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Memo

To: Fatih Gordu, P.E., Chief Water Resources Engineer, SJRWMD

From: Silong Lu, Ph.D., P.E., D.WRE, Dynamic Solutions, LLC.

Date: 1/21/2020

Re: **INDEPENDENT TECHNCIAL PEER REVIEW SERVICES**
REVIEW OF LAKE SYLVAN HSPF MODEL-DEVELOPMENT, DOCUMENTATION, AND LONG-TERM SIMULATION REVIEW

Introduction

The SJRWMD's Minimum Flows and Levels (MFLs) Program is a District-wide effort to establish MFLs for priority lakes, streams and rivers, wetlands, springs, and groundwater aquifers. MFLs designate the minimum hydrologic conditions that must be maintained in these systems to prevent significant harm resulting from permitted water withdrawals.

SJRWMD has identified Lake Sylvan as a priority lake, which is listed on the 2019 MFLs priority list and scheduled for completion by 2020. Lake Sylvan is located approximately 5 miles west of Sanford and 4 miles northwest of the City of Lake Mary in Seminole County, Florida. It has a lake surface area of nearly 200 acres within the Yankee Lake Watershed. The Lake Sylvan watershed contains a Direct Tributary Area of 627 acres (without including the lake surface area). The watershed contributes both surface runoff and surficial groundwater flow to the lake and a Limited Discharge Tributary Area of 350 acres which contributes groundwater flow only to the lake.

The previously-developed 2005 HSPF hydrologic model was updated and recalibrated and validated by CDM Smith (CDM Smith, 2017). The updated HSPF model was calibrated to the period of 2008 through 2016 and validated to the period of 1997 through 2007 with an hourly time step. Major model updates and refinements included

- Tributary area: the refined and updated tributary area included both the Direct Tributary Area (contributing both runoff and surficial groundwater flow) and Indirect Tributary Area (contributing groundwater only);
- Land use: the 2009 land use was provided by the District and categorized into 13 land use types;

- Rainfall and potential evapotranspiration (PET) data: hourly rainfall and PET data were provided by the District;
- Lake surface discharge: an outfall structure constructed in 2014 was considered in development of the relationship between lake stage and surface discharge at high lake levels along with the relationship that reflected the overland flow surface discharge prior to the new structure;
- Lake bathymetry: The Lake Sylvan bathymetry data provided by the District and supplemented by available topography were used to estimate lake surface area and associated storage at different lake elevations;
- Lake surface area: the lake surface area calculated by HSPF was used to update the contributing riparian area using the Special Action of HSPF to track change of the total land-based contributing area as the lake stage changed; and
- Lake seepage: the seepage from the lake to the UFA was simulated based on the surface area of the lake calculated by HSPF, the head difference between the lake water surface elevation calculated by HSPF and the groundwater level at well S-0718 in the UFA.

MFLs assessment requires frequency analysis of lake levels. It is necessary to perform frequency analysis using long-term lake levels so that the effect of short- and long-term climatic variations on lake levels can be captured. Therefore, long-term lake levels need to be simulated using a hydrologic model to ensure the MFLs are met. The long-term simulation model of Lake Sylvan developed by the SJRWMD (SJRWMD, 2019) extended the calibration and validation years (1997-2016) to a long-term simulation period of 1948 through 2016. Three time series including hourly rainfall, hourly PET, and daily Upper Floridan Aquifer (UFA) groundwater level were extended and used as model input files.

The Lake Sylvan HSPF models were reviewed by Dynamic Solutions, LLC (DSLLC), with an emphasis on available data, model conceptualization, model parameter values, model assumptions, and model calibration. Overall, the model development generally followed standard engineering practice, utilizes the best available data, and made reasonable assumptions.

This technical memorandum summarizes DSLLC’s review of the HSPF models and associated model files [two HSPF models: calibration and validation model and long-term simulation model] including the following documentation:

- *Lake Sylvan MFL Evaluation (CDM Smith, 2017)*
- *Lake Sylvan Long-term Simulation (SJRWMD, 2019)*

Scope of review of the HSPF models and the associated documentation reports is to assess

- Adequacy and appropriateness of the data used in model development, calibration and long-term simulations;
- Validity, defensibility and appropriateness of the development, calibration, and long-term simulations of the model;

- Deficiencies, errors, or areas for improvements in model development, calibration, and long-term simulations; and
- Validity and appropriateness of all assumptions in the development of any statistical relationships used for the determination and /or assessment of MFLs.

Review Questions

The review questions below were provided by the District. To assess each question, model input files and model documentation were reviewed by DSLLC. DSLLC responses to the review questions are provided below.

1) Assess the adequacy and appropriateness of the data used in model development and calibration

Data used for hydrology model development and calibration for this study shall include

1. Tributary area
2. Land use and land cover
3. Soil data
4. Topographic data
5. Rainfall and potential evapotranspiration data
6. Lake Sylvan stage data
7. Groundwater elevations in the UFA from existing observation wells
8. Lake bathymetry

The data and other information provided with the model input files and report/technical memorandum were reviewed to determine if the best available data were utilized for the models, and ultimately for MFL development. The following datasets were reviewed for adequacy and appropriateness:

- Tributary area
- Land use and land cover
- Soil data
- Topographic data
- Rainfall and potential evapotranspiration data
- Lake Sylvan stage data
- Groundwater elevations in the UFA from existing observation wells
- Lake bathymetry
- Recharge data

Tributary Area

Tributary areas/basin boundaries for the Lake Sylvan study area provided by the District were presented in Figure 4 and Figure 10 of Appendix A (CDM Smith, 2017) with three different contributing basins

- Lake Sylvan basin which is expected to contribute surface runoff and groundwater flow the lake;
- Limited Discharge basin which may contribute surface runoff during extreme wet conditions but will primarily be limited to contributing groundwater to the lake; and
- Land Locked Lakes basin which is expected to contribute only groundwater inflow to the lake.

Based on review of the groundwater table elevation map (CDM Smith, 2017), the Land Locked Lakes basin (Figure 10 of Appendix A, CDM Smith, 2017) as shown Figure 1 below, in which groundwater is unlikely to flow toward Lake Sylvan was excluded and not simulated for this study.

The Limited Discharge Basin was further delineated into three different sub-basins based on the field observation (Figure 2 of Appendix B, CDM Smith, 2017) as shown in Figure 2 below. Limited Discharge Basin-Buckingham Estate was expected to contribute groundwater flow only to the lake and Limited Discharge Basin-Wetlands West discharged surface flow only from the storage area south of South Lake Sylvan Road to the lake when South Lake Sylvan Road is overtopped at an elevation of 44 ft NAVD. The modeled seepage flow from the storage area was considered to discharge to Lake Sylvan as groundwater flow. Limited Discharge Basin-Wetlands East, which is connected by a 12-inch culvert with the estimated invert of 38 ft NAVD under South Lake Sylvan Road, was considered part of the Direct Tributary Area to Lake Sylvan.

The final version of the tributary area/contributing basins used in the HSPF model appeared to be adequate and appropriate for the purpose of this study.

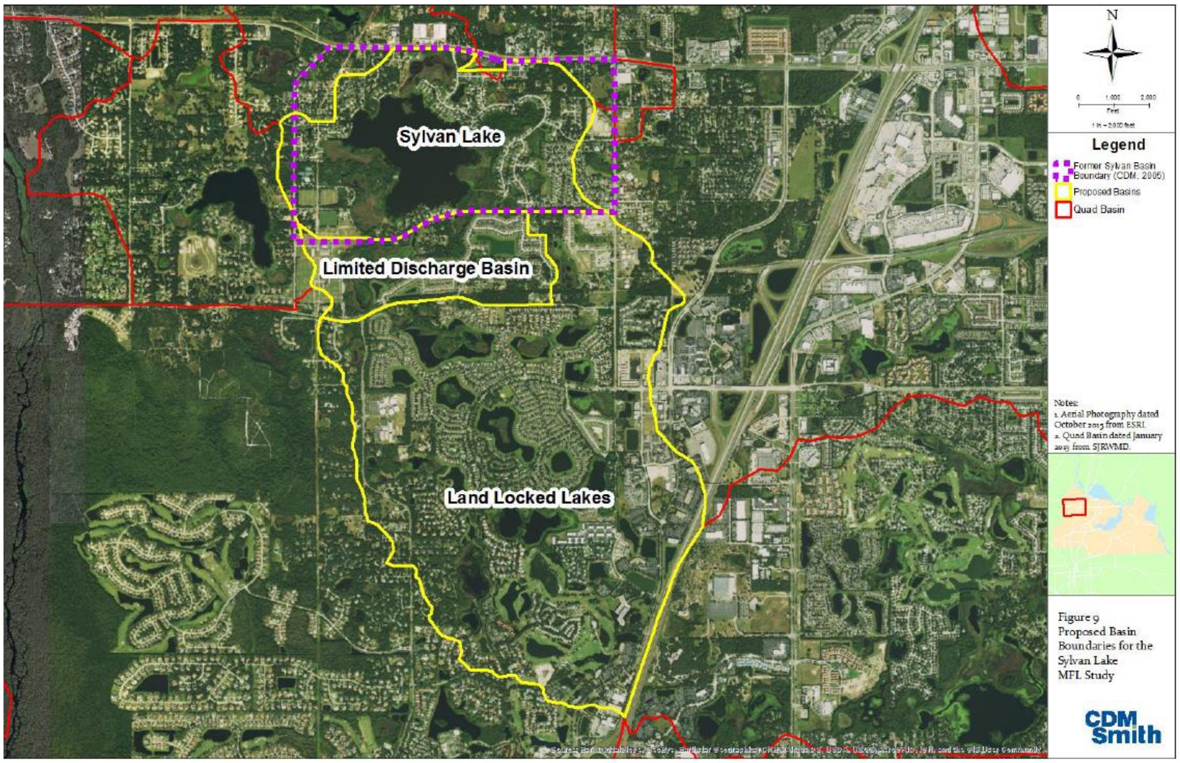

Figure 1 Land Locked Lakes Basin

Figure 2 Limited Discharge Basin

Land Use and Land Cover

Land use and land cover presented in Figure 1 of Appendix B (CDM Smith, 2017) was taken from the SJRWMD 2009 land use coverage provided by the District and categorized into 13 standard land use classes based on similarities in their hydrologic properties that has been used for HSPF modeling by the District. In the Direct Tributary Area, the primary land use is medium density residential (26.5%), followed by wetlands (20.1%), forest (10.9%) and low density residential (10.2%). The 2009 land use and land cover were also used to delineate wetlands as shown in Figure 1 of Appendix B to better represent the impact of wetlands on the drainage pattern in the basin.

As the calibration period of the HSPF model is from 2008 to 20016, selection of the 2009 land use and land cover data appears to be an appropriate choice and adequate for the purpose of the study especially when considering most of the land use change occurred in the late 1990s and early 2000s.

Land use data were used to develop model parameters including interception storage capacity, pervious and impervious land use areas, lower and upper zone nominal storages, Manning's n value, and lower zone ET parameter, etc.

I believe that percentage of the Lake Sylvan study area in each land use category presented in Table 3 of Appendix A (CDM Smith, 2017) is for the whole basin shown in Figure 4 of Appendix A, not for the area directly contributing to Lake Sylvan as the report stated (CDM Smith, 2017)

Soil Data

Digital soil coverage data was provided by the district and presented in Figure 6 of Appendix A (CDM Smith, 2017). The primary hydrologic soil groups are A and A/D groups which indicate that high infiltration is expected. Hydrologic parameters such as INFILT (index to infiltration) was established accordingly in the HSPF model.

The hydrologic soil data used for the model development is adequate and appropriate.

Topographic Data

Figure 4 of Appendix A (CDM Smith, 2017) indicated that USGS quadrangle map was used in determining the tributary areas of Lake Sylvan which was provided by the District. However, it is unclear what year's quadrangle map was used and if any topography was changed after the quadrangle map was created.

It should be noted that the tributary areas/basin boundaries used in the HSPF model may still be adequate and appropriate but the specific topographic data used for development of the tributary areas/basin boundaries needs to be discussed and identified.

Rainfall and Potential Evapotranspiration Data

Both rainfall and potential evapotranspiration data are critical to accurately simulate watershed runoff. The hourly rainfall data collected at Sanford Station from 1914 through 2016 was provided by the District in a WDM (Watershed Data Management) file. Similarly, hourly PET data from 1948 through 2016 at Sanford Station was provided by the District in a WDM file. The PET data were calculated on a daily basis using maximum and minimum air temperature using the Hargreaves equation, and then disaggregated to hourly values using WDMUtil. An adjusting factor of 0.8888 for PET for use in the HPSF was implemented in the UCI file as requested by the District.

Hourly precipitation data were used in the HSPF model to generate watershed surface runoff and to calculate direct rainfall on the waterbodies in the watershed while hourly PET data was used to calculate evapotranspiration loss from pervious and impervious land segments and waterbody surface direct loss.

Review of both hourly rainfall and PET data in the WDM file and annual total rainfall and PET presented in Table 1 of Appendix (CDM Smith, 2017) indicated both rainfall and PET data appear to be reasonable and are adequate and appropriate for the purpose of the study.

Lake Sylvan Stage Data

Daily lake stage data from October 1978 through April 2017 were provided by the District. During that period, the lake stages ranged from 32.9 to 42.0 ft NAVD with an average value of 38.3 ft NAVD. The amount and duration of the data were adequate and appropriate for model calibration and validation.

Groundwater Data

Five Upper Floridan wells (S-0718, V-0101, L-0045, L-0043 and OR-0047 as shown in Figure 2 of Appendix A (CMD Smith, 2017)) data were provided by the District. The S-0718 well is the preferred data source for the groundwater potentiometric surface at the lake. Data are available at this well for the period of February 2009 to April 2017. Correlation analyses between S-0718 well and the other four wells were conducted to determine well OR-0047 levels have the best correlation with S-0718 well levels. Consequently, records from OR-0047 were used to synthesize well levels at S-0718 for the period when no records available at S-0718 well using the maintenance of variance extension type 3 (MOVE 3) method of the USGS program Streamflow Record Extension Facilitator (SREF) version 1.0.

The groundwater level records at S-0718 for the period February 2009 to April 2017 and synthesized data for the missing period using the records from OR-0047 well are considered to be adequate and appropriate for the purpose of the study.

Lake Bathymetry Data

Paired elevation/area data from elevation of 38.6 ft NAVD down to minimum elevation of 24.6 ft NAVD and associated lake volumes were provided by the District. Area/elevation data above 38.6 ft NAVD were established using available topographic data in order to simulate the lake levels above that level. The bathymetry data used to develop the FTABLE of the lake appear to be adequate and appropriate.

Recharge Data

The latest Floridan aquifer recharge map was provided by the District yet was not directly used in the model. Figure 3 of Appendix B (CDM Smith, 2017). The moderate (5-10 inches per year) to high (10-15 inches per year) recharge values within the contributing basin indicate that a high value of the parameter DEEPFR (fraction of water passing from the lower soil zone that is directed to deep recharge rather than to active groundwater that ultimately discharges as baseflow) needs to be considered in the model. The recharge data was used to check if the model simulates deep recharge reasonably well. Therefore, the recharge data is considered to be adequate and appropriate for model development and calibration.

a. Was "best information available" utilized to develop and calibrate the model?

The best information available was used to develop and calibrate the HSPF hydrologic model.

b. Are there any deficiencies regarding data availability?

Based on adequacy of the data discussed above, there are no deficiencies regarding data availability for the hydrology model. All the data used in the models were available in sufficient spatial and temporal resolutions.

c. Was relevant information available that was discarded without appropriate justification? Would use of discarded information significantly affect results?

Based on the data presented in the documentation and knowledge of additional data sources, there is no indication that other relevant information was available and/or that information was discarded without appropriate justification.

2) Assess the validity, defensibility and appropriateness of the model development and calibration.

a. Determined if the model is appropriate, defensible, and valid, given the District's MFLs approach.

Development of the HSPF hydrologic Lake Sylvan model utilized the following key datasets:

- seven (7) land use categories regrouped using the District's 2009 land use dataset based on the thirteen (13) standard land use categories provided by the District;
- initial lake watershed and sub-watershed boundaries provided by the District and modified by using the groundwater table map to exclude the Land Locked Lakes basin, field survey and topography data to finalize the Lake Sylvan basin boundary;
- hourly rainfall data from Sanford Station provided by the District;
- hourly PET data provided the District which were calculated on a daily basis using maximum and minimum air temperature from Sanford Station using the Hargreaves equation, and then disaggregated to hourly values using WDMUtil;

- paired lake elevation-area-volume data provided by the District for development of the lake FTABLE, with extension for elevation above 38.6 ft NAVD based on the available topographic data; and
- daily groundwater level data at local well S-0718 provided by the District used to compute lake seepage to Floridan aquifer. The dataset was back extended from February of 2009 by using a good correlation relationship between this well and well OR-0047.

Using those datasets for model setup and simulation is appropriate and defensible.

"Special Actions" options in HSPF were used to account for variable PERLND and RCHRES surface areas to eliminate some double counting of rainfall and evaporation when lake water levels are high and some undercounting when lake water levels are low for accurate model simulations.

The model was manually calibrated and validated within an acceptable range of possible parameter values including key parameters of LZSN, INFILT, CEPSC, UZSN, LZETP, and DEEPFR in the hydrological models as shown in Table 2 of Appendix A (CDM Smith, 2017)

Model results for the 9-year calibration period (2008 to 2016) and the 11-year validation period (1997 to 2007) that included dry, average, and wet years were evaluated both graphically and statistically. Extension of the model simulation period is believed to be sufficient for purpose of the hydrological model simulations. Time series plots and frequency-exceedance curve plots of the observed lake stages versus HSPF simulated lake stages were provided for visual comparison and evaluation. Overall, the hydrologic HSPF models simulated lake stages well for both calibration and validation periods.

Water budgets for four major land use for the Direct Tributary Area are summarized in Table 1 below. The ratio of the average annual runoff by land use category to the average annual rainfall flow budget is reasonable and consistent with our experience in Central Florida given the types of soil and land use in the tributary. The average annual accumulative total ET loss and total surface runoff for each land use category appears to be reasonable within typical ranges of the values found in Central Florida. By land use category, the highest total ET loss was associated with the wetland land use and the highest surface runoff occurred in the medium residential which was expected.

Table 1 Average Annual Flow (in inch/acre/year) by Major Land Use Category

Flow (in/ac/yr)	Medium Density Residential	Wetland	Forest	Low Density Residential
Surface Runoff	6.65	1.98	0.03	2.74
Baseflow	2.82	6.62	2.48	3.15
Rainfall	50.62	50.62	50.62	50.62
Leakage to Inactive Deep Groundwater	9.98	0.00	8.75	11.16
Total Simulated ET	31.28	42.19	39.54	33.69

Table 3 of Appendix C (CDM Smith, 2017) shows the average annual Lake Sylvan water budget for the model calibration period. Percent of inflow from direct rainfall to the lake surface, inflows from the pervious land, impervious land, and baseflow of the Direct Tributary Area and percent of lake evaporation and lake outflow to Floridan Aquifer appeared to be reasonable.

For the area discharging directly to the lake, the overall average annual deep recharge was within the ranges of the values on the District-provided recharge map.

Overall, the calibrated and validated HSPF hydrologic model is considered to be appropriate, defensible, and valid, given the District's MFLs approach, with the exception of some minor comments given in the Summary section below.

b. Evaluate the validity and appropriateness of all assumptions used in the model development and calibration.

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

There are five (5) key assumptions used in the hydrologic HSPF model development including:

- The Land-Locked Lakes area was assumed not to contribute any surface runoff and groundwater flows to Lake Sylvan; therefore, it was not simulated in the HSPF model;
- The Limited Discharge Basin-Buckingham Estates was assumed to contribute only groundwater flow to Lake Sylvan;
- Limited Discharge Basin-Wetlands West was assumed to discharge surface flow only (from the storage area south of South Lake Sylvan Road) to the lake when South Lake Sylvan Road is overtopped at an elevation of 44 ft NAVD. The modeled seepage flow from the storage area was considered to discharge to Lake Sylvan as groundwater flow.
- Limited Discharge Basin -Wetlands East was assumed to be part of the Direct Tributary Area to Lake Sylvan; and

- Well levels at well S-0718 at the lake were assumed to be correlated with the UFA levels at well OR-0047 which is about 18.3 miles south of the lake; therefore, derived regression equation was used to extend the well levels for the missing period.

Due to its topographical setting, the Land-Locked Lakes area does not contribute surface runoff to downstream areas rather recharges groundwater aquifer. Based on review of the groundwater table elevation map, it was concluded that groundwater from the Land-Locked Lakes area does not contribute to Lake Sylvan. Therefore, it is reasonable to assume that the Lake-Locked Lakes area do not contribute any surface and groundwater flows to Lake Sylvan.

Review of the Buckingham estates development plans suggest that the runoff generated within the estates is expected to route into the ponds within the estates; therefore, it is reasonable to assume that the Limited Discharge Basin-Buckingham Estates contributes only groundwater flow to Lake Sylvan.

Because of the topography, surface runoff within the Limited Discharge Basin-Wetlands West discharges to the storage area south of South Lake Sylvan Road. Surface discharge from the storage area over the road to the lake only occurs when the water elevation in the storage area is high enough. The storage area is relatively large compared to its contributing area and is close to the lake; therefore, the modeled seepage from the storage area which considered to discharge to the lake as groundwater is reasonable.

The Limited Discharge Basin- Wetlands East is connected to Lake Sylvan by a culvert estimated to be 12 inches in diameter based on the field survey. The culvert invert of 38 ft NAVD is the same as the minimum average lake level (Figure 1 of Appendix A, CDM Smith, 2017). Initial model calibration also indicted that during wet conditions the Lake Sylvan water levels tended to be significantly higher than in the storage south of the road in the Limited Discharge Basin-Wetlands East, suggesting that the lake will actually flow back through the culvert into the area south of the road and the Lake Sylvan FTABLE was modified to include the storage area south of the road. Therefore, it is reasonable to assume that the Limited Discharge Basin-Wetland East is part of the Lake Sylvan direct tributary.

Using the derived equation based on a good correlation relationship (R^2=0.82) between the well levels at well S-0718 at the lake and the well levels at another UFA well OR-0047 for data extension at well S-0718 appears to be scientifically defensible and reasonable.

In short, all the assumptions used in the hydrologic HSPF model appear to be reasonable and consistent given the best information available.

- **Is there information available that could have been used to eliminate any of the assumptions? Could the use of this additional information substantially change the models results?**

To my knowledge, there is no other information available that could have been used to eliminate any of the assumptions used in the hydrologic HSPF model.

It is important to recognize that assumptions are inevitably needed to complete modeling excise for various reasons including data limitation. Potentially, model assumptions may change results of the model simulations. However, the use of this additional information should not substantially change the model results.

c. Review of HSPF model input and output data including:

- **Model elevations vs collected data to verify same datum used consistently**

  Raw Lake Sylvan stage data and bathymetry data were not provided for review. However, the Lake Sylvan stage data in ft NAVD88 was downloaded from the District's website for comparison with the lake stage data presented in Figure 1 of Appendix A (CDM Smith, 2017). It appears both datasets are identical. Review of the paired elevation-surface area-volume data in Table 5 of Appendix A, the FTABLE of Lake Sylvan in the UCI file, and the USGS quadrangle contour map, it appears that both the lake stage data and lake bathymetry are in the same datum of NAVD88.

  Raw groundwater level data were not provided for review either. However, those groundwater level data were downloaded from the District's website. Groundwater level data at well S-0718 (should be S-0717 as shown on the District's website) and well OR0047 were downloaded for comparison with the well level data presented in Figure 8 of Appendix A (CDM Smith, 2017) and in the WDM file. It appears that both well S-0718 and well OR0047 level data are in the same datum of NAVD88 as the Lake Sylvan stage data.

  In short, modeled lake elevations, observed lake stage, lake bathymetry, and groundwater level data are in the same datum of NAVD88.

- **Flow/stage plots to look for model instabilities**

  By carefully examining the hydrological model-simulated instream flow and lake stage, no model instabilities were observed in the hydrologic HSPF models. It should be noted that the simulated reach/lake stages are dependent on the bottom elevations of the reach/lake the modeler specified.

- **Output file for model warnings (full flow channels, flooded nodes, etc.) and flow classification summary**

  No warnings were found in the output file.

- **Continuity error and convergence data**

  No continuity or convergence errors were found in the HSPF model.

- **Runoff and infiltration volumes to check for reasonableness**

  The HSPF UCI file was modified to output surface runoff and infiltration volumes by landuse category for the Direct Tributary Area. The annual average surface runoff and infiltration from the Direct Tributary Area over the model calibration and validation period of 1997 to 2016 are 3.37 and 34.11 inches, respectively.

  In the Direct Tributary Area, most of hydrologic soils group are A group with a high infiltration rate; therefore, higher infiltration was expected. About 67.4% of annual average rainfall was infiltrated vertically and some of the infiltration was converted as baseflow and some of the infiltration was further percolated into lower zone and lost into the deep inactive groundwater aquifer.

  The majority of the land use in the Direct Tributary Area are medium density residential (29.5%), wetlands (26.5%), forest (14.4%) and lower density residential (12.8%). Five percent (5%) of the lower density residential and fifteen percent (15%) of the medium density residential were treated as direct impervious connected area (DCIA) (Table 1 of Appendix B, CDM Smith, 2017). Factoring in high infiltration A soils group, lower surface runoff from the tributary was expected.

  In brief, the model simulated runoff and infiltration were reasonable for this tributary area.

- **Values assigned to model parameters to check for reasonableness**

  As discussed in the previous section (Section 2), values of the key parameters of LZSN, INFILT, CEPSC, DEEPFR, LZETP and UZSN by land use category used in the calibrated hydrologic model were set at the middle of the range of values suggested by *BASINS Technical Note 6: Estimating Hydrology and Hydraulic Parameters of HSPF* (EPA, 2000) and are within the acceptable ranges for the Central Florida region.

- **How groundwater data was used in model inputs**

  Local UFA well S-0718 data was used to dynamically compute lake seepage to the UFA using Darcy Law in the Special Action. Specifically, lake seepage in the model was calculated as a function of the lake surface area and the head difference between the lake stage and the well elevation.

- **Methodologies used to develop input data for long-term simulations**

  Input data for the long-term simulation of 1948 through 2016 include hourly rainfall, hourly PET, and daily UFA groundwater levels.

  The hourly rainfall data for the long-term simulation simply extend the Sanford station back to beginning of 1948 based on the hourly rainfall data of 1997 through 2016 used for model calibration and validation. Hourly rainfall data from October 2007 to December 2016 was from the newer and closer USGS gage in Lake Sylvan Park when it became available.

The hourly PET data at the Sanford station, used for the model calibration and validation, was also used for the long-term simulation. The same correction factor used for the period of the model calibration and validation was also used for the long-term simulation period.

The same equation using the MOVE.3 method for the period of model calibration and validation was used to extend the Sylvan UFA groundwater (Well-0718) timeseries for the long-term simulation from January 1, 1948 to December 31, 2016.

The methodologies used for extension of the input data discussed above for the long-term simulation appear to be consistent and technically sound.

- **Long-term simulation results to check for reasonableness**

  Compared to the observed lake stages, simulated long-term Lake Sylvan stages as shown in Figure 4 (SJRWMD, 2019) appear to be well simulated and reasonably follow the data trend with the exception of the 7/13/1979-8/11/1980 period where the simulated lake stages are much lower than the observed. The possible reasons for the discrepancy were discussed (SJRWMD, 2019).
  It would be useful to provide some statistics such as the Nash-Sutcliffe score along with the time series plot in the evaluation of model performance for the long-term simulation.

d. Development of an independent water budget

The UCI file was modified to output Lake Sylvan water budget including direct rainfall to the lake surface, evaporation from the lake, total watershed inflow to the lake, lake seepage to Floridan aquifer, and lake surface discharge for the period of 1997 to 2016 (a total of 20 years). Modeled average annual water budget for the lake is summarized in Table 2 below. Compared to the water budget in Table 3 of Appendix C (CDM Smith, 2017) for the model calibration period of 2008 to 2016, inflows and outflows components are very comparable with slightly different values as the result of different model simulation periods.

Table 2 Average Annual Lake Sylvan Water Budget for the Period of 1997 to 2016 (20 years)

Lake Inflows	Average Annual Volume (ac-ft)	Average Annual Value (inches over lake surface)	Percent of Inflow or Outflows
Direct Rainfall to Lake	793	50.3	63%
Total Watershed Flow	469	29.8	37%
Total	1,262	80.1	100%
Lake Outflows			
Evaporation from Lake	810	51.4	63%
Lake Seepage to Floridan Aquifer	485	30.8	37%
Lake Surface Discharge	0	0.0	0%
Total	1,295	82.2	100%

Values in inches based on average lake surface area during the period of 1997 to 2016 (189 acres)

Summary

In development and calibration of the HSPF hydrologic model, the best information/data available were utilized. No apparent deficiencies regarding data availability were found. Additional data collection in the future, including rainfall and groundwater data at/near the lake site under different hydrological conditions, is not needed/recommended.

The methodology used to extend the groundwater level dataset is appropriate and defensible and used the best data available. The Special Actions options used in the HSPF model to calculate variable areas of the wetlands and surface areas of the lake are valid and appropriate.

The average annual water budgets by land use category are considered to be reasonable for the area of the study. The average annual inflows and outflows to/from the lake also appear to be reasonable.

The assumptions used in the model development are reasonable and consistent given the best information/data available. The hydrologic HSPF Lake Sylvan model was calibrated and validated very well.

In summary, the model is considered to be appropriate, defensible, and valid given the District's MFLs approach with the following minor comments:

- Correct the Outflow Pre-Construction column of the FTABLE for Lake Sylvan in Table 4 by using the values in the model UCI file;

- Table 3 of Appendix A (CDM Smith, 2017) appears to present the percentage of the Lake Sylvan study area for each land use category for the whole basin shown in Figure 4 of Appendix A, rather than the area directly contributing to Lake Sylvan as the report stated;
- Discuss and identify the topographic data used for development of the tributary areas/basin boundaries; and
- Provide a reference for the 2005 HSPF hydrologic model in the letter report of *Lake Sylvan MFL Evaluation* (CDM Smith, 2017)

References

CDM Smith, 2017. Lake Sylvan MFL Evaluation.

SJRWMD, 2019. Lake Sylvan Long-term Simulation.