
APPENDIX F – SIMULATED VERSUS OBSERVED HYDROGRAPHS OF LOWER FLORIDAN AQUIFER CALIBRATION TARGET WELLS

Appendix F includes hydrographs and duration curves of the observed and simulated groundwater heads during the transient model simulation period (2005 through 2018) for 38 Lower Floridan Aquifer (LFA) calibration target wells. Many of the LFA wells in SWFWMD were installed within the last decade and little data was available over the calibration period. Therefore, a linear regression methodology was implemented to develop a synthesized time-series of groundwater levels in LFA target wells using available monitoring data from UFA monitoring wells. The methodology and a comprehensive review of the dataset is provided in a technical memo within this appendix.

The synthesized LFA groundwater levels were converted to equivalent freshwater heads before calibration and residual calculation. Equivalent freshwater heads were calculated based on the average observed groundwater salinity. The simulated groundwater head was retrieved for each stress period from the MODFLOW cell where the target well was located.

The hydrograph on the top of each page illustrates a monthly time-series of groundwater heads. The stage-duration curve on the bottom of each page represents groundwater heads and the corresponding percentage of time that a particular groundwater head is exceeded for each calibration target well. The same dataset was used to construct each hydrograph and stage-duration curve pair.

Note: The following definitions apply to all figures included in this appendix. Additional information regarding the presented statistics is included in Chapter 4.

ME = mean error

MAE = mean absolute error

R^2 = coefficient of determination

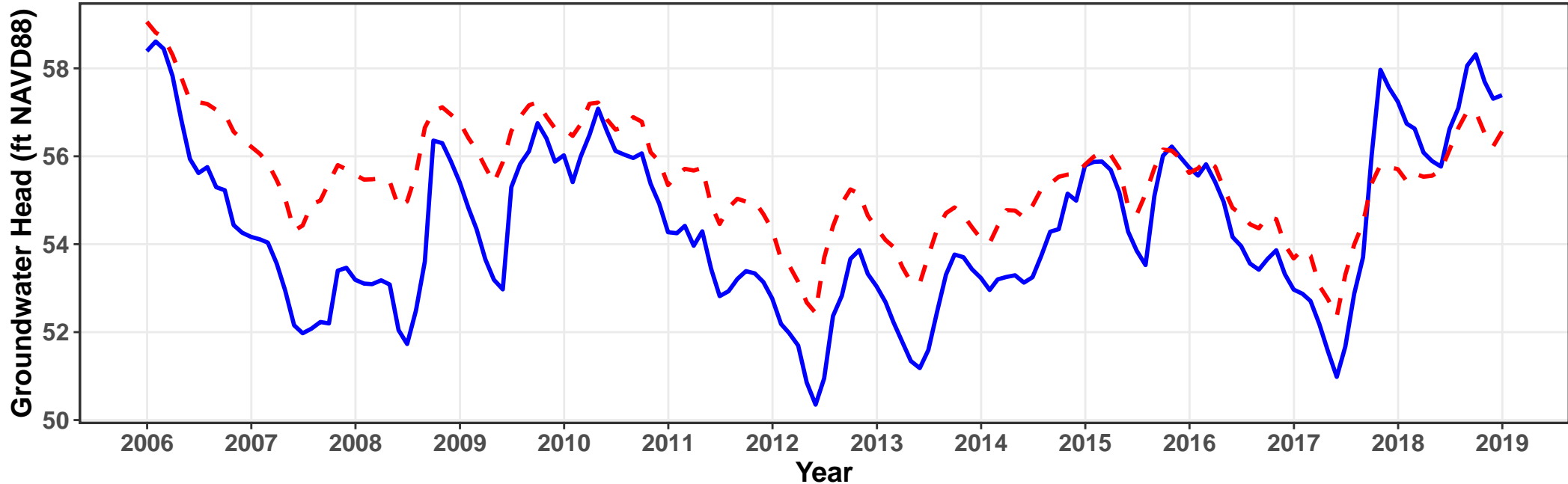
NSE = Nash-Sutcliffe efficiency coefficient

Ft NAVD88 = feet relative to the North American Vertical Datum of 1988

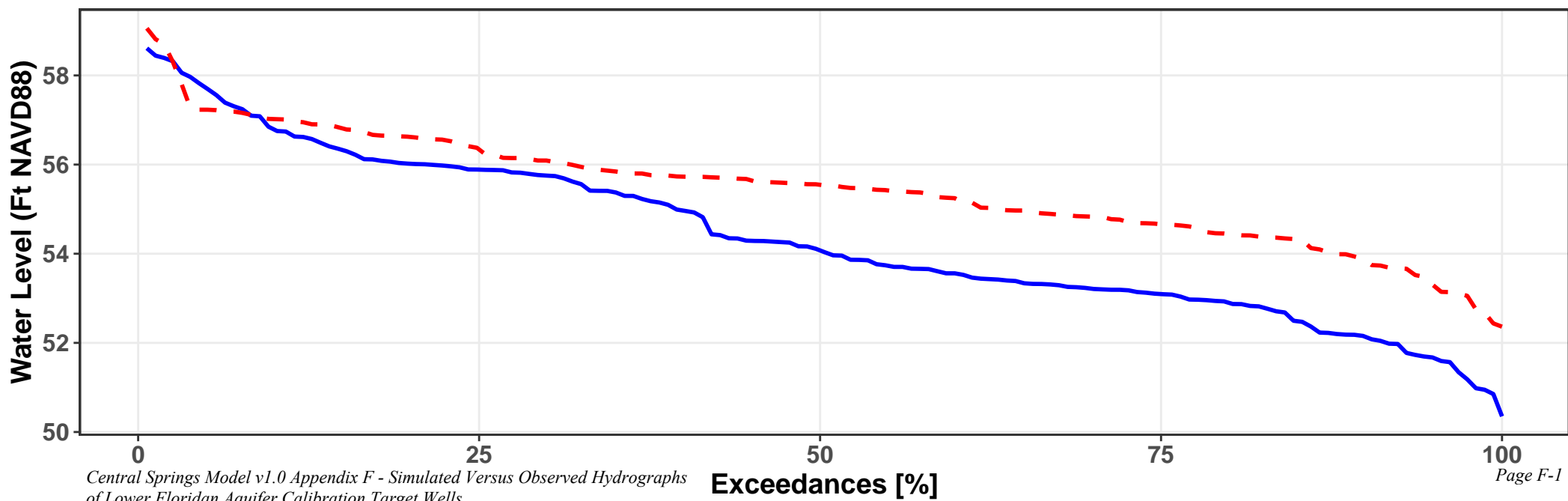
L-0599 – LFA @ Carrot Barn

ME = 1.1 MAE = 1.3 $R^2 = 0.7219$ NSE = 0.343

— Observed — Simulated



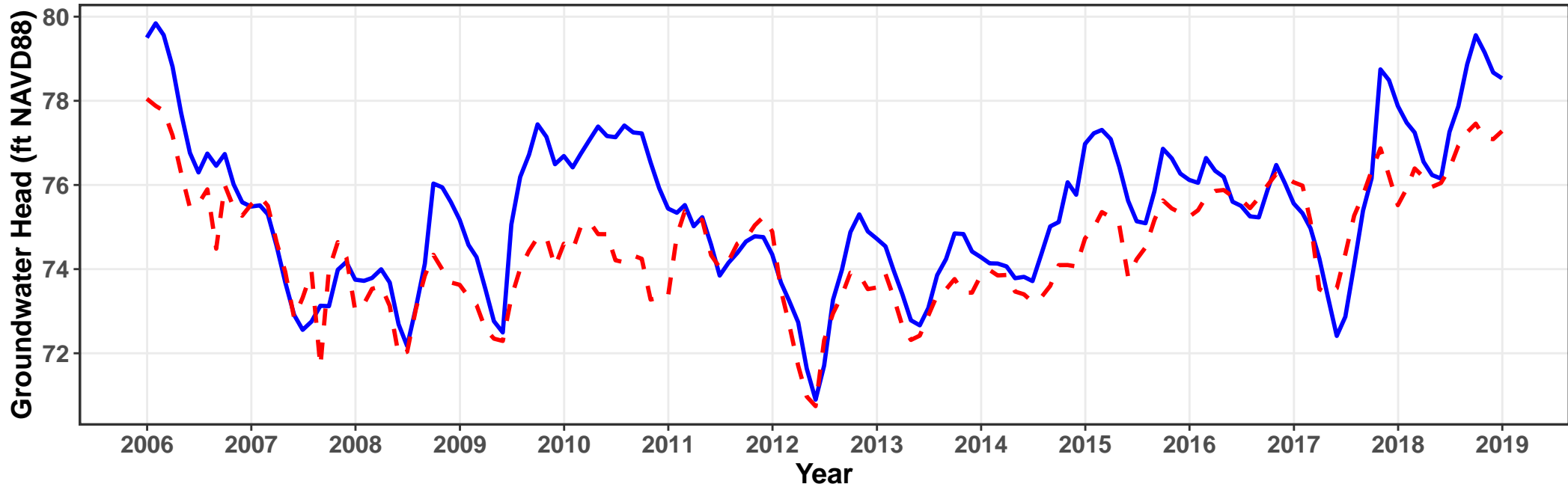
Stage Duration Curve



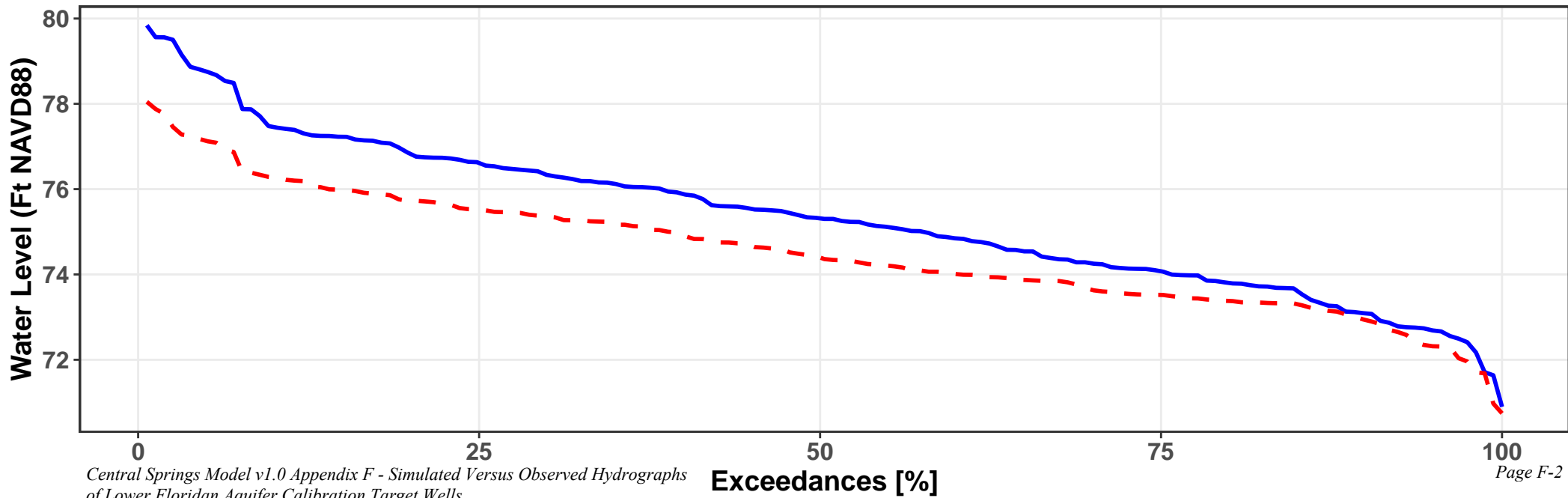
L-0729 – LFA @ Keene Lk Wells

ME = -0.8 MAE = 1 $R^2 = 0.6971$ NSE = 0.477

— Observed - - Simulated



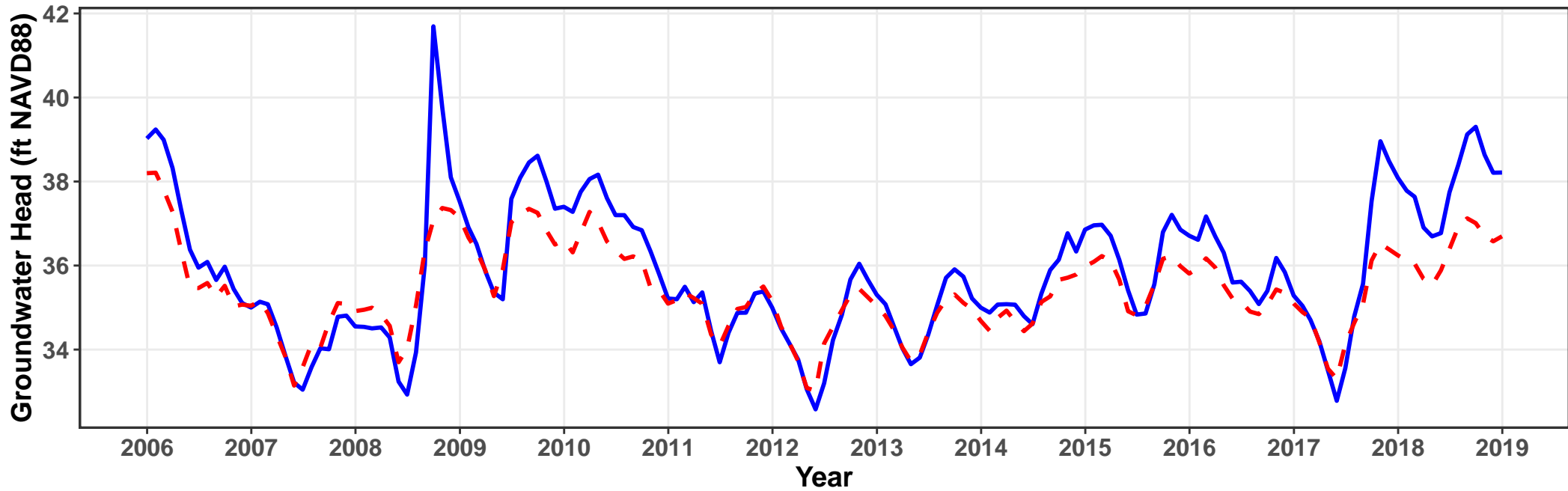
Stage Duration Curve



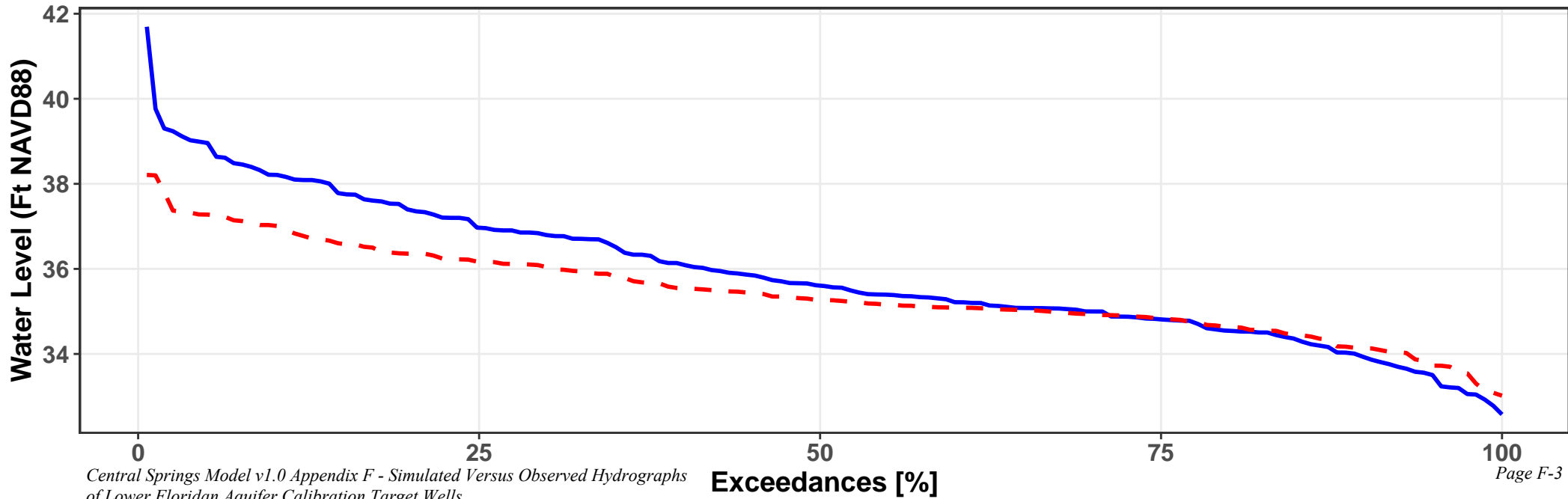
L-0817 – LFA @ Seminole SF New

ME = -0.5 MAE = 0.6 $R^2 = 0.8943$ NSE = 0.72

— Observed - - Simulated



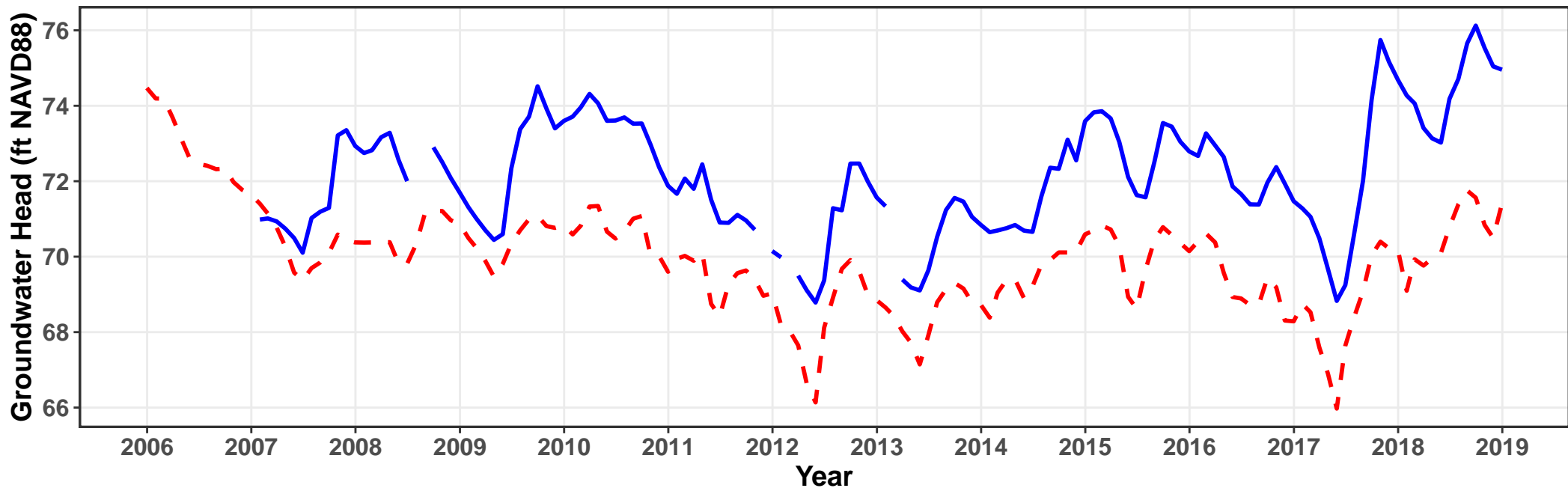
Stage Duration Curve



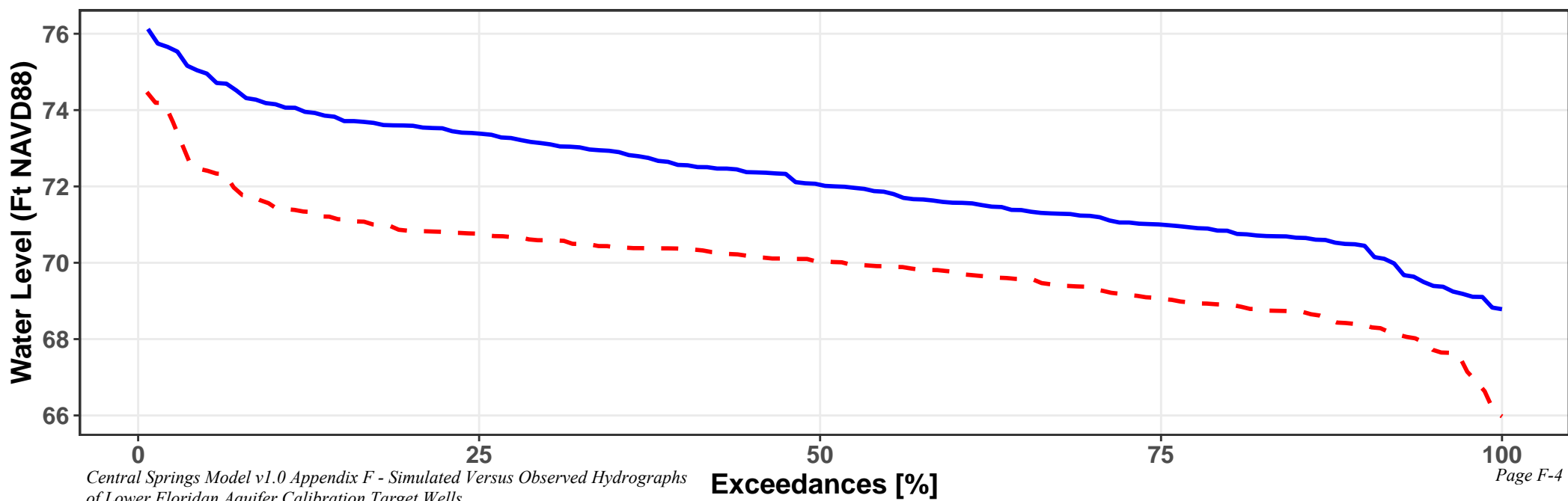
L-1049 – LFA @ Leesburg WWTF

ME = -2.4 MAE = 2.4 $R^2 = 0.607$ NSE = -1.749

— Observed - - Simulated



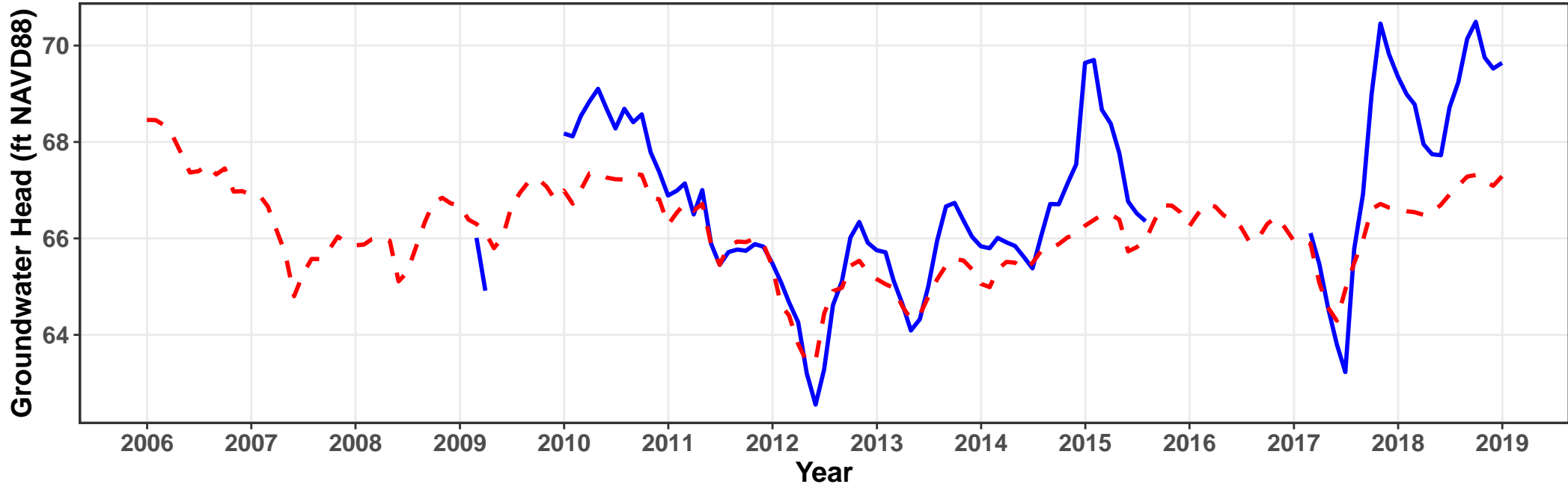
Stage Duration Curve



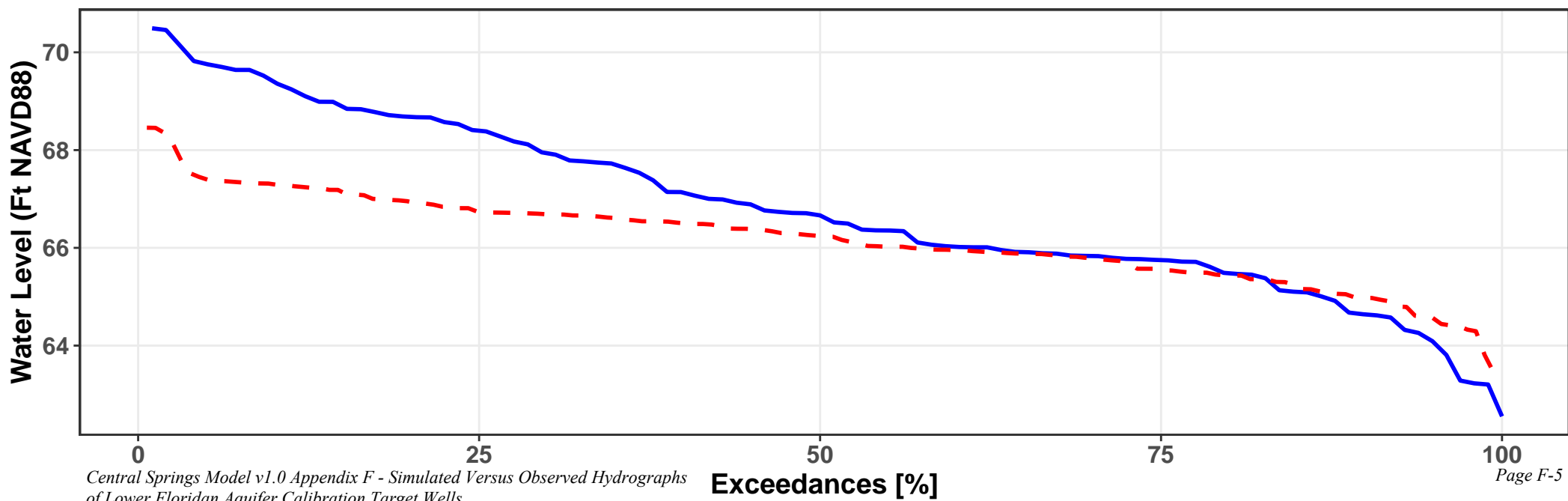
L-1076 – LFA @ Duda-Whittle Wells

ME = -0.9 MAE = 1 $R^2 = 0.7991$ NSE = 0.422

— Observed - - Simulated



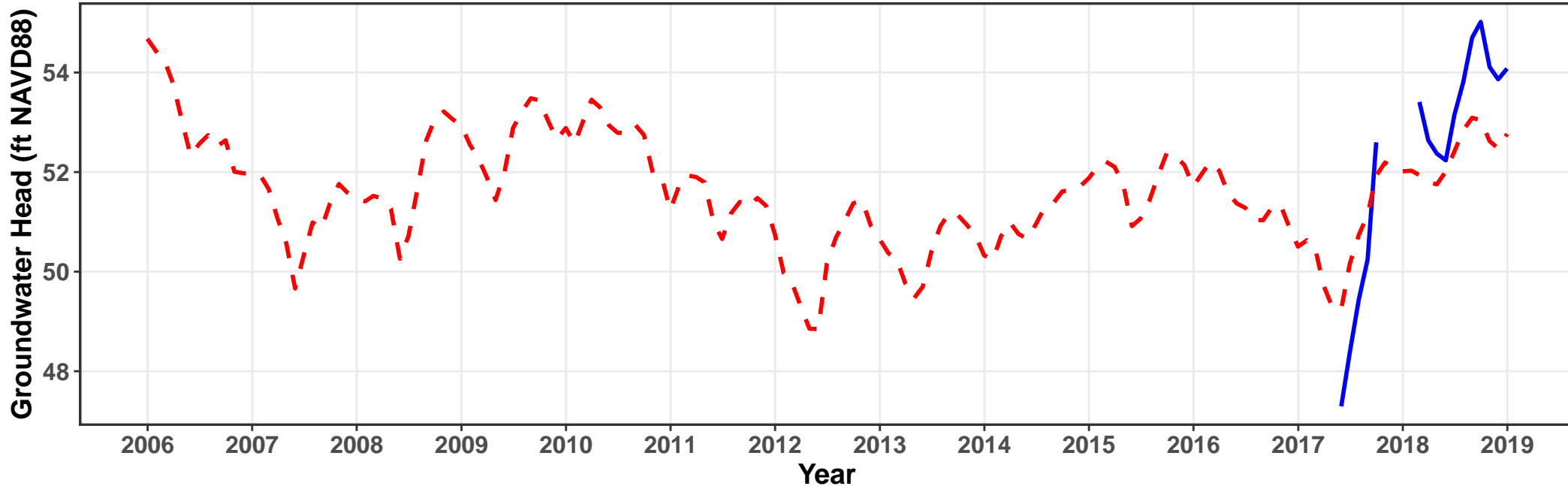
Stage Duration Curve



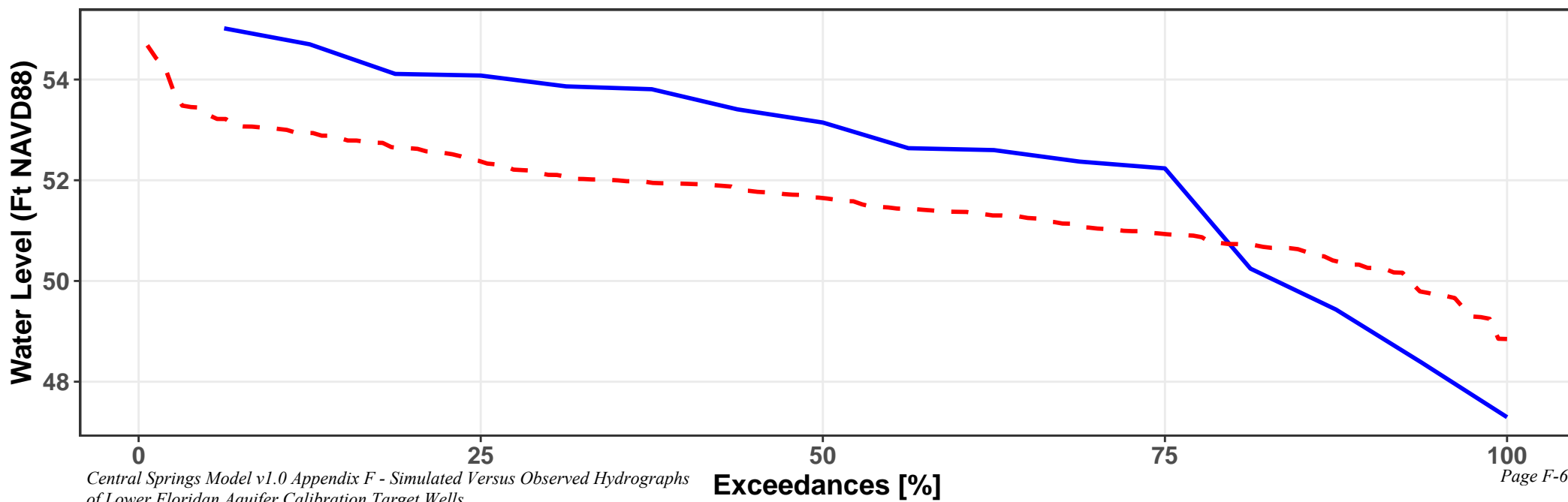
L-1085 – LFA @ Pine Meadows C A

ME = -0.5 MAE = 1.2 $R^2 = 0.9634$ NSE = 0.659

— Observed — Simulated



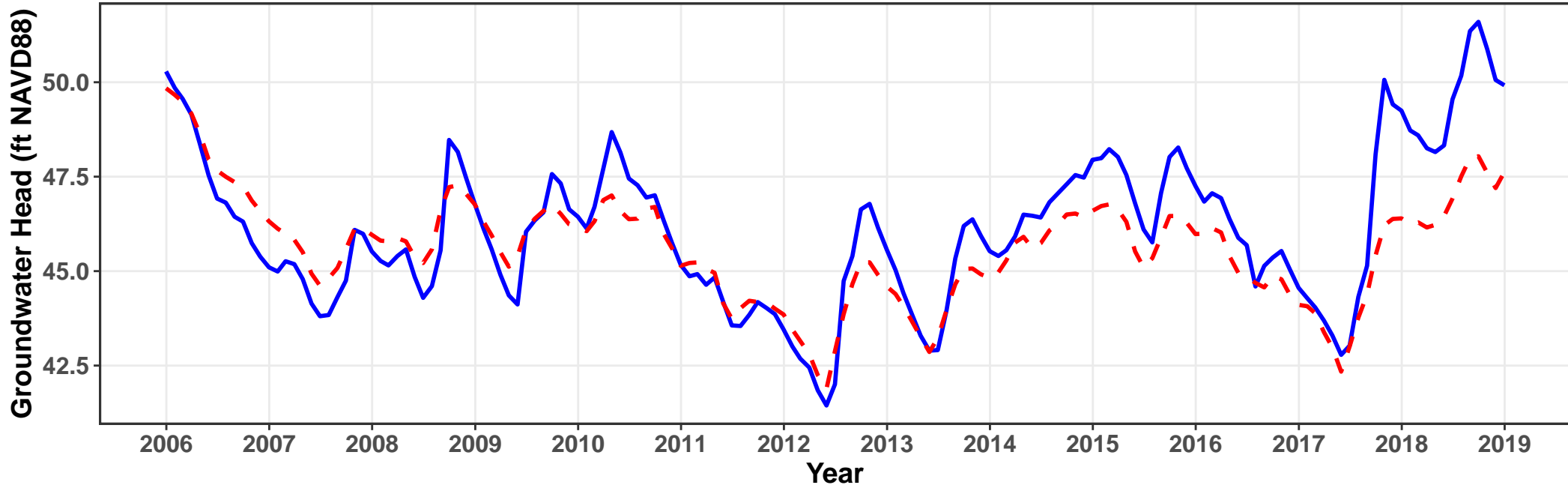
Stage Duration Curve



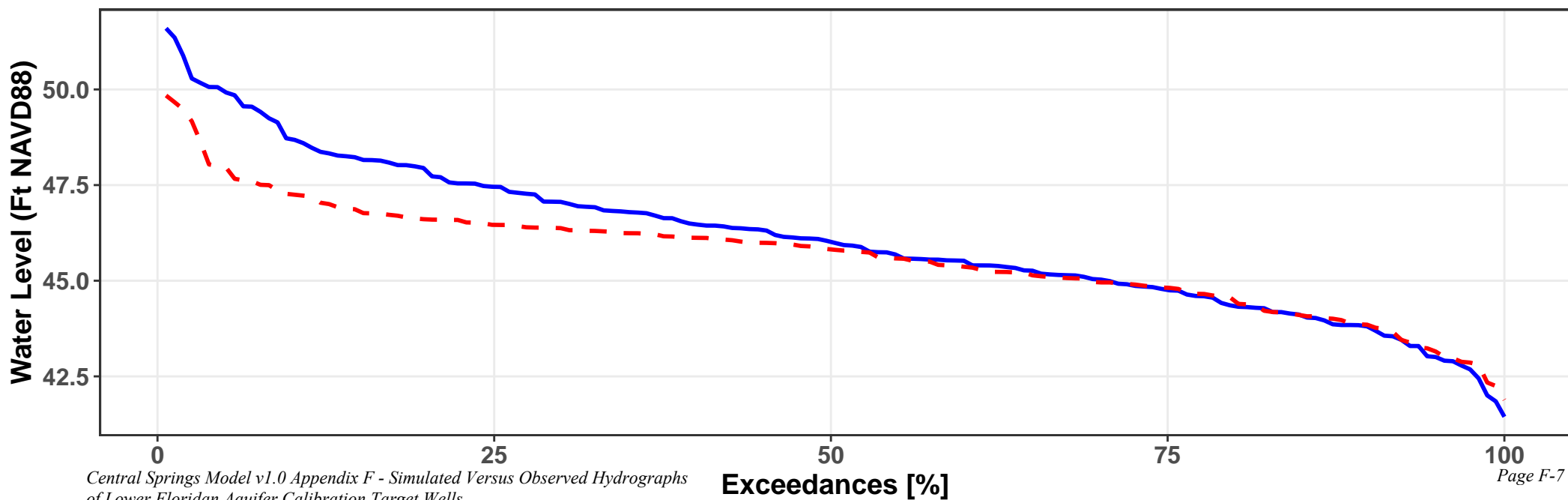
M-0788 – LFA @ Tiger Den nr CR 464

ME = -0.5 MAE = 0.9 $R^2 = 0.7429$ NSE = 0.665

— Observed - - Simulated



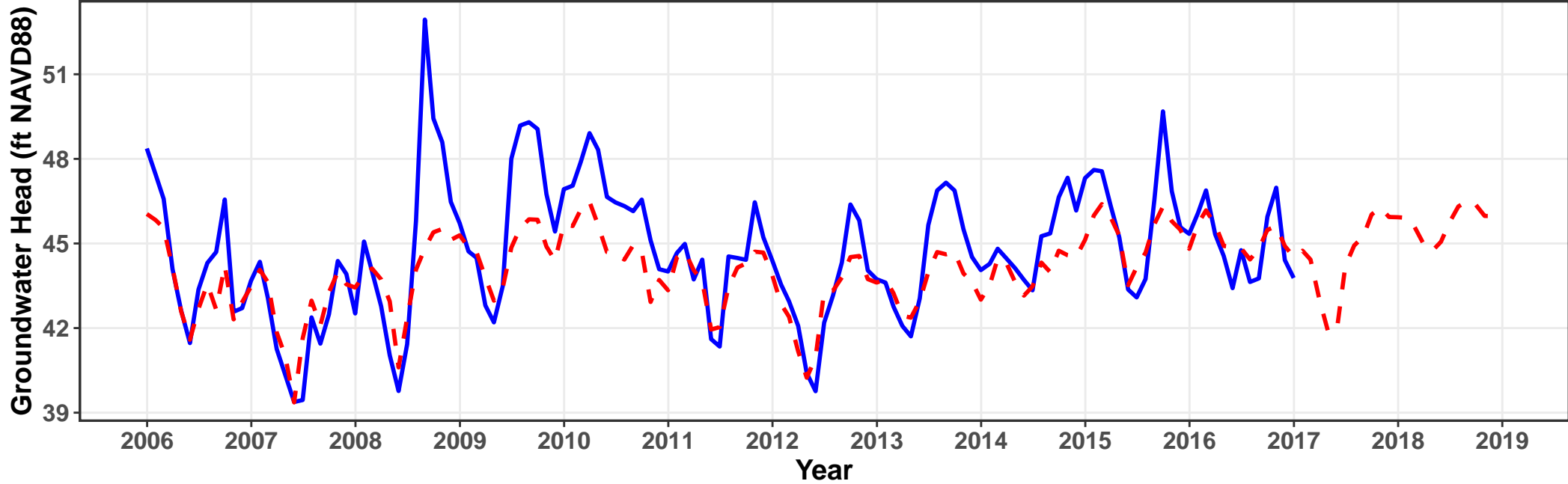
Stage Duration Curve



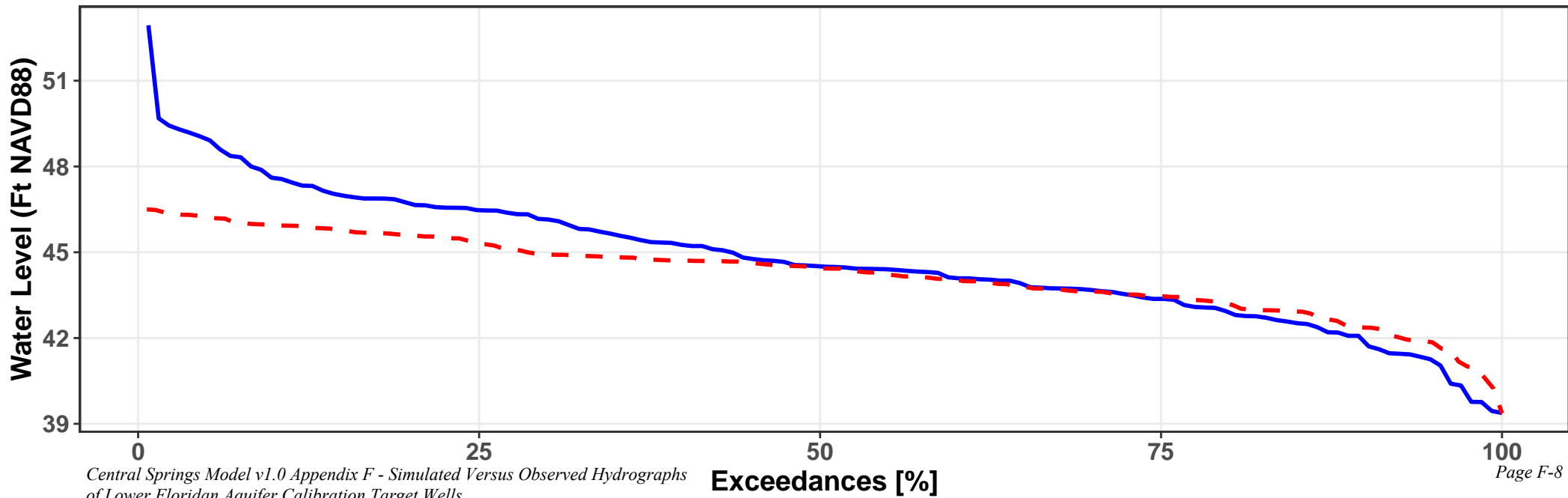
OR0009 – FAS @ Lk Adair

ME = -0.7 MAE = 1.1 $R^2 = 0.73$ NSE = 0.566

— Observed - - Simulated



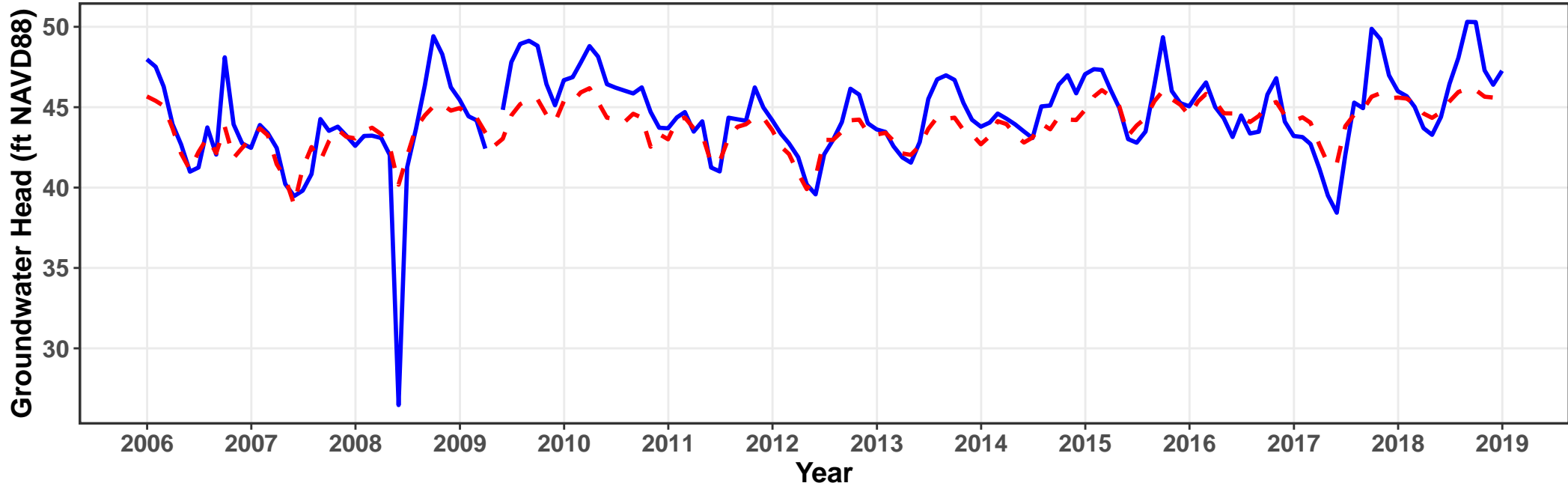
Stage Duration Curve



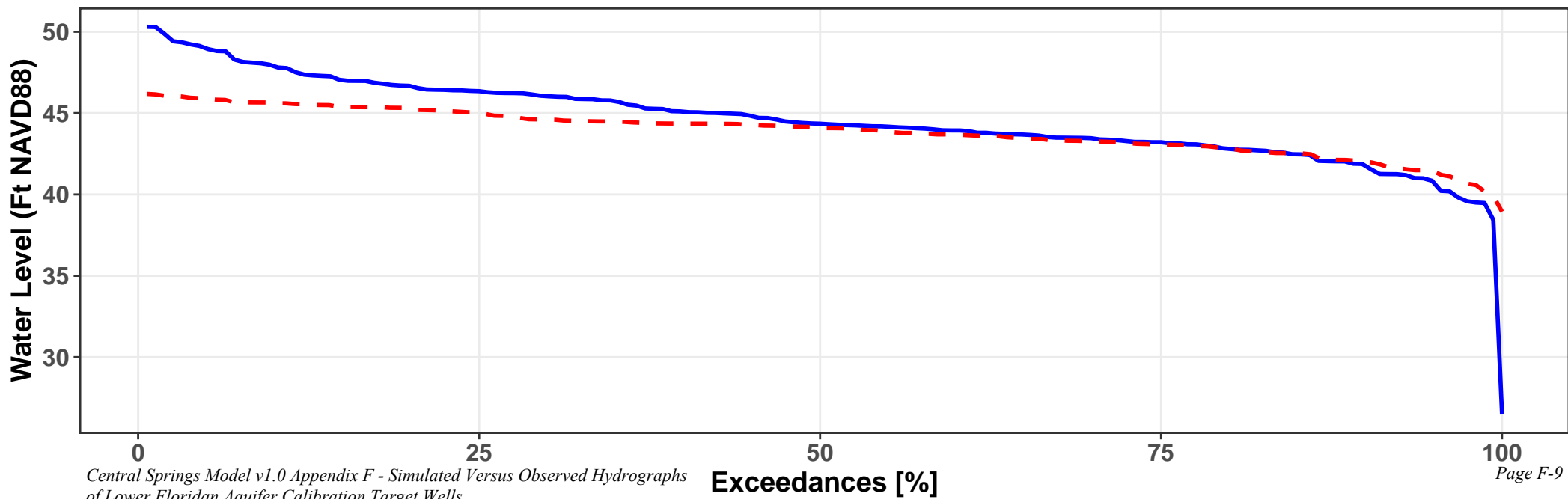
OR0467 – LFA @ Lk Ivanhoe

ME = -0.7 MAE = 1.3 $R^2 = 0.6687$ NSE = 0.517

— Observed - - Simulated



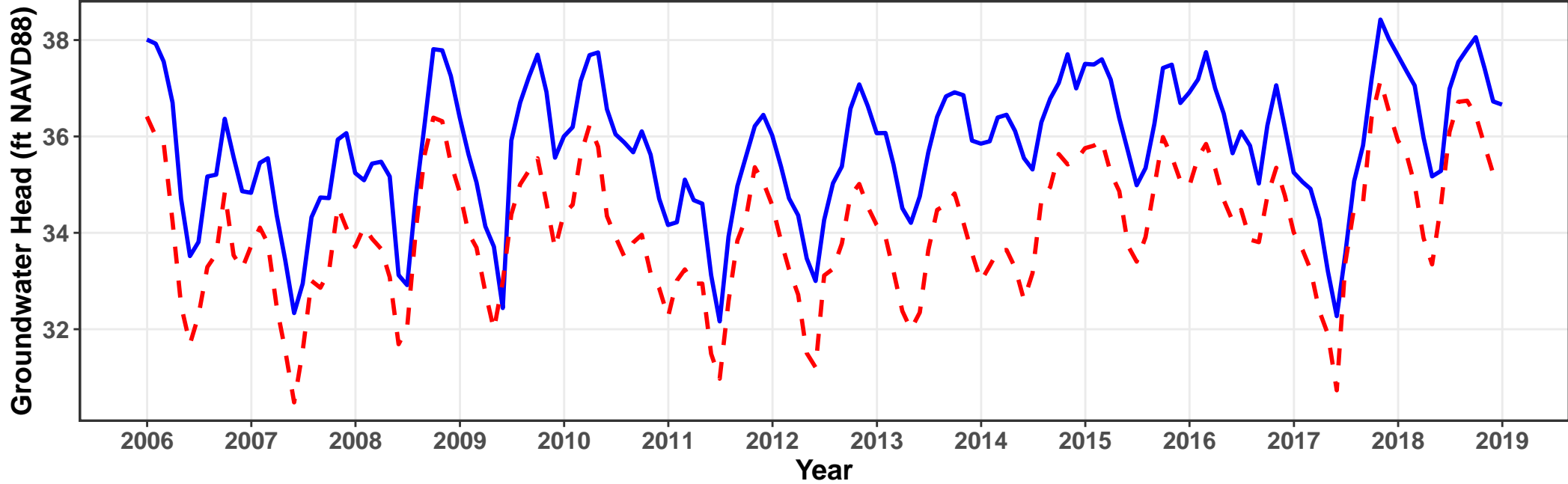
Stage Duration Curve



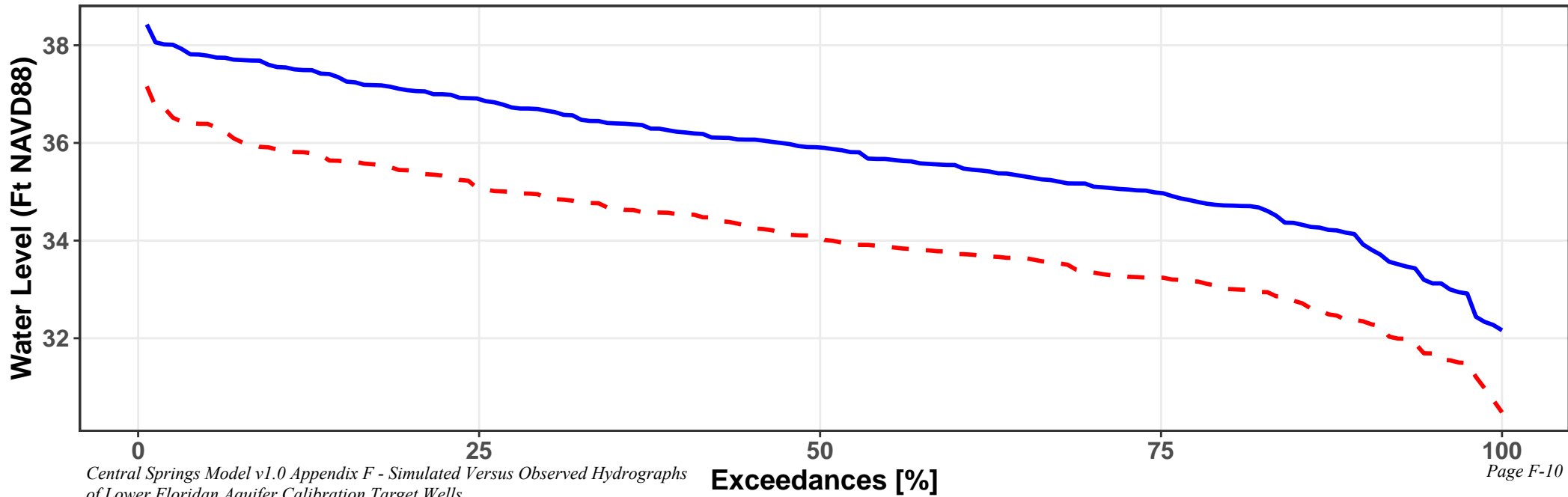
OR0614 – LFA @ Cocoa WF Site S

ME = -1.7 MAE = 1.7 $R^2 = 0.8764$ NSE = -0.608

— Observed — Simulated



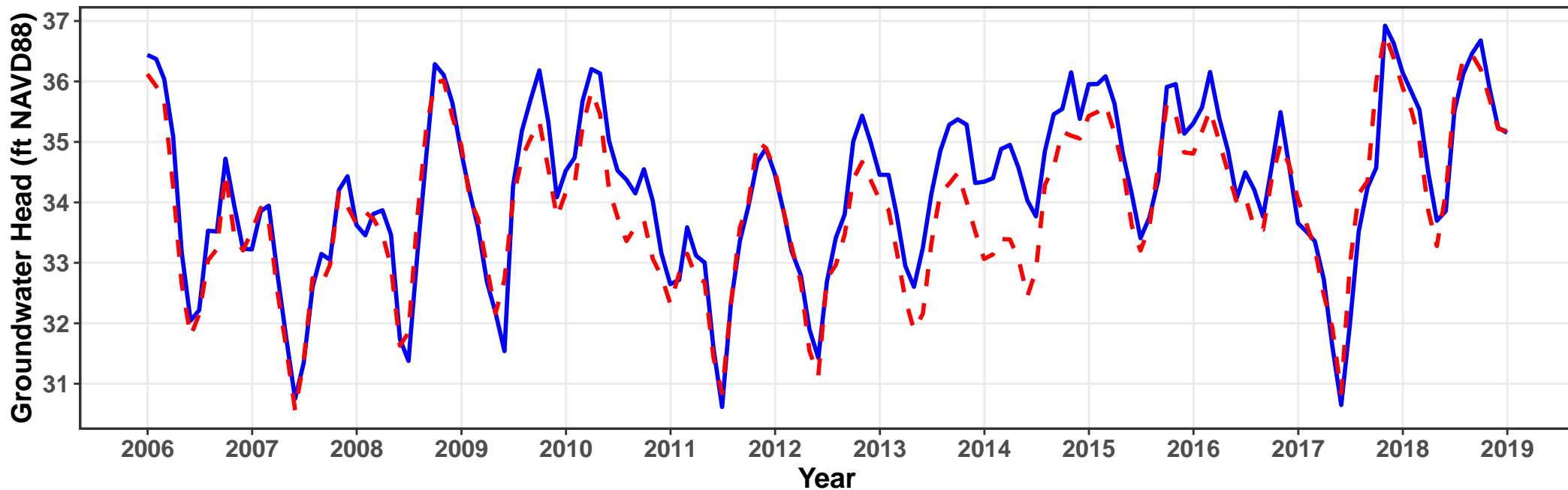
Stage Duration Curve



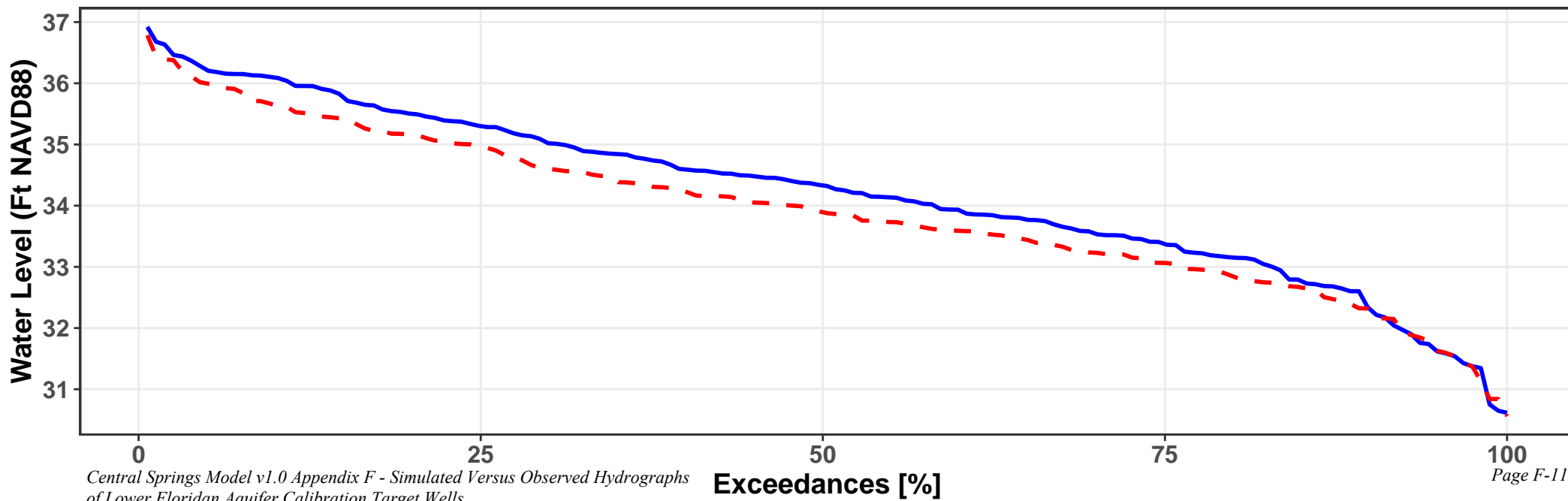
OR0618 – LFA @ Long Brch

ME = -0.3 MAE = 0.4 $R^2 = 0.8844$ NSE = 0.835

— Observed - - Simulated



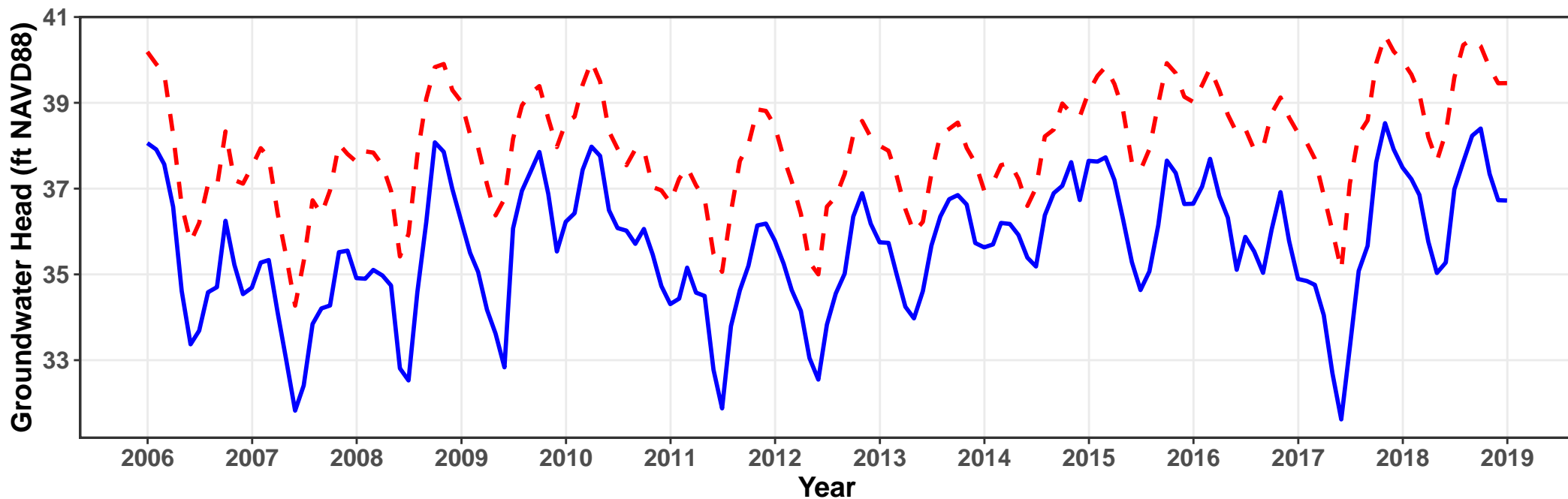
Stage Duration Curve



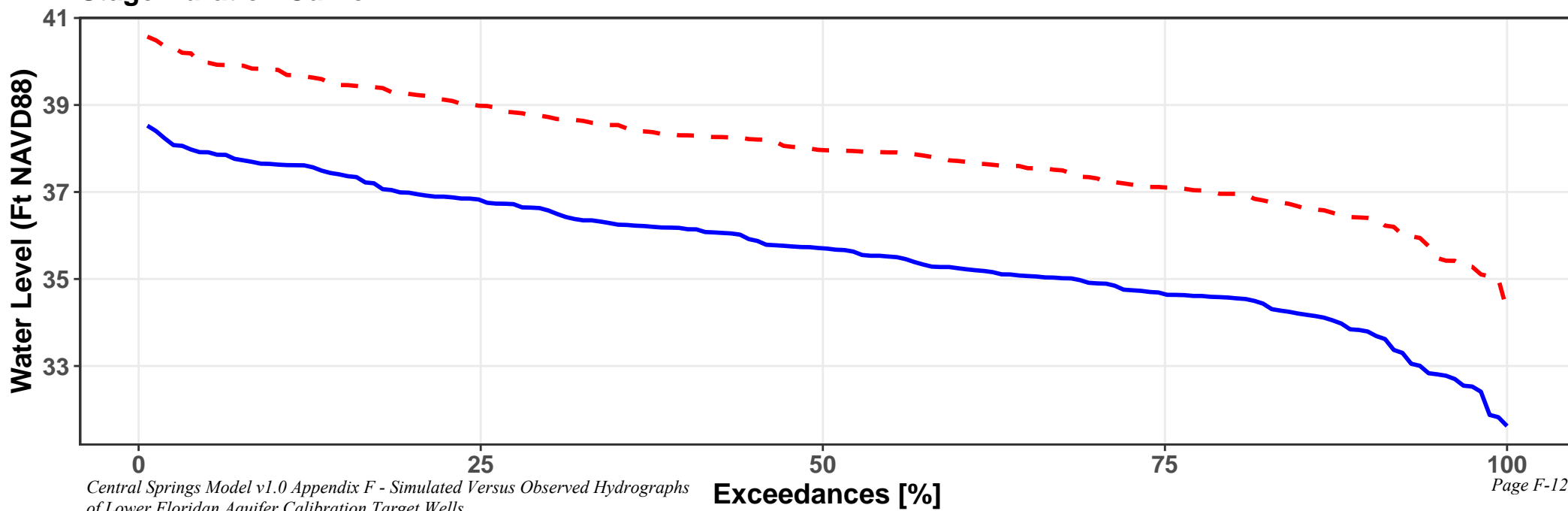
OR0676 – LFA @ Alafaya Trl WTP

ME = 2.4 MAE = 2.4 $R^2 = 0.8864$ NSE = -1.583

— Observed - - Simulated



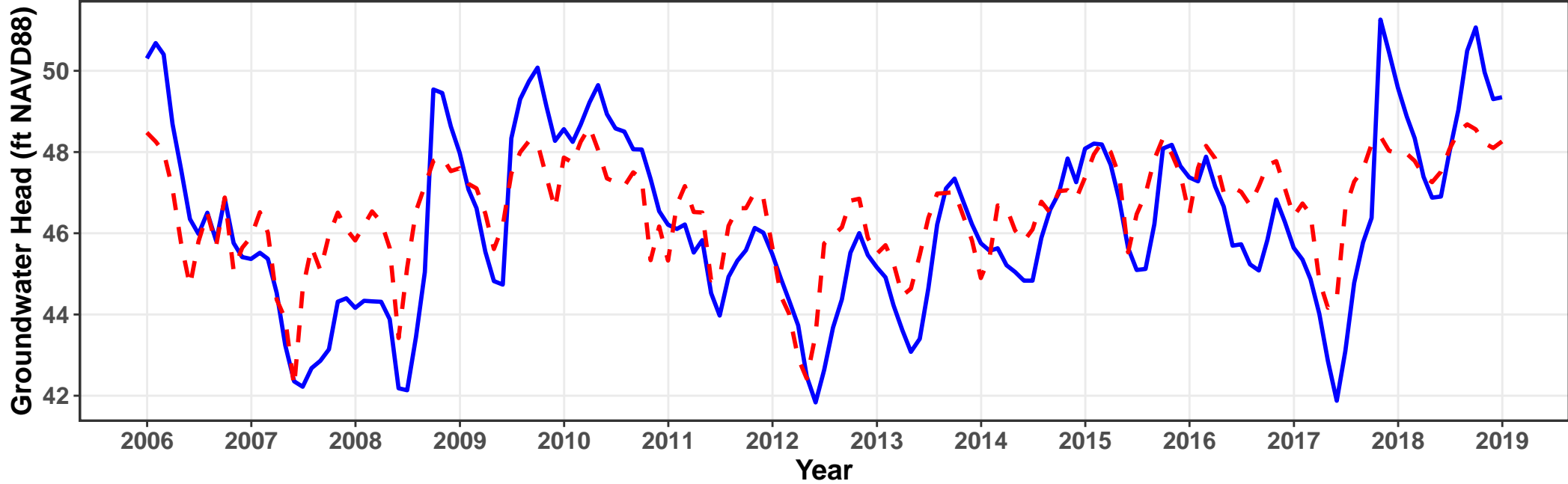
Stage Duration Curve



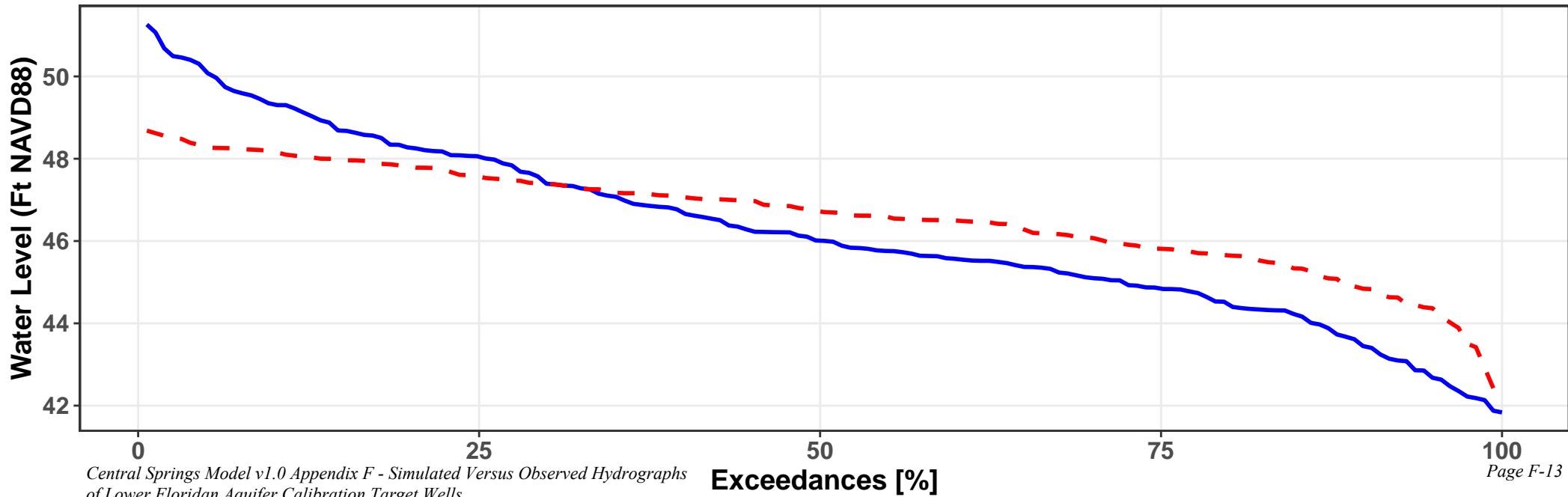
OR0794 – LFA @ Plymouth Twr

ME = 0.3 MAE = 1.1 $R^2 = 0.6566$ NSE = 0.591

— Observed - - Simulated



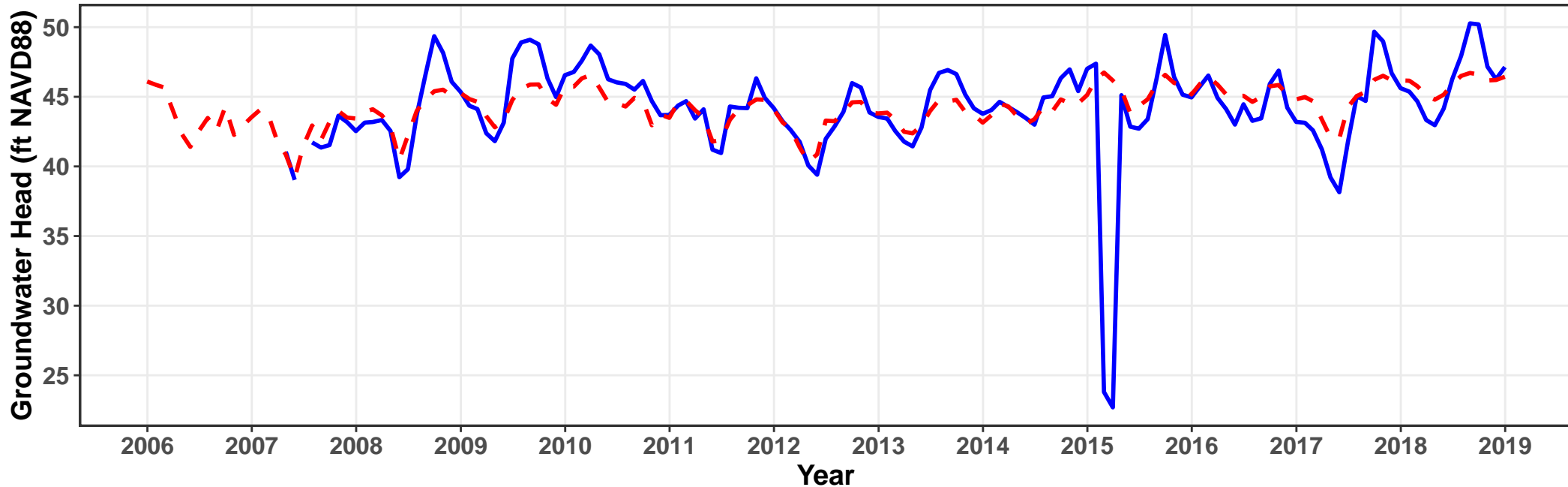
Stage Duration Curve



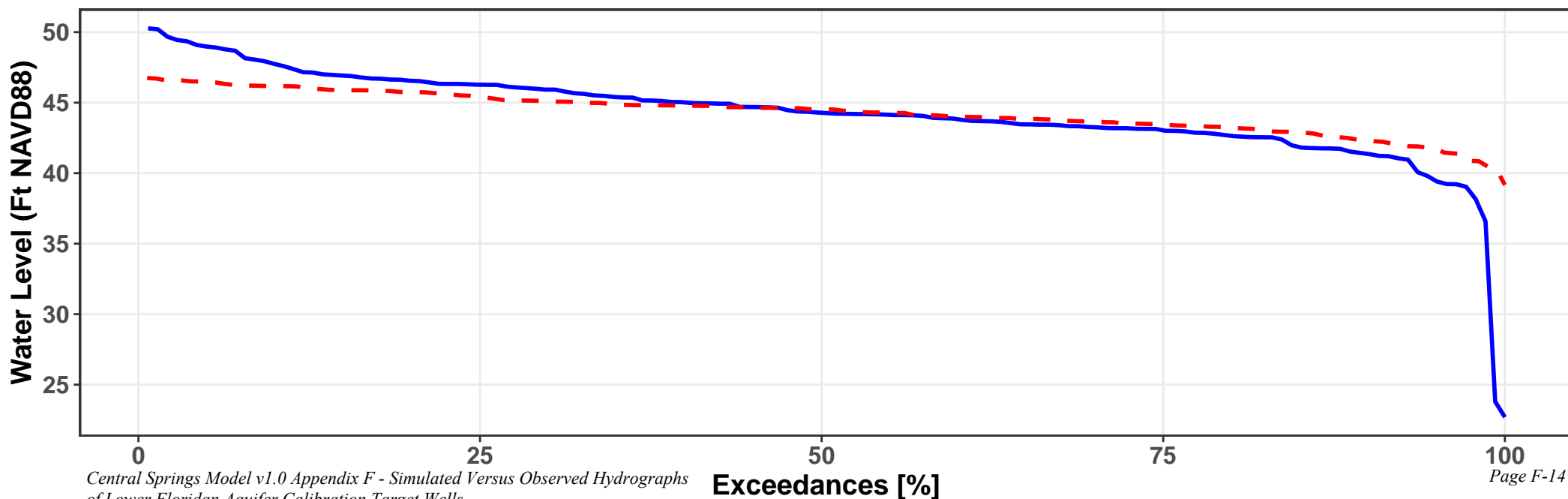
OR0829 – LFA @ Wadeview Pk

ME = 0.2 MAE = 1.5 $R^2 = 0.1759$ NSE = 0.172

— Observed — Simulated



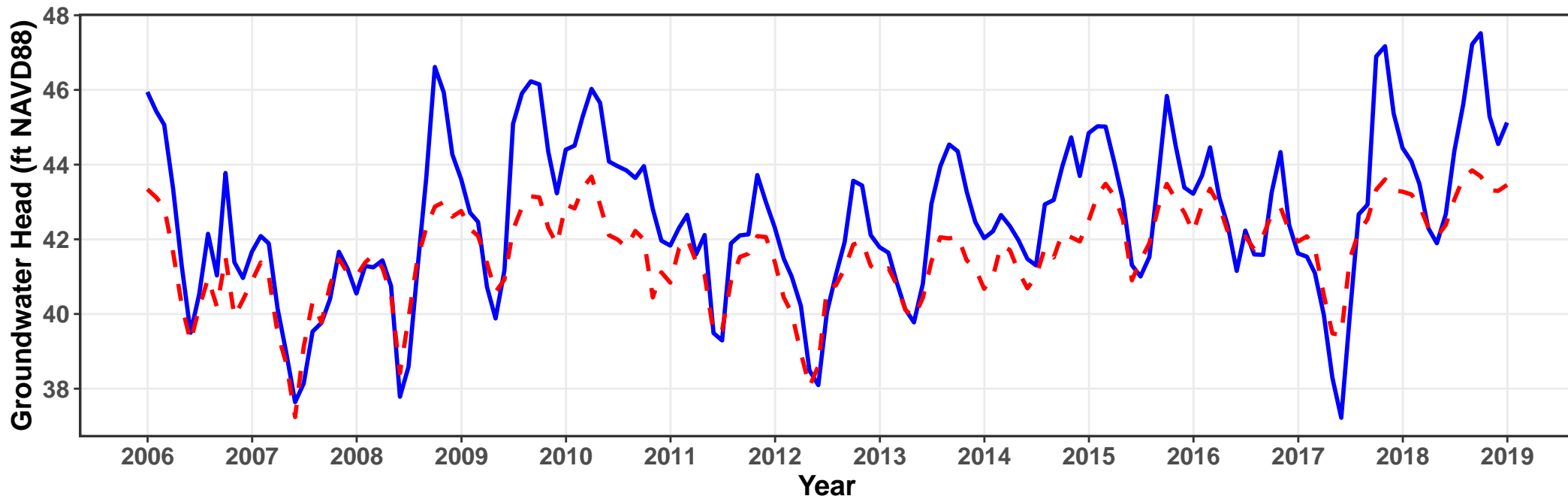
Stage Duration Curve



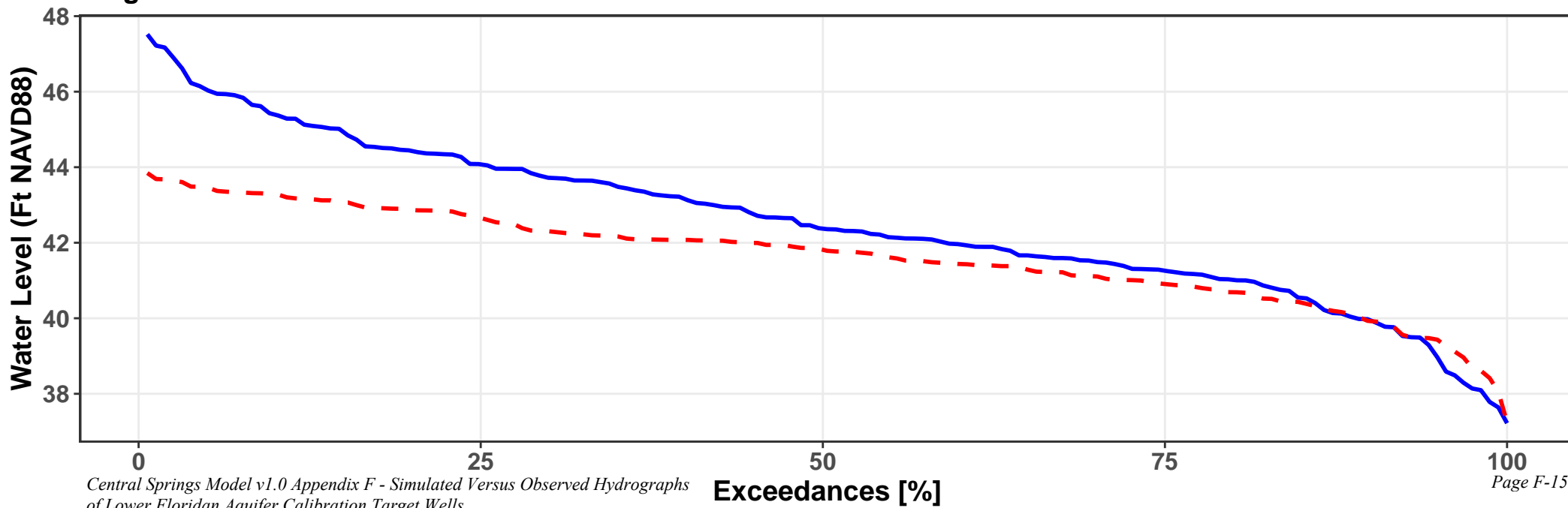
S-1024 – LFA @ Charlotte St

ME = -0.9 MAE = 1.2 $R^2 = 0.809$ NSE = 0.529

— Observed - - Simulated



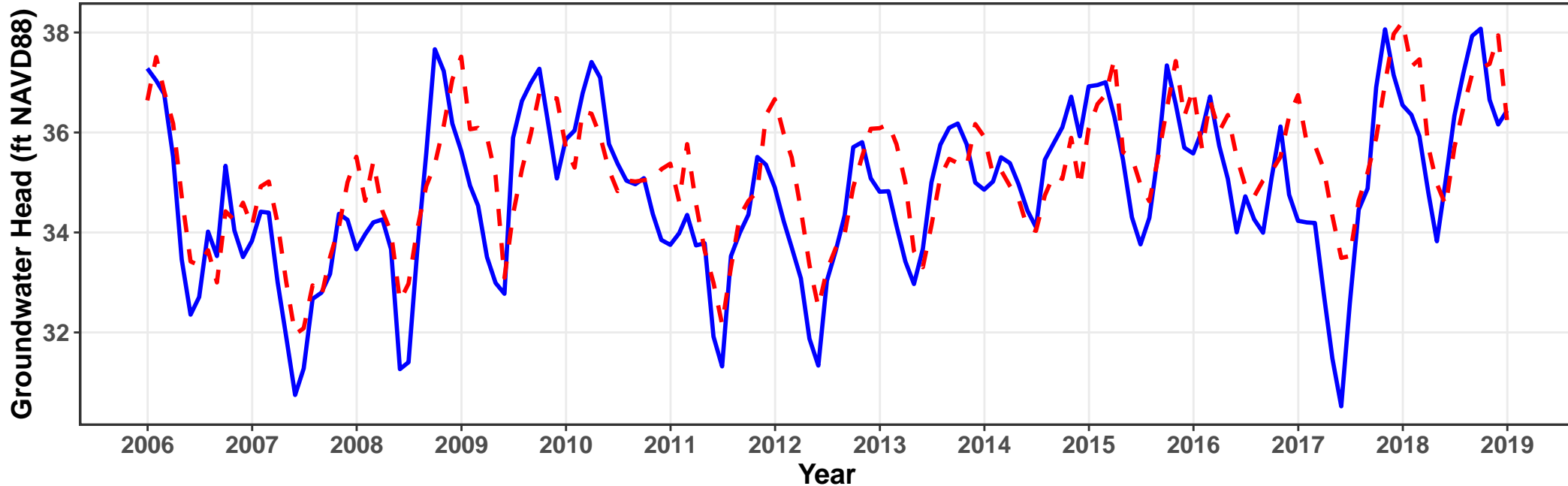
Stage Duration Curve



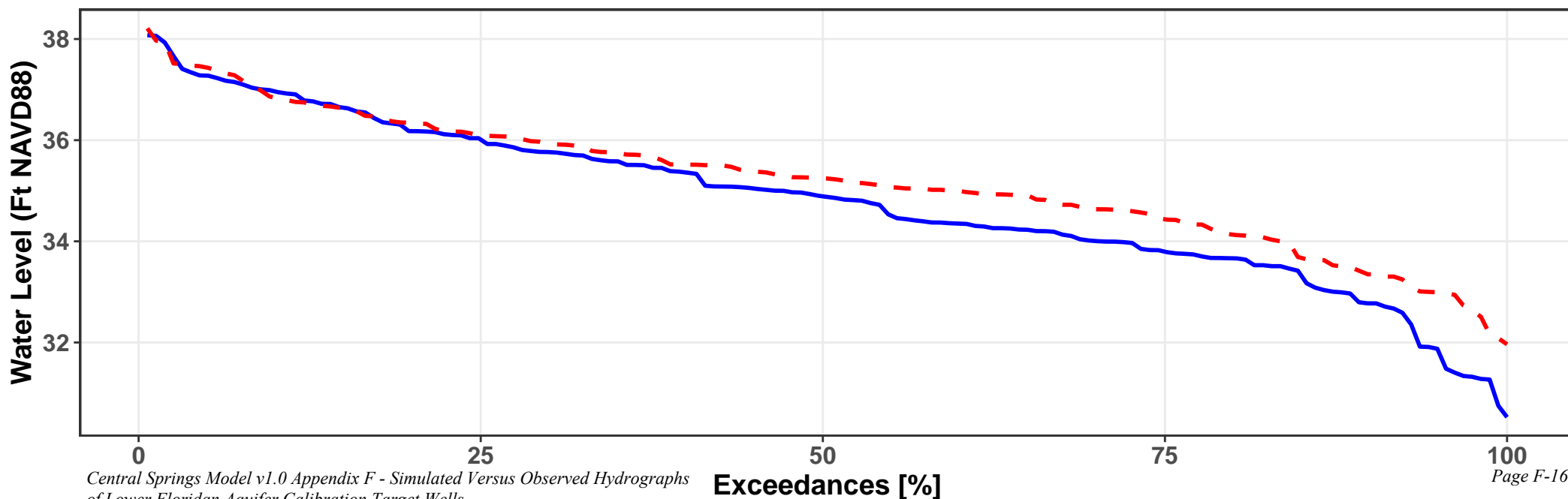
S-1078 – LFA @ Oviedo WTP

ME = 0.4 MAE = 0.9 $R^2 = 0.6276$ NSE = 0.564

— Observed — Simulated



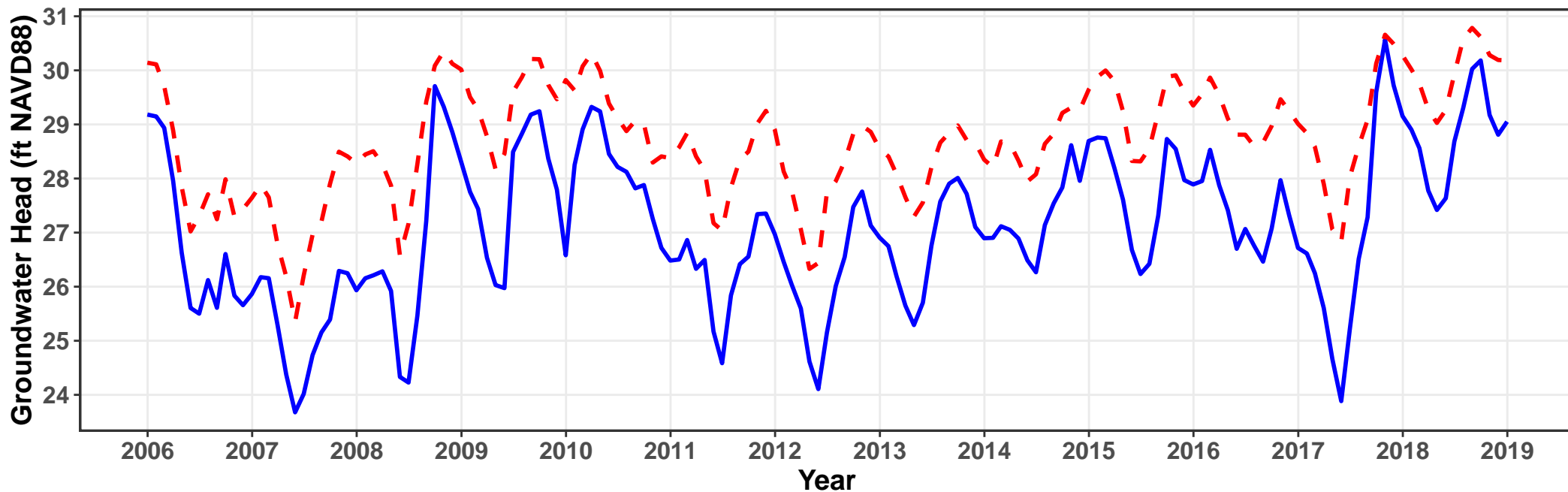
Stage Duration Curve



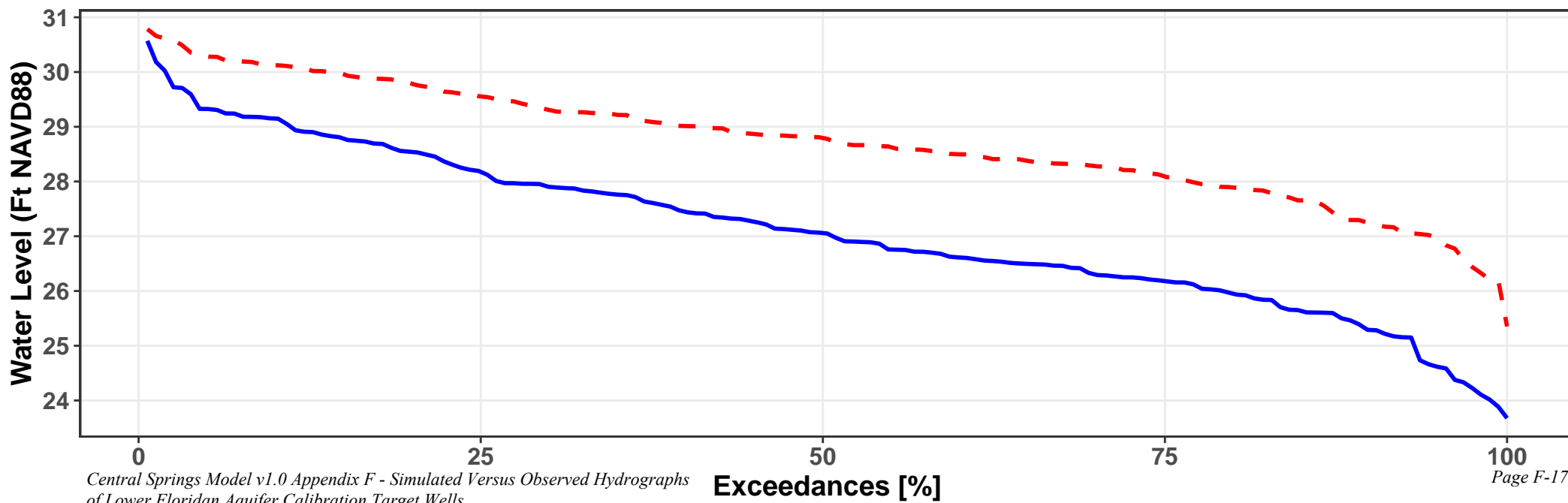
S-1225 – LFA @ Yankee Lk

ME = 1.6 MAE = 1.6 $R^2 = 0.9046$ NSE = -0.414

— Observed - - Simulated



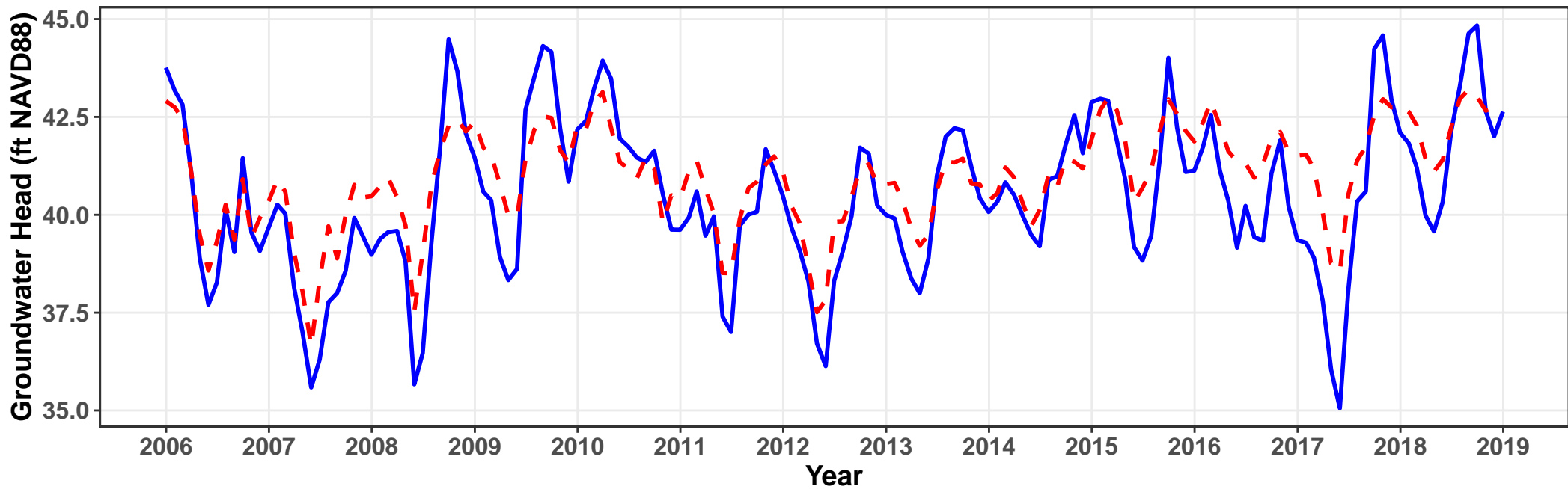
Stage Duration Curve



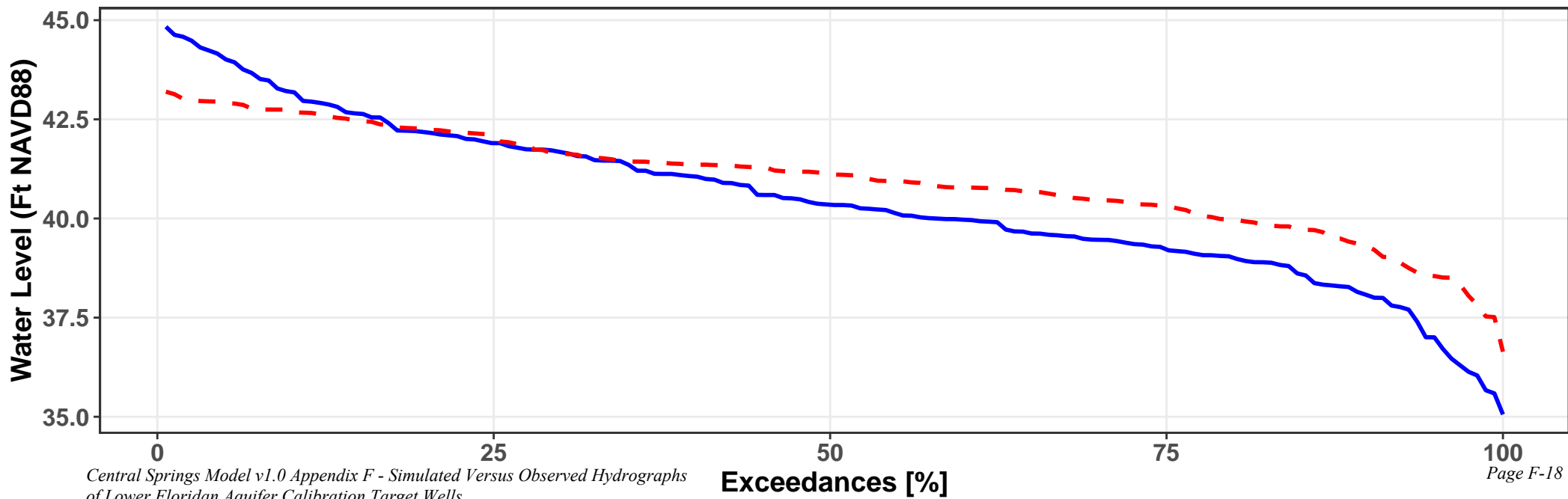
S-1329 – LFA @ Citrus Rd

ME = 0.5 MAE = 0.9 $R^2 = 0.8093$ NSE = 0.683

— Observed - - Simulated



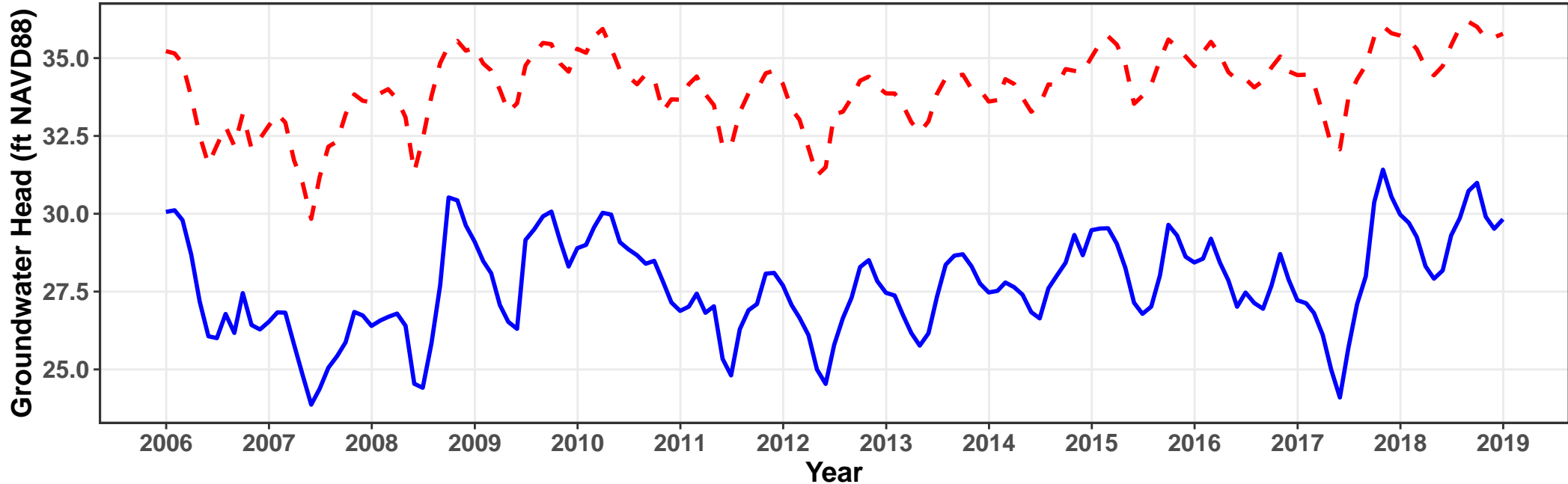
Stage Duration Curve



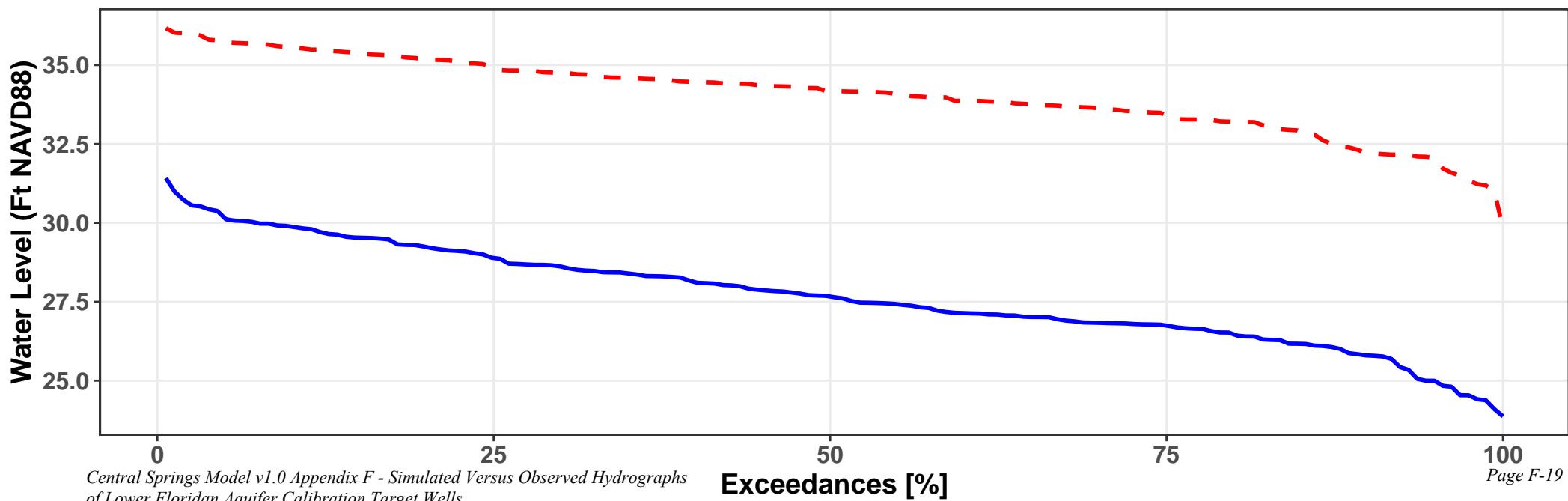
S-1351 – LFA @ Lk Mary Disposal

ME = 6.4 MAE = 6.4 $R^2 = 0.8419$ NSE = -15.557

— Observed — Simulated



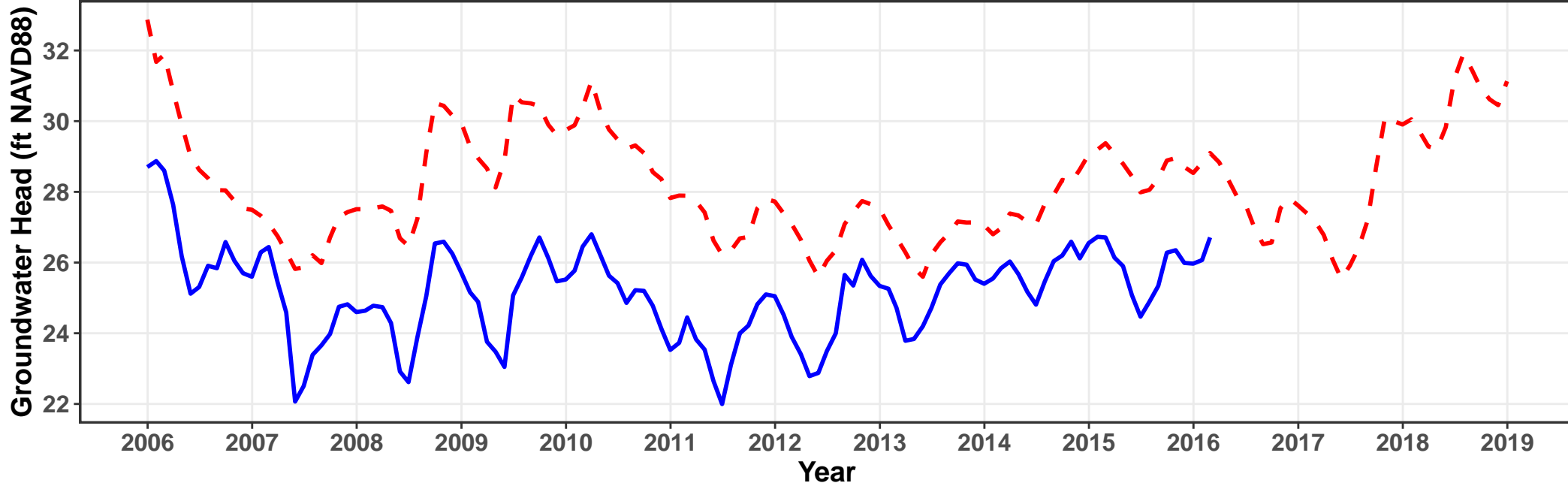
Stage Duration Curve



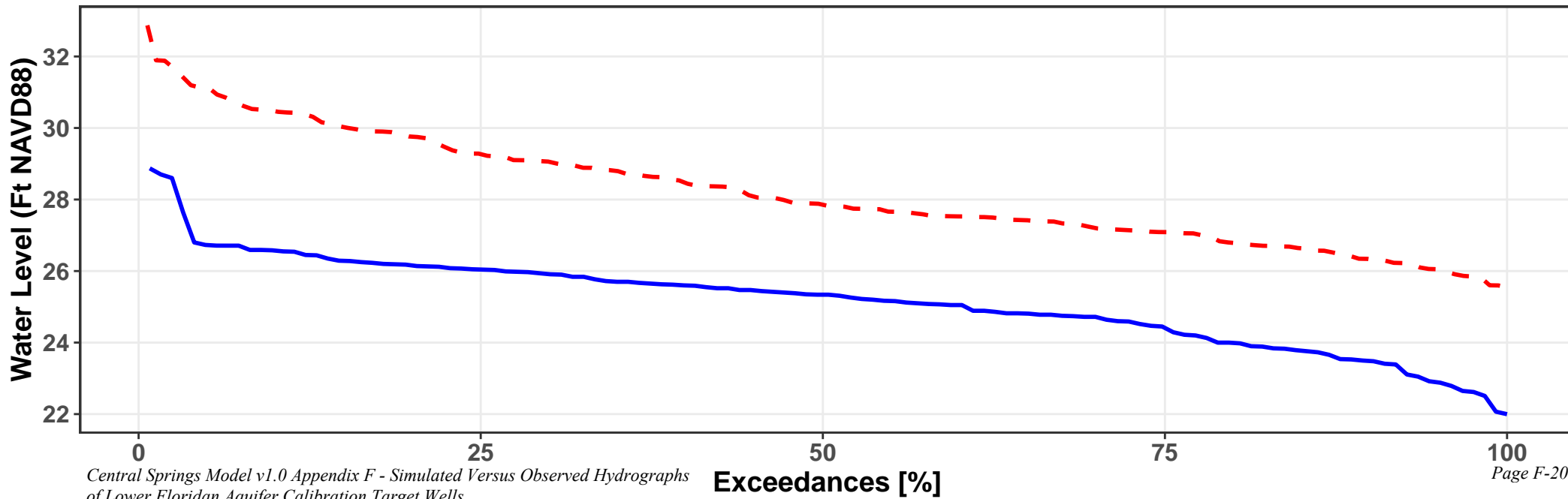
V-0100 – LFA @ Deland USGS

ME = 2.9 MAE = 2.9 $R^2 = 0.5025$ NSE = -4.94

— Observed — Simulated



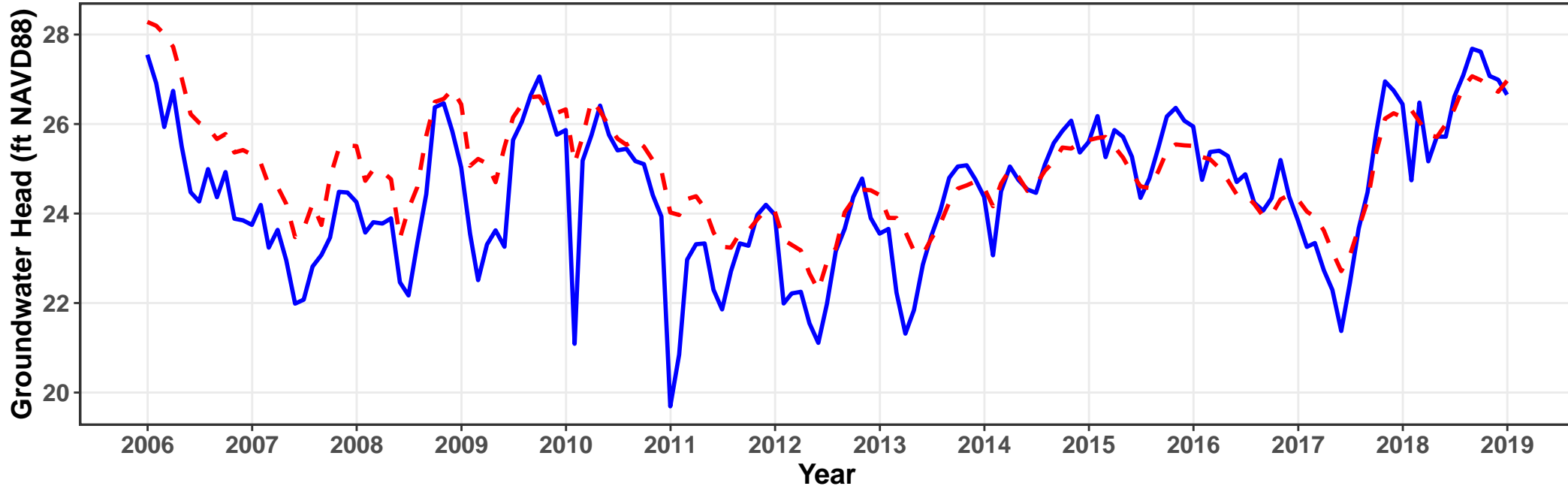
Stage Duration Curve



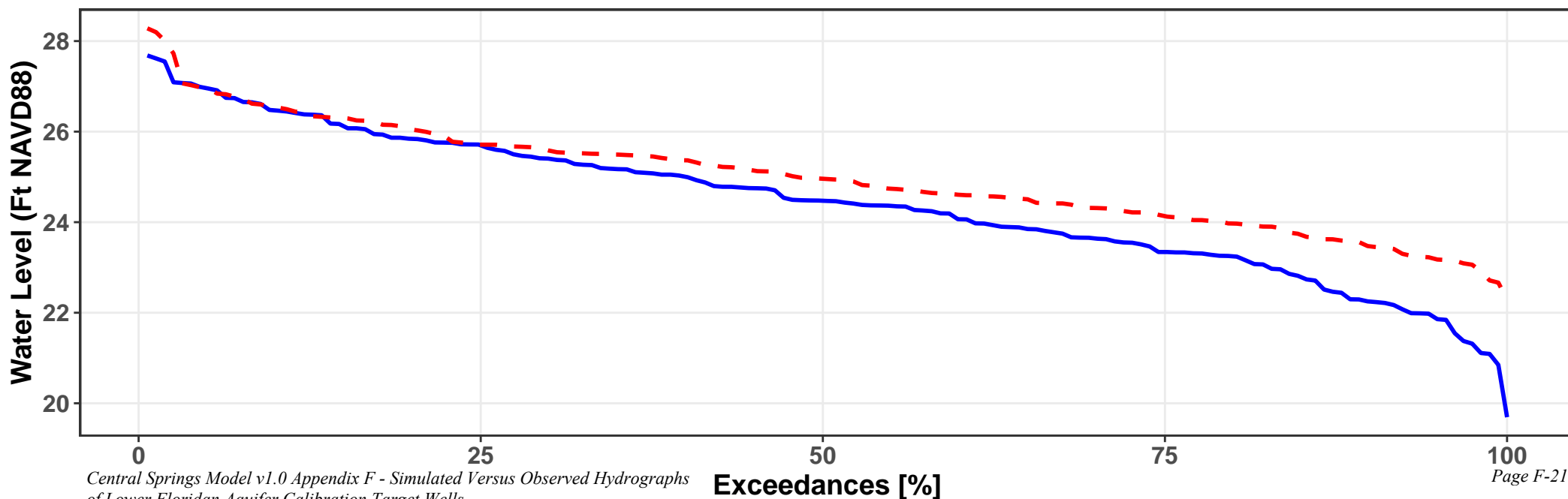
V-0530 – LFA @ Pierson AP

ME = 0.6 MAE = 0.8 $R^2 = 0.6852$ NSE = 0.556

— Observed — Simulated



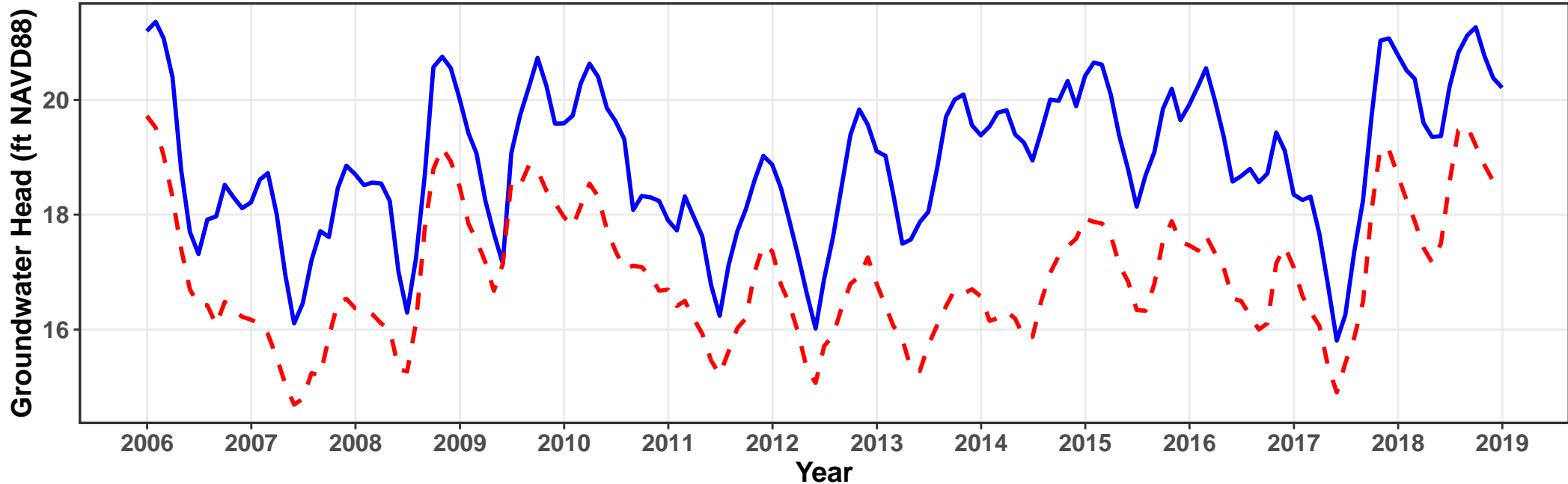
Stage Duration Curve



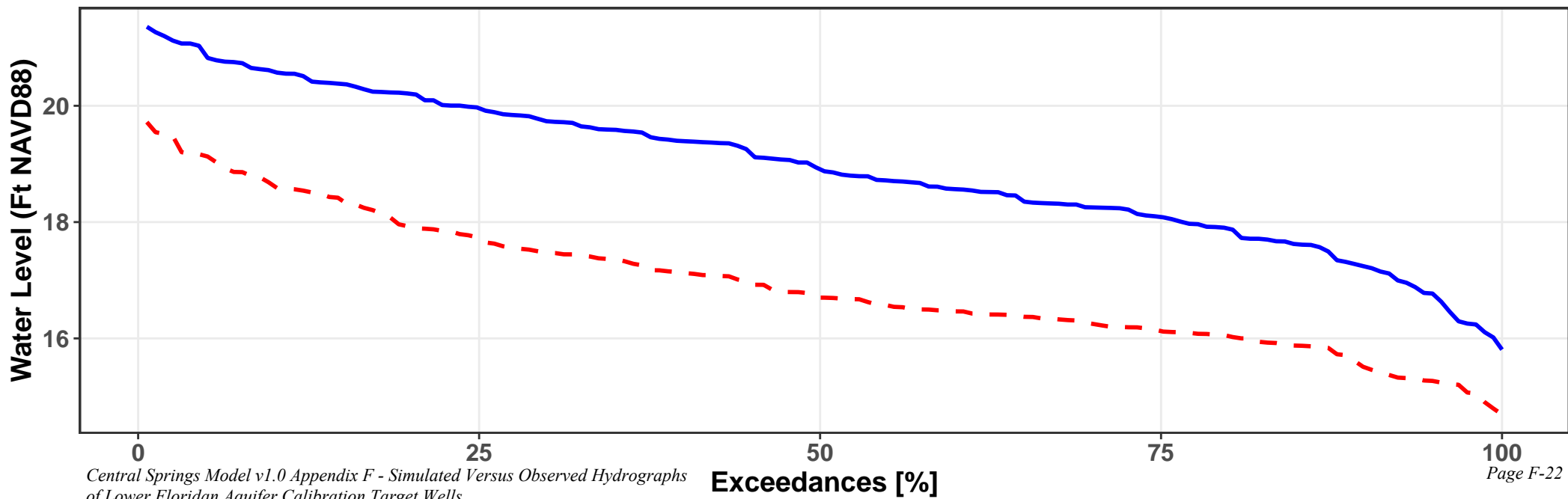
V-0774 – LFA @ Galaxy MS

ME = -2 MAE = 2 $R^2 = 0.749$ NSE = -1.681

— Observed - - Simulated



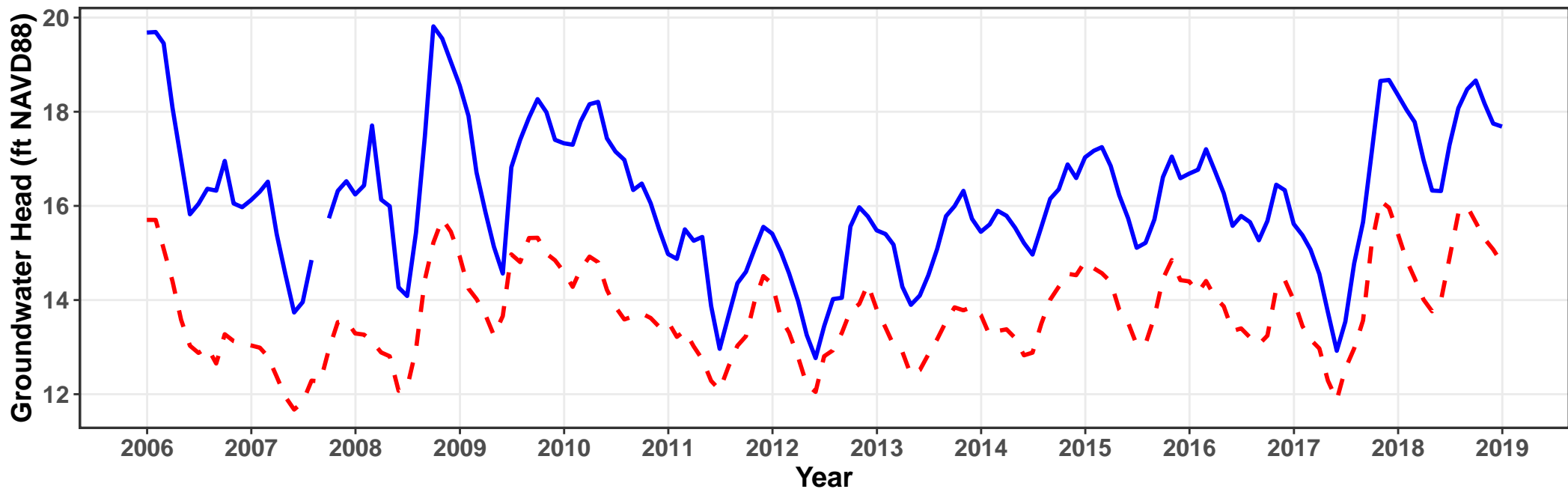
Stage Duration Curve



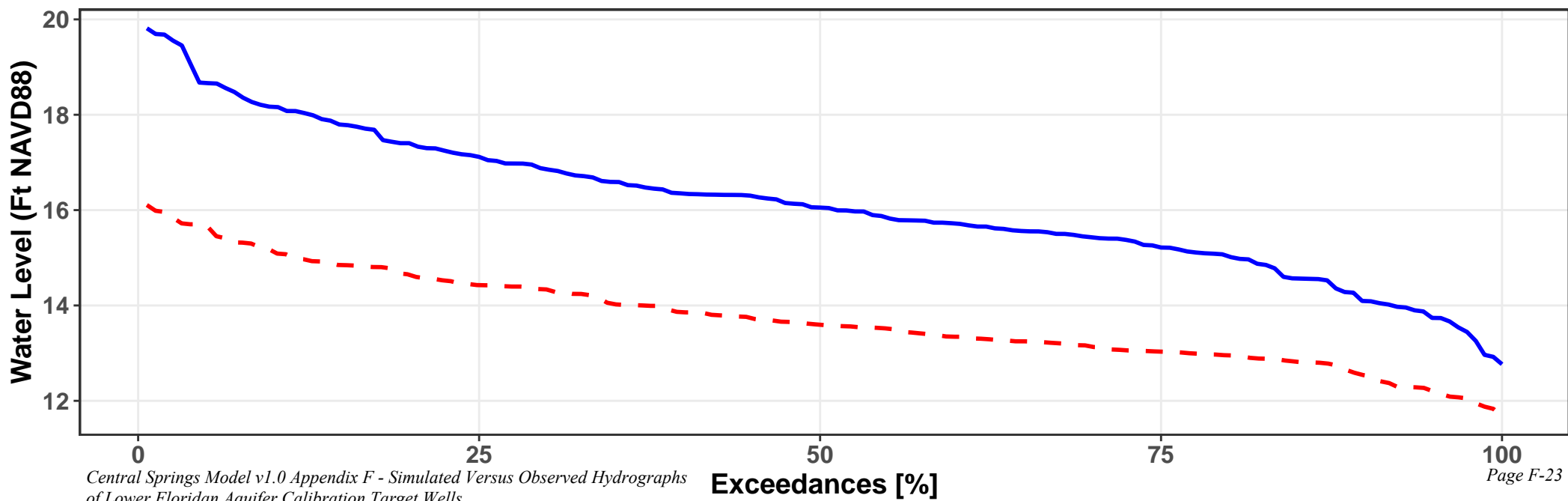
V-0780 – LFA @ Orange City Ftwr

ME = -2.4 MAE = 2.4 $R^2 = 0.7584$ NSE = -1.89

— Observed — Simulated



Stage Duration Curve

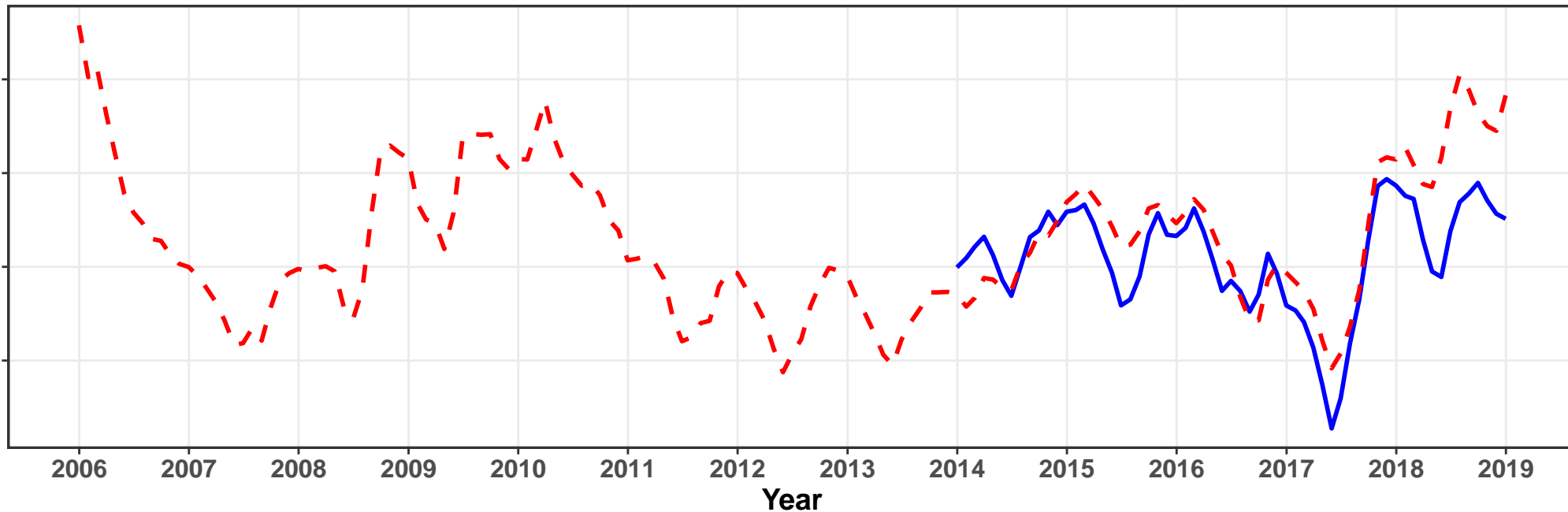


V-0802 – LFA @ Clark Bay

ME = 0.6 MAE = 0.8 $R^2 = 0.6462$ NSE = 0.06

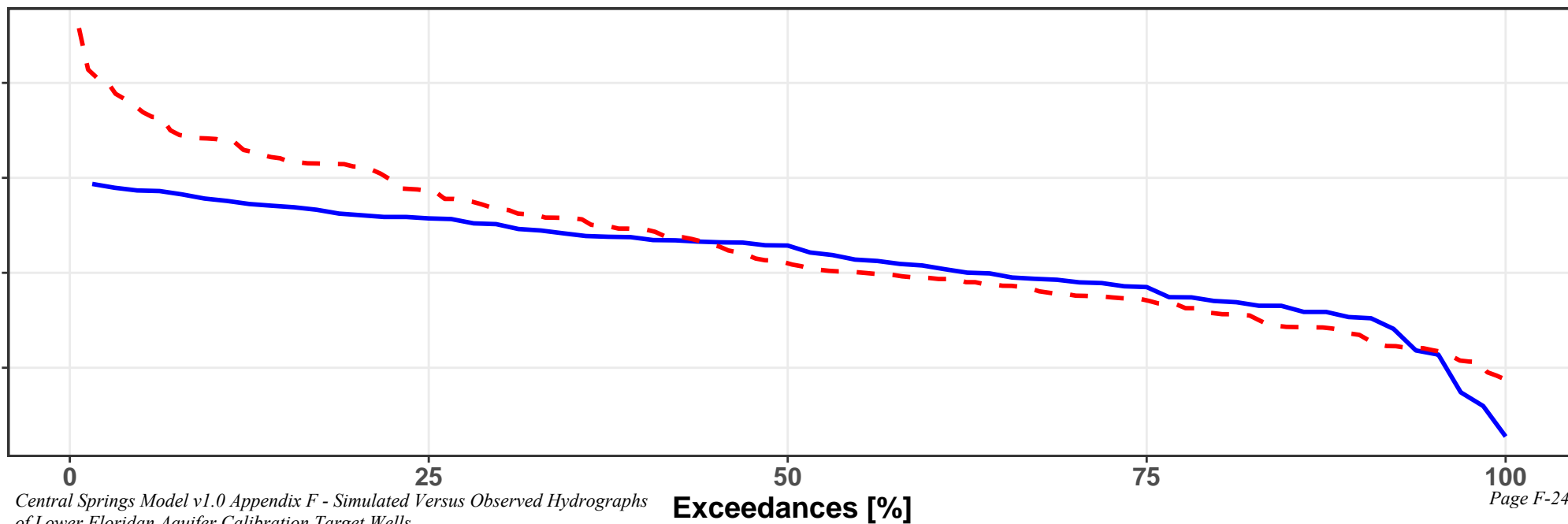
— Observed — Simulated

Groundwater Head (ft NAVD88)



Stage Duration Curve

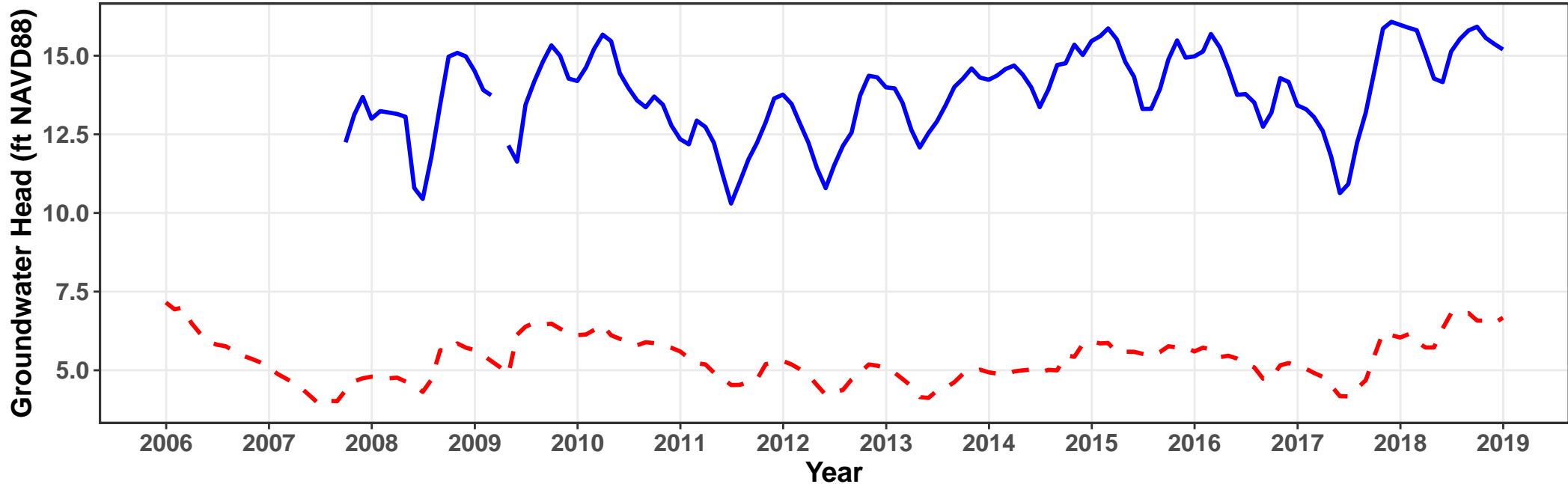
Water Level (Ft NAVD88)



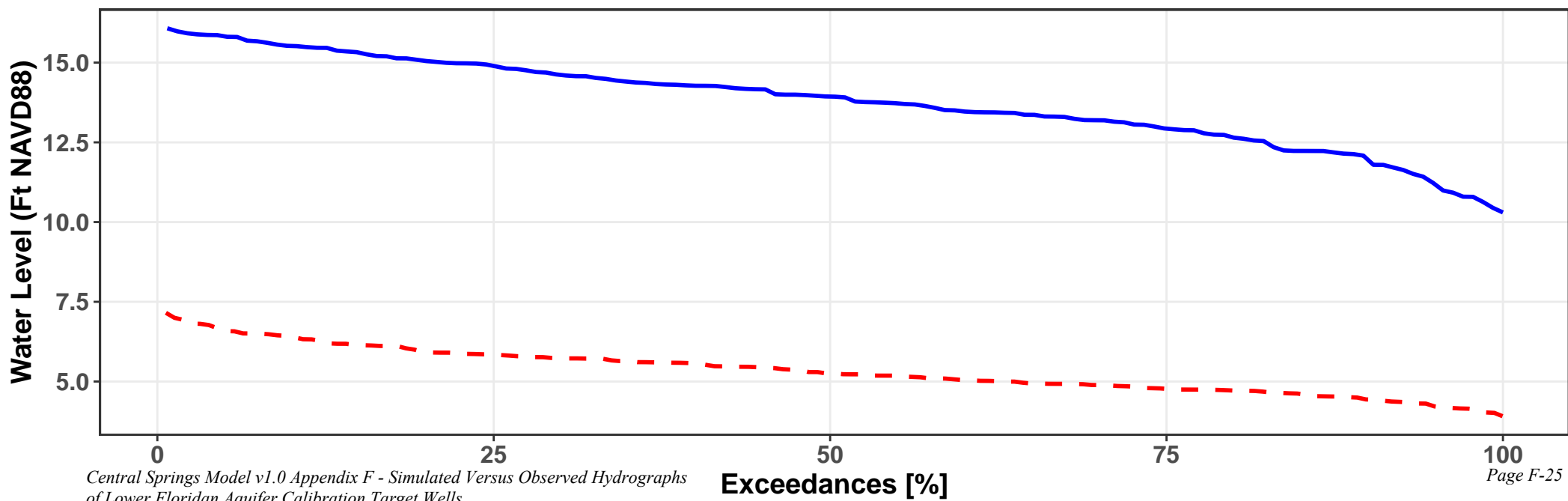
V-0817 - LFA @ Daytona Bch AP2

ME = -8.4 MAE = 8.4 $R^2 = 0.5399$ NSE = -37.781

— Observed — Simulated



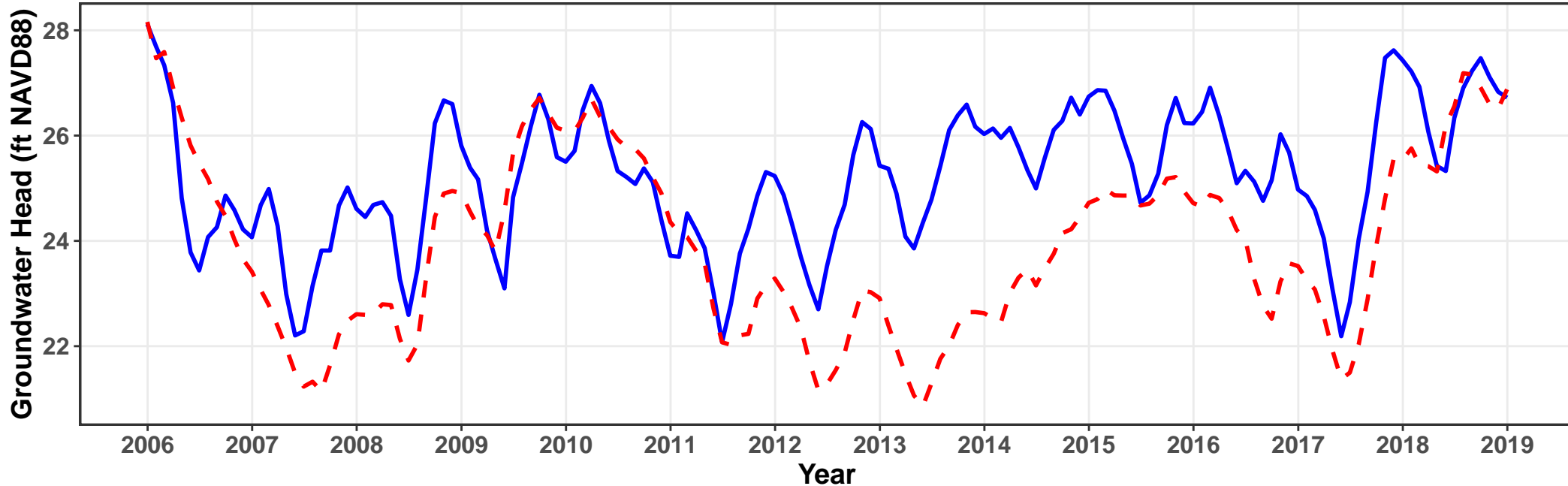
Stage Duration Curve



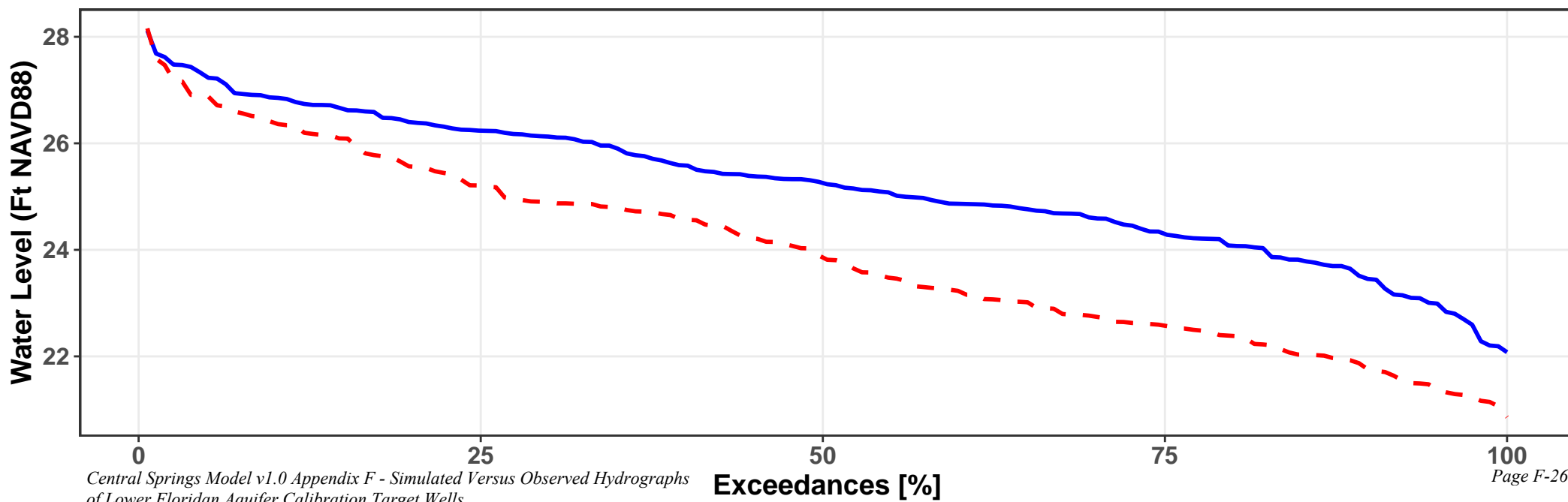
V-0819 – LFA @ Tiger Bay nr Samsula

ME = -1.3 MAE = 1.5 $R^2 = 0.4388$ NSE = -0.911

— Observed - - Simulated



Stage Duration Curve

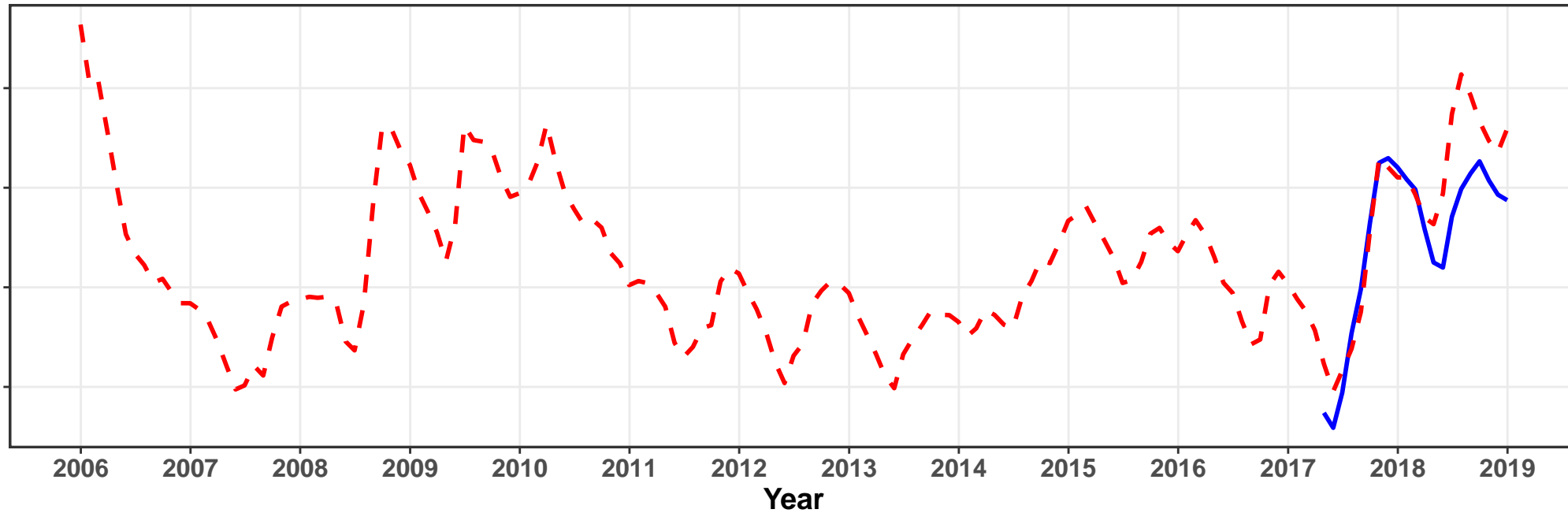


V-1252 – LFA @ Kemcho Wells

ME = 0.4 MAE = 0.8 $R^2 = 0.7398$ NSE = 0.593

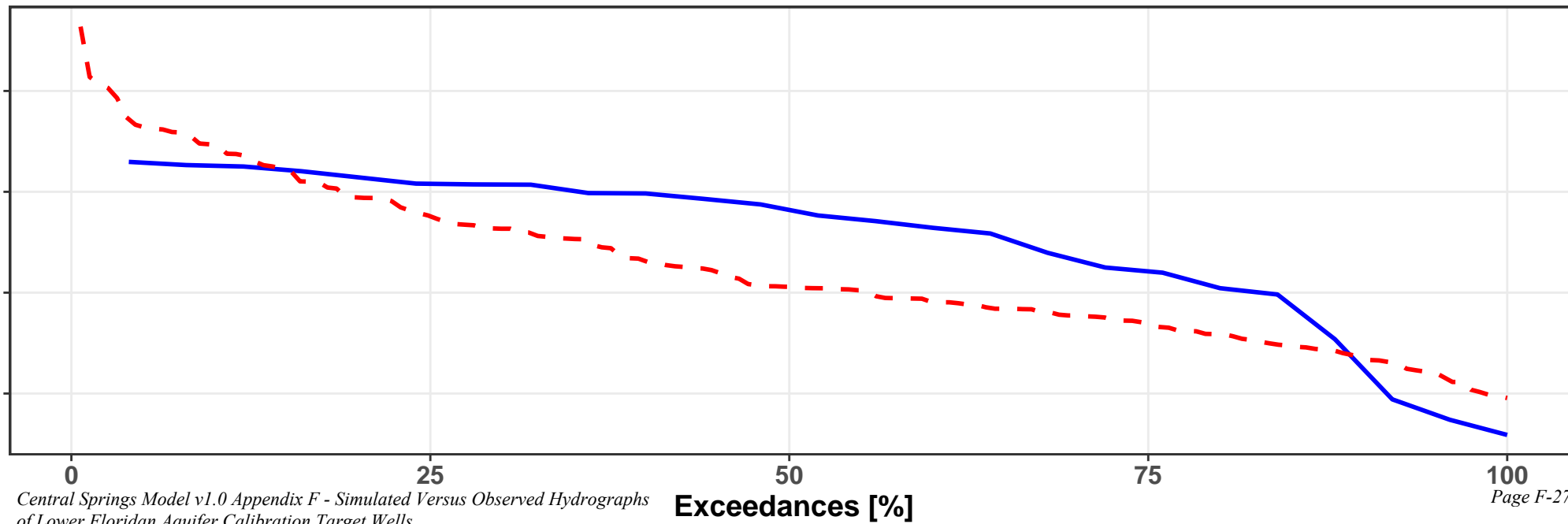
— Observed — Simulated

Groundwater Head (ft NAVD88)



Stage Duration Curve

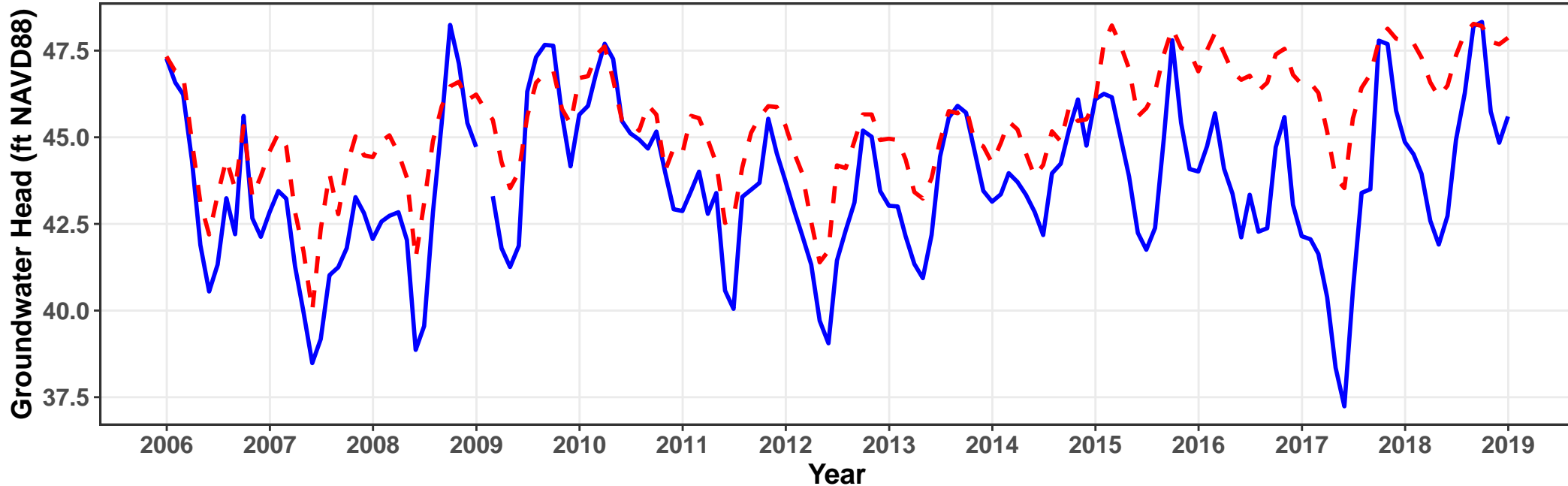
Water Level (Ft NAVD88)



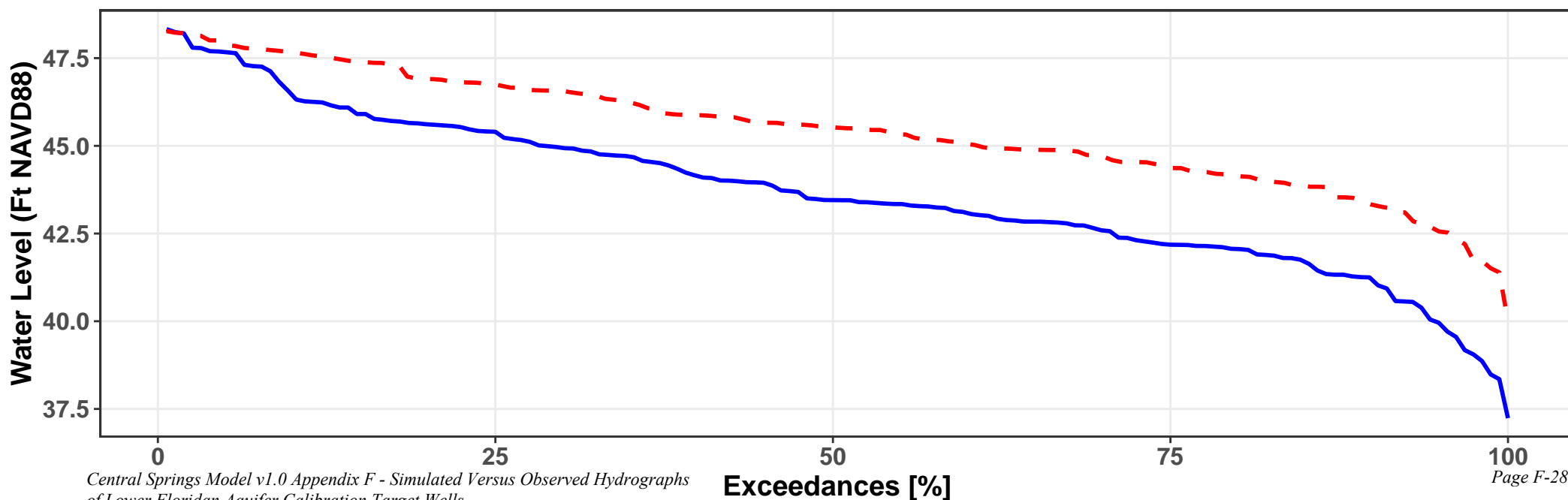
AIR19W2 @ PT638

ME = 1.8 MAE = 1.9 $R^2 = 0.598$ NSE = -0.05

— Observed - - Simulated



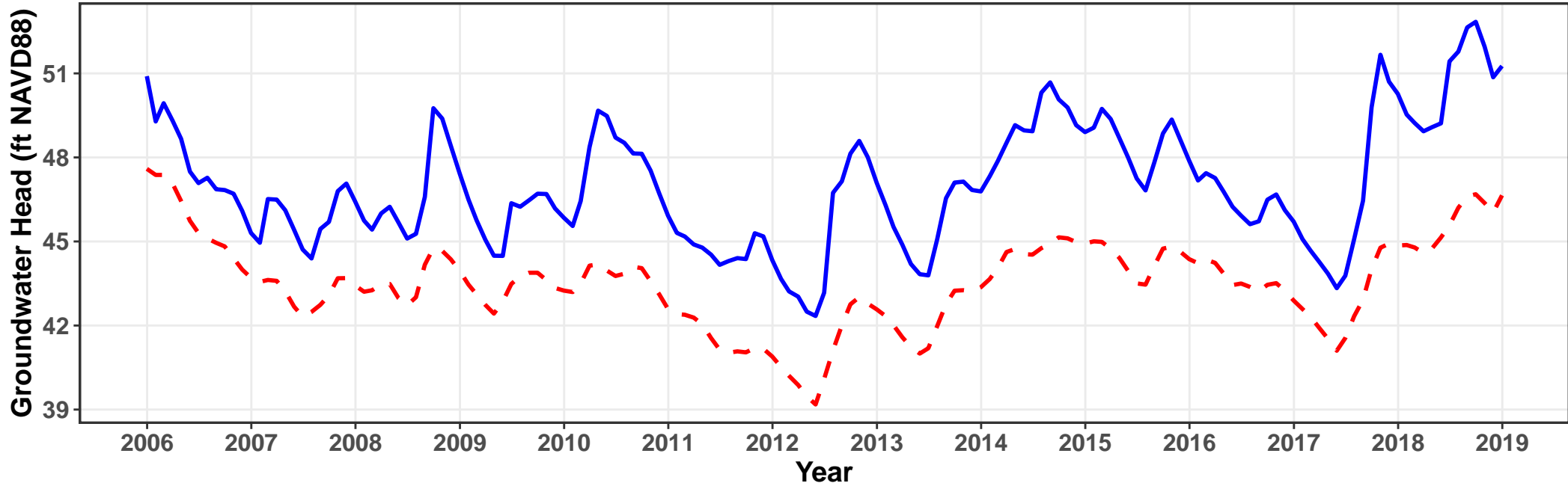
Stage Duration Curve



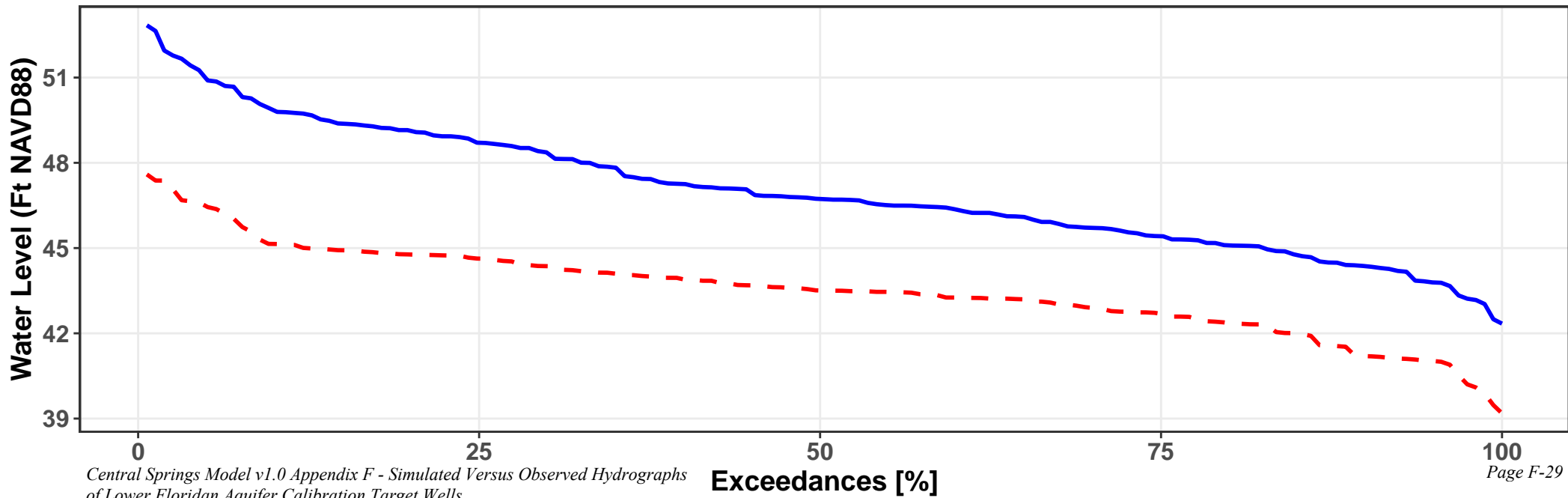
M-0628 – LFA @ Indian Lk SF Wells

ME = -3.5 MAE = 3.5 $R^2 = 0.7582$ NSE = -1.785

— Observed — Simulated



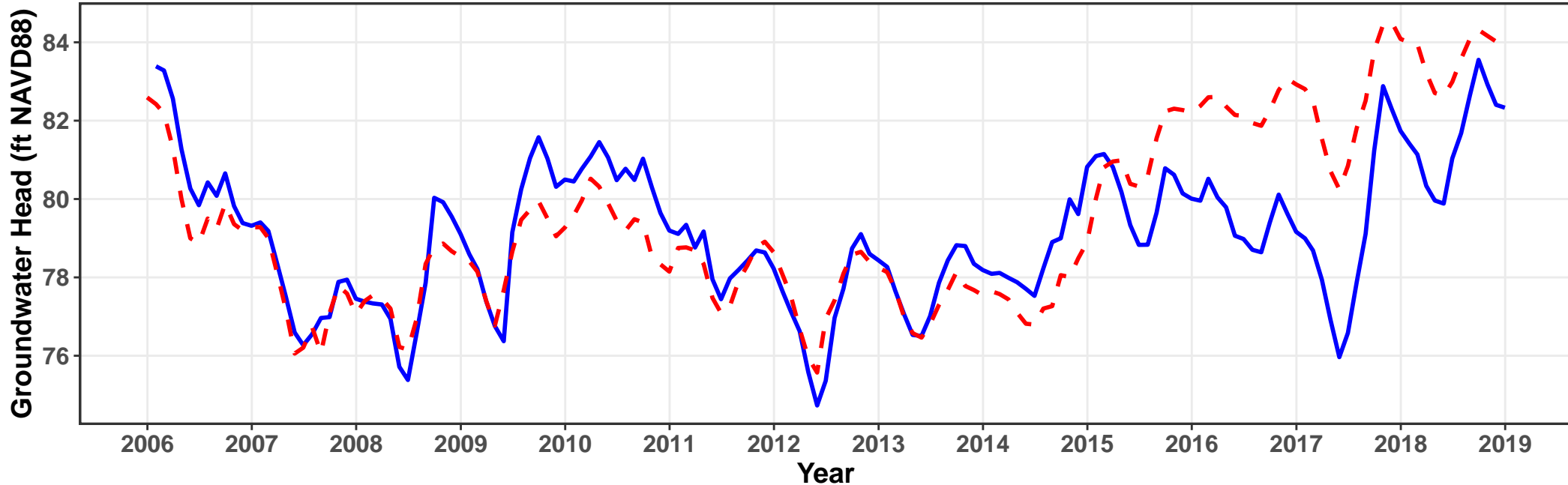
Stage Duration Curve



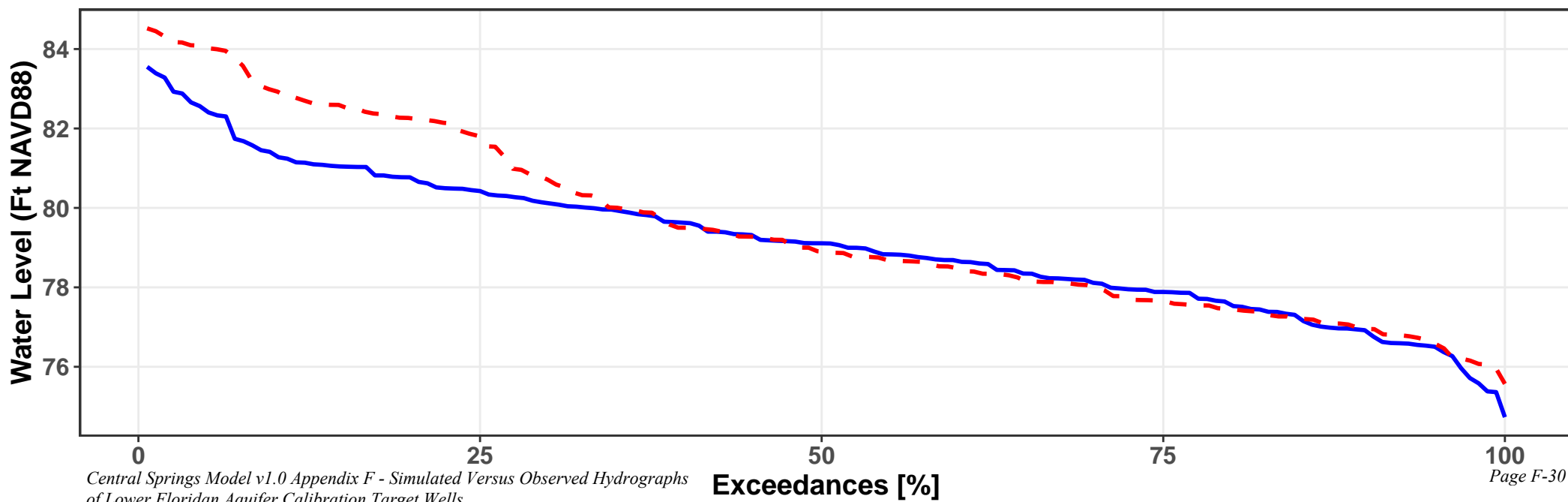
ORF-60 @ TO069

ME = 0.4 MAE = 1.2 $R^2 = 0.5538$ NSE = 0.208

— Observed - - Simulated



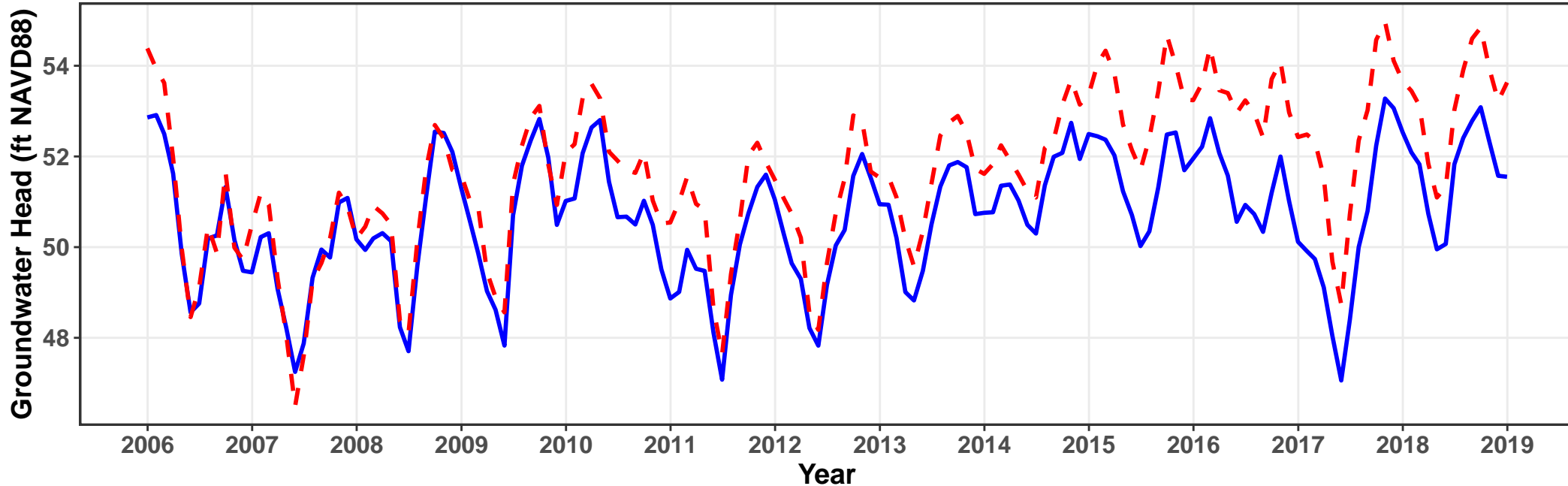
Stage Duration Curve



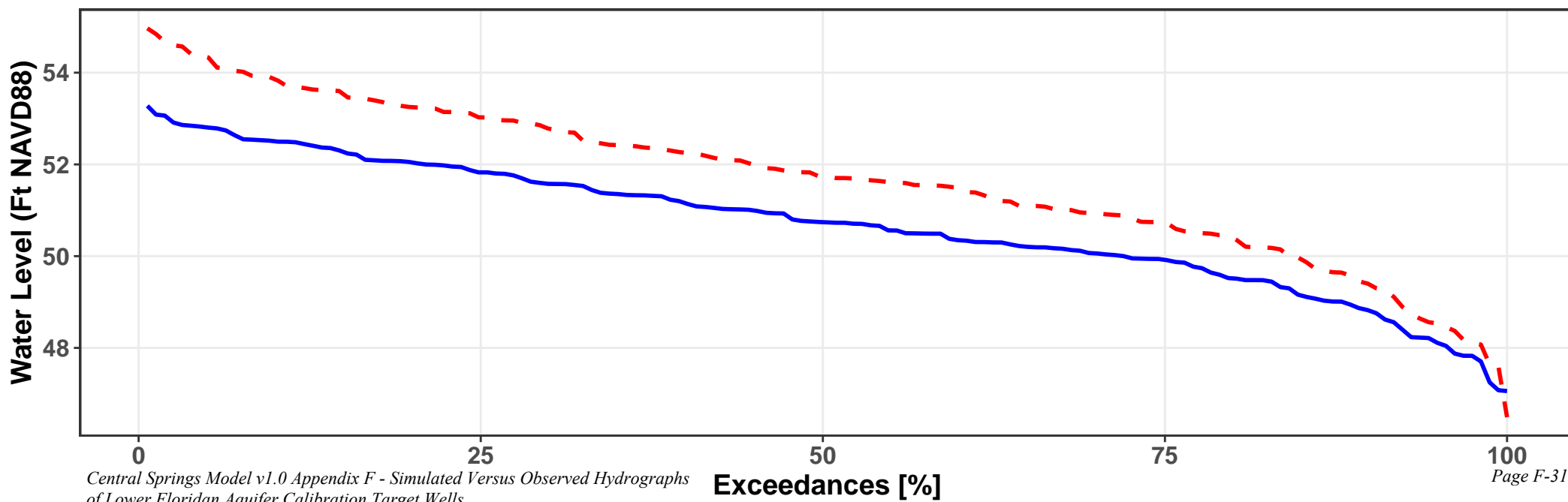
OSF-98 @ PS971

ME = 1 MAE = 1 $R^2 = 0.8324$ NSE = 0.244

— Observed - - Simulated



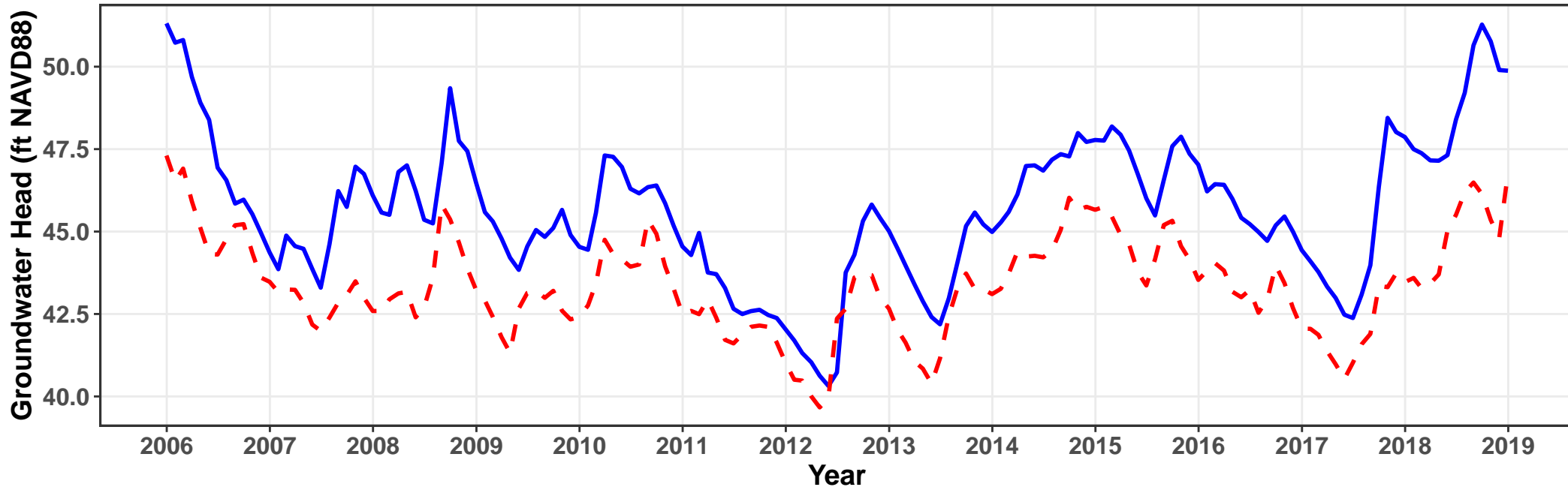
Stage Duration Curve



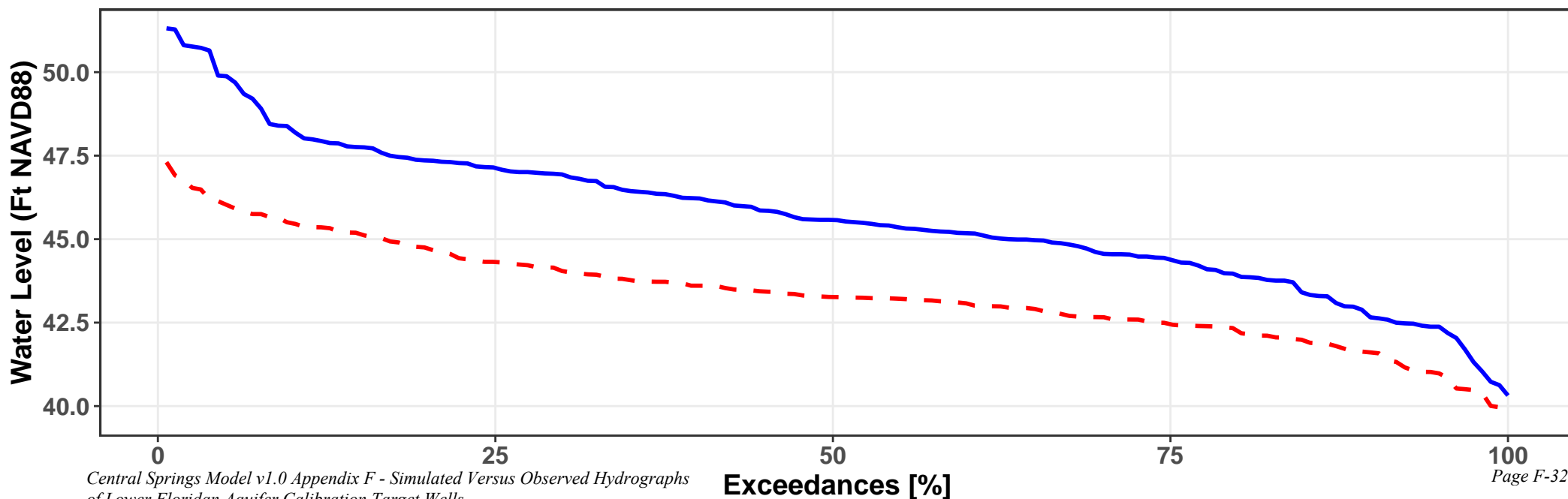
SID665234 @ ROMP 119.5 L Fldn Aq (Below MCU I) Sulfate Monitor

ME = -2.3 MAE = 2.3 $R^2 = 0.7851$ NSE = -0.334

— Observed - - Simulated



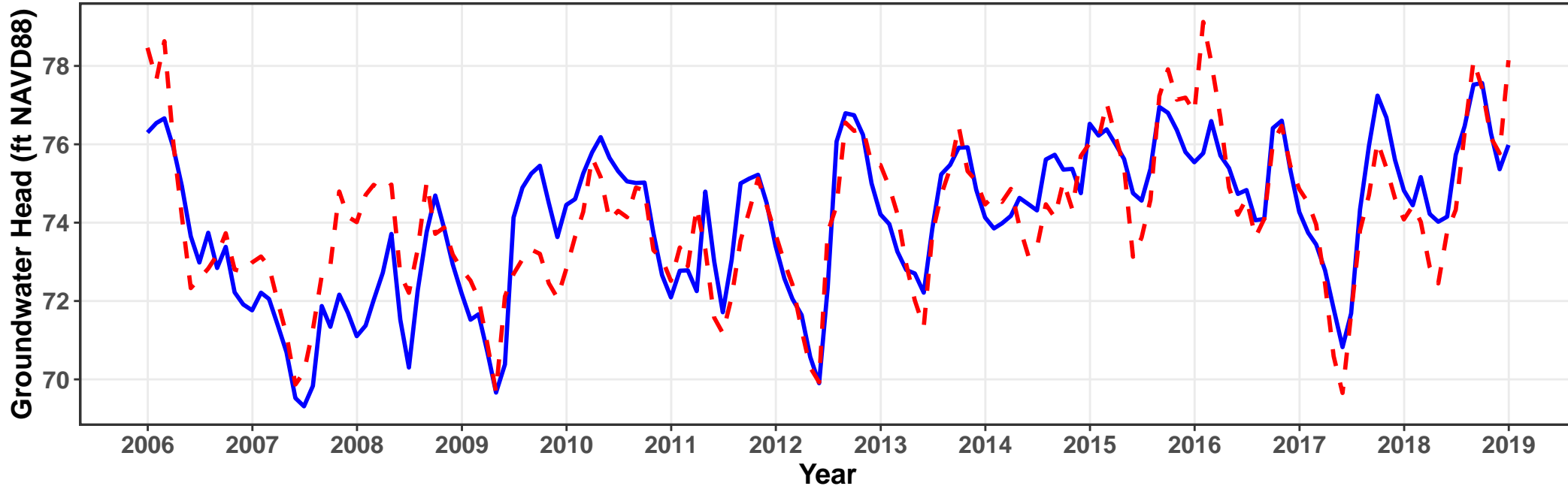
Stage Duration Curve



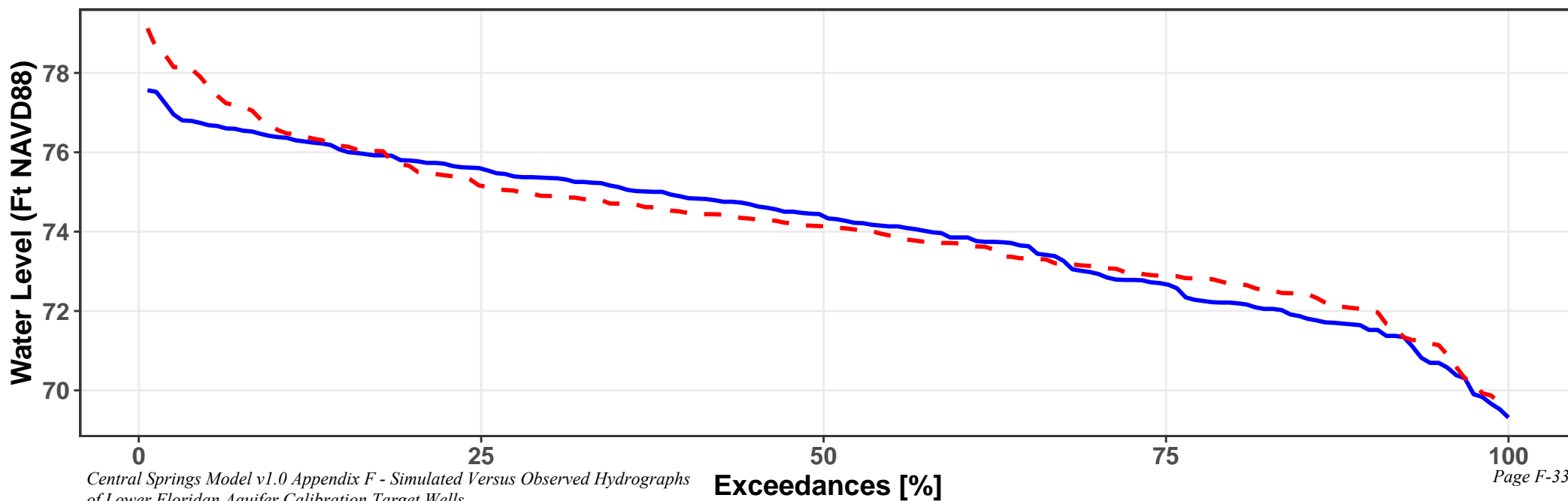
SID714922 @ ROMP 100 L Fldn Aq (Below MCU I) Monitor

ME = 0.1 MAE = 0.9 $R^2 = 0.6786$ NSE = 0.647

— Observed - - Simulated



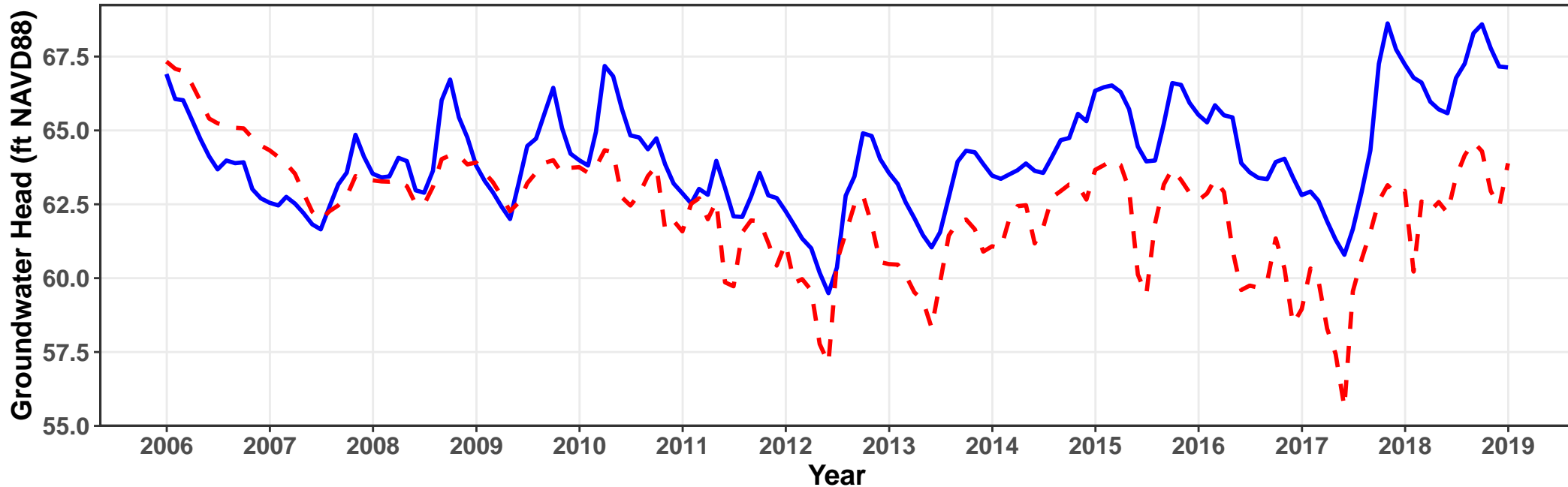
Stage Duration Curve



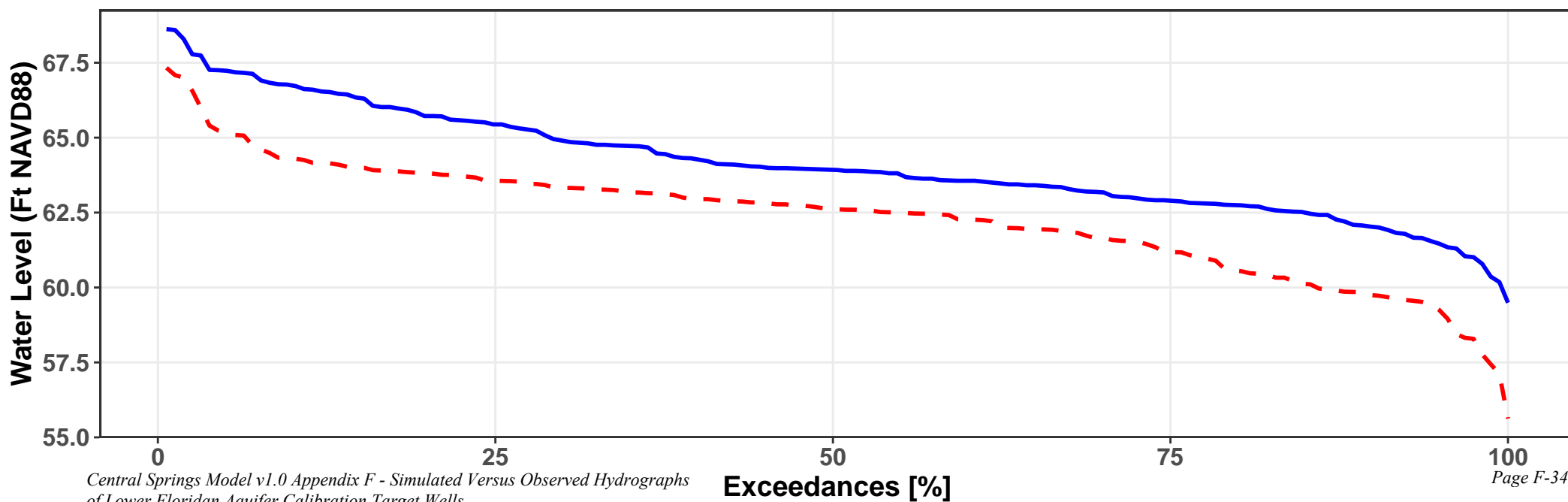
SID736139 @ ROMP 117 L Fldn Aq (Below MCU I) Temp Pump Monitor

ME = -1.8 MAE = 2.1 $R^2 = 0.3417$ NSE = -0.924

— Observed - - Simulated



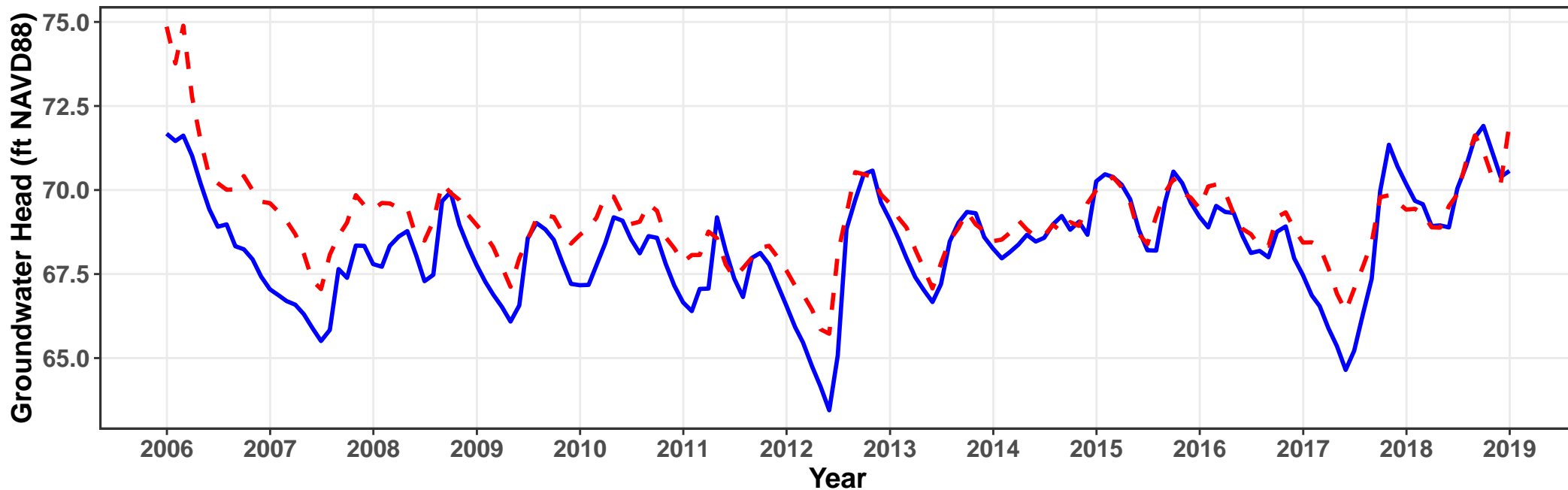
Stage Duration Curve



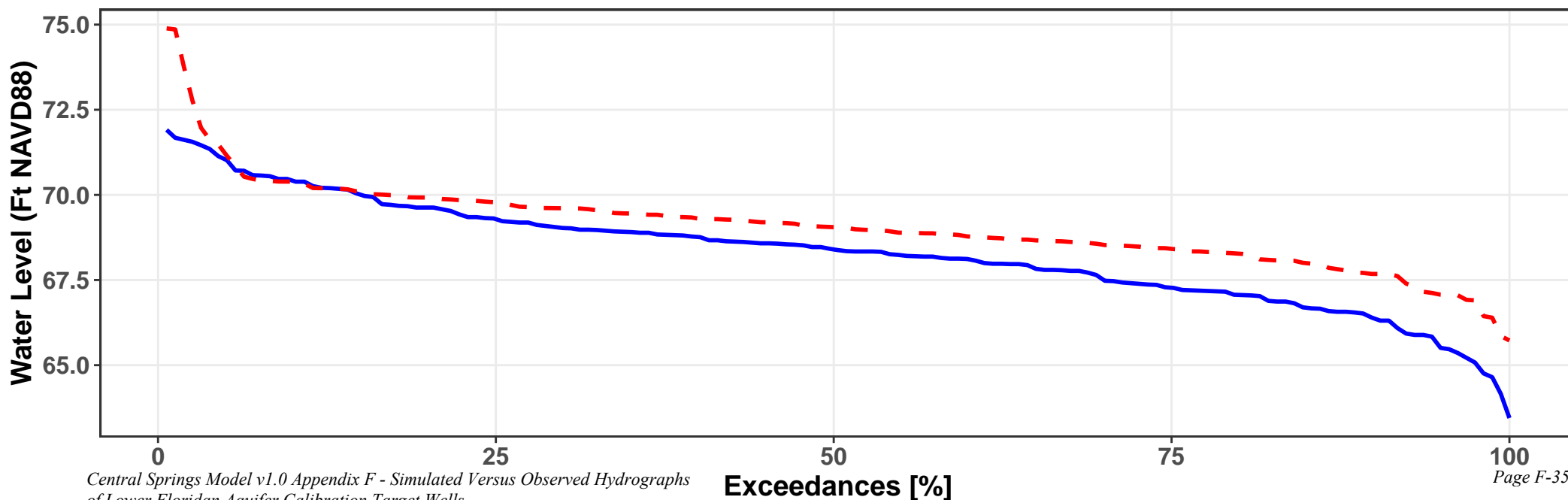
SID771460 @ ROMP 102.5 L Fldn Aq (Below MCU I) Monitor

ME = 0.8 MAE = 0.9 $R^2 = 0.7067$ NSE = 0.46

— Observed — Simulated



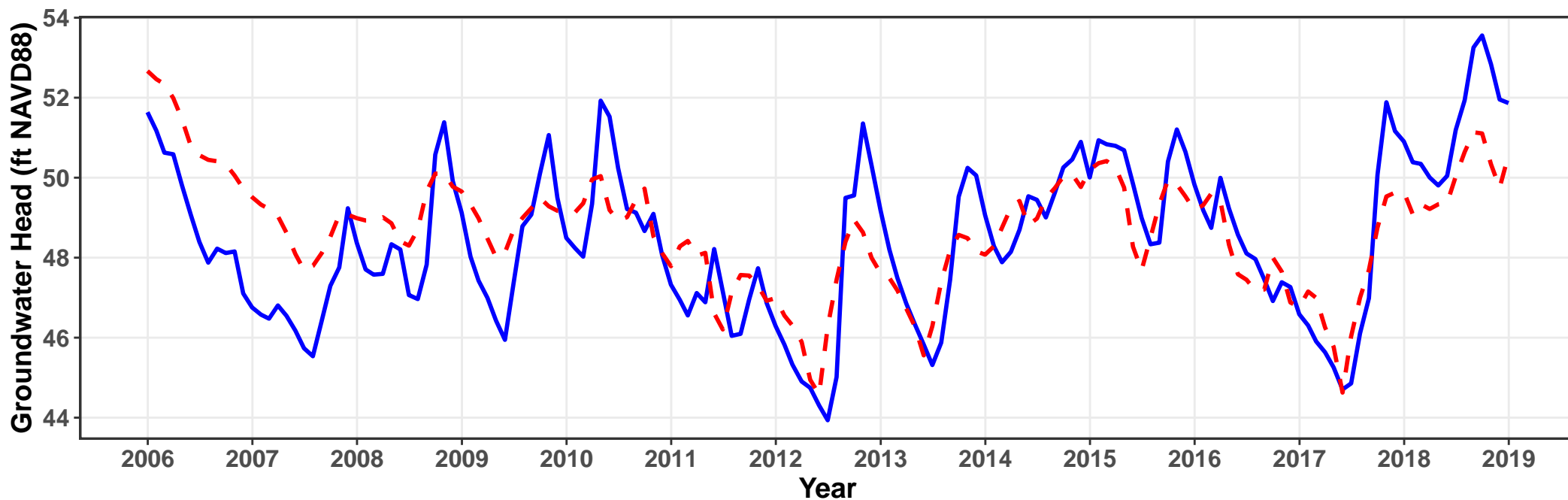
Stage Duration Curve



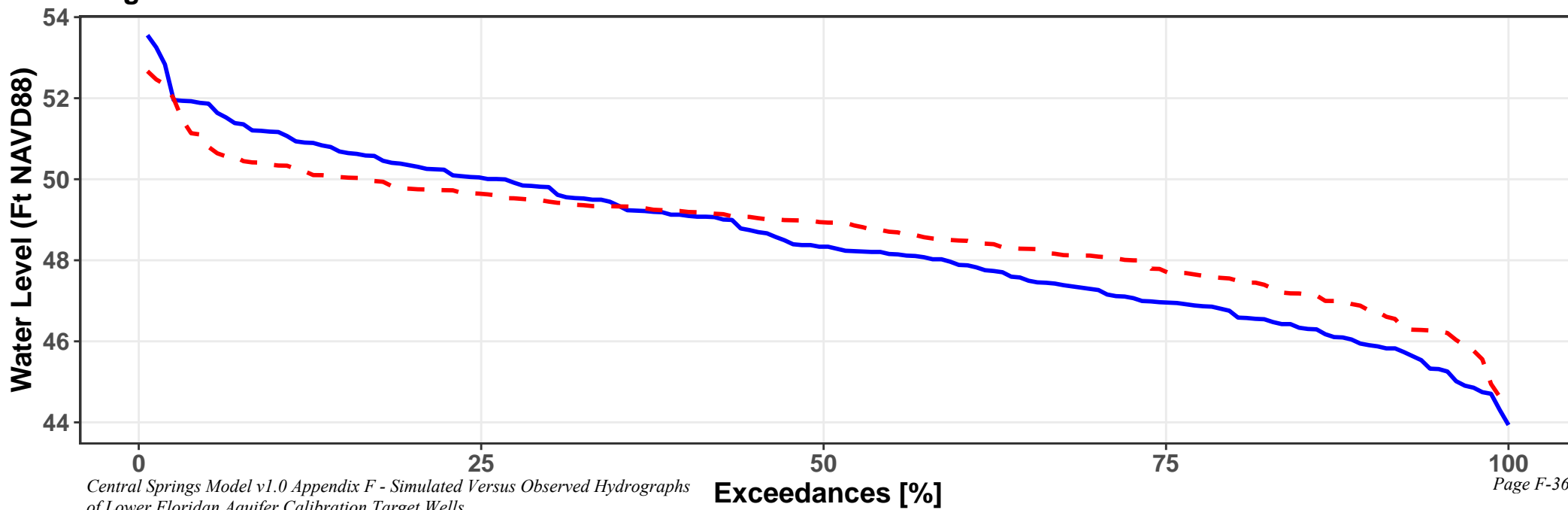
SID872386 @ ROMP 115 L Fldn Aq (Below MCU I) Monitor

ME = 0.2 MAE = 1.1 $R^2 = 0.576$ NSE = 0.563

— Observed - - Simulated



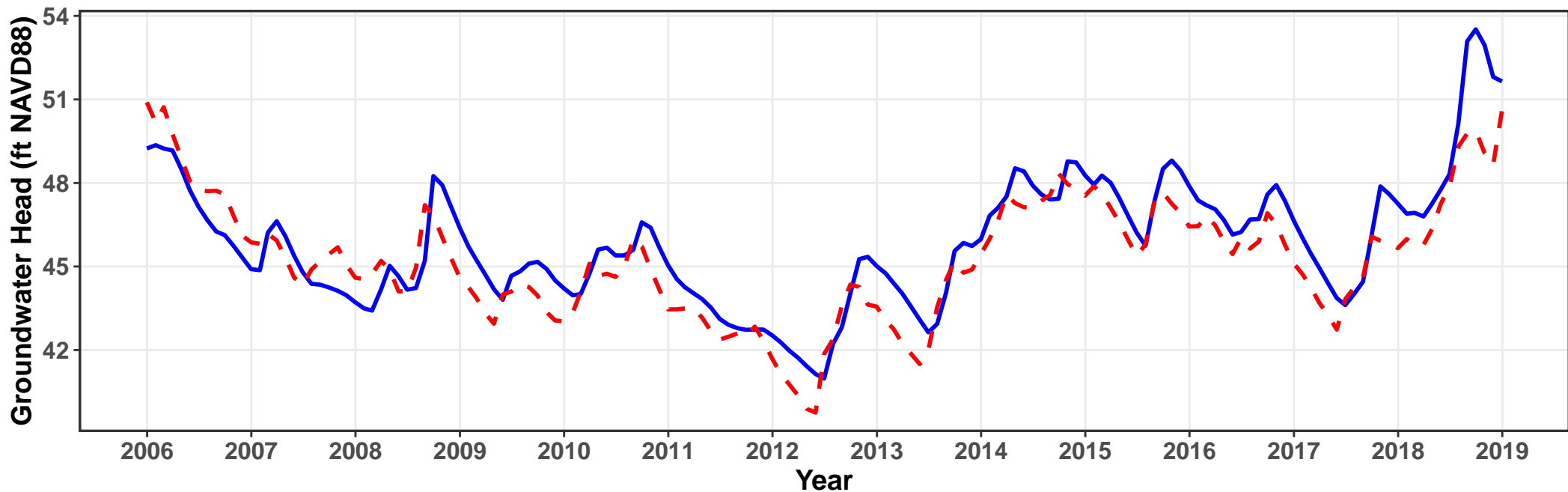
Stage Duration Curve



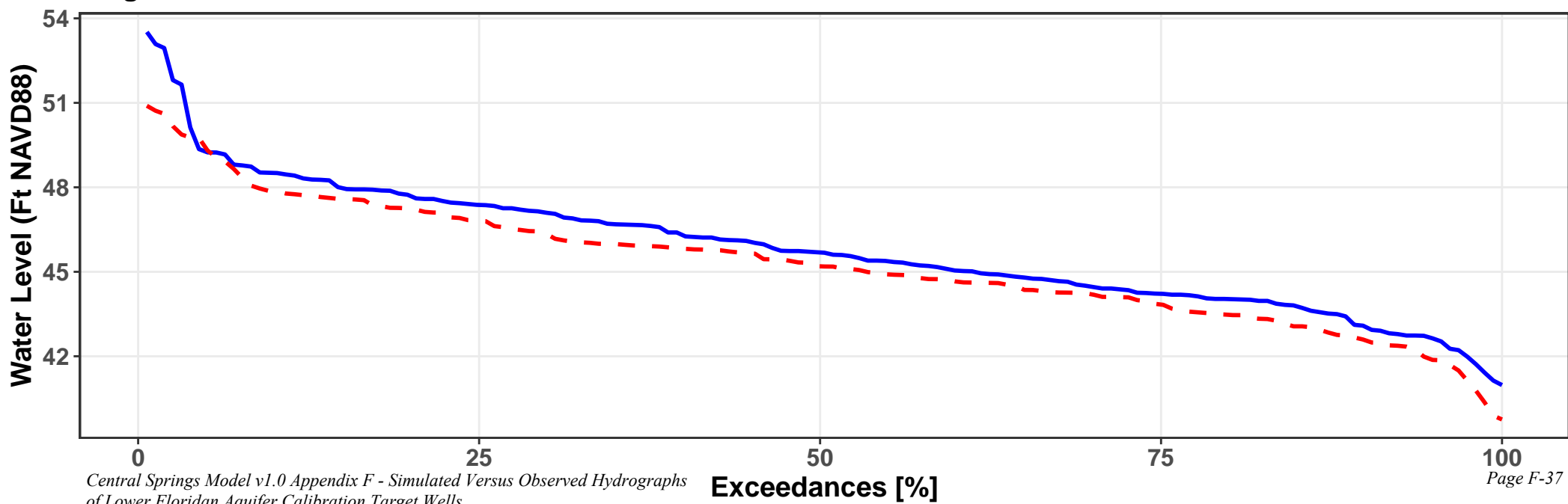
SID905297 @ ROMP 131.5 L Fldn Aq (Below MCU I) Monitor

ME = -0.6 MAE = 1 $R^2 = 0.8046$ NSE = 0.738

— Observed - - Simulated



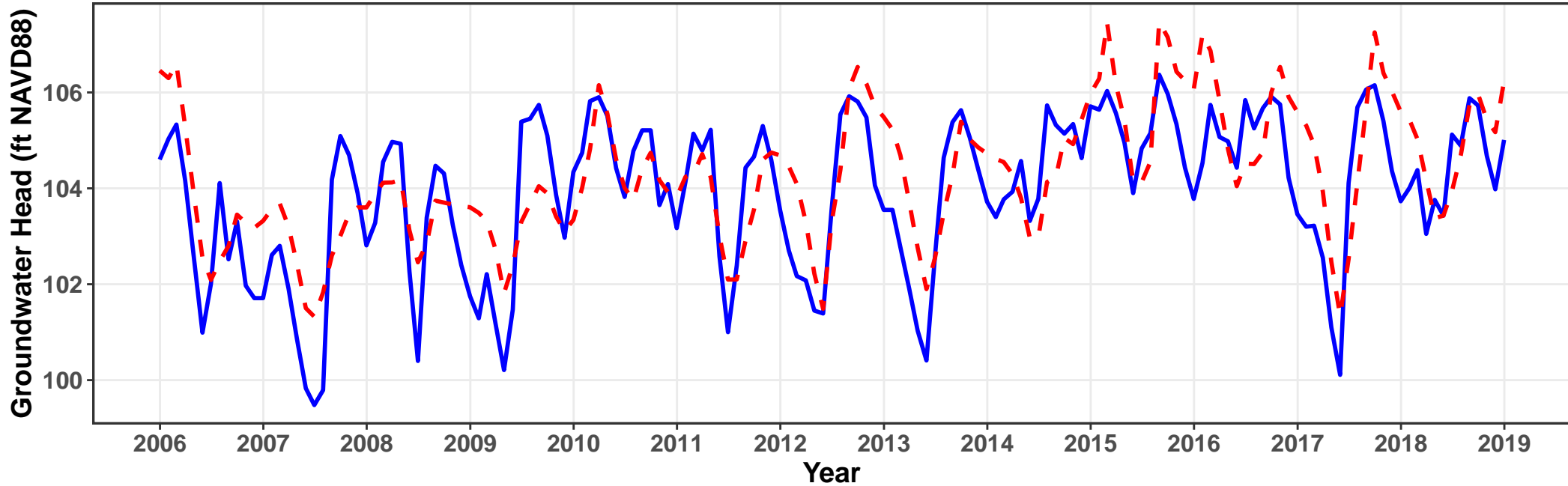
Stage Duration Curve



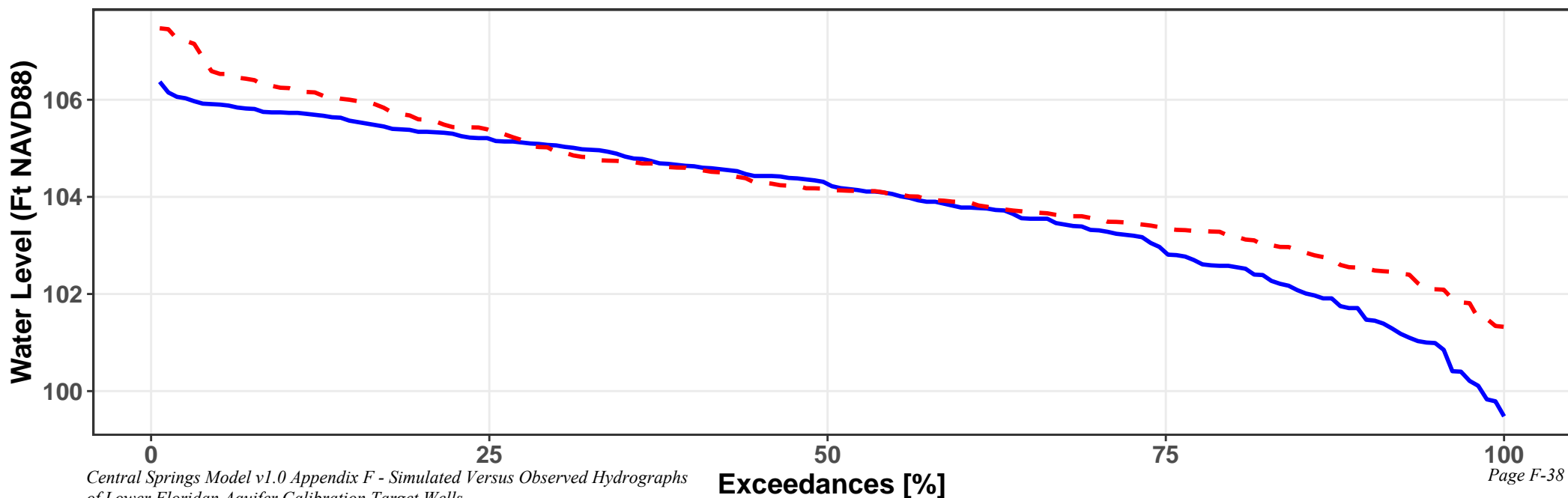
SID938830 @ ROMP 88 L Fldn Aq (bl MCU I) Monitor

ME = 0.4 MAE = 1 $R^2 = 0.5397$ NSE = 0.465

— Observed - - Simulated



Stage Duration Curve



TECHNICAL MEMORANDUM

TO: Michelle Brown, P.E., Bureau Chief, Bureau of Watershed Management & Modeling, St. Johns River Water Management District
Dua Guvanasen, P.E., Project Manager, HydroGeoLogic, Inc.

FROM: Hua Zang, P.G., Professional Hydrogeologist, Natural System and Restoration, Southwest Florida Water Management District
Ron Basso, P.G., Chief hydrogeologist, Natural System and Restoration, Southwest Florida Water Management District

DATE: February 10, 2022

SUBJECT: Lower Floridan Aquifer (LFA) targets for Central Spring Model (CSM) calibration

The Central Spring Model (CSM) includes the Lower Floridan Aquifer (LFA) below Middle Confining Unit I (MCU I). The calibration of CSM in the LFA requires adequate time series of groundwater head observations of target wells. The observation wells installed into the LFA generally contain varying lengths of observations, mainly from a few years to as many as ten. Because many of these wells were installed over the last decade, there is a general lack of LFA calibration targets in SWFWMD for the 2005 steady state model.

An examination of available time series reveals a strong correlation between observed groundwater heads of Upper Floridan Aquifer (UFA) and LFA. Therefore, a linear regression methodology is proposed to develop a synthesized time series of LFA target well water levels using available long-term monitoring data from UFA monitoring wells. A total of 8 LFA wells are included in this analysis (Table 1 and Figure 1). ROMP 75 LFA I well (SiteID: 861747) is located outside the CSM active domain but is included in the analysis to provide a soft target as it represents the highest LFA groundwater level observed in the area.

Pairs of UFA-LFA wells are identified using the following criteria: 1) Daily or Monthly monitoring time series at the UFA well started before year 2005; 2) Proximity between the LFA well and respective UFA well; and 3) Significant correlation between the observed groundwater level between the UFA and LFA well pair. The 8 selected UFA-LFA pair is given in Table 1 and their locations are plotted in Figure 1.

Monitoring at the UFA wells at ROMP 119.5 and ROMP 88 was initiated before the year 2005 and used to hindcast LFA heads at the same site. UFA wells at other 6 sites all started after year 2005 and UFA wells in the vicinity of the sites were identified. For ROMP 131.5, daily time series at USGS Near Bronson (S131736001) was obtained from the Suwannee River Water Management District (SRWMD). For both ROMP 115 and ROMP 117, monthly time series at Wildwood (SiteID: 23135) was used for the linear regression. Daily monitoring data at Webster City Fldn (SiteID: 23078) was used for the hindcast of ROMP 102.5 because of their strong correlation. UFA well at ROMP 101 (SiteID: 17728) was used to estimate the LFA water level at ROMP 100 and UFA well at ROMP 76 (SiteID: 17696) was used for ROMP 75. Daily or monthly time series of the monitoring wells are downloaded from the Environmental Data Portal (EDP) of the SWFWMD and all available time series are illustrated in Figures 2-9.

Linear regression was applied to the daily or monthly time series of the UFA-LFA well pairs. The regression results are displayed on Figures 10-17. Regression statistics and calculated parameters are given in Table 2. The regression results demonstrate that there is significant correlation (coefficient of determination R^2 between 0.85 and 0.98) between UFA and LFA wells for the 8 well pairs. The root mean square error (RMSE) of linear estimation was between 0.17 and 0.89 ft. The equations (Figures 10-17) established from the linear regression analysis were then used to hindcast the LFA water levels prior to the commencement of observation. Comparison between estimated and monitored water levels are illustrated in Figures 18-25.

As a final step, a synthesized dataset of monthly water level was developed for the 8 LFA target wells. The synthesized dataset is a combination of monthly observed time series at LFA monitoring wells and hindcasted water levels using linear equations where monitored data is not available. The monthly time series of synthesized LFA water levels for the years 2005-2018 is illustrated in Figure 26 and the mean annual water level is shown in Table 3. Based on the result of the analysis, we recommend using the synthesized LFA time series for the calibration of CSM model.

Table 1. UFA-LFA well pairs used in the linear regression and reconstruction of LFA groundwater level time series.

LFA I Well		UFA Well		Distance (mile)	Frequency
Name	ID	Name	ID		
ROMP 131.5	905297	USGS Near Bronson	S131736001	5.7	Daily
ROMP 119.5	665234	ROMP 119.5 U Fldn Aq	23244	0.4	Daily
ROMP 115	872386	Masters Avenue at Wildwood	23135	7.0	Monthly
ROMP 117	736139	Masters Avenue at Wildwood	23135	3.0	Monthly
ROMP 102.5	771460	Webster City Fldn	23078	4.5	Daily
ROMP 100	714922	ROMP 101 U Fldn Aq	17728	9.8	Daily
ROMP 88	938830	ROMP 88 U Fldn Aq (Avpk)	17708	0.02	Daily
ROMP 75	861747	ROMP 76 U Fldn Aq	17696	5.1	Daily

Table 2. Linear regression statistics.

Name	R ²	RMSE ft	Slope	Intercept ft
ROMP 131.5	0.983	0.26	0.71	14.92
ROMP 119.5	0.882	0.89	0.80	9.33
ROMP 115	0.865	0.83	0.84	7.94
ROMP 117	0.857	0.79	0.72	29.1
ROMP 102.5	0.880	0.62	0.65	15.5
ROMP 100	0.846	0.62	1.27	-50.0
ROMP 88	0.984	0.17	0.91	9.84
ROMP 75	0.944	0.34	1.18	-30.31

Table 3. Annual mean groundwater level of synthesized time series.

Year	ROMP 131.5	ROMP 119.5	ROMP 115	ROMP 117	ROMP 102.5	ROMP 100	ROMP 88	ROMP 75
	SID9052 97	SID6652 34	SID8723 86	SID7361 39	SID7714 60	SID7149 22	SID9388 30	SID8617 47
2005	49.2	51.2	51.5	66.8	71.4	76.2	104.6	122.7
2006	47.0	47.3	48.6	64.0	68.9	73.8	102.9	119.2
2007	44.8	46.1	46.7	62.8	66.6	70.9	102.3	116.3
2008	45.3	45.9	48.3	64.1	68.1	72.4	103.3	117.1
2009	44.7	44.7	48.1	63.9	67.2	72.9	103.3	117.4
2010	45.3	45.9	49.0	64.6	67.8	74.5	104.7	119.0
2011	43.3	43.0	46.7	62.7	67.2	73.5	104.0	118.6
2012	42.8	42.8	46.8	62.2	67.0	73.5	103.6	119.3
2013	44.3	43.8	47.5	62.7	67.8	74.0	103.4	119.6
2014	47.8	46.8	49.2	64.2	68.5	74.8	104.6	121.3
2015	47.6	47.0	49.9	65.5	69.3	75.7	105.2	123.0
2016	46.9	45.3	47.9	64.1	68.3	75.2	105.0	123.1
2017	45.4	44.6	47.3	64.0	67.2	73.9	103.8	122.0
2018	49.8	48.8	51.2	66.8	69.9	75.4	104.5	122.6

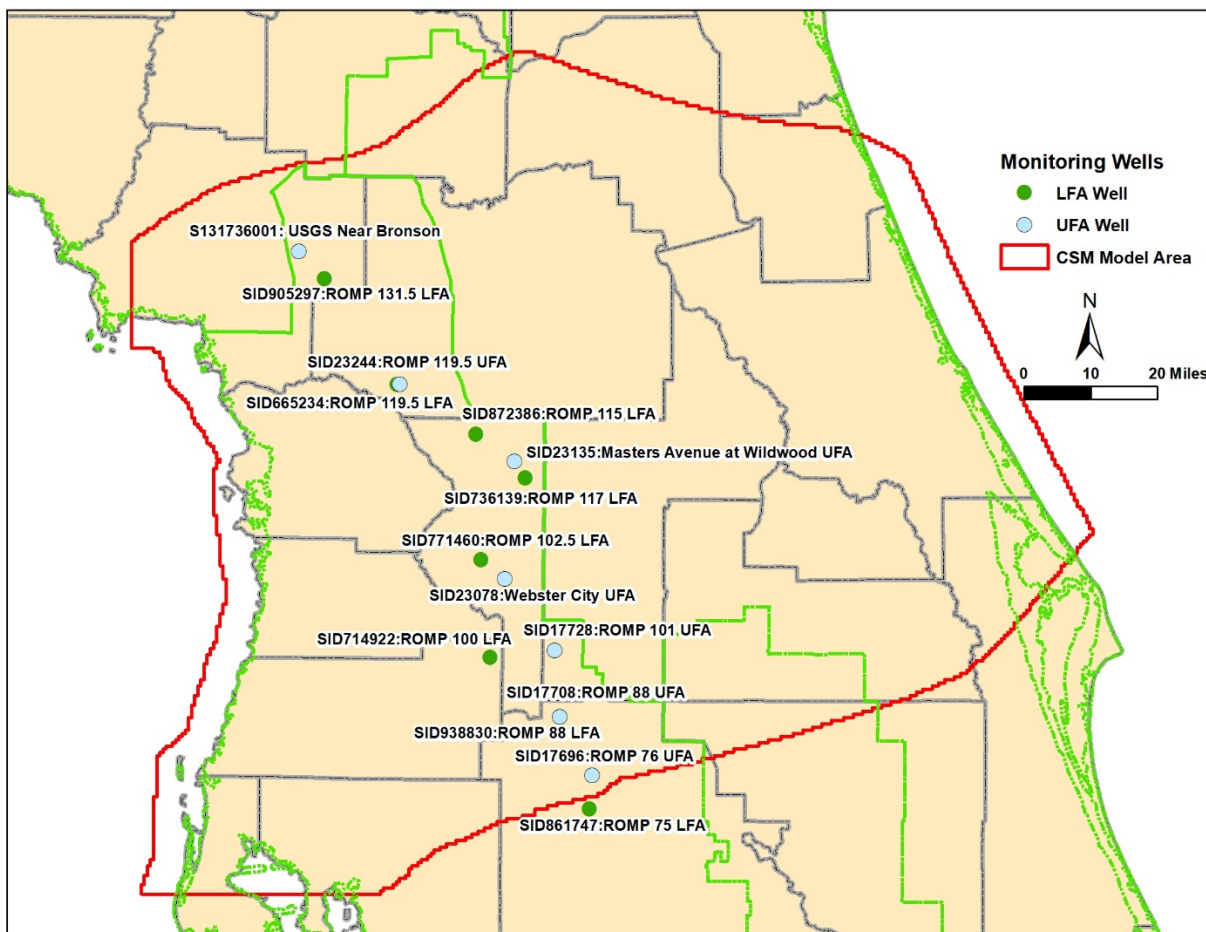


Figure 1. Location of the UFA-LFA well pairs for linear regression and time series reconstruction

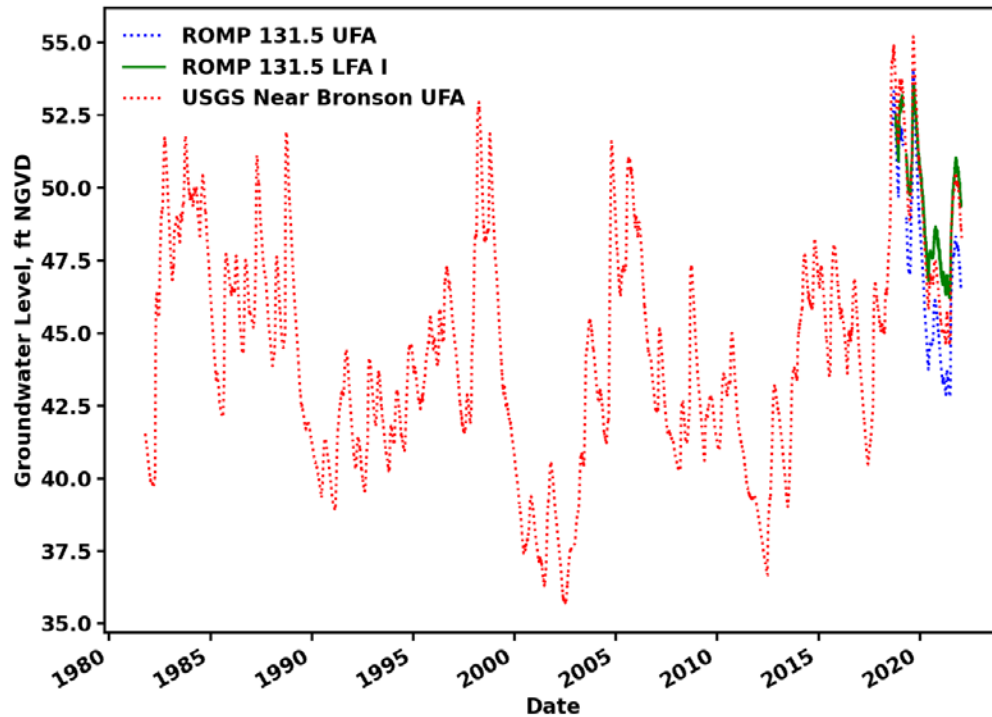


Figure 2. Monitored time series of groundwater level at ROMP 131.5 and USGS Near Bronson (S131736001)

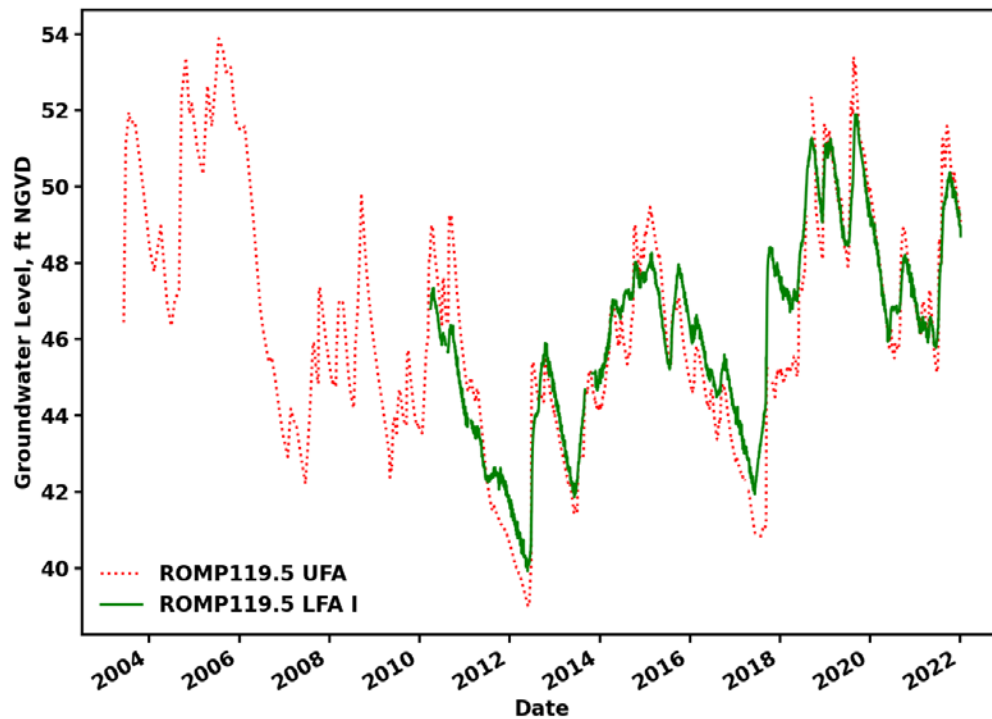


Figure 3. Monitored time series of groundwater level at ROMP 119.5

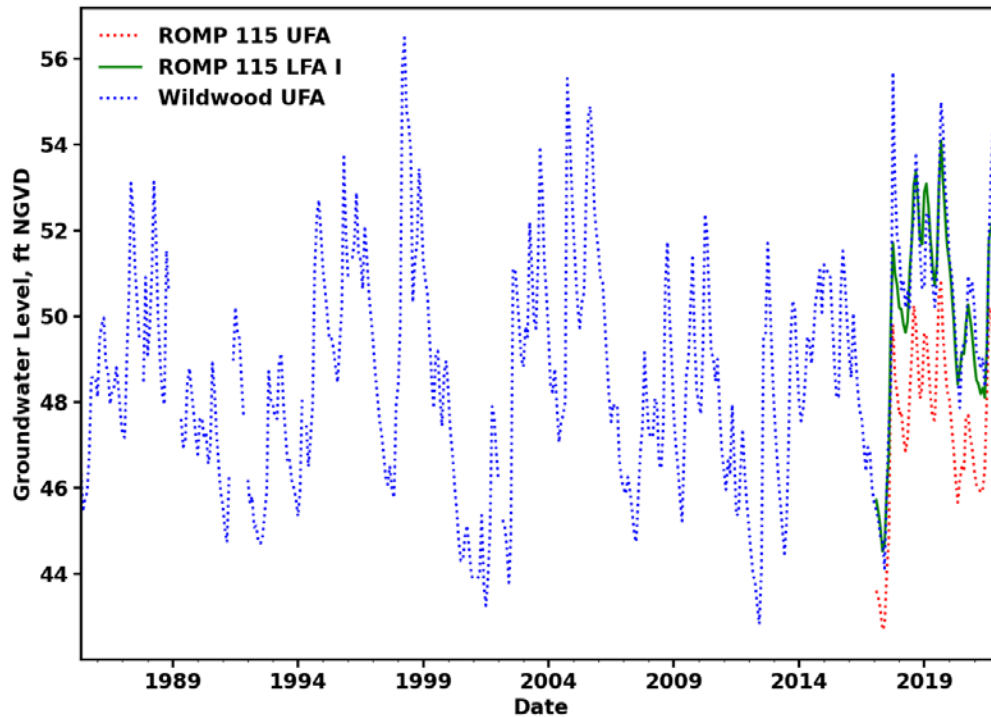


Figure 4. Monitored time series of groundwater level at ROMP 115 and Masters Avenue at Wildwood (SiteID: 23135)

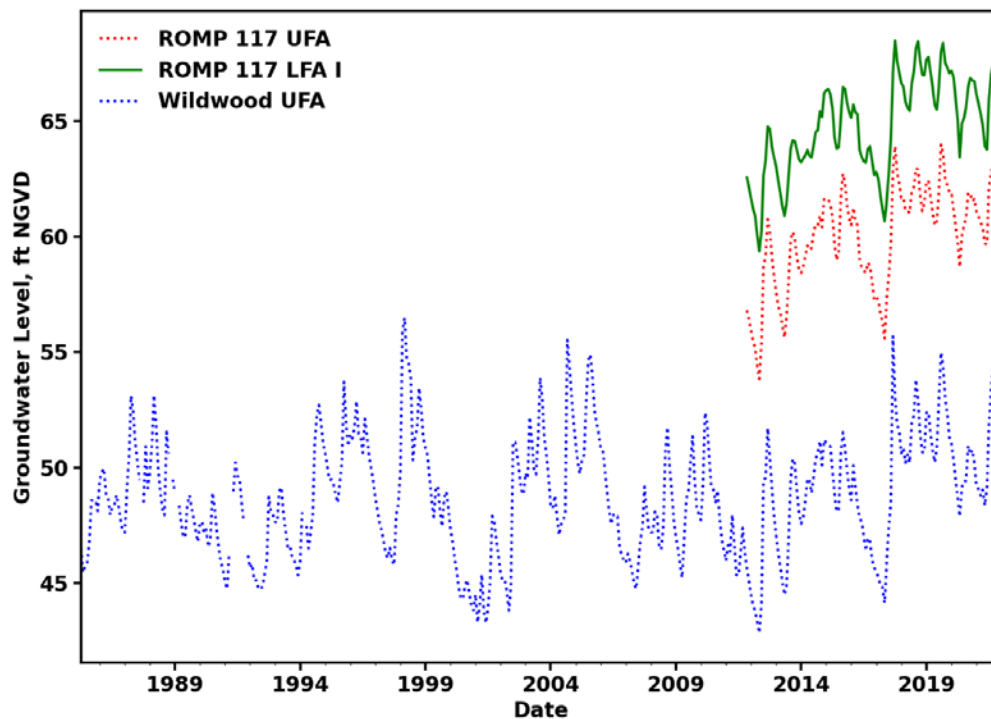


Figure 5. Monitored time series of groundwater level at ROMP 117 and Masters Avenue at Wildwood (SiteID: 23135)

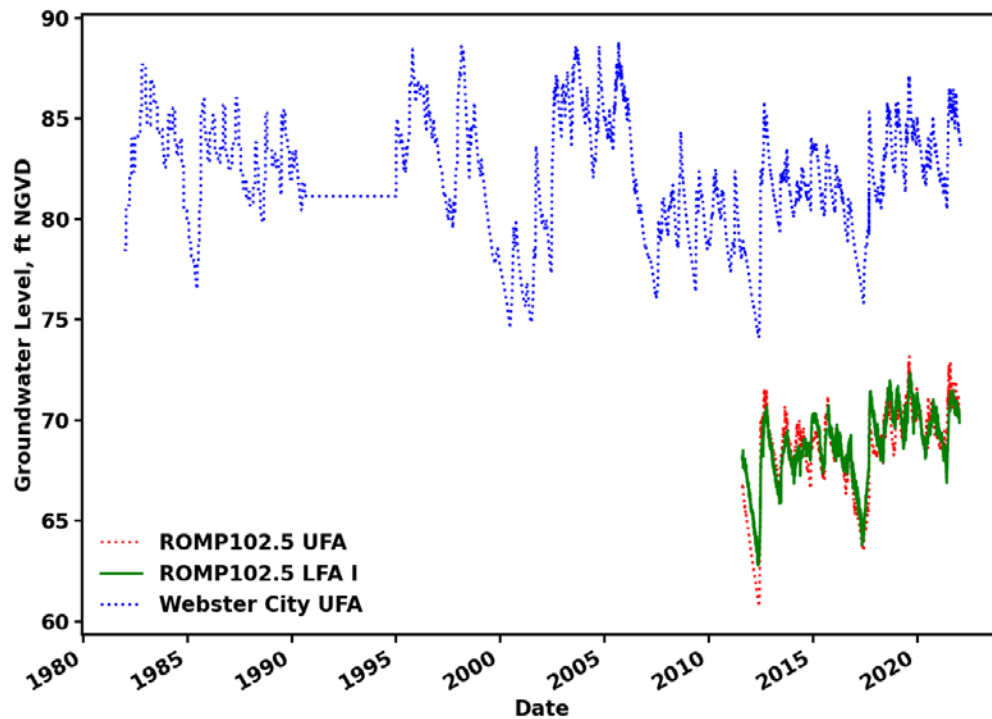


Figure 6. Monitored time series of groundwater level at ROMP 102.5 and Webster City Fldn (Site ID: 23078)

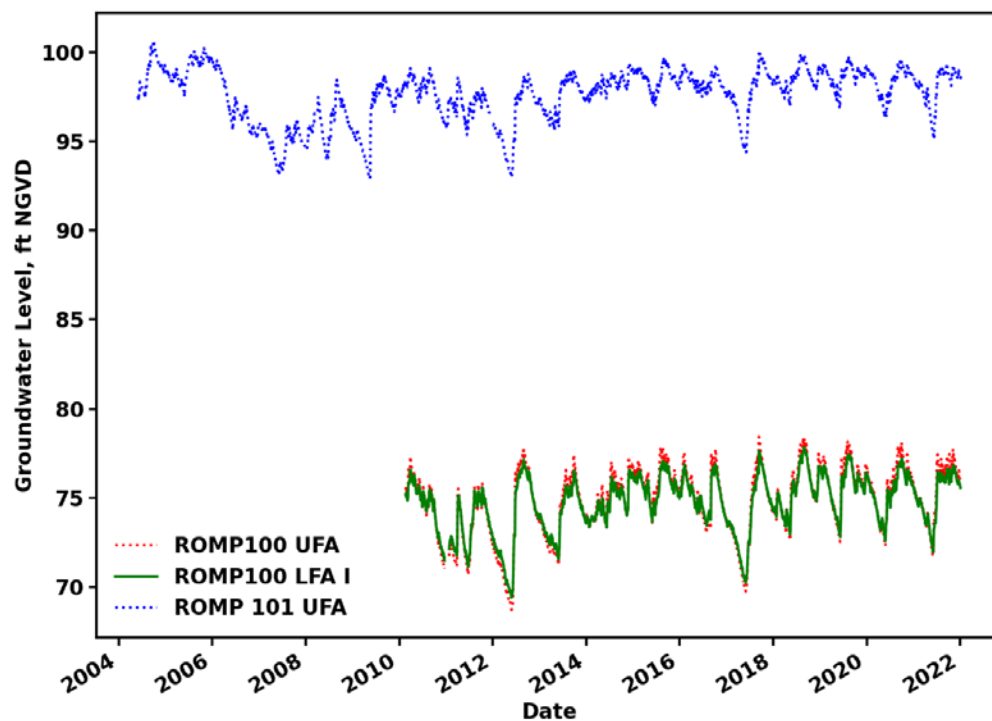


Figure 7. Monitored time series of groundwater level at ROMP 100 and ROMP 101 U Fldn Aq (Site ID: 17728)

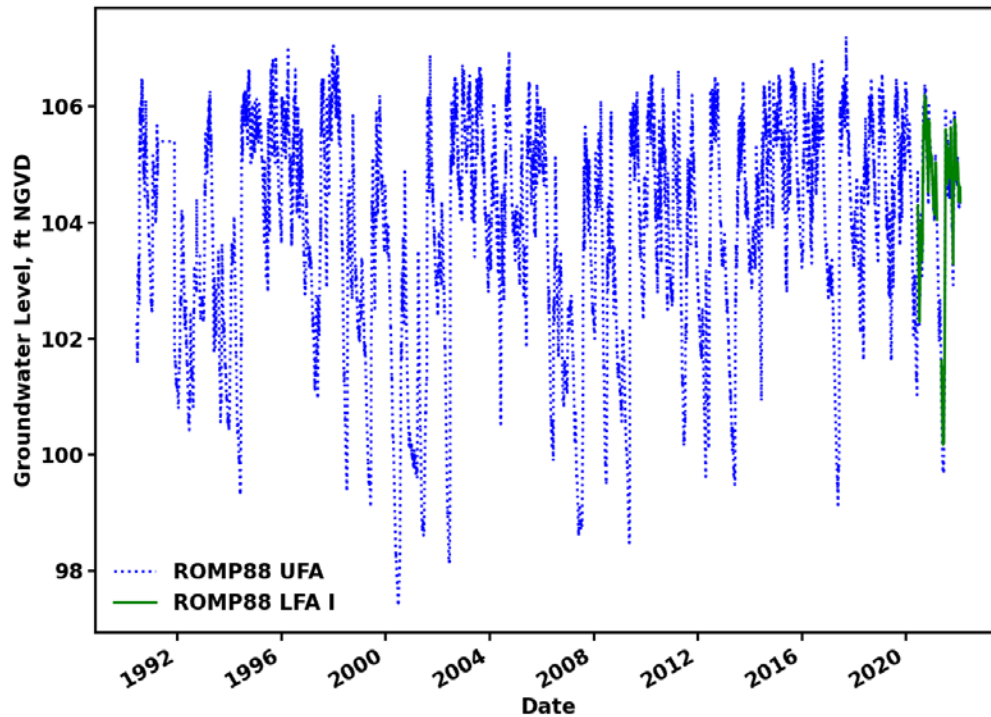


Figure 8. Monitored time series of groundwater level at ROMP 88

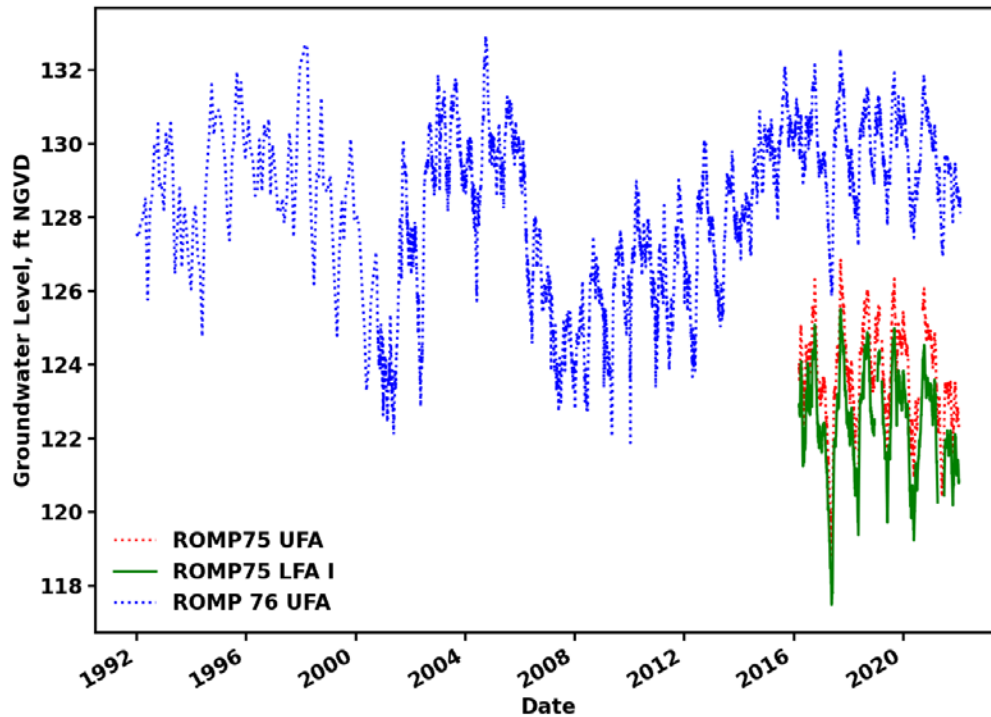


Figure 9. Monitored time series of groundwater level at ROMP 75 and ROMP 76 U Fldn Aq (Site ID: 17696)

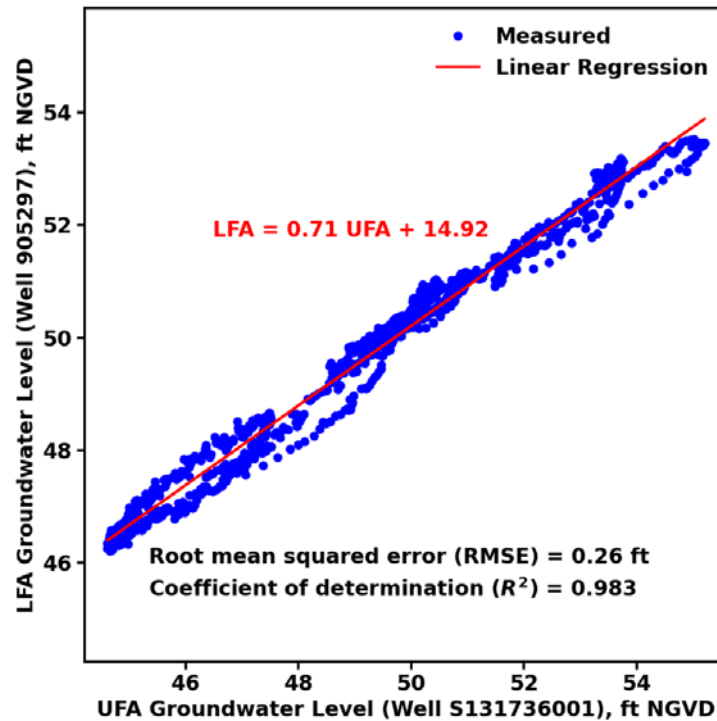


Figure 10. Correlation between groundwater level at ROMP 131.5 LFA (905297) and USGS Near Bronson (S131736001)

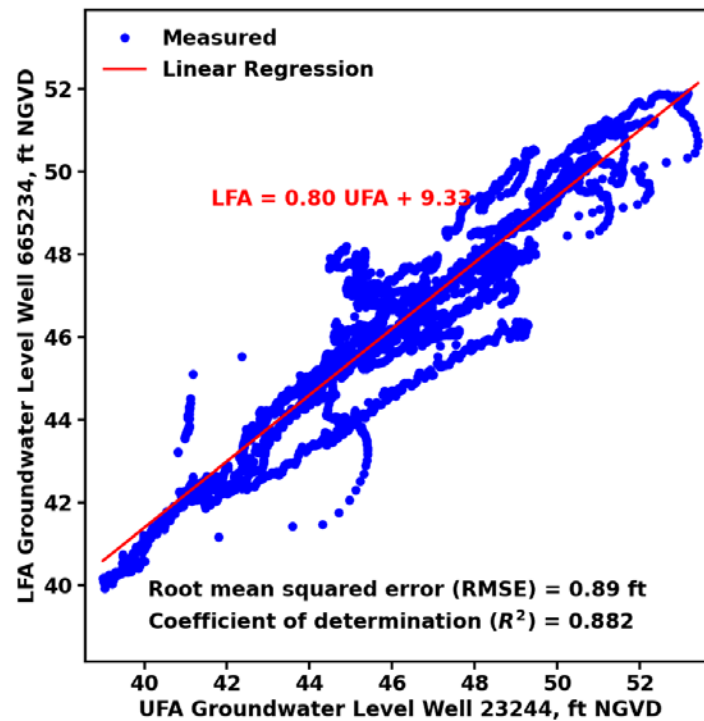


Figure 11. Correlation between groundwater level at ROMP 119.5 UFA (23244) and LFA (665234)

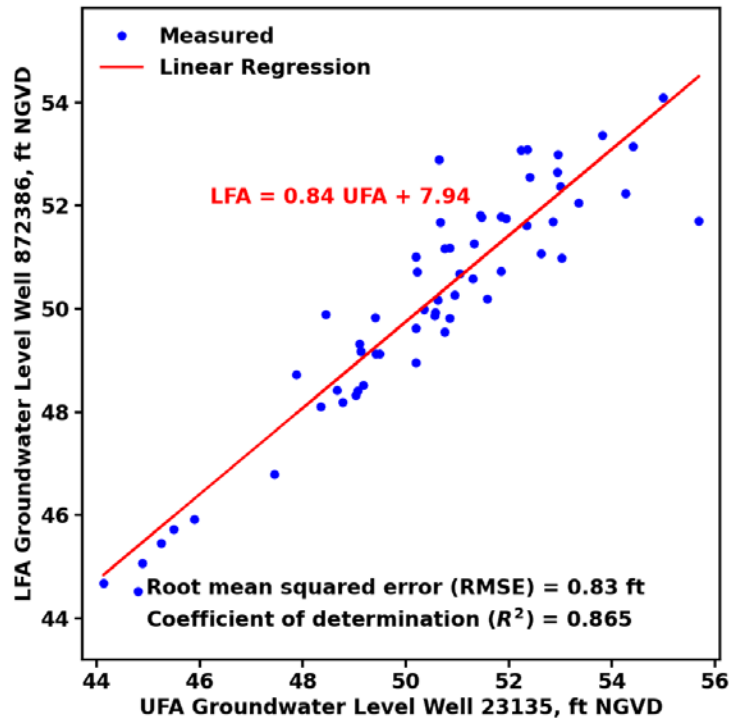


Figure 12. Correlation between groundwater level at ROMP 115 LFA (872386) and Masters Avenue at Wildwood (SiteID: 23135)

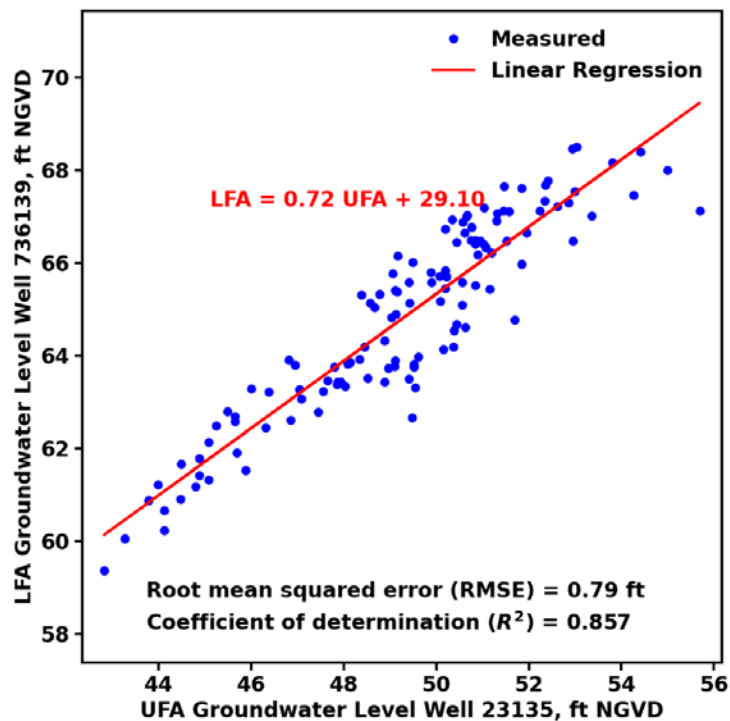


Figure 13. Correlation between groundwater level at ROMP 117 LFA (736129) and Masters Avenue at Wildwood (SiteID: 23135)

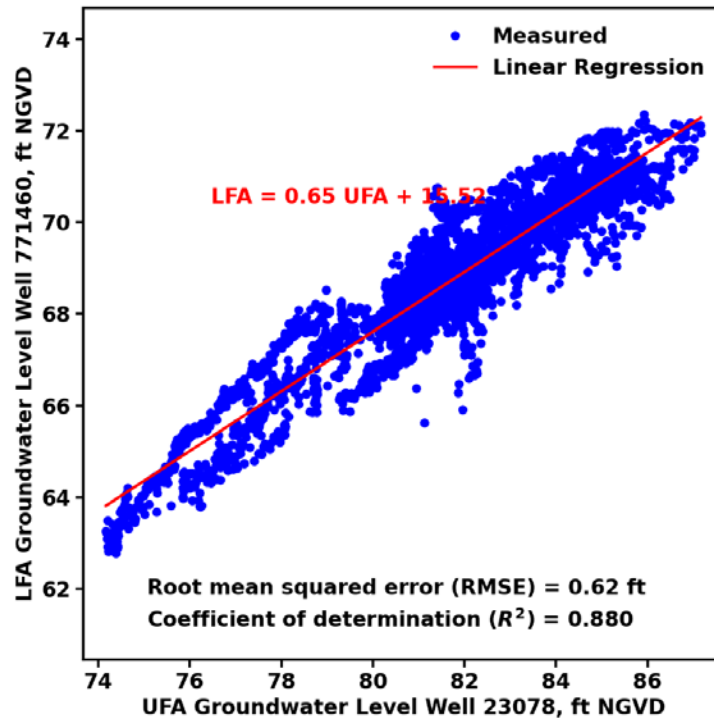


Figure 14. Correlation between groundwater level at ROMP 102.5 LFA (771460) and Webster City Fldn (23078)

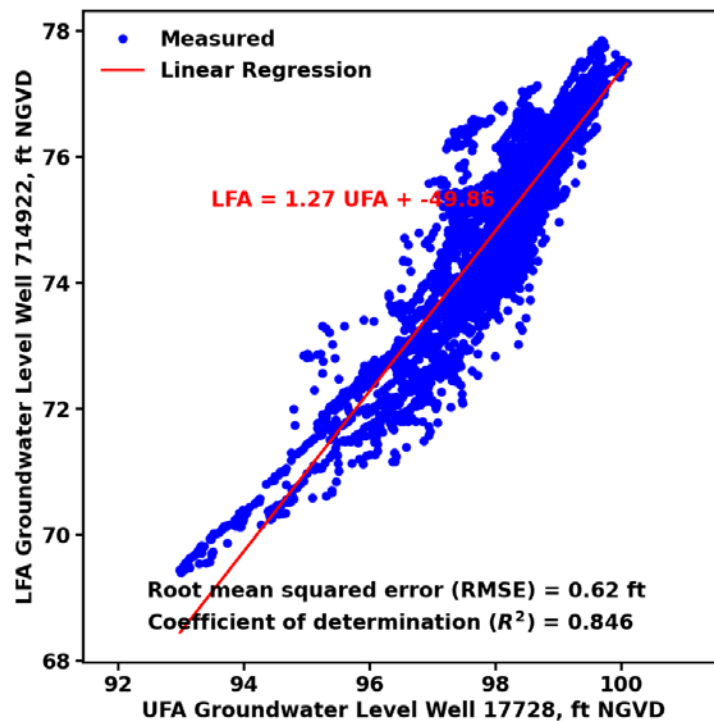


Figure 15. Correlation between groundwater level at ROMP 100 LFA (714922) and ROMP 101 UFA (17728)

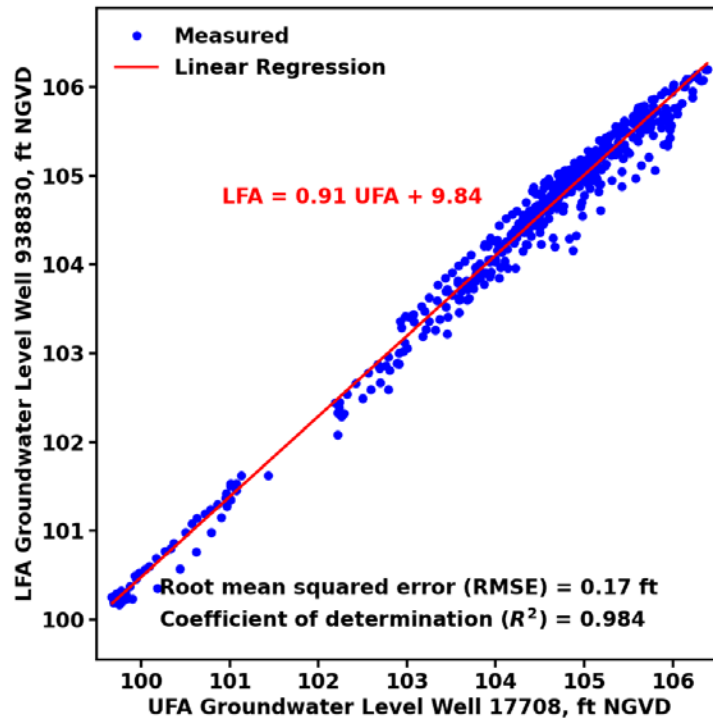


Figure 16. Correlation between groundwater level at ROMP 88 LFA (938830) and UFA (17708)

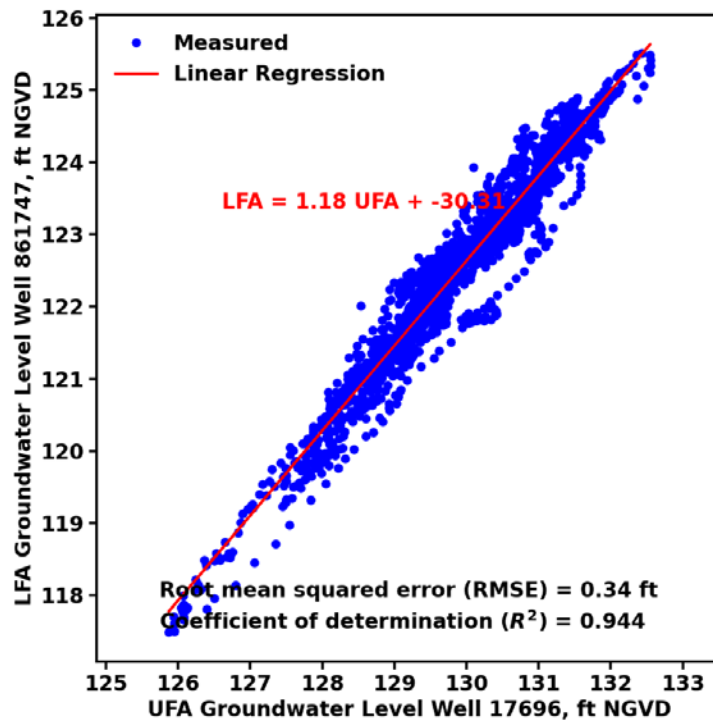


Figure 17. Correlation between groundwater level at ROMP 75 LFA (861747) and ROMP 76 UFA (17696)

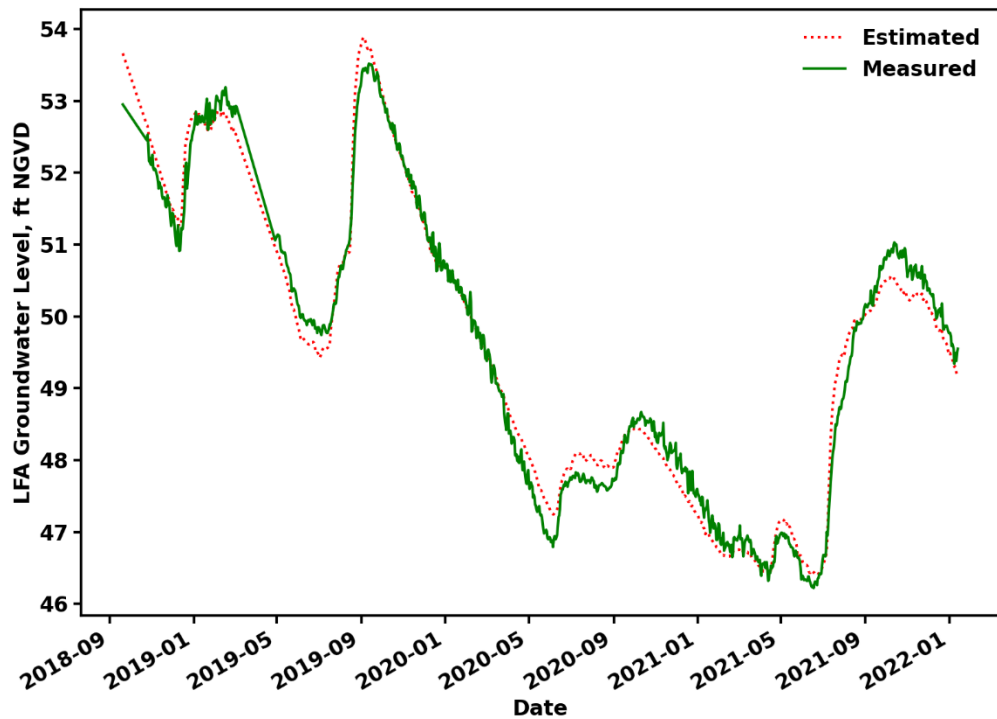


Figure 18. Comparison between monitored and estimated water level at ROMP 131.5 LFA (905297)

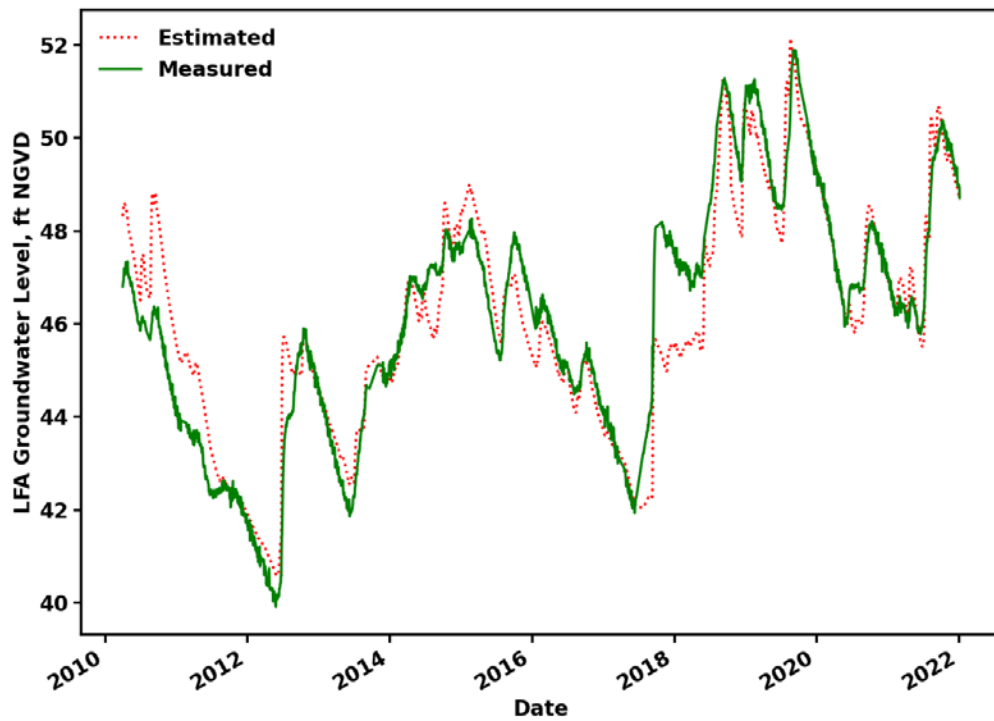


Figure 19. Comparison between monitored and estimated water level at ROMP 119.5 LFA (665234)

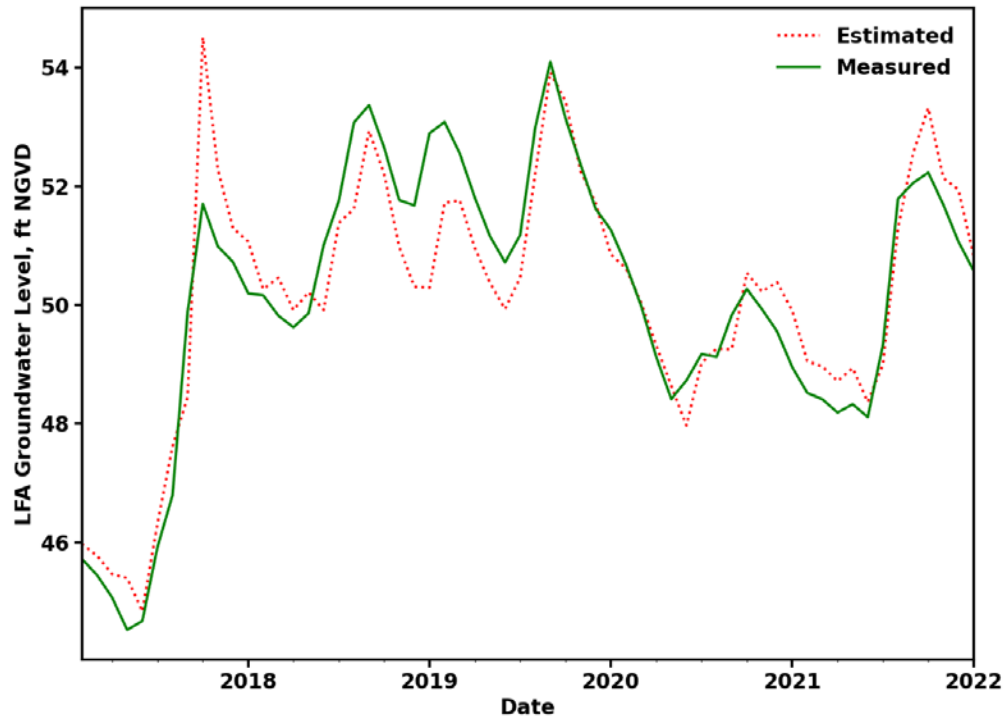


Figure 20. Comparison between monitored and estimated water level at ROMP 115 LFA (872386)

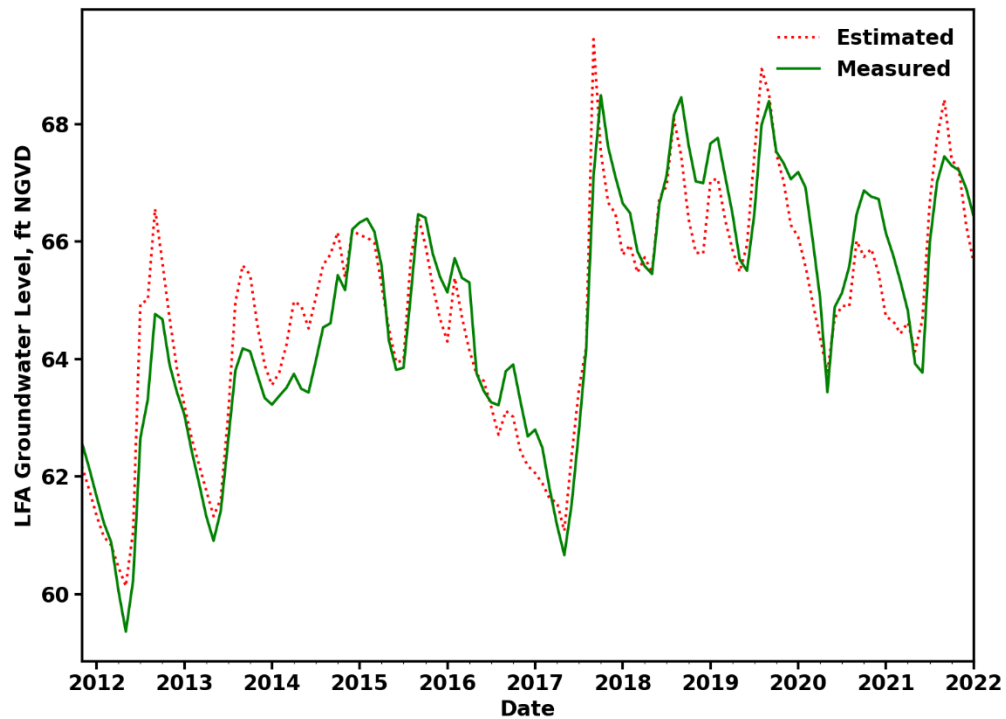


Figure 21. Comparison between monitored and estimated water level at ROMP 117 LFA (736129)

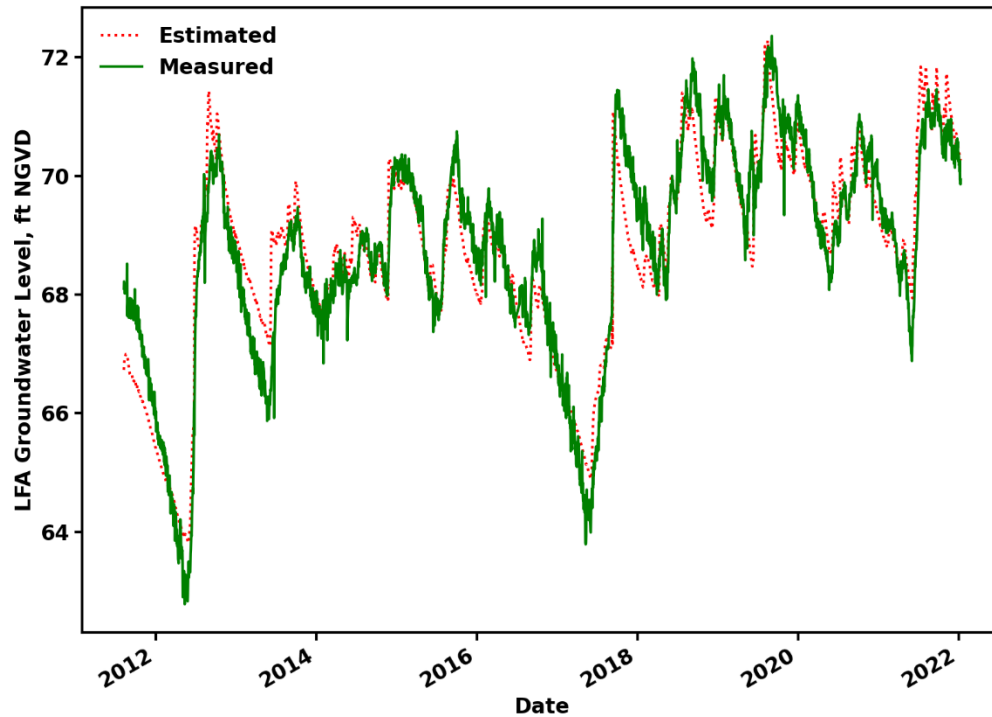


Figure 22. Comparison between monitored and estimated water level at ROMP 102.5 LFA (771460)

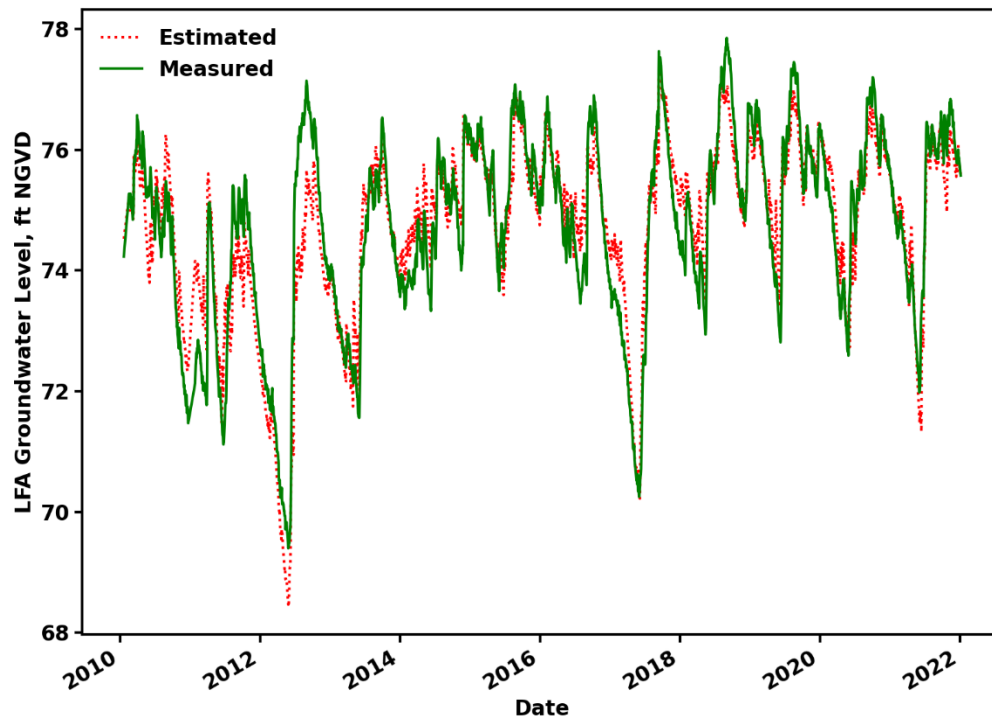


Figure 23. Comparison between monitored and estimated water level at ROMP 100 LFA (714922)

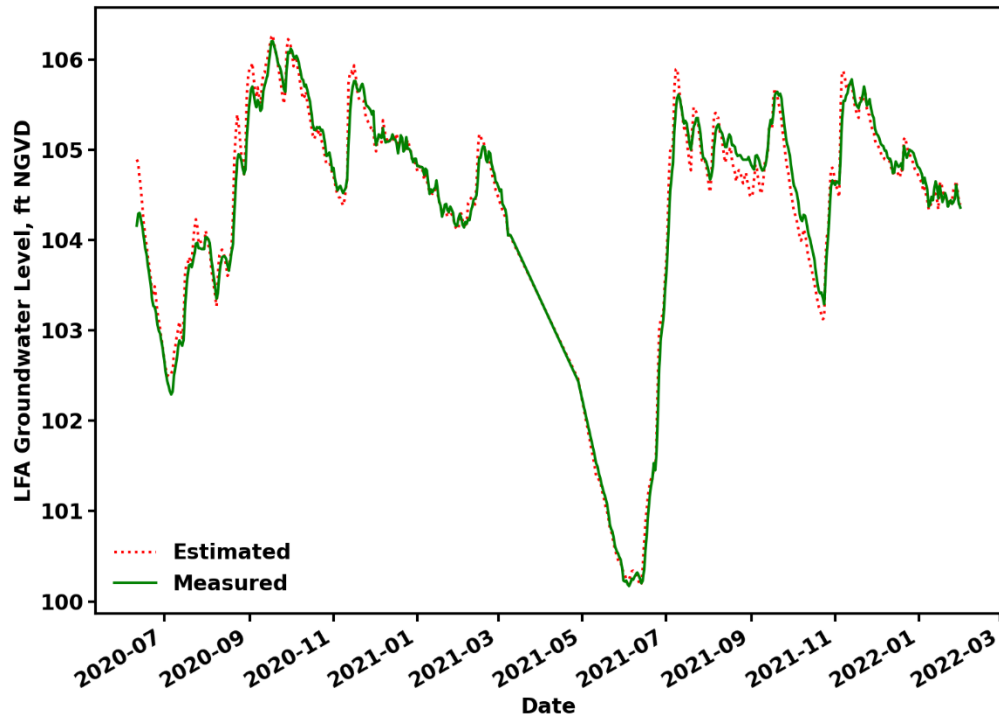


Figure 24. Comparison between monitored and estimated water level at ROMP 88 LFA (938830)

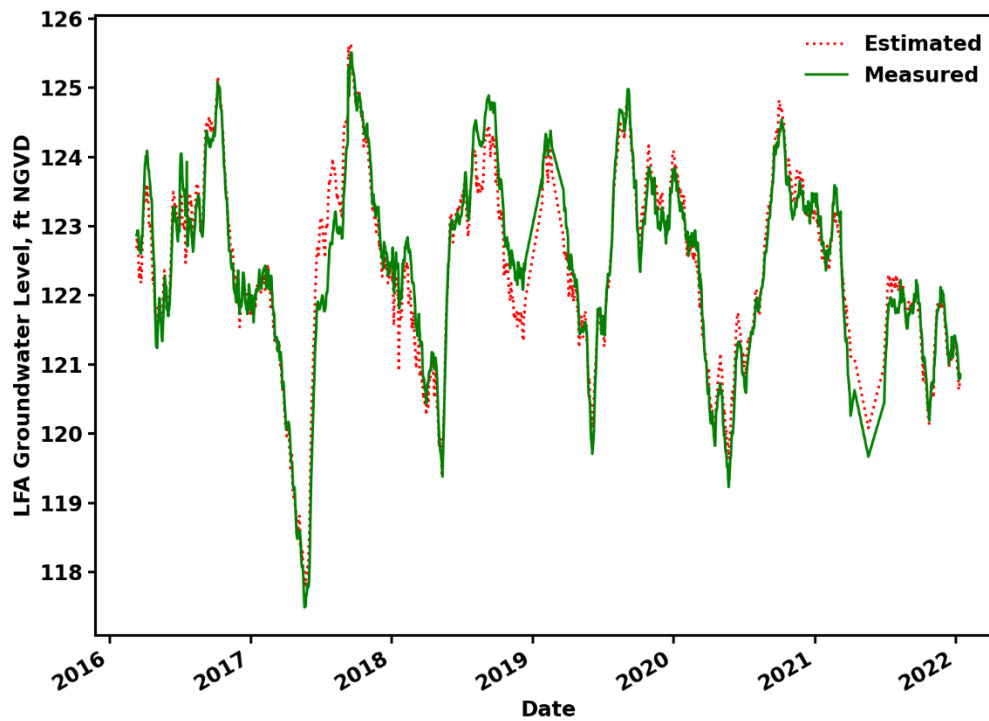


Figure 25. Comparison between monitored and estimated water level at ROMP 75 LFA (861747)

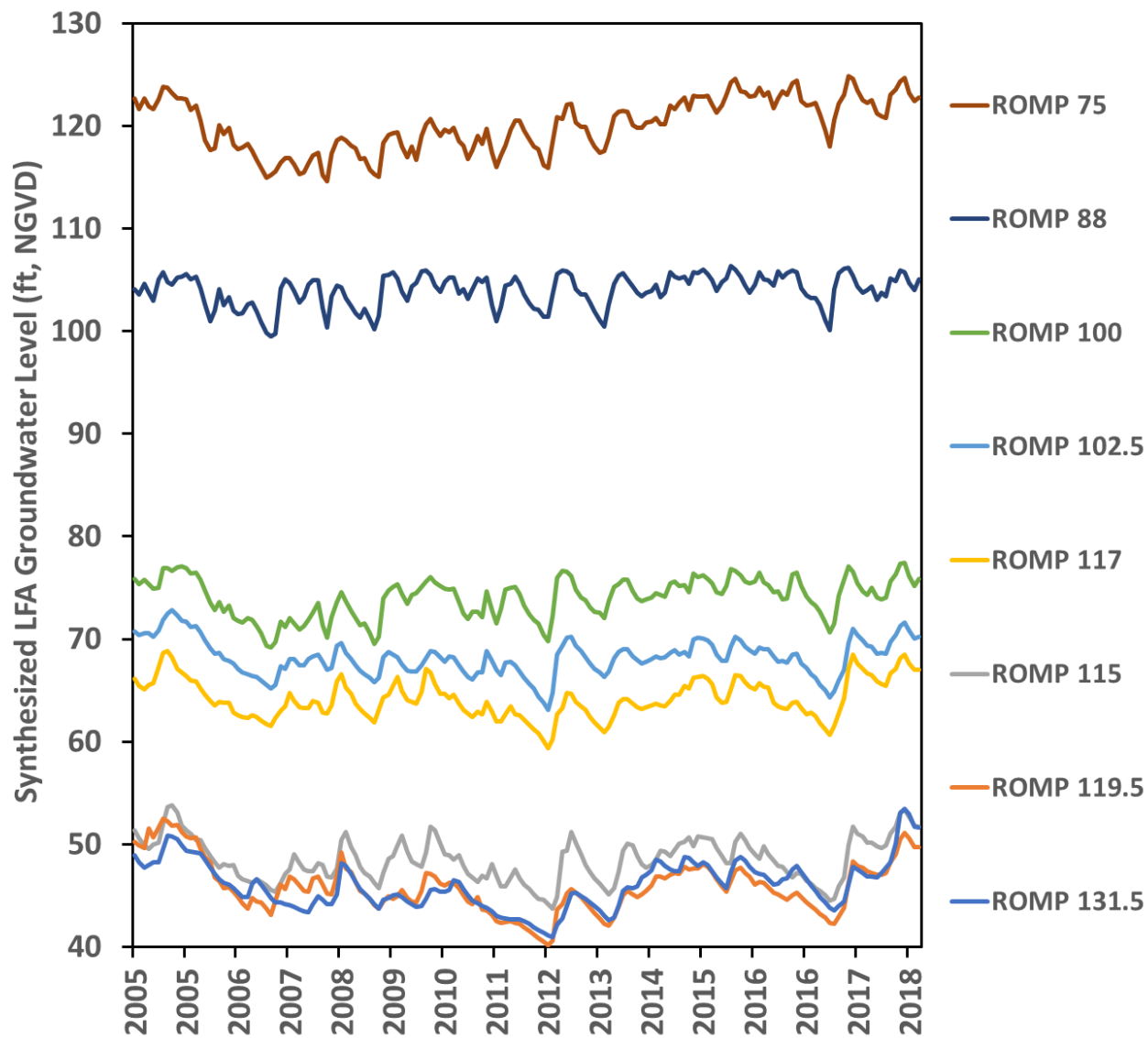


Figure 26. Synthesized monthly time series of Lower Floridan Aquifer water level at ROMP Sites