is simply an *estimate of the mean* over the full time series. That estimate improves as the interval used is reduced (averaging values along 1 percent intervals of the elevation exceedance curve would yield a slightly better estimate of the mean). Ultimately, however, there is no need to *estimate* the mean at all because it would be more straightforward to simply calculate the average of the daily values for the entire no-pumping condition.

Because Steps 2 and 3 reduce to a simple arithmetic mean over the no-pumping condition, this approach still produces a single-value metric, albeit one that uses the mean instead of the median. As the Criteria Memo points out in Section C.4, "a percent shift from the median (or mean) may not adequately protect functions at lower lake elevations." Therefore, the proposed approach may not be adequately protective throughout the entire hydrologic regime.

If a single-value metric is chosen, using the mean is marginally better than the median under some conditions. Because the mean is more sensitive to extreme values in the dataset, it has a larger chance of being impacted and pulled toward extreme values if they are one-sided, If extreme values exist on both sides of the mean, they will be offset to some degree. Like the median, using a criteria based on the mean is not inherently protective of the full lake level regime. Ultimately the concerns about using a single-value metric discussed in the Criteria Memo and summarized above would still apply when using the mean and therefore are not addressed by the District's proposed Natural Lake Level Regime framework as currently proposed.

### 4.1.3 Separate evaluation of wet and dry periods

One potential approach to developing minimum levels that are protective over more of the range of the natural lake level regime would be to develop criteria separately for wet and dry periods as expressed in the peer review report by Cardno, Inc.:

> *The Panel also wonders if SJRWMD has given any thought to evaluating all its proposed criteria under essentially two different elevation regimes by segregating the no-pumping record (1957 to 2015) into a "wet" and a "dry" period (Figure 3). If this strategy was adopted, SJRWMD could develop minimum levels for each period and adopt the more conservative of the two. We do realize this strategy has the potential to be over protective for some periods; however, the other strategy has the potential to be under protective for some periods. Some members on this panel (Jones et al. 2017) and others (Neubauer et al. 2007) have been critical of using exceedance probability curves because they can obscure seasonal and even decadal trends in the data. This approach would explicitly address the climatic variability so evident in the data. (page 2-16)*

Evaluating criteria separately under high and low lake elevations and adopting minimum levels that are protective for both directly addresses the issue of setting criteria that are protective across the entire natural lake level regime, which the District identifies as a goal in the Criteria Memo. However, the District noted some issues with this approach.

*Issue 1. Minimum levels set for dry conditions may be overly restrictive.*

The District noted concerns from stakeholders that minimum levels set to protect during dry periods would be overly restrictive during wet periods. While the Panel does not contest that statement, we note that the same logic applies to criteria set based on average conditions: minimum levels based on average conditions will be under-protective during dry periods. The challenge with these highly fluctuating lakes then is to distinguish between periods of below-average water levels that are subject to protection through minimum levels, while not setting criteria so limiting that they are an attempt to "drought-proof" the system.

*Issue 2. Managing permits would be difficult without knowing future conditions.*

*"The primary issue is related to how minimum levels set to protect during dry periods would be used/enforced during decades-long wet periods. Management implications include how to construct, issue or modify long-term consumptive use permits, not knowing whether the next extended period will be wet or dry."*

The Panel agrees there is no mechanism available to set permit levels based on unknowable future hydrologic conditions. As with all MFLs, criteria are set, and permits are issued using only existing knowledge of the system. Setting MFLs through a process that looks at previous periods of wet and dry conditions separately does not mean that permits would need to be issued specifically for wet or dry future conditions. It simply means that the criteria were established using the best available information to maximize protection of the resource given uncertain future conditions. Like all MFLs, there is always the possibility that they would be over protective for some periods of time; it is part of the process of setting MFLs to ensure the limits are appropriate and, again, not an attempt to "drought-proof" the system. If future conditions are significantly different from those that have been observed (in magnitude or duration of specific conditions), the District has the ability to review and revise the minimum levels set for Lakes Brooklyn and Geneva as necessary.

*Issue 3. Delineating between wet and dry periods is subjective.*

The District used the NOAA standard precipitation index (SPI) to identify wet and dry periods and noted assumptions must be made in developing that index including setting a time scale for the analysis (the District used an averaging period of 5-years). Choosing a different length of time for the averaging could lead to different minimum levels and changing the amount of water available for withdrawals. The choice of 5-years is reasonable, but arguments could be made for choosing other values and ultimately the resulting minimum levels would be set with some arbitrariness. Stakeholders noted that other methods for determining wet and dry periods could lead to yet a different set of minimum levels. The Panel agrees that these methods of determining wet and dry periods may be considered subjective and should be avoided.

An alternative approach to delineate between wet and dry periods would be to simply separate the historical record into the highest 50 percent and lowest 50 percent of observed lake elevations and use this as a surrogate for wet and dry periods. Because the proposed application of the minimum levels is achieved through comparing modeled scenarios over the entire period of record, separate impact thresholds could be evaluated for different portions of the natural lake level regime. For example, one threshold could apply to the entire period of record (e.g. the currently proposed 15 percent impact) while allowing for some exceedance of that value (possibly an average of 20-25 percent) for the driest or wettest 50 percent of the record. The increased threshold for the lower subset inherently acknowledges that droughts occur and the minimum levels cannot be expected to be equally protective during the most extreme conditions. At the same time, it acknowledges the importance of protecting values within this specific range of conditions.

## 4.2 Revisions to Previously Proposed Criteria

### 4.2.1 Fish and Wildlife Habitat

The revisions to the Fish and Wildlife Habitat metrics replace the standard protection metrics of the habitat areas associated with the 25th, 50th, and 75th percentile lake levels with the proposed approach for incorporating the entire lake level regime as discussed in Section 4.1.2 above. Because of the concerns raised above, the Panel believes the advantages and rationale provided in the Criteria Memo are not actually realized.

The Criteria Memo states in Section E.1 that "only focusing on one or a few percentiles may fail to capture large impacts from groundwater withdrawals that occur at water levels below the median." However, the current approach evaluates only the difference between the *average* habitat areas under the no-pumping and proposed pumping scenarios. In this case, the average will be closer to the median (the 50th percentile value considered in the draft MFLs Report) than either the 25th or 75th percentile values previously evaluated. In fact, in the draft MFLs Report, the 25th and 50th percentile values were not even evaluated because at those lake elevations, there was no scenario in which reducing elevation would result in reduced habitat area. As a result, the only percentile evaluated was the 75th percentile value—a value which would result in a more protective criteria than the median and which is no longer being considered under the new framework. Therefore, the proposed changes have the potential to be less protective of impacts below the median than the original.

Despite these criticisms, the actual impact of the Habitat criteria on minimum levels is likely to be minimal or non-existent. Each of the habitat criteria being evaluated get larger with reduced water elevation throughout the full natural lake level regime for Lake Geneva and down to the 75th percentile elevation for Lake Brooklyn. In the case of Lake Brooklyn, the declines in habitat area from the 75th to 100th percentile elevations still result in habitat area greater than the mean habitat area over the 1st to 75th percentiles, based on the figures provided in the Draft MFLs Report (Figures 25, 26, 35 and 36).

Given the general improvement in status for the fish and wildlife habitat metrics with groundwater withdrawals, the other metrics being considered will likely be more restrictive on groundwater withdrawals. If the fish and wildlife habitat criteria have no practical impact on the final minimum levels established for Lakes Brooklyn and Geneva, it could be helpful for the District to either simplify the minimum levels by removing the criterion altogether or acknowledge that their place in the report is to explicitly document the consideration of these important environmental values in the minimum levels determination.

### 4.2.2 Lake Connectivity Metric

The Lake Connectivity Metric is designed to maintain the duration of time when lobes within the lakes are connected to the main lake with enough water to allow boat travel and fish passage. To evaluate this metric, the critical water elevation meeting this criterion must be determined. The draft MFLs Report considered the elevations between lobes both connected to the main lobe and lobes within the main lobe. However, stakeholders referred to evidence that the existing bathymetry data used within the main lobes was not in agreement with aerial photography. Because of this concern, the revised metric is based only on the connections between the main lobe and adjacent smaller lobes (ignoring lobes that form within the main lobe at low elevations).

The Panel supports updating the criteria to eliminate the incorporation of problematic data into the development of minimum levels. However, the updated Criteria Memo does not provide the new Minimum Lake Connectivity elevations or associated allowable shifts in elevation to more thoroughly assess the revision.

# Section 5: Summary

- The Panel agrees with the District's decision to remove the minimum dock access, aesthetics, and species richness criteria due to their limited applicability to sandhill lakes like Lakes Brooklyn and Geneva.
- The Panel supports the decision to add the open water, surface area, and average depth criteria to better protect the aesthetic, recreational, and ecosystem values of Lakes Geneva and Brooklyn. These criteria address these values in a more straightforward way than the three criteria they replace.
- The Panel supports the District's goal of finding a standard protection statistic that is more protective along the entire natural lake level regime for these lakes due to their large naturally occurring fluctuations. Unlike lakes with more stable water levels, these lakes can persist for long periods of time at water levels that are significantly different from average levels.
- The Panel believes the District's proposed methodology – using the arithmetic average change from the no-pumping condition over the modeled period of record— does not necessarily achieve the goal of being protective across the entire natural lake-level regime.
- The Panel believes evaluating historical wet and dry conditions separately can supplement the District's proposed approach to improve applicability of minimum levels over the lakes natural range of lake level fluctuations. Explicitly allowing a greater degree of change over the drier conditions would prevent the criteria from being significantly over-protective, while still placing limits on the degree of change acceptable during decades-long periods when water levels are naturally below average.
- The Panel suggests adding graphics that illustrate the differential impacts of groundwater withdrawals on the proposed criteria over the natural lake level regime and a summary table similar to Table 10, "Summary of Environmental Criteria and minimum levels" as found in the draft MFLs Report.

# Section 6: Literature Cited

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