### Lake Sylvan HSPF Model Development, Documentation, and Long-Term Simulation Review

for St. Johns River Management District

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#### Outline

- SJRWMD's MFLs
- Sylvan Lake Model History
- Review of Documentation and Model Files
- Scope of Review
- Review Questions
- Summary

#### SJRWMD's MFLs

- 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.
- Sylvan Lake is listed on the 2019 MFLs priority list.

#### Sylvan Lake Model History

- 2005 hydrologic HSPF model by CDM
- Peer-Reviewed by Intera
- 2017 hydrologic HSPF model developed and updated by CDM Smith

#### Model Updates and Refinements

- Tributary area -Direct Tributary Area and Indirect Tributary Area
- 2009 land use
- Hourly Rainfall and PET
- Lake surface discharge an outfall structure built in 2014
- Lake bathymetry
- Lake surface area and land-based contributing area by the Special Action of HSPF
- Lake seepage to the UFA

#### Review of Documentation and Model Files

- Sylvan Lake MFL Evaluation (CDM Smith, 2017)
- Sylvan Lake Long-term Simulation (SJRWMD, 2019)
- Model Files:
  - 1. SYLVAN\_1997\_2017\_CALIB\_VALID\_v13.uci and associated WDM file
  - 2. SYLVAN\_Longterm.uci and associated WDM file

#### Scope of Review

- 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.

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

#### Data Reviewed and Assessed

- Tributary area old and new basin boundaries
- Land use and land cover 2009 SJRWMD land use
- Soil data hydrologic soil groups A and A/D
- Topographic data USGS quadrangle map
- Rainfall and potential evapotranspiration data hourly at Sanford Station

#### Data Reviewed and Assessed (cont.)

- Sylvan Lake stage data
- Groundwater elevations in the UFA from existing observation wells – local well S-0718 and well OR-0047. A regression equation was developed to extend groundwater levels at S-0718 using groundwater levels at OR-0047
- Lake bathymetry –provided by the District and extended above 38.6 ft NAVD using available topo data
- Recharge data- moderate (5-10 in/yr) to high recharge (10-15 in/yr)

#### Tributary area

Three different contributing basins

- 1) Sylvan Lake Basin
- 2) Limited Discharge Basin
- 3) Land Locked Lakes Basin



### Limited Discharge Basin

#### Final Version of Tributary Area

- Land Locked Lakes Basin does not contribute any surface and groundwater flows
- Land Limited Discharge Basin-Buckingham Estates contributes groundwater flow only
- Land Limited Discharge Basin-Wetlands East- is part of the Sylvan Lake Basin (the Direct Tributary Area to Sylvan Lake)
- Land Limited Discharge Basin-Wetlands West- surface flow discharge when overtopping the road. Modeled seepage flow from the storage to the lake.

#### **Review Questions**

- a. Was "best information available" utilized to develop and calibrate the model?
   Yes.
- **b.** Are there any deficiencies regarding data availability? No.
- c. Was relevant information available that was discarded without appropriate justification? Would use of discarded information significantly affect results? No.

# 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.
- Key datasets for model setup and simulation
- Special Actions for variable PERLAND and RCHRES surface areas
- Key parameters of LZSN, INFILT, CEPSC, UZSN, LZETP, and DEEPFR with acceptable range of possible values
- Calibration (2008-2016) and validation (1997-2007) include dry, avg and wet years

- a. Determined if the model is appropriate, defensible, and valid, given the District's MFLs approach.
- Lake stage was well calibrated and validated –time series plots, frequency-exceedance curve plot, Nash-Sutcliffe score
- Simulated deep recharge is within the ranges of the values on the District-provided recharge map
- Lake water budget and water budget by land use category are reasonable

#### Lake Water Budget

#### Table 3. Average Annual Sylvan Lake Water Budget for Calibration Period

LAKE INFLOWS	Average Annual Volume (acre-feet)	Average Annual Value (inches over lake surface)	Percent of Inflows or Outflows
Direct Rainfall	734	48.9	63%
Pervious Inflow – Direct Tributary Area	225	15.0	19%
Impervious Inflow – Direct Tributary Area	130	8.7	11%
Baseflow Inflow – Indirect Tributary Area	74	4.9	6%
TOTAL	1,163	77.5	100%
LAKE OUTFLOWS			Percent of Outflows
Evaporation	773	51.5	66%
Lake Seepage to Floridan Aquifer	399	26.6	34%
Lake Surface Discharge	0	0.0	0%
TOTAL	1,172	78.1	100%

Values in inches based on average lake surface area during calibration period (180 acres)

#### Average Annual Flow 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

#### Conclusion:

# The model is appropriate, defensible, and valid, given the District's MFLs approach.

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

#### Five Key Assumptions

- 1) The Land-Locked Lakes area
- 2) The Limited Discharge Basin-Buckingham Estates
- 3) Limited Discharge Basin-Wetlands West
- 4) Limited Discharge Basin Wetlands East
- 5) Correlation of Groundwater Levels Between Wells S-0718 and OR-0047

#### **Review Questions**

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

No other info available. No, it should not.

Model elevations vs collected data to verify same datum used consistently

In the same datum of NAVD88 ft.

- Flow/stage plots to look for model instabilities No model instabilities were observed.
- Output file for model warnings (full flow channels, flooded nodes, etc.) and flow classification summary No warnings were found.

- Continuity error and convergence data
  No continuity error and convergence data
- Runoff and infiltration volumes to check for reasonableness
  - i. Annual avg 3.37 inches runoff vs 34.11 inches infiltration for the Direct Tributary Area for the period of 1997 to 2016
  - ii. Considered to be reasonable for the type of soils (mostly A) and land use (MDR, wetland, forest, LDR)
- Values assigned to model parameters to check for reasonableness

#### Values assigned to model parameters to check for reasonableness

#### Table 2. Hydrologic Parameter Input Values in Sylvan Lake HSPF Model

Land Use Type	LZSN (inches)	INFILT (in./hr.)	CEPSC (inches)	UZSN (inches)	LZETP	DEEPFR
Low Density Residential	5.0	0.50	0.05	0.70	0.60	0.78
Medium Density Residential	5.0	0.50	0.05	0.70	0.60	0.78
Industrial and Commercial	5.0	0.50	0.05	0.70	0.60	0.78
Open and barren land	5.7	0.68	0.03	0.70	0.60	0.78
Pasture	5.7	0.68	0.08	0.70	0.60	0.78
Agriculture general	6.3	0.80	0.08	0.80	0.70	0.78
Forest	7.5	1.00	0.12	1.00	0.80	0.78
Wetlands	3.0	0.40	0.12	0.40	0.90	0.00

- How groundwater data was used in model inputs
  - i. Local UFA well S-0718 data used to dynamically compute lake seepage to the UFA using Darcy Law in the Special Action
- Methodologies used to develop input data for long-term simulations
  - i. Used the same methods from the calibration model for PET and groundwater levels extensions.
  - ii. Hourly rainfall-1948 to 10/2007 at Sanford Station, 10/2007 to 12/2016 USGS gage in the park.

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

- i. Well simulated and reasonably follow the data trend with the exception of the 7/13/1979-9/11/1980
- ii. Provide statistics such as Nash-Sutcliffe score to confirm model performance

### d. Development of an Independent Water Budget

# Average Annual Sylvan Lake Water Budget for the Period of 1997 to 2016

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%

#### 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 of 1997-2016 are very comparable with slightly different values as the result of different model simulation periods.

#### Summary

- ✓ The best information/data available were utilized. No apparent deficiencies regarding data availability were found.
- ✓ The methodology used to extend the lake stage dataset is appropriate and defensible given the best data available.
- ✓ Using the Special Actions options in HSPF to calculate variable areas of the wetlands and surface areas of the lake is valid and appropriate.
- The average annual water budgets by land use category are reasonable.

#### Summary (cont.)

✓ 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 Sylvan Lake 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

#### Improvements Needed

- Correct the Outflow Pre-Construction column of the FTABLE for Sylvan Lake in Table 4 by using the values in the model UCI file
- Percentage of the Sylvan Lake study area in each land use category presented in Table 3 of Appendix A is believed for the whole basin shown in Figure 4 of Appendix A, not for the area directly contributing to Sylvan Lake as the report stated;
- Discuss and clarify the topographic data used for development of the tributary areas/basin boundaries; and
- Provide a reference for the previously-developed 2005 HSPF model report in the letter report of *Sylvan Lake MFL Evaluation* (CDM Smith, 2017)