Crystal Lake MFLs

HSPF Model Peer Review
Kick-off Meeting

12/13/2023

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Agenda

- Overview of Crystal Lake and MFLs process
- Overview of HSPF model development
- Comments / Questions
- Site visit


East Crystal Lake


West Crystal Lake

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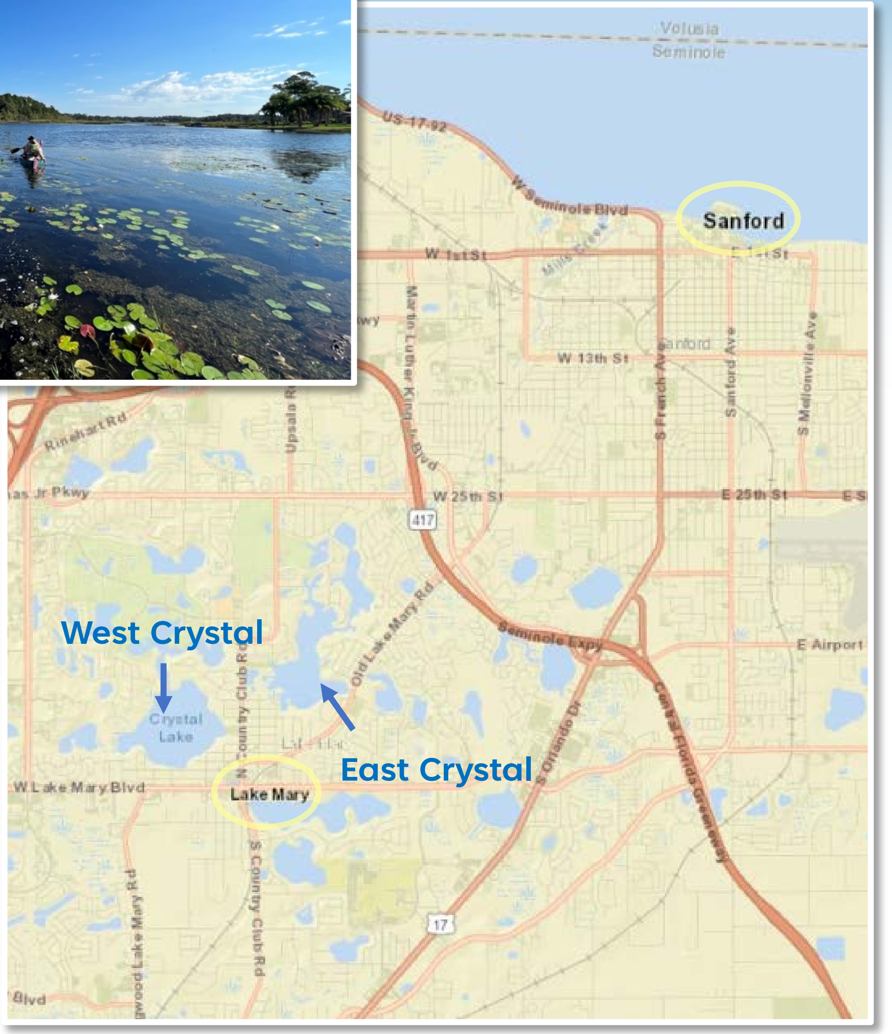
Crystal Lake

- Located in Seminole County, in cities of Lake Mary and Sanford; highly urbanized basin
- Two major lakes, West Crystal Lake (~140 acres), and East Crystal Lake (~120 acres)
- Chain flows north to Lake Monroe
- Both East and West Crystal have locally important public parks.
- Chain of lakes provide important recreational opportunities; and important habitat for wading birds, fish, and wildlife.



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Statutory Directive

Water management districts must establish MFLs that set…

"…the limit at which further withdrawals would be significantly harmful to the water resources or the ecology of the area."

Section 373.042(1), Florida Statutes (F.S.)

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Statutory Directive

"...consideration shall be given to... non-consumptive uses, and environmental values..."

62-40.473, F.A.C.

- Recreation in and on the water
- Fish & wildlife habitats and the passage of fish
- Estuarine resources
- Transfer of detrital material
- Maintenance of freshwater storage & supply
- Aesthetic and scenic attributes
- Filtration / absorption of nutrients & pollutants
- Sediment loads
- Water quality
- Navigation

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MFLs Process – Overview

MFLs Determination:

- Determine the most critical environmental features to protect and the minimum hydrologic regime required for their protection (MFLs condition)

MFLs Assessment:

- Determine the current impacted hydrologic regime (current-pumping condition)
- Compare the MFLs and current-pumping conditions to determine if water is available (freeboard)

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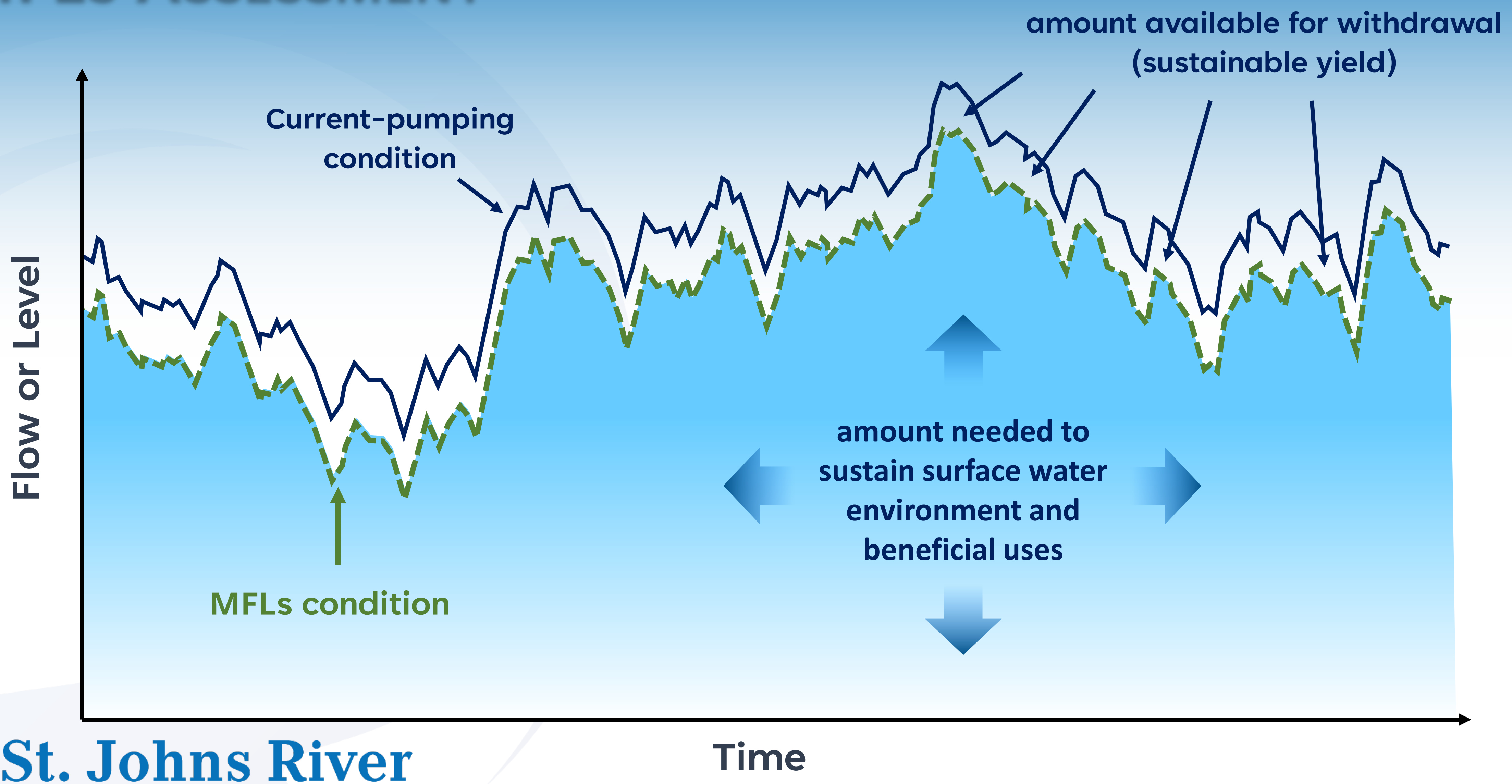
MFLs Assessment



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Hydrological Analyses

Dataset

Lake and UFA Levels

Pumping Impact Assessment

Determine the impact from pumping on UFA beneath the lake using ECFTX groundwater model

Current-Pumping Condition Flows/ Levels

Develop no- and current-pumping condition lake levels using HSPF model

Current Status of MFLs

Estimate freeboard or deficit in the UFA beneath the lake under current pumping condition to assess current status of MFLs

Future Status of MFLs

Estimate freeboard or deficit in the UFA under future pumping condition using ECFTX

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Use of HSPF Model for MFLs

- Simulation of interaction between the lake and the UFA
- Evaluation of the effect of pumping on critical lake levels needed for water resource values (fish and wildlife habitat, recreation, water quality, etc)
- Assessment of the current status of MFLs to estimate water availability or deficit

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Model Simulations

- Long-term simulations (1953-2019)
- Scenarios (by adjusting UFA boundary condition)
    - No-pumping condition simulations
    - Current-pumping condition simulations

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Peer Reviewer

- Silong Lu, PhD, PE (Dynamic Solutions)

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Crystal Chain of Lakes

Hydrologic Modeling

Olkeba T. Leta, Ph.D.

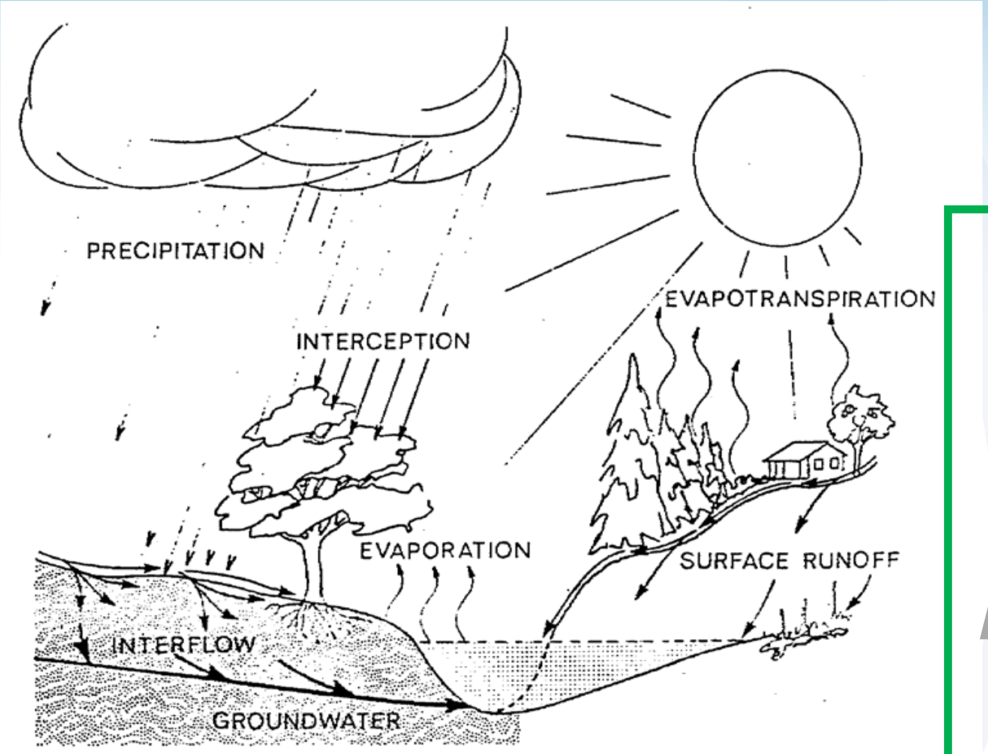
Bureau of Watershed Management & Modeling

Outline

- Background
- Hydrological System Program – FORTRAN (HSPF) Model:
  - GIS and hydro-meteorological data
  - Set-up
  - Calibration and validation
- Sensitivity analysis
- Long-term simulation

HSPF Model

Soil-plant-atmosphere interaction processes



GIS Data

Inputs

Hydro-meteorological Data

DEM, bathymetry

Land use/land cover map,

Soil map

Sub-watersheds RCHRES

Intersect with sub-watersheds

Derive properties

UCI

Run

Outputs

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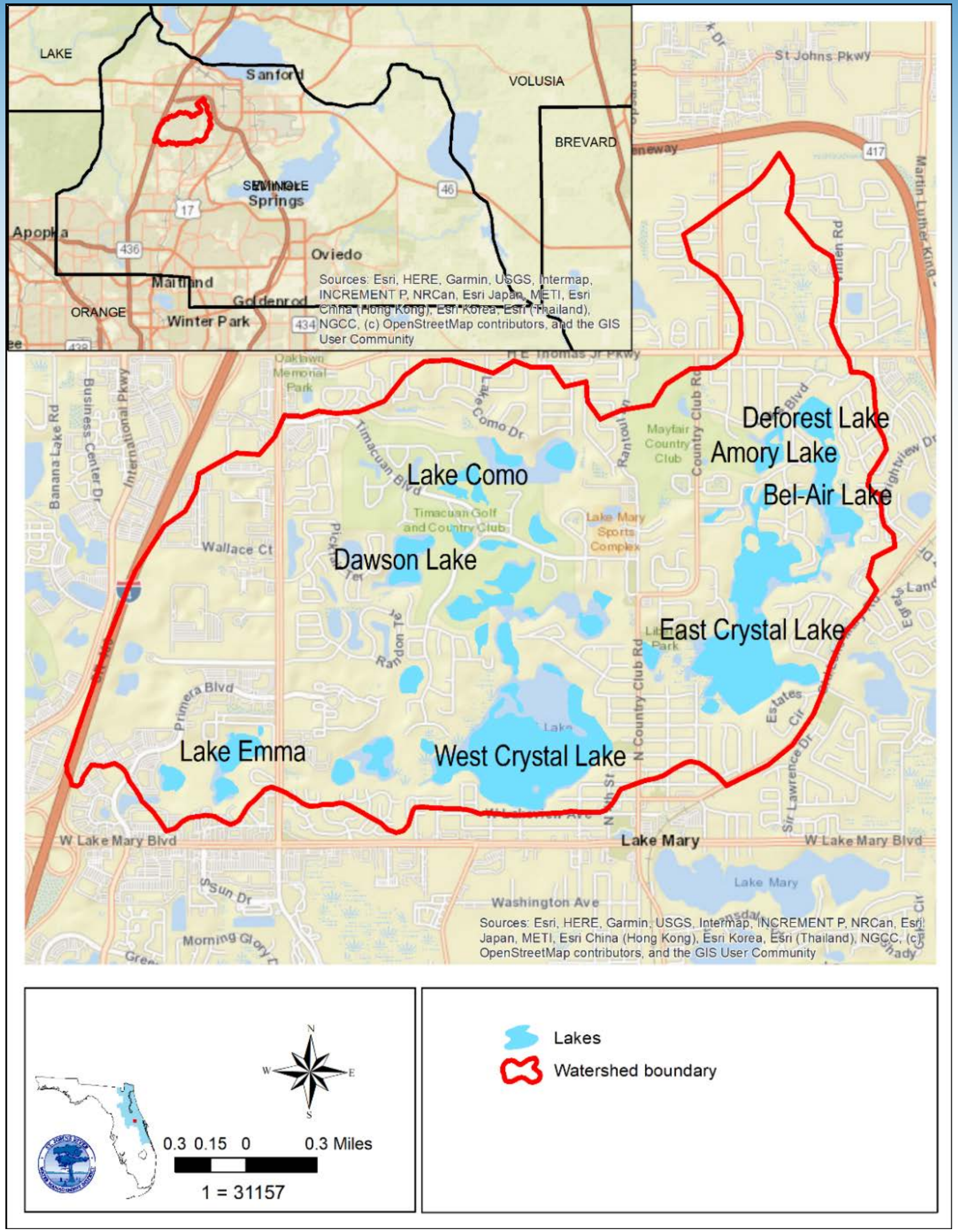
Crystal Chain of Lakes

- Located in Seminole county
- 7 major lakes
- Presence of backwater effects during high levels



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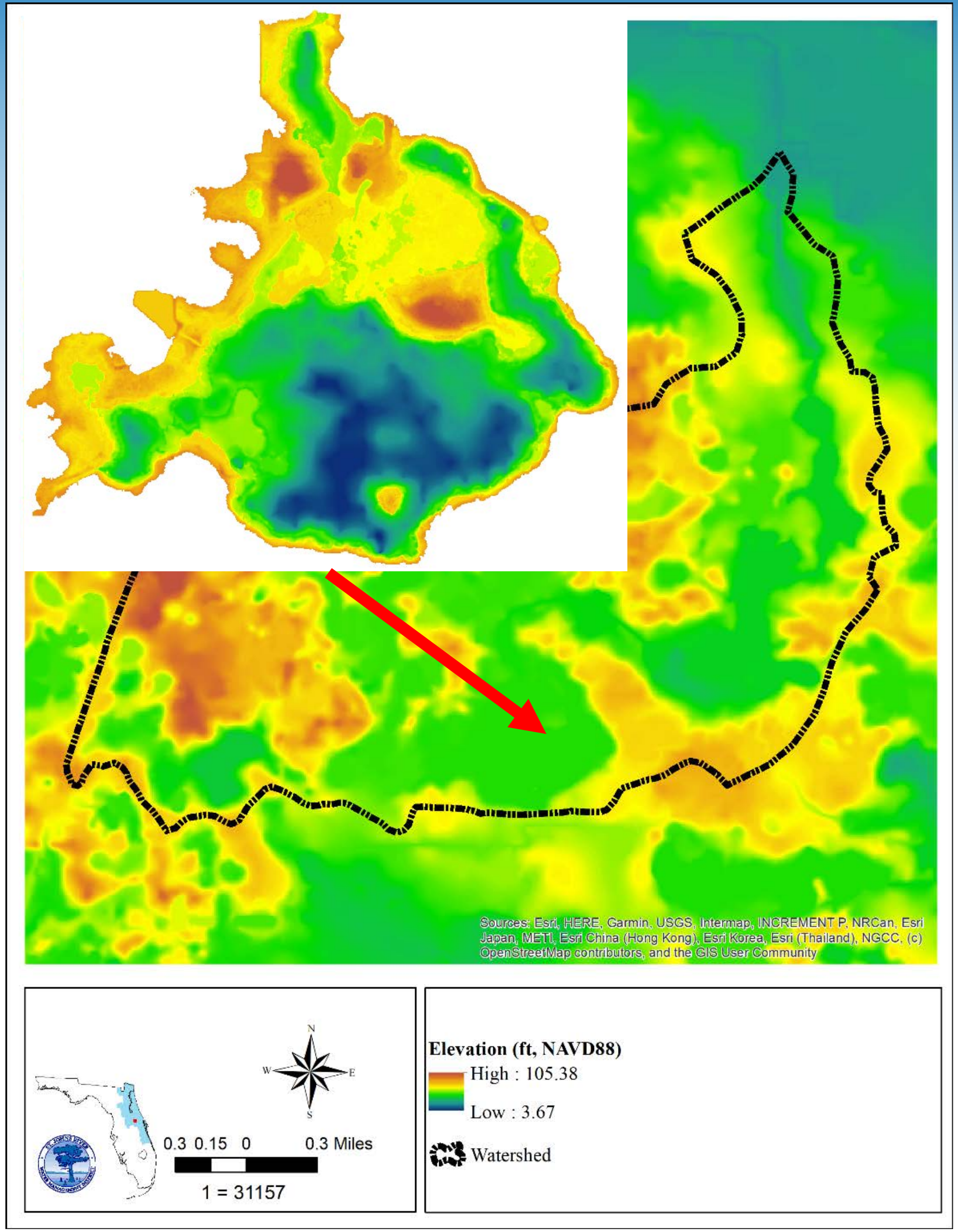
DEM and Bathymetry

- **DEM:** SJRWMD
- **Bathymetry:**
  - o SJRWMD (West Crystal, 2023)
  - o Environmental Research and Design (ERD, 2014) stage-area-volume data for:
    - ✓ East Crystal
    - ✓ Bel-Air
    - ✓ Amory
    - ✓ Deforest
  - o ICPR model (CDM, 2002)
    - ✓ Stage-area-volume data
    - ✓ Flow data



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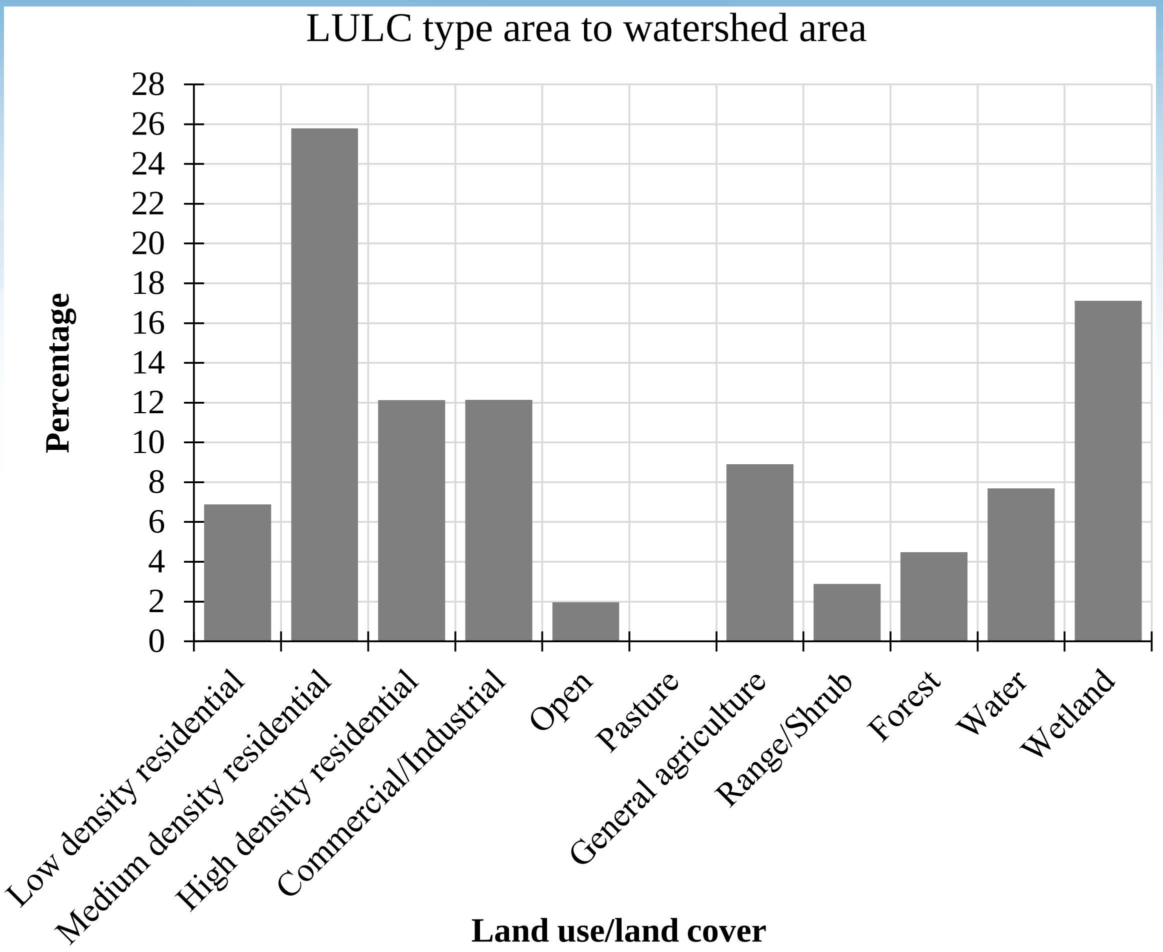
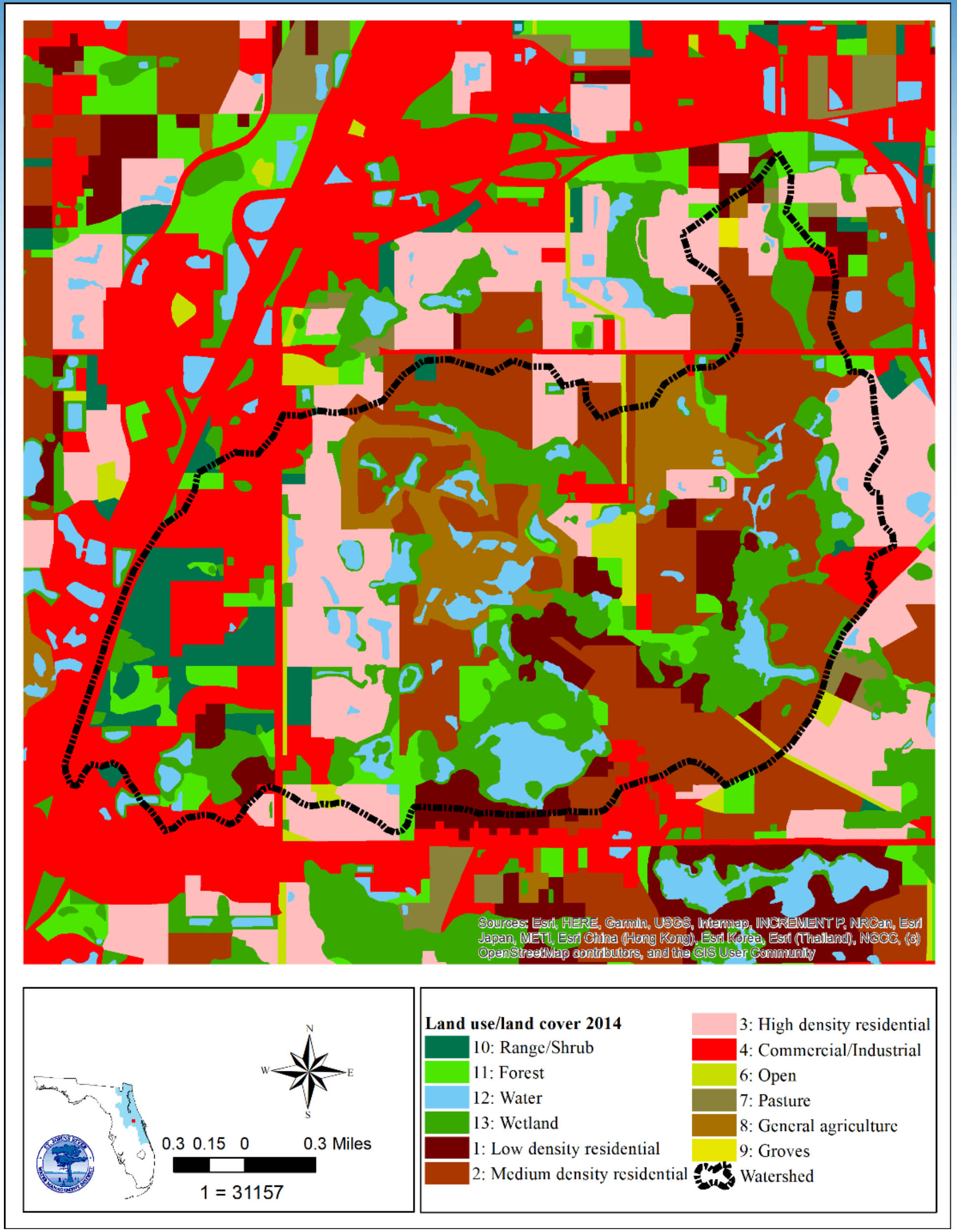
Land Use/Land Cover





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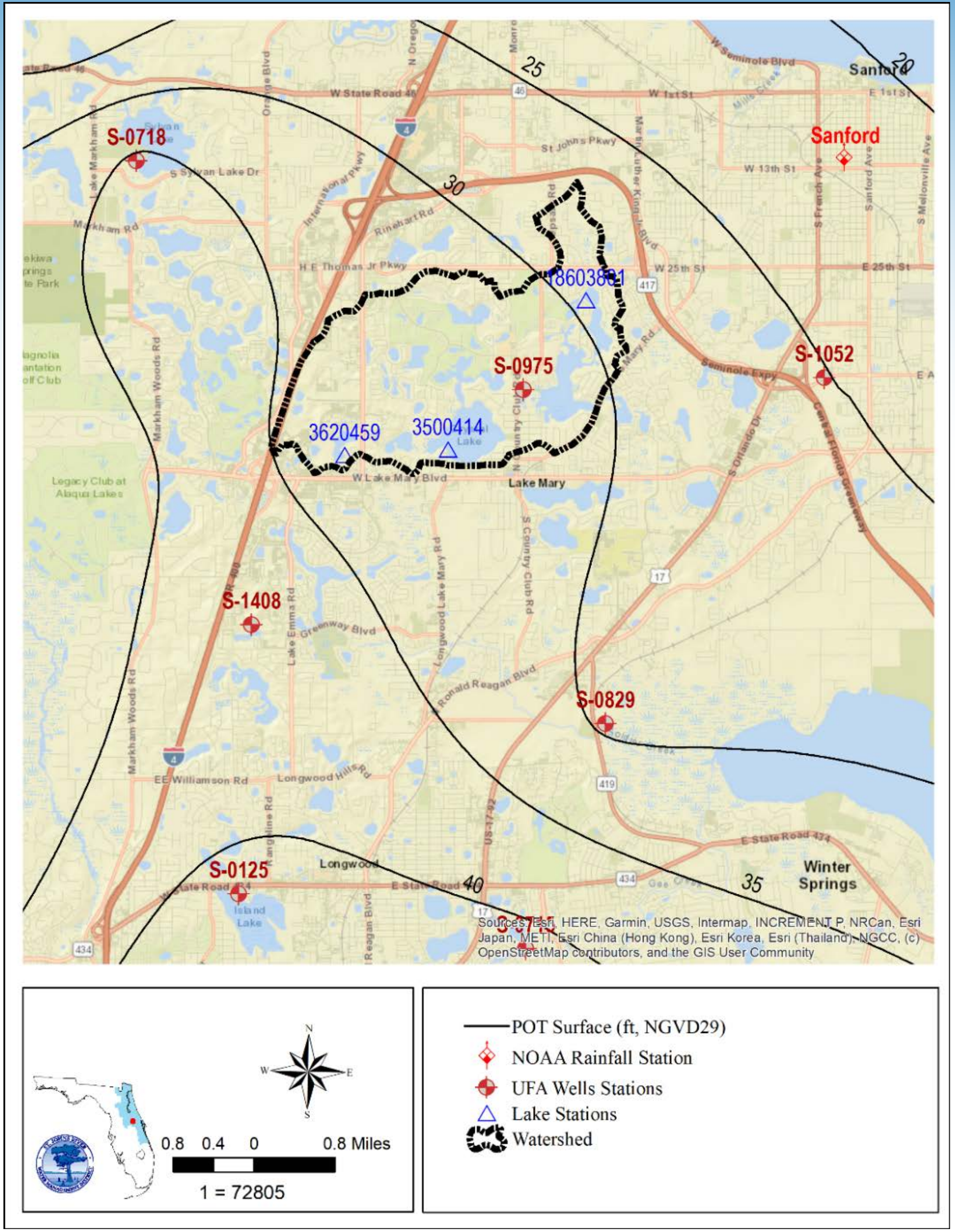
Hydro-meteorological Stations

- Rainfall/Potential Evapotranspiration
  - NOAA Sanford station
- UFA levels
  - S-0975 and S-0125
- Observed lake levels
  - SJRWMD and Seminole County



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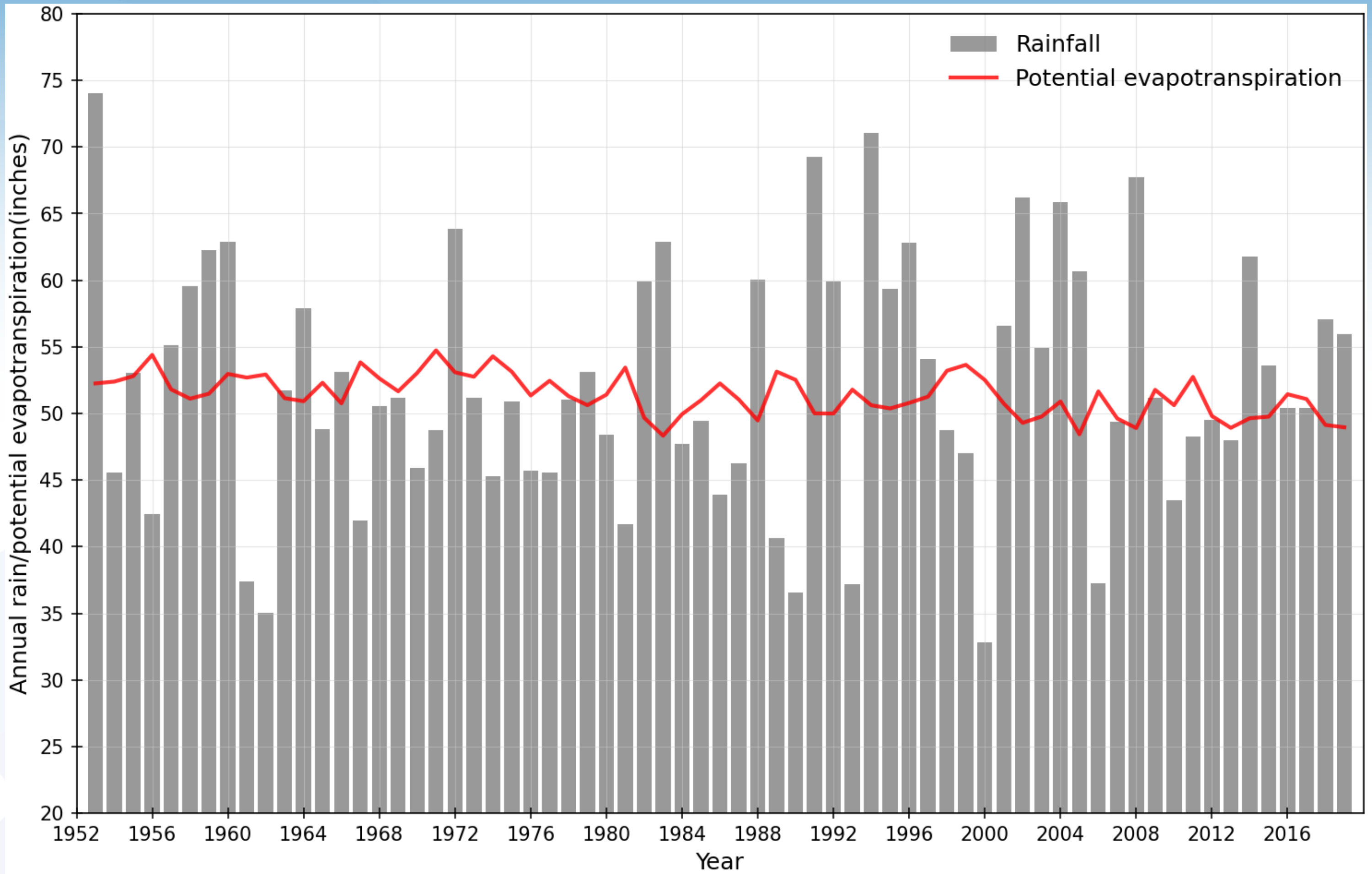
Annual Rainfall and PET at Sanford



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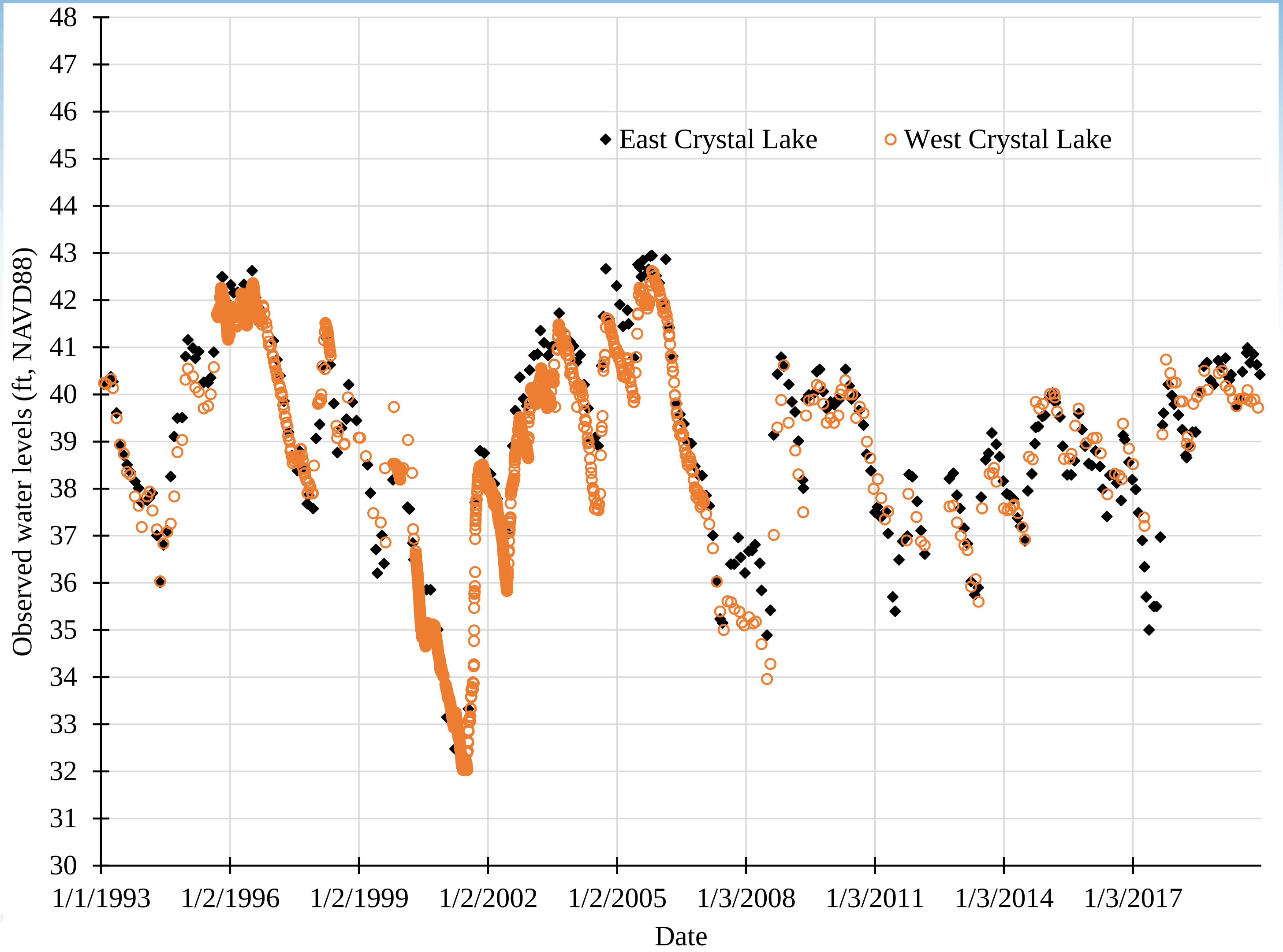
Observed Lake Levels

- Available since 1993 for both Lakes



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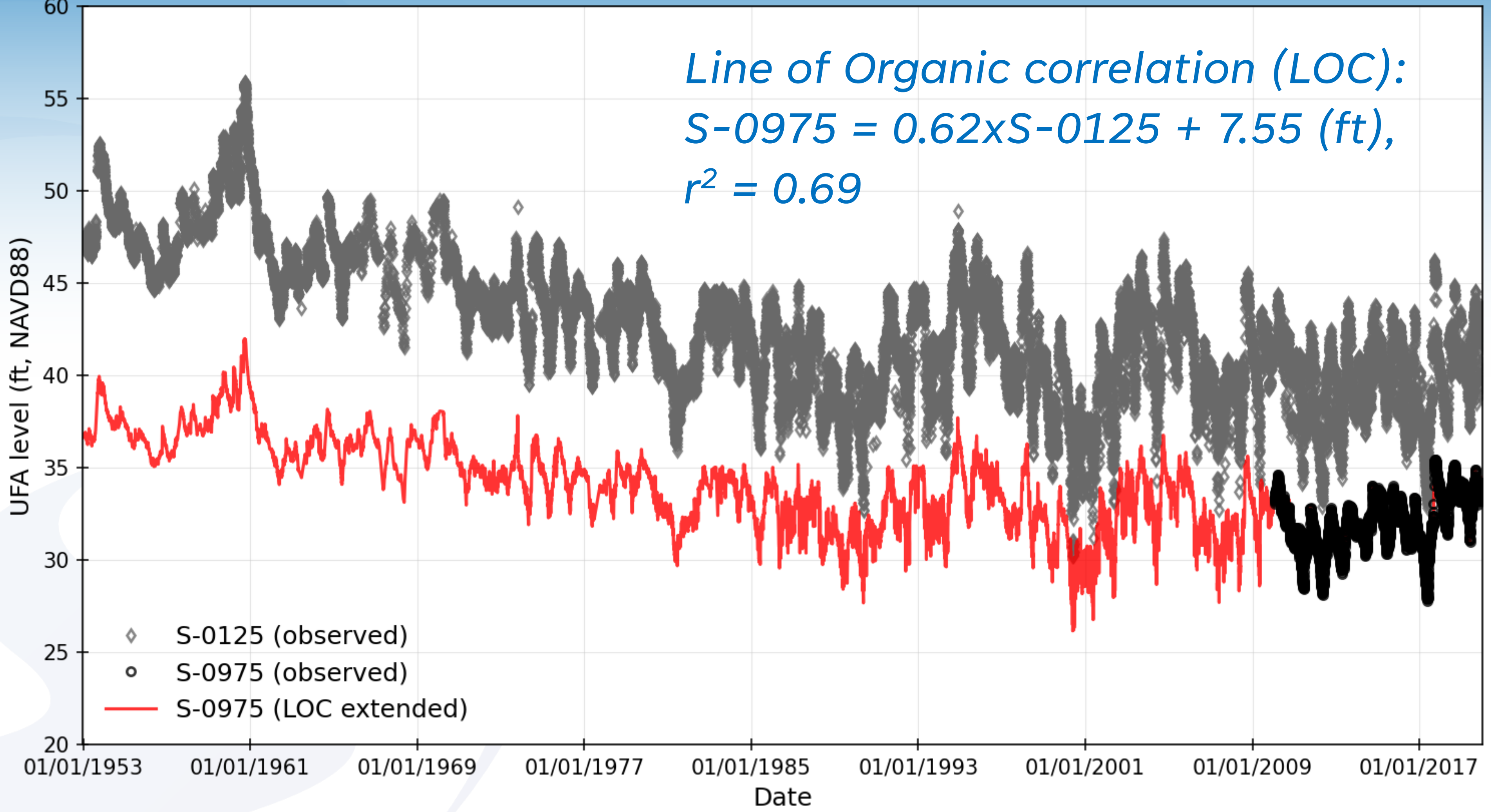
EAST AND WEST CRYSTAL LAKES OBSERVED LEVELS

Groundwater Levels



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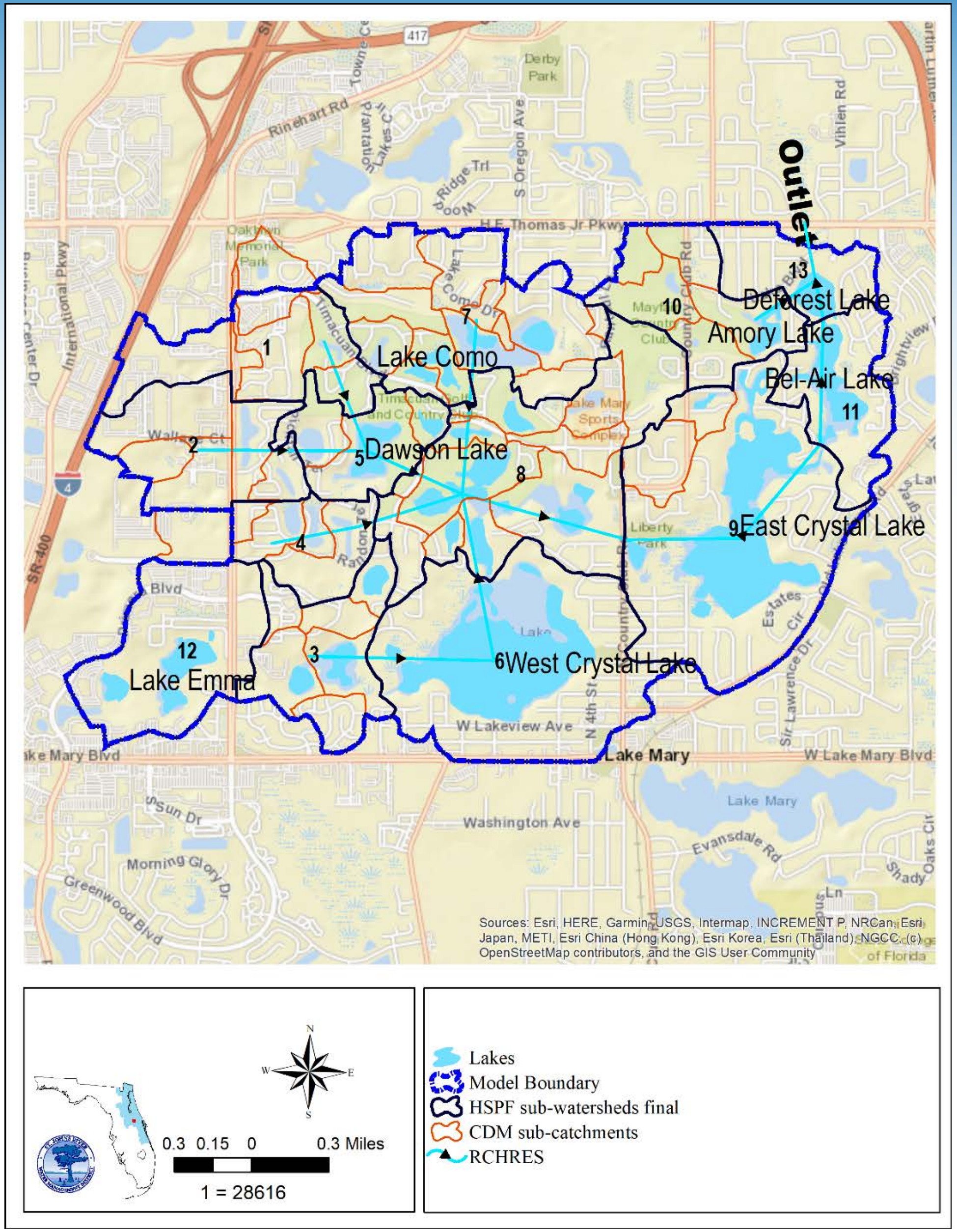
HSPF Model Set-up

- **SJRWMD's watershed modified:**
  - o *CDM's watershed boundary*
  - o *Based on field visit (6/10/2021)*
- **Watershed delineation:**
  - o *Limited to Deforest Lake outlet*
  - o *13 sub-watersheds*
- **Backwater effects:**
  - o *Sub-merged rectangular weir equations*
  - o *Rating curves estimated by ICPR4*
  - o *Special action module of HSPF*



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Model Calibration and Validation

- Calibration
  - 1/1/2007 to 12/31/2019
  - Manually calibrated the model
  - Evaluated model performance using graphical and statistical metrics
- Validation
  - 1/1/1995 to 12/31/2006
  - Evaluated model performance using graphical and statistical metrics

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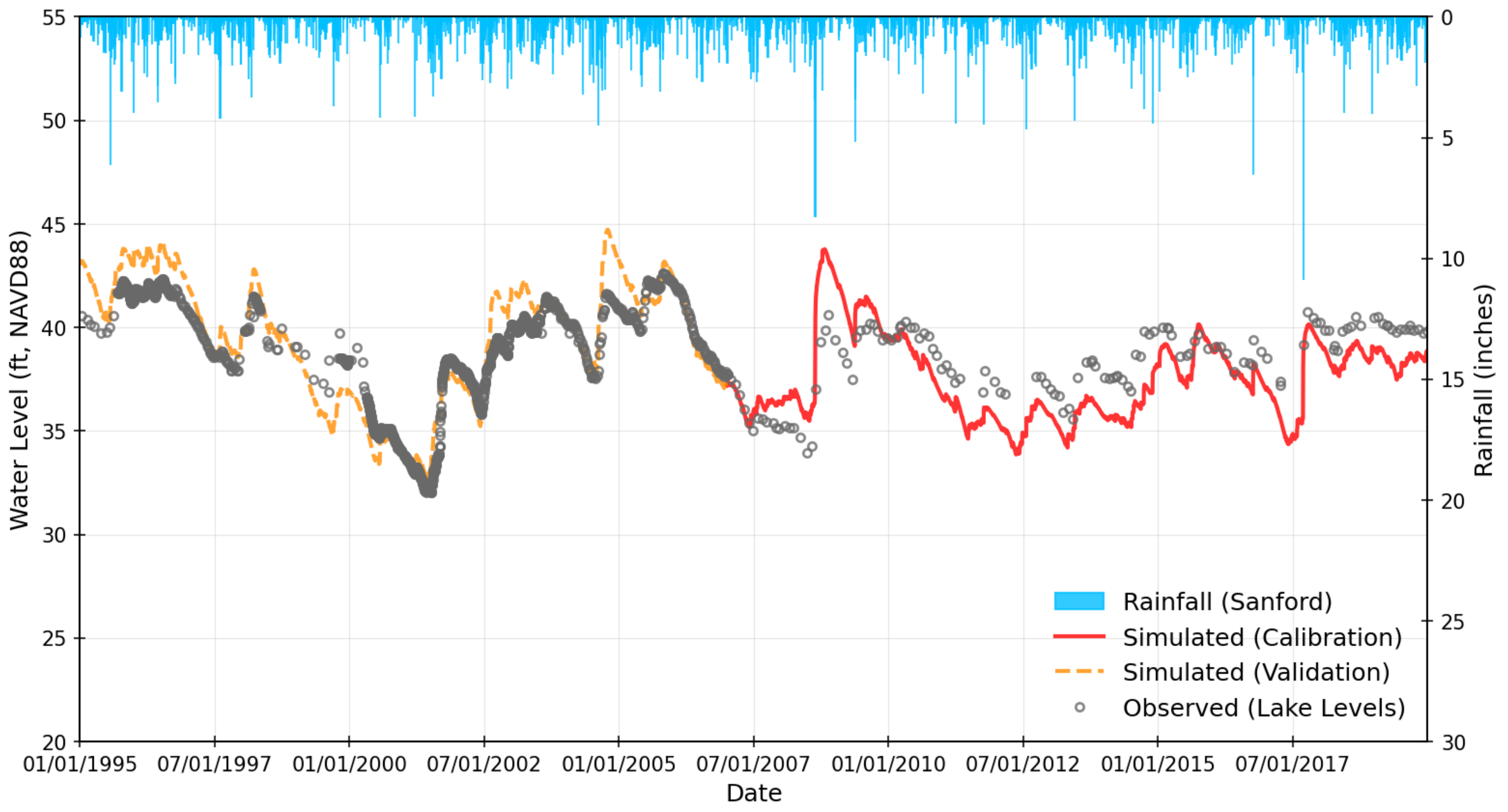
West Crystal Calibration and Validation



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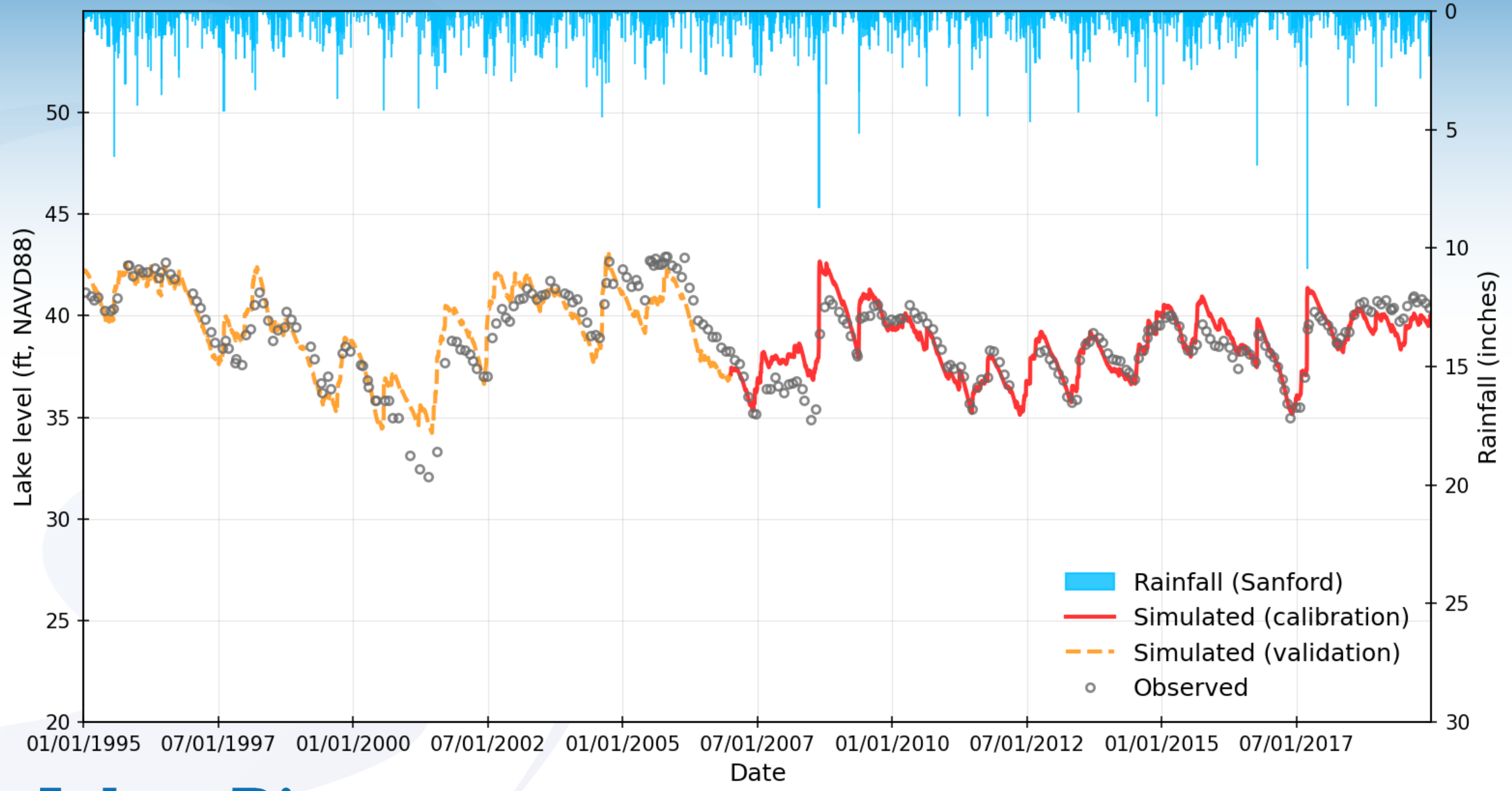
East Crystal Calibration and Validation



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Model Performance

Period	Statistics	Description	Target	West Crystal	East Crystal
Calibration (2007-2019)	NSE	Nash-Sutcliffe Efficiency	≥ 0.80	0.14	0.73
	RMSE	Root Mean Squared Error	≤ 1 ft	1.51	0.82
	ME	Mean Error	$\leq \lvert \pm 1 \rvert$ ft	-0.61	0.17
	±1ft (%)	% of observations bracketed within ± 1 foot	≥ 85	29.93	81.01
Validation (1995-2006)	NSE	Nash-Sutcliffe Efficiency	≥ 0.70	0.82	0.76
	RMSE	Root Mean Squared Error	≤ 1 ft	1.26	1.14
	ME	Mean Error	$\leq \lvert \pm 1 \rvert$ ft	0.57	-0.06
	±1ft (%)	% of observations bracketed within ± 1 foot	≥ 75	51.18	58.96

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Watershed Annual Water Balance

- Annual average values over the calibration/validation period (inches/year)
- Actual Evapotranspiration dominates the water balance components, followed by surface runoff from residential/commercial areas

Period	Description	LDR	MDR	HDR	CI	OPN	PAS	AGR	RNG/SHB	FRS	WTL	Watershed
Calibration	Rainfall	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8
	Deep recharge	5.9	6.1	5.8	6.1	10.2	6.6	6.4	6.3	4.8	7.0	5.3
	Evapotranspiration	35.0	32.5	27.5	23.8	26.4	37.2	39.0	37.7	41.2	42.9	34.0
	Runoff	12.2	15.1	21.4	25.9	16.2	8.9	7.2	8.7	6.6	2.6	13.4
	Baseflow	6.7	6.5	6.8	6.5	10.6	6.5	5.6	6.4	5.7	2.5	4.7
Validation	Rainfall	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9	53.9
	Deep recharge	6.4	6.6	6.3	6.6	10.4	7.3	7.4	7.1	5.9	7.0	5.7
	Evapotranspiration	34.3	31.9	27.1	23.5	26.5	36.5	38.2	36.9	40.3	43.4	33.6
	Runoff	13.7	16.5	22.8	27.2	17.1	10.3	8.6	10.1	8.1	4.6	14.9
	Baseflow	7.4	7.1	7.4	7.2	10.9	7.4	6.7	7.3	7.2	4.5	5.6

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Lake Annual Water Balance

- Annual average over the calibration/validation period (ac-ft/year)
- Seepage from lakes dominates the outflow components, followed by evaporation process
- Strong connection between the lake and UFA systems

Lake	Period	Direct Rainfall	Watershed Inflow	Evaporation	Seepage	Surface Outflow	Total Inflow	Total Outflow	Storage Change
West Crystal	Calibration	486.3	741.6	463.3	531.3	218.9	1227.9	1213.4	14.5
	Percent	**39.6**	**60.4**	**37.7**	**43.3**	**17.8**			**1.2**
	Validation	662.1	2303.4	613.3	854.3	1579.8	2965.4	3047.4	-82.0
	Percent	**22.3**	**77.7**	**20.7**	**28.8**	**53.3**			**-2.8**
East Crystal	Calibration	428.9	800.5	402.9	576.3	227.3	1229.4	1206.5	22.9
	Percent	**34.9**	**65.1**	**32.8**	**46.9**	**18.5**			**1.9**
	Validation	549.1	1301.6	493.9	730.1	679.6	1850.7	1903.6	-52.9
	Percent	**29.7**	**70.3**	**26.7**	**39.5**	**36.7**			**-2.9**

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Parameter Sensitivity Analysis

Parameter	Description	Calibrated value	Change
DEEPFR	Fraction of groundwater inflow to deep aquifer	Varied with sub-watershed	Decreased by 10% or 20% Increased by 10% or 20%
INFILT	Soil infiltration capacity index	Varied with LULC type	Decreased by 10% or 20% Decreased by 10% or 20%
LZSN	Lower zone nominal storage	Varied with LULC type	Decreased by 10% or 20% Increased by 10% or 20%
LZETP	Lower zone Evapotranspiration	Varied with LULC type	Decreased by 10% or 20% Increased by 10% or 20%
k	Leakance	Varied with RCHRES	Divided by 2 or 3 Multiplied by 2 or 3

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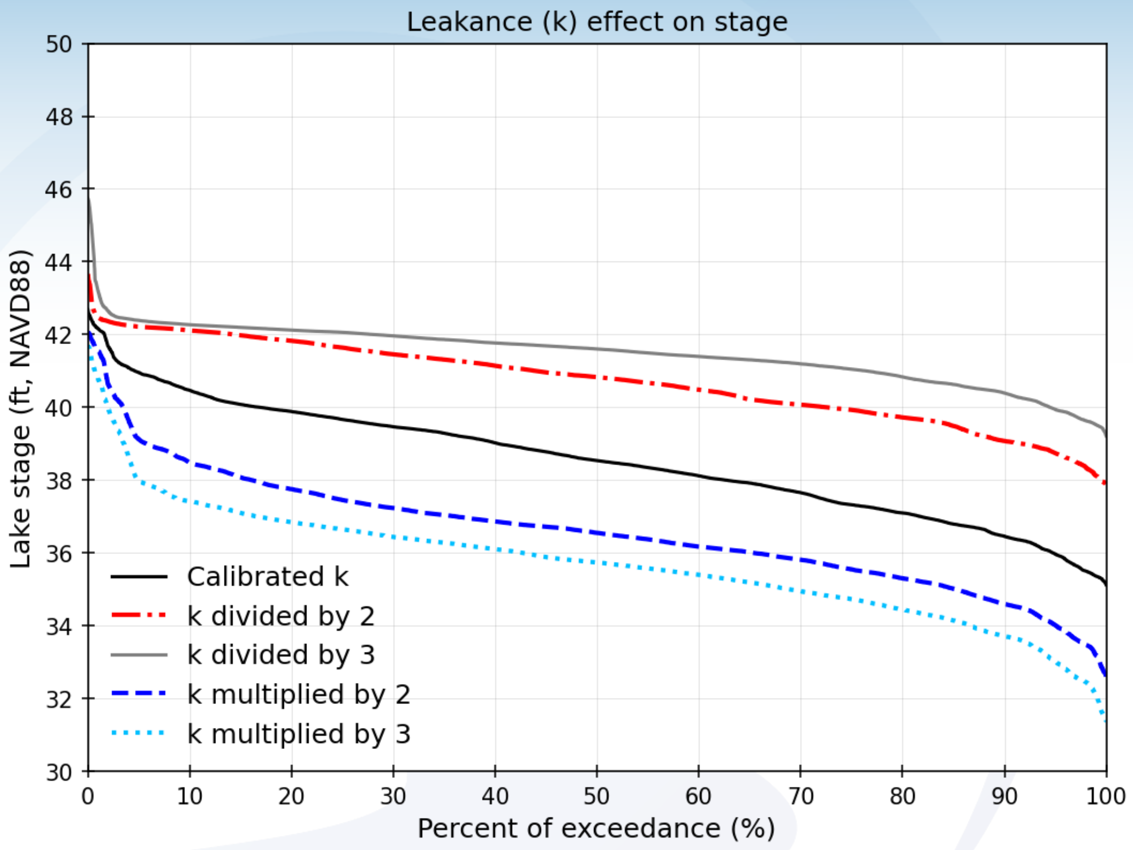
Sensitivity Analysis Results



- Leakance showed more impacts on low to medium stages
- Leakance (k) – most sensitive
- DEEPFR and LZETP – moderately sensitive
- INFILT and LZSN – not sensitive

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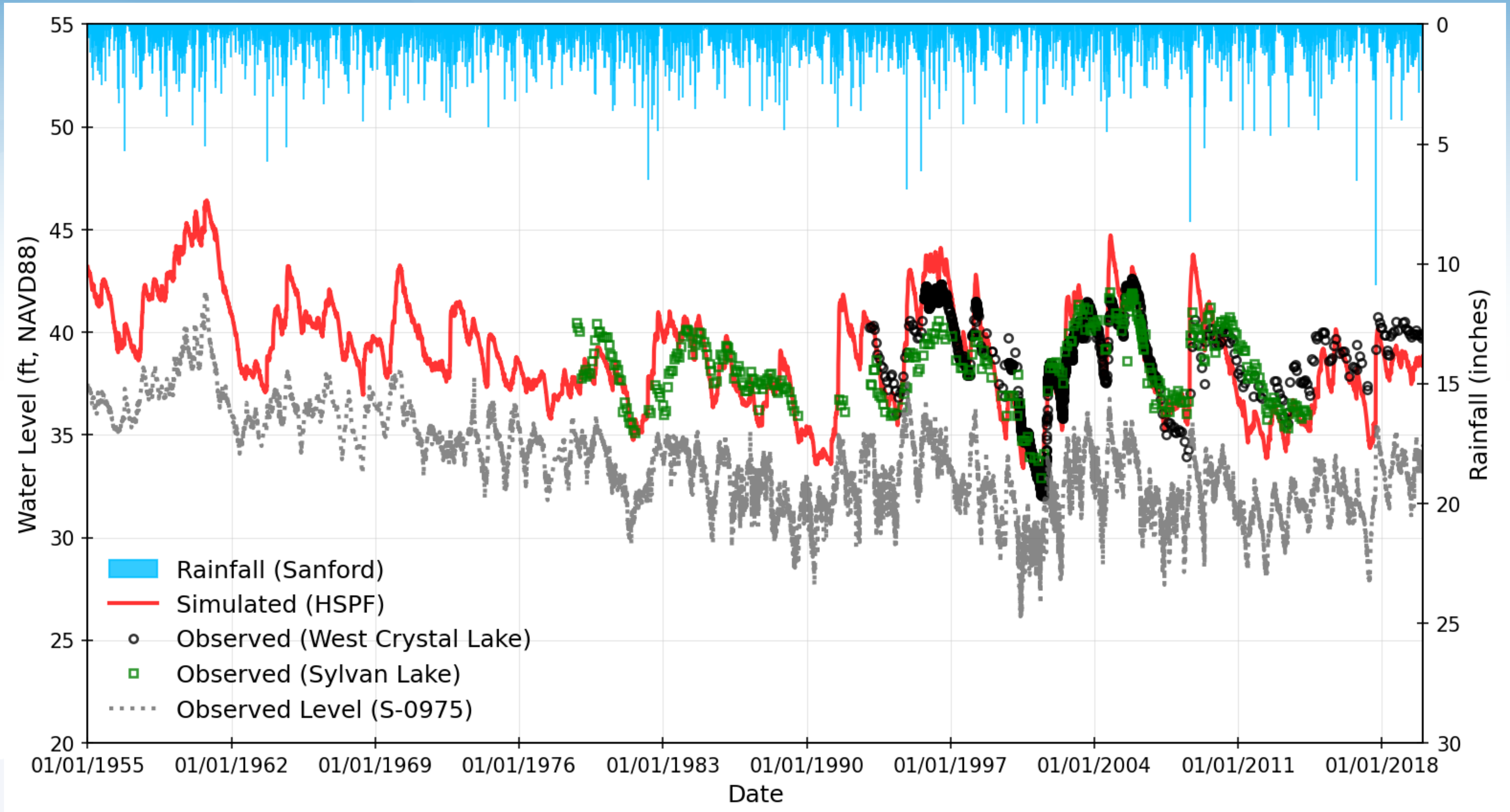
Long-term Simulation

- Extended the calibrated and validated to 1/1/1953 to 12/31/2019
  - Hourly rainfall data (used Sanford station)
  - Hourly PET (used Sanford station)
  - Daily UFA groundwater levels
- All hydrologic parameters were kept the same

West Crystal Long-term Simulation Results



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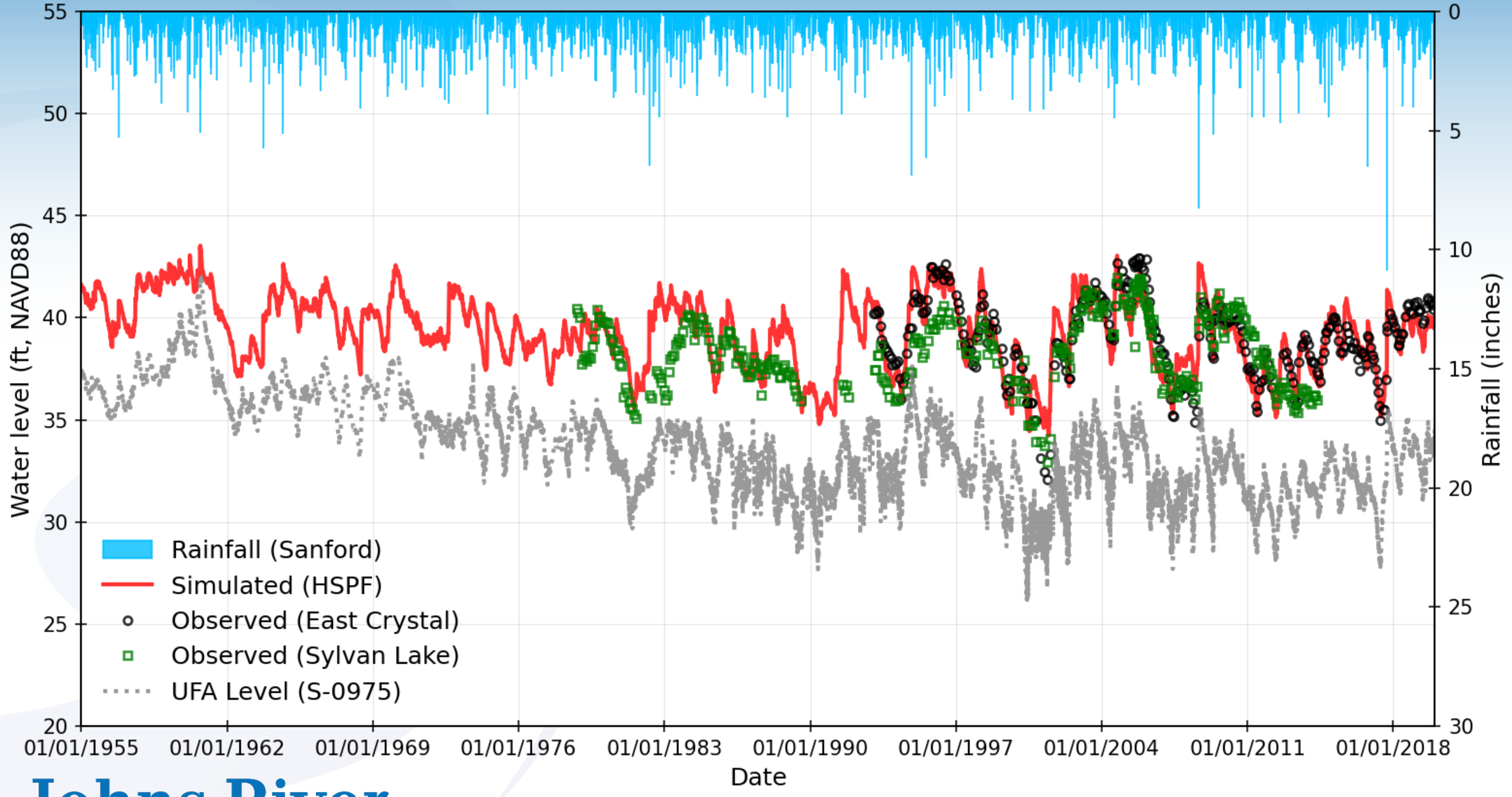
East Crystal Long-term Simulation Results



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Conclusions

- The HSPF model simulated daily variations and magnitudes of lake levels for calibration, validation, and long-term periods reasonably well
- Simulated watershed and lake water balances are good
- The lakes are significantly connected with UFA system
- The model can be used to simulate groundwater-surface water interactions and minimum levels analysis

Next Steps

• Reviewer to discuss initial findings (teleconference)	January 10, 2024
• Draft model review TM	January 31, 2024
• Reviewer to discuss final comments (teleconference)	February 7, 2024
• Final TM	February 16, 2024
• Draft MFLs Report	End of 2024
• Rulemaking	End of 2025

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For more information on the Crystal Lake HSFP model and MFLs development go to:

https://www.sjrwmd.com/minimumflowsandlevels/crystal-lake/

...or email Andrew Sutherland at:

asutherl@sjrwmd.com

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