

Final Report

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Peer Review of the Lake Avalon SSARR Model

Prepared for:



The St. Johns River
Water Management District

Prepared by:



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Lake Avalon SSARR Model

Lake Avalon is located in Orange County, Florida, approximately five miles southwest of Winter Garden. Currently, Lake Avalon is listed on the *MFLs Priority Water Body List and Schedule* (SJRWMD 2008). Pursuant to Florida Statutes 373.042(2), as an included waterbody, minimum levels must be established for the lake. Setting minimum flows and levels for this lake provides initial limits to Floridan aquifer withdrawals for the area surrounding the lake. The ultimate function of the Lake Avalon SSARR model will be to evaluate the impacts of consumptive use withdrawals on lake stages to ensure that withdrawals do not cause a violation of the MFLs.

The recommended MFLs for Lake Avalon are shown in Table 1. In order to evaluate proposed aquifer withdrawals and their impacts on Avalon, a hydrologic model was developed for the lake. The Streamflow Synthesis and Reservoir Regulation (SSARR) model developed by the Portland District of the U.S Army Corps of Engineers (USACE 1986) was selected to be utilized for the development of a model of Lake Avalon. SSARR is a continuous simulation model whose watershed model simulates rainfall-runoff and accounts for interception, evapotranspiration, baseflow infiltration and runoff routing into a stream network. This portion of the model accounts for groundwater flow through the local water table, but not through the regional water table, the intermediate, or the Floridan aquifer. Interaction between the Floridan Aquifer and Lake Avalon is a significant portion of the water budget for the lake. Due to this fact, a seepage routine was developed in SSARR to simulate regional aquifer fluxes. The SSARR model includes the approximately 180-acre main portion of Lake Avalon. The eastern lobe of the lake, which is approximately 50-acres, is not included in the current model.

Table 1. Lake Avalon MFLs

	Minimum Level (ft NGVD)	Duration (days)	Return Interval (years)
Frequent High	90.0	30	3
Frequent Low	86.4	120	3

This technical memorandum evaluates the current SSARR model for Lake Avalon with regard to model selection, input data, calibration, and simulation results. The input data and model assumptions are examined, and the potential impacts of these assumptions on the MFL will be discussed.

Task A: Assess adequacy of hydro-meteorological records in terms of quality, spatial coverage, and length of record.

- 1) Was "best information available" utilized to develop the hydrologic model?
- 2) Are there any deficiencies regarding data availability?



There is a limited amount of information available for Lake Avalon. That being said, the best information available was utilized to develop the model. For the calibration of the model, the following data was utilized:

2000 Land Use. Land use estimates from 2000 were utilized in order to determine the amount of impervious area draining into the lake. Examination of the land use indicated approximately 0.014 square miles of impervious area due to low-density residential development. The model includes an impervious basin corresponding to 0.014 square miles of impervious area and a pervious basin corresponding to 1.100 square miles of pervious area. The selected land use data might not be the best for calibration since the calibration begins back in 1989. It might be more appropriate to use a land use distribution that represents a condition that captures the average condition throughout the calibration period, not the conditions at the end of the calibration period. This would be very important in basins of dramatic land use change over the calibration period. Since there are not dramatic land use changes in the Avalon model domain, however, the implications for the Avalon model should be minimal.

Best Available Bathymetry. Bathymetry was not available for Lake Avalon. The storage capacity curve used for the SSARR model was based on areas derived from contours and the water surface from the USGS quadrangle map for the lake. The available areal photography was not of sufficient quality to be utilized for the determination of the lake area. Due to the lack of data, the storage capacity curve will have large uncertainties which may impact the model results. The storage capacity curve was developed using common engineering practices and represents the best available data.

Observed Stages at Lake Avalon. Stage data was gathered by Orange County, and was available for irregular intervals on an approximately monthly basis from 1960 to 1983 and from 1987 to 2001. This represents the best available stage data for Lake Avalon and served as data for the calibration targets.

Daily Rainfall. Daily rainfall totals were utilized for the model calibration and long term simulation. The calibration of the model utilized a daily rainfall recorded by the District (Lake Apopka at Turnpike). The long term simulation utilized the Turnpike station as well as the Clermont and Isleworth NOAA daily rainfall records. The data processing of the rainfall appears to be produced with common engineering practices. More comparisons with the "homogeneous" rain gauge might be helpful in determining if the merged rain data show a low bias due to poor data collection.

Potentiometric Surface. For the calibration period, the potentiometric surface beneath Lake Avalon was simulated using data from the District's L-052 monitoring well. For the long-term simulation, the potentiometric surface was simulated using the L-052 well, with supplemental data from the Clermont and Mascotte wells, as described in Table 2. The L-052 data was available on a monthly basis. Using the monthly data, straight line interpolation between observed data points was utilized in order to develop a daily time series for model input. Other available observation wells recorded the aquifer level on a daily basis, as shown in Table 2. While it is possible that the L-052 was utilized because it was the closest well to Lake Avalon, it should be noted that the Turnpike well, which has a daily record, is also located in close proximity to the lake. Justification for not using the Turnpike well should be included in the report. Additionally, a simple linear regression analysis might improve the fit when fitting data from other wells to fill missing data. A



linear regression would provide not only an offset, which was used in the data preparation, but also a slope which would help fit the range in the wells.

Table 2. Available Wells

Well Name	USGS Number	Period of Record	Comment
City well replacement at Clermont, FL	283314081455501	1977-2001	Daily with occasional gaps
Mascotte deep well	283204081544901	1959-2001	Daily with occasional gaps
L-052	DIST 05310981	1984-2001	Monthly
Lake Apopka at Turnpike	DIST 38003797	1989-2001	Daily with a gap between 03/93 and 08/94
OR-47 well at Orlovista, FL	283253081283401	1943-2001	Daily with occasional gaps

Pan ET Data. Pan evaporation data was available from 4 NOAA stations within the SJRWMD (Gainesville, Lake Alfred, Lisbon and Vero Beach). The Lisbon Pan data was utilized for the model calibration. Pan evaporation is utilized by SSARR in order to calculate direct evaporation from the lake and to estimate actual evapotranspiration from the basin. The Pan data was organized into two separate time series: one for the basins and one for the lake. The lake ET data was aggregated into a weekly time series in order to prevent round off errors (Robison, 2009). This should have little effect on the accuracy of the lake water budget since the AET is never limited by available water in the lake simulation.

The above data represents the best data currently available for Lake Avalon and the surrounding basin. All available observed stage, bathymetry, rainfall, land use and potentiometric surface data was utilized. The best available data was utilized to develop the model. Based on review of "Lake Avalon Minimum Flows and Levels Hydrologic Methods Report" and a review of the model input files, there was no information found to be discarded from the model development and calibration.

Task B: Assess methods and procedures for data analysis.

- 1) Are the analytical methods and procedures appropriate?
- 2) Are there any deficiencies and/or errors in the analytical methods?

Model Conceptualization. Overall, the analytical methods and procedures utilized were appropriate and sound engineering principles were adhered to. When conceptualizing a model, the available data and the ultimate purpose of the model should both be considered. SSARR is a numerical hydrologic model that simulates rainfall-runoff while accounting for interception,



evapotranspiration, soil moisture, baseflow infiltration, and routing of runoff into the stream system. This is an appropriate model selection for the current purpose given the available data.

The conceptualization of the model included 2 basins (1 pervious and 1 impervious) draining into Lake Avalon. Dividing the computation of separate land use is a good engineering practice to follow. Lumping regions of different hydrologic processes together will produce very poor results. From the lake, water was routed into 2 seepage sinks. One seepage sink was operative for all lake stages, and the other seepage sink was assumed to stop seeping water when Lake Avalon stages reached 84 feet. According to the model documentation, this assumption was checked by examination of aerial photographs, which verified that the lake could break up into 2 lobes at an approximate stage of 84 feet.

There were several assumptions with regard to the conceptualization of the model. These assumptions include the following:

- Baseflow from outside the immediate basin is small compared to the overall water budget. Despite this assumption of the model, the inclusion of the groundwater fluxes from the potentiometric surface does account for the regional water budget and therefore flows from outside the immediate basin.
- Bathymetry below certain levels could be estimated using USGS quadrangle maps.
- The effect of Water Conserv II (WC II) project, a water re-use project located to the south and southwest of the lake, was assumed to primarily manifest itself by changing the Floridan aquifer levels (as reflected in the L-052 well).
- The potentiometric surface beneath Lake Avalon can be estimated using the District's L-052 well. When this data was unavailable, it was supplemented with the USGS's Clemont and Mascotte wells.

Additional assumptions were made regarding the calibration of the model. All the noted assumptions follow typical engineering practices. Given the lack of data, best available methodologies were used in the hydrologic analysis. It was assumed that the calibration covers a wide enough range of flow regimes and hydrologic conditions to ensure that the long-term model simulation will be realistic.



Task C: Assess hydrologic models.

- a. Determine if the model is appropriate, defensible, and valid, given the District's MFLs approach.
- b. Was there adequate data to develop, calibrate and apply the model?
- c. Given the available data and the District's MFLs approach, are there more appropriate models for assessing the water body?
- d. Evaluate the validity and appropriateness of all assumptions used in the development of the hydrologic model.
 - e. Are the assumptions reasonable and consistent given the "best information available"?
 - f. Is there information available that could have been used to eliminate any of the assumptions? Would the use of this additional information substantially change the model results?
 - g. Are the assumptions stated clearly?
 - h. What, if any, additional assumptions are implied or inherent in the development of the model?
 - i. Are other methodologies (modeling or non-modeling) available that would require fewer assumptions but could provide comparable or better results? Are adequate data available to support using these alternative methodologies?
 - a. Are there deficiencies and/or errors in model development, calibration, or application?
 - i. If so, describe each deficiency and/or error and enumerate and describe the necessary remedies, and provide an estimate of the time and effort required to develop and implement each remedy.
 - ii. If the identified deficiencies cannot be remedied, then identify and describe one or more alternative methodologies (modeling or non-modeling) that are scientifically defensible given the available data. Provide an estimate of the time and effort required to develop and implement them.

Model Conceptualization. The model schematic is shown in Figure 1. The input to the lake consists of a previous basin and impervious basin consisting of areas of 1.10 and 0.014 square miles, respectively. Outflow from Lake Avalon flows to two sinks: one permanent sink (the Floridan aquifer), and one temporary sink, which is active below 84 feet NGVD. The second sink was added to the model during the calibration process because the simulated stages were systematically diverging from observed values at stages lower than about 84 feet. The development of this additional sink essentially assumes that the model breaks up into two separate lobes at stages lower than 84 feet. While this may be a valid assumption, if the lake breaks up into



2 separate lobes, the drainage areas should also be broken up into a pervious and impervious basin for each lobe. Otherwise, when the temporary sink is inactive, the model is utilizing the drainage areas for both lobes of the lake and applying the runoff generated to the actively seeping lobe. In reality, a portion of that drainage area is contributing to the other lobe. The effect of this is that there could be too much runoff contributing to the actively seeping lobe.

An alternate methodology for simulating 2 lobes of the lake would be to simulate the lake as 2 separate lakes that are connected above a specified elevation. This would eliminate the errors associated with the entire basin contributing one lobe of the lake when the temporary sink is inactive.

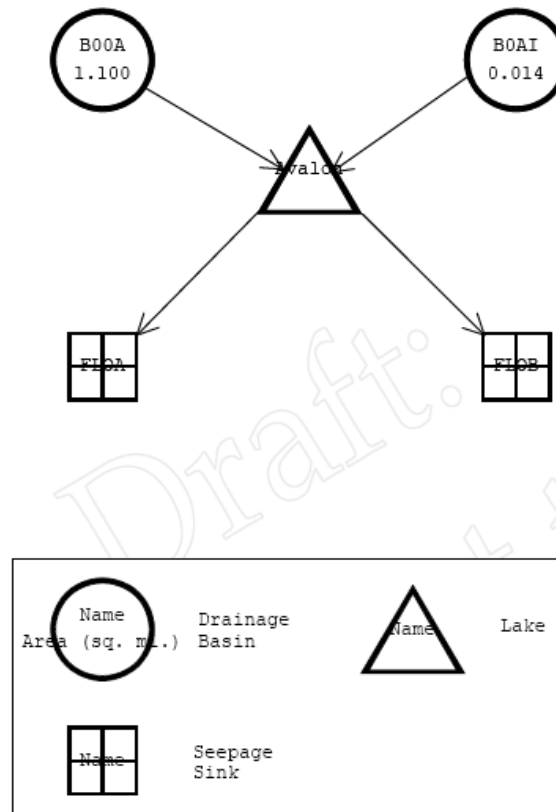


Figure 1. Lake Avalon SSARR Model Schematic. Source: (Robison, 2008)

The model is currently run at a 1-day time step. SSARR has the capability to utilize a time increment as short as 0.1 hours. Using daily time steps with infiltration excess modeling, such as the pervious basin, results in model calibration that tends to over estimate low flows and under estimate high flows. In effect, long time steps average a wide range of hydrologic conditions. There is no way for the model to differentiate the difference between 2 inches of rain in 0.5 hour versus 2 inches over 12 hours. Based on the available data however, a daily time step is appropriate, especially given the lack of flow data to use as a calibration target.



Model Adequacy and Assumptions. There was adequate data to develop, calibrate and apply the model. It would be desired to have more calibration data, especially basin flows as an additional calibration target. Nevertheless, given the use of the best available data, the model development followed proper engineering procedures. There are several simplifying assumptions made in the conceptualization of the model which may affect the model's performance. The assumptions which are of the most concern are those associated with the utilization of the L-052 well data, and the development of an additional temporary sink in the model. These assumptions could potentially have implications to the performance of the model for the historical simulation period.

Utilization of L-052 Well Data. Data from the District's L-052 well was utilized for the calibration period (1989-2001). This data consisted of a monthly record with some additional data gaps. Linear interpolation was utilized to fill daily values between monthly readings. More information is needed with regards to why this well was chosen for use as the primary data source for potentiometric surface in the model. Based on the available well data shown in Table 1, there are more complete well records available. Comparison of the L-052 well data to the Clermont and Mascotte wells is shown in Figures 2 and 3, respectively. As shown in the figures, there is a good comparison between the L-052 and Clermont well records, with the exception of the higher stages recorded at L-052 in the 1990s (1995 and 1998) and the much lower levels recorded at L-052 in the early 2000s. It would be highly useful to run the model with one of these available well records (such as the un-shifted Clermont well) in order to determine the impact of using the L-052 well time series.

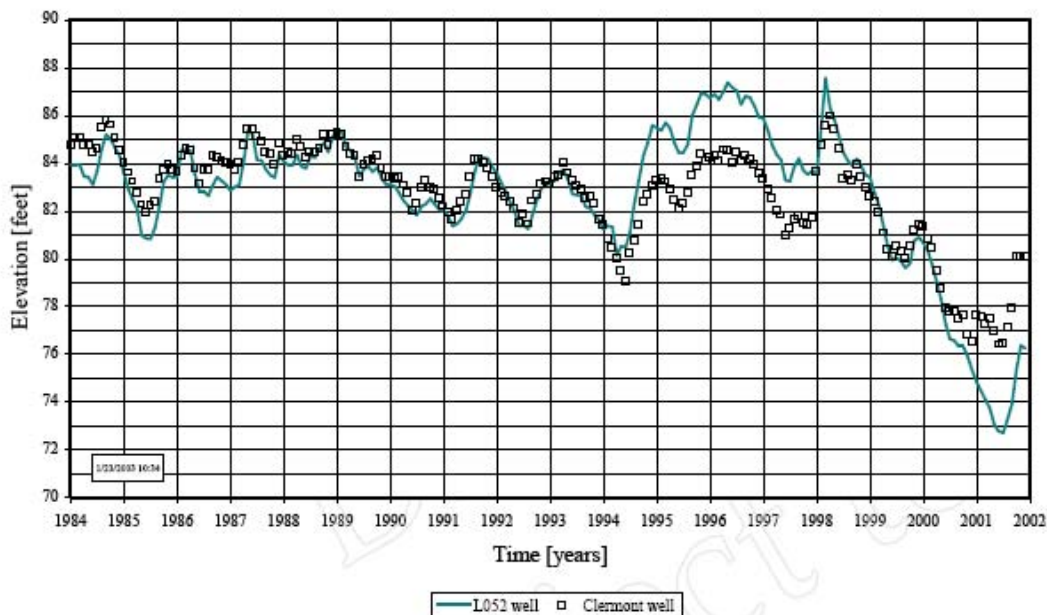


Figure 2. Comparison of L-052 and Clermont Wells. Source: (Robison, 2008)

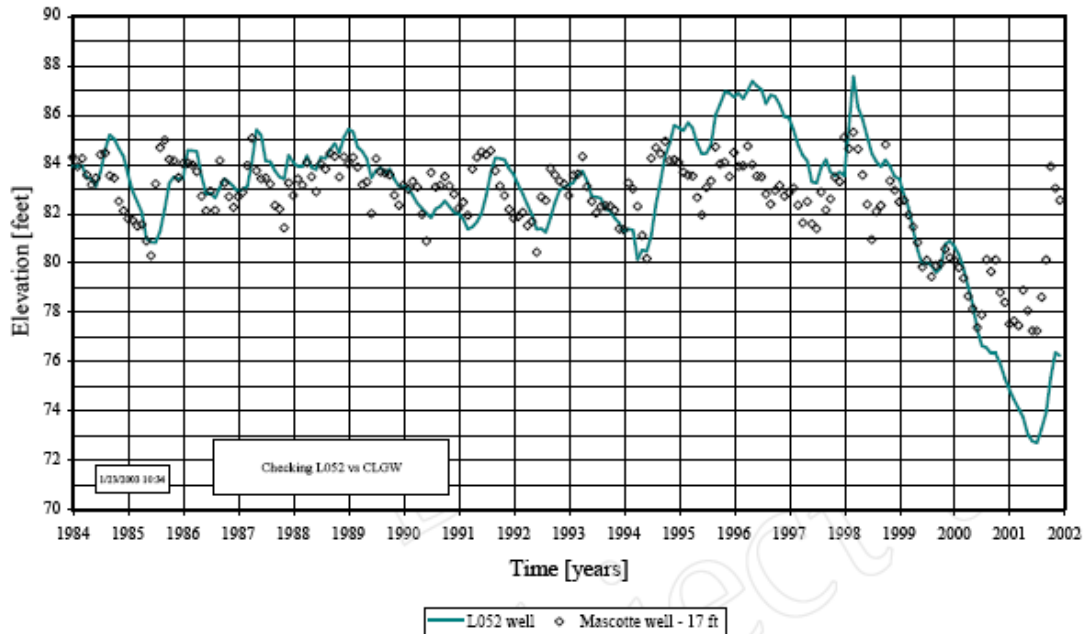


Figure 3. Comparison of the L-052 and Mascotte Wells. Source: (Robison, 2008)

For the extended simulation (1959-2001), the Clermont and Mascotte wells were used to supplement the L-052 record. More information is needed in order to determine how the L-052 record was supplemented. As shown in the figures, although there is generally good agreement for the time series between the L-052 and Clermont and shifted Mascotte well, there are periods (such as in the 1990s and early 2000s) where there is a greater range of elevations shown at the L-052 well than the other 2 wells. When data from one well is supplemented with data from another, it is important to scale the data by both shifting the data based on the potentiometric surface difference, and scaling it by a factor to preserve the range of values seen at the original well. This will ensure that the characteristics of the original well (L-052) are preserved. A comparison of the approximate minimums, maximums, and well ranges is shown in Table 3. As shown in the original table, although the wells generally compare favorably, the more extreme events seen at the L-052 well result in a much greater range of values than at the other 2 wells.

Table 3. Well Statistic Comparison

Well Name	Approximate Maximum Level, ft NGVD	Approximate Minimum Level, ft NGVD	Range, ft
L-052	87.3	72.9	14.4
Clermont	86.1	76.1	10
Mascotte (shifted 17-feet)	85.1	77.5	7.6



Based on the model documentation, it appears that a shift was applied to the Mascotte well, but no other processing was done. If this is the case, it would be beneficial to develop a time series for the extended simulation that also preserves the range of the L-052 record. This would be a fairly straightforward algorithm to run and would not require a great deal of additional effort. The SSARR model can be re-run with this new time series, and the difference in the lake stages between the two runs can be compared in order to determine the impact of developing a time series that preserves the original well characteristics.

Examination of Long Term Potentiometric Surface. In addition to preserving the range of the L-052 record, the long term potentiometric surface should be examined in order to verify that the shifts that were applied to the L-052 record (based on the September 1990 potentiometric surface maps) are representative of the entire calibration and extended simulation period. If the shifts (zero for the Clermont well, and 17-feet for the Mascotte well) are not representative of the entire simulation period, it may be necessary to apply a seasonal or decadal shift based on trends due to precipitation or water use. If the shifts that were applied to the current time series are representative of the entire simulation period, it would be helpful to add additional graphics to the model documentation illustrating that the potentiometric surfaces are similar between years and seasons. Again, this is a small recommended enhancement which would give more confidence in the time series used to drive the model.

Change in Basin Area based on Lake Stage. The stage-area curve for Lake Avalon is shown in Figure 4. As shown in the figure, the area of Lake Avalon ranges from over 550 acres at a stage of 110-feet to an area of 100 acres at a stage of approximately 75-feet. During the calibration period, the lake stage ranged from approximately 80-feet to 92-feet. These stages correspond to lake areas of approximately 115 acres and 215 acres, respectively. Table 4 shows the range of the lake area during the calibration period as well as the areas of the basins used in the model. As shown in the table, the variability in the lake area represents a large percentage of the contributing basin. When the stage of the lake goes down and decreases the lake area, there is a decline in lake area of approximately 100 acres (from high stage to low stage). This additional area should be added to the pervious basin area since it is still contributing to the overall basin. Although SSARR has the ability to change the area of the lake with stage (for lake water budget calculations such as direct evaporation), when the lake stage is low, for example, it does not add the reduced lake area to the pervious basin area (thus causing a mass balance error). This is particularly important since the basin is small, and an additional 100 acres represents a large percentage of the pervious area. It might be noted that, in the lake water balance, direct precipitation is offset by direct ET from the lake. The assumption can be made that the error in mass balance would be negligible given the fact that precipitation and ET are similar on an annual average. Given the timing differences in rainfall and ET, however, the assumption that changing the lake area does not affect the overall water balance is wrong. With the base area of the lake of 180 acres and the lake area ranging from 115 to 215 acres during the calibration period, the corresponding change in the pervious basin would be from 769 acres (at low stage) to 669 acres (at high stage). This represents a range of change in the pervious basin from +9.2% to -5.0%.



Table 4. Model Area Comparison

	Area, acres
Pervious basin	704
Impervious basin	8.96
Lake (during calibration period)	115 - 215

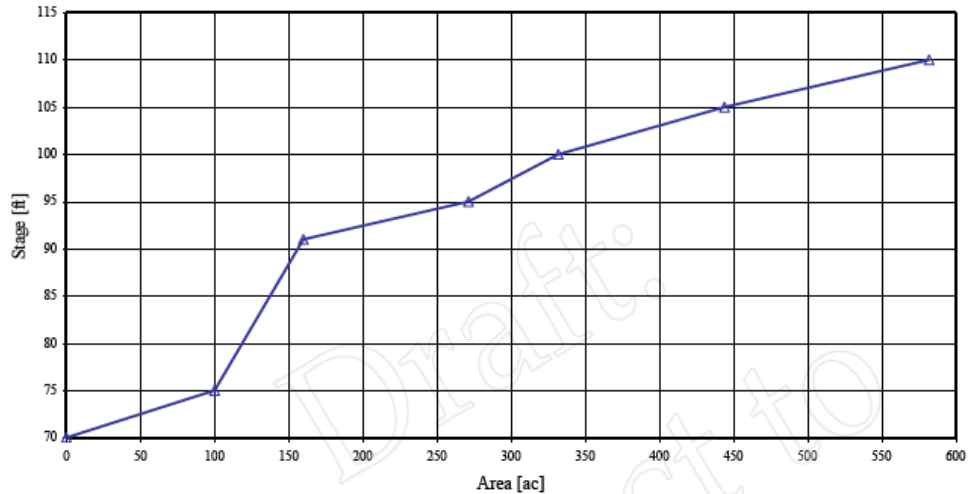


Figure 4. Lake Avalon Stage Area Curve. Source: (Robison, 2008)

Comparison of Long Term Simulations. A comparison of the Lake Avalon SSARR results to the Lake Avalon gauge for the calibration period is shown in Figure 5. As shown in the figure, there is a good agreement between the observed and predicted stages for the calibration period. The results for the long term simulation are shown in Figure 6. As shown in the figure, there is no comparison of the SSARR results to observed data for the long term simulation in the original report documentation. All historical observed stage data should be added to this graphic in order to better assess the performance of the model.

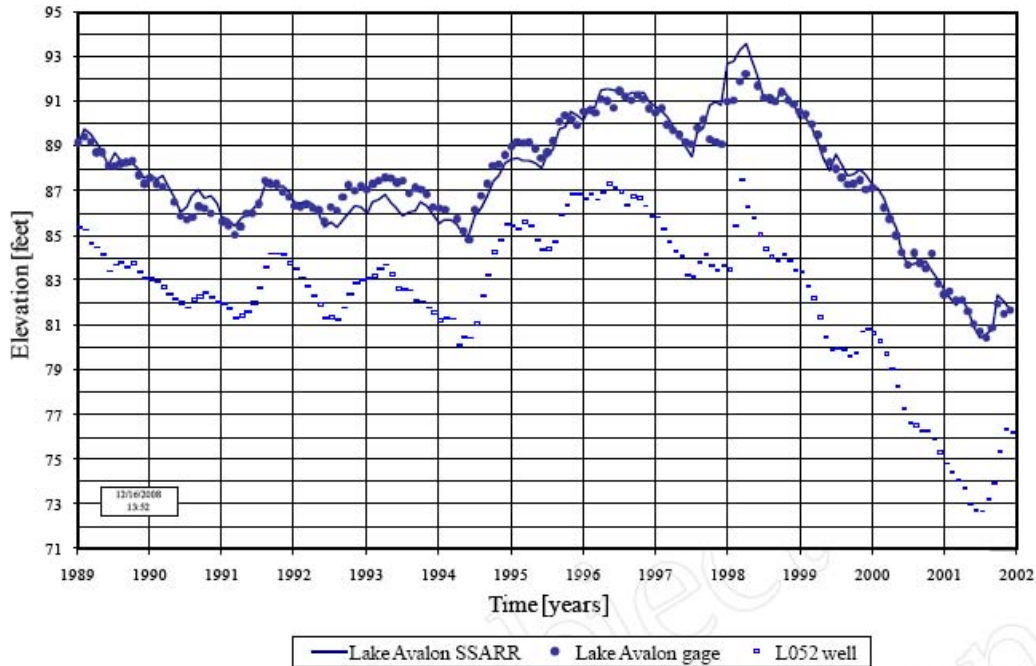


Figure 5. Observed and Simulated Hydrographs (Calibration Period). Source: (Robison, 2008)

The report documentation discusses two long term simulations, as shown in Table 5. These two long term simulations utilize identical input data with the exception of the input rainfall time series, as shown in the table. In the model documentation, the output stage hydrograph is only given for the 'Existing Conditions' simulation. The output stage hydrograph for the 'Existing Conditions-Alternate' simulation should also be added to the report documentation, preferably on the same graphic as the 'Existing Conditions' simulation and the observed data. Examination of this data is vital in order to be able to assess the impact of the rainfall time series on the model.

Table 5. Long-Term Simulation Descriptions. Source: (Robison, 2008)

Simulation	Rainfall Station	Floridan Aquifer Well)	Pan Evaporation Station
Calibration	Turnpike	L-052	Lisbon
Existing Conditions [1959–2001]	Turnpike [1989–2001] Winter Garden [1983–88] Isleworth [1959–1982]	L-052 [1984–2001] Clermont [1978–83] Mascotte [1959–77]	Lisbon
Existing Conditions-Alternate [1959–2001]	Turnpike [1989–2001] Clermont 7S [1959–88]	L-052 [1984–2001] Clermont [1978–83] Mascotte [1959–77]	Lisbon

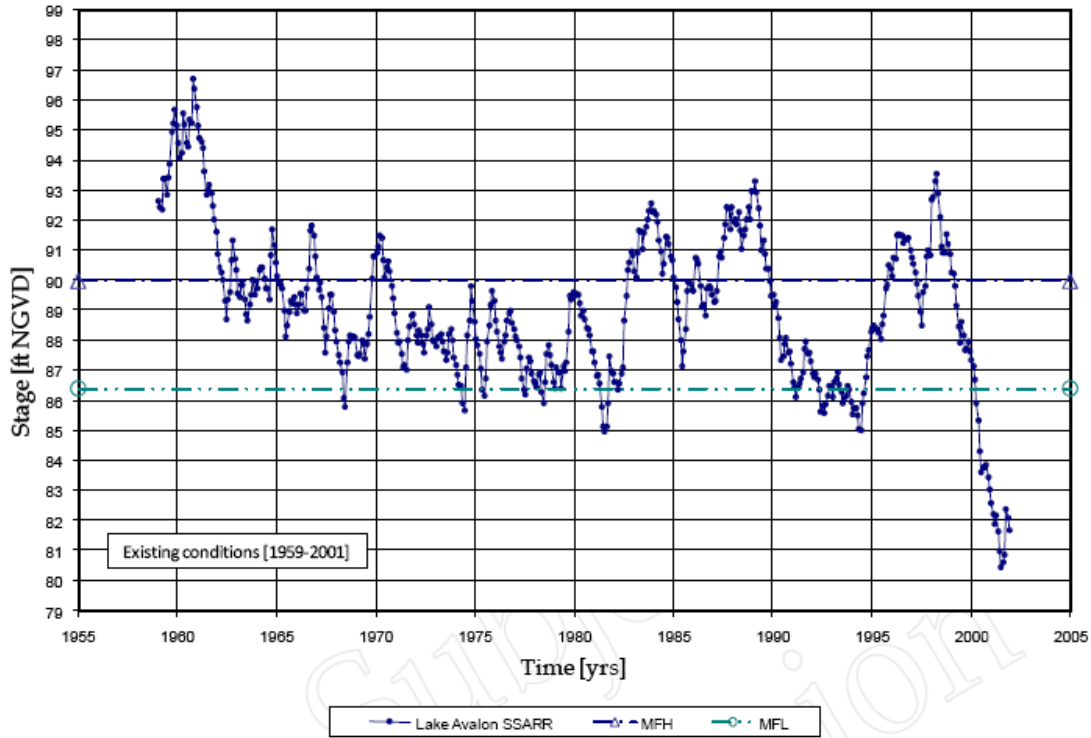


Figure 6. Existing Conditions SSARR Simulation Hydrograph. Source: (Robison, 2008)

Although the documentation does not show the stage hydrograph for the Alternate simulation, the MFL curves are developed using both long term simulations. It is important to note that the only difference between these simulations is the rainfall input time series. Despite this slight difference between the models, there are visible differences in the probability plots resulting from these simulations (and used to evaluate the MFH and MFL). The rainfall time series for each of these models should be detailed further (annual totals, event totals, etc.) in order to further investigate the differences in the simulations. Again, this recommendation is based solely on the data available in the documentation. No simulation results were given for the alternative simulation, with the exception of the MFH and MFL curves.

Inclusion of Additional Source Flows. There has been discussion regarding the lack of inclusion of additional sources in the model, specifically flows due to septic tank seepage and the Water Conserv Project. It is this reviewer's opinion that these flows need not be included in the model for two reasons. First, the septic discharges are small (especially given the undeveloped nature of the Avalon Basin) and unregulated, making it difficult to accurately estimate actual flow rates. Second, flows due to septic tank seepage would have very little effect on the overall lake water budget because the majority of septic tank discharge is lost to root uptake and evapotranspiration. Moreover, any additional inflows would be offset with increased losses to the aquifer due to the potable supply pumping. With regards to the Water Conserv Project, this review agrees with the Avalon Lake report that any impacts of the Water Conserv Project may have on the lake should be represented by the local Floridan well, provided that the well is close to the project. Since the primary source of Floridan Aquifer data (the L-052 well) is located on the opposite side of Lake



Avalon from the RIBs, the impacts of the rapid infiltration basins (RIBs) would be muted. It would be desirable to look into a method to account for the muted impacts.



Figure 7. Water Conserv II Project

Basin Water Balance. The documentation for Lake Avalon poorly documented basin (or contributing watershed) water balance. The basins provide a significant source of water to the lakes (as per the report, the pervious runoff is the most significant water balance term for the lake). The runoff for the pervious and impervious basin is shown in Table 6. These values were obtained from the report as well as a spreadsheet provided by the model developer (Water Budget after impervious.xls). These values represent the average annual runoff magnitudes for the long term simulation. At first glance, the runoff volumes appear reasonable. If they are converted to a depth over each of the contributing basins (using the basin areas provided in the documentation), however, the impervious basin runoff is very high (approximately 103 inches per year, or 8.59 feet per year). This is not physically possible since rainfall, the primary input into the model, is typically on the order of 52 inches per year. This issue needs to be further investigated in order to determine why the impervious basin runoff is so high. It would be expected that, for an impervious basin, the basin runoff would be slightly less than the annual rainfall (minus initial abstractions for each event, which are eventually lost to ET) or approximately 20-40 inches per year.



Table 6. Basin Water Budget, Existing Conditions Simulation

Pervious Basin Runoff, ac-ft/year	Impervious Basin, ac-ft/year	Pervious Basin Runoff, ft/year (Pervious basin area = 704 acres)	Impervious Basin Runoff, ft/year (Impervious basin area = 8.96 acres)
769 ac-ft/year	77 ac-ft/year	1.09 ft/year	8.59 ft/year

Sources of Model Uncertainty. There are several sources of uncertainty in the model, including, but not limited to:

1. Impacts in lake leakage or potentiometric surface estimation,
2. The placement of the temporary sink in the lake,
3. Errors in the assumed soil moisture relationship,
4. Selection of rainfall time series, and
5. Errors associated with the impervious basin water balance.

A sensitivity analysis was conducted by the model developer with regard to the rainfall time series by using 2 different rainfall time series for the long term simulations. Nevertheless, the output stage hydrographs for these two simulations need to be compared, which was not done in the original documentation. In order to address some of the additional sources of uncertainty in the model, additional sensitivity analyses can be conducted by creating additional input time series for additional model runs. The impact of potentiometric surface, for example, can be evaluated by using input time series from other wells instead of the L-052 well.

Conclusions and Recommendations

SSARR is a continuous simulation lumped parameter rainfall runoff model. The selection and utilization of this model to support Lake Avalon MFL protection was an appropriate use of the model and followed sound engineering principles. The development of the model included the utilization of best available data. The SSARR model developed for Lake Avalon is well documented (Robison 2008) and contains detailed descriptions of all input data sets and model assumptions. The model performs well during the calibration period. For the long term simulation, more information is needed in order to assess its performance. A stage hydrograph is needed for the Alternative long term simulation in order to determine the effect of the utilization of different rainfall time series on the long-term simulations. Additionally, the long term model simulations need to be compared to all available long term observed data, which was not done in the original model documentation.

Based on the model developed, there are no recommendations for additional data collection at this time. Instead, the majority of the recommendations for the Lake Avalon model focus on processing the existing data and running additional simulations or displaying additional model results. Given the fact that MFLs are to be defined using best available data, these recommendations are really suggestions for future MFL revisions. The recommendations include:



- Examining additional potentiometric surface maps for Lake Avalon in order to verify the assumption of the September 1990 potentiometric surface being representative of the entire simulation period. If it is not, a seasonally corrected potentiometric surface time series for Lake Avalon based on published potentiometric surfaces should be developed,
- Examining and addressing the errors in the impervious basin water budget.
- Supplementing the current documentation by adding additional graphics for the long term simulation,
- Analyzing the rainfall time series used for the long term simulations in order to quantify the differences between the input data sets,
- Providing justification as to why the L-052 monthly well data was used, as opposed to a nearby daily well,
- Developing an L-052 time series for the extended simulation that preserves the range of the well levels in the original observed record, and
- Conducting additional sensitivity analysis for model parameters.

It should be noted that while all of these recommendations may improve the performance of the model, the implementation of these recommendations must be considered within the context of available data and the District's MFL program. The final goal of the model is to determine stages that can be used to develop MFL curves and evaluate impacts of consumptive use withdrawals on the MFL. Ultimately, the determination of whether or not an MFL is being met is made through frequency analysis. This frequency analysis relies heavily on the selection and definition of key ecological signatures. These ecological features define the stages in the lake that will be considered as "significant harm". It is the selection of these features which the defined MFL will heavily rely upon. The frequency analysis, which is a component of the hydrologic modeling, is the optimal method for assessing environmental impacts. Harm in any system can be defined in terms of exposure to events. It is the frequency, duration, and intensity of the events that allow accurate assessment of "significant harm" in numerical terms. That being said, given the available data, the overall modeling methodology in defining the MFLs for Lake Avalon follows sound engineering practices.

It is highly recommended that the District adopt a standard report format for all lake MFL studies, which must include both a lake water budget and a basin water budget. Given the lack of data, especially for calibration targets, it is desired to review the basin water balance to assure the reader the basin simulations are reasonable. The report only documented the pervious basin outflow budget term as 13 inches per year. It is highly recommended to include a water balance report of all basins and basin budget terms. Careful examination of both of these water budgets will give confidence in the reliability of the model for predictive purposes, and hence, in the ability of the model to evaluate the MFL and potential future MFL impacts.

References

Robison, C.P. (2008). *Lake Avalon Minimum Flows and Levels Hydrologic Methods Report*. Report for the St. Johns River Water Management District, Draft 12/19/2008.