APPENDIX D — MFLS STATUS ASSESSMENT

CURRENT STATUS ASSESSMENT

Current MFLs status for Wekiva River basin systems was based on the 2014–2018 current-pumping condition and was assessed for each of the environmental criteria used in the MFLs determination. The MFLs threshold for each of the final criteria was compared to the current-pumping condition to determine a flow freeboard for each criterion. Flow freeboards were compared to determine the most constraining environmental criterion for each water body, and the most constraining system in the basin.

Event-based metrics

Current status for event-based metrics (i.e., FH and MA) was assessed using frequency analysis. The current-pumping condition frequency of each event was compared to the recommended minimum frequency to determine if the level was met under current conditions. The difference between the current-pumping condition water level and MFLs magnitude represents the freeboard or deficit in the river / floodplain.

Frequent High (FH)

Calculating the probability of exceedance of the FH involved the following three steps:

1. Determine the annual maximum elevation continuously exceeded for the specified duration for each water year. The water year for flooding events is from June 1 to May 31.
2. Rank annual maximums from step 1 in descending order.
3. Use Weibull plotting position formula to calculate the probability of exceedance.

$$P(S \geq \hat{S}_m) = \frac{m}{n+1}$$

where $P(S \geq \hat{S}_m)$ = probability of S equaling or exceeding $\hat{S}_m$
m = rank of event
n = number of water years

<u>Wekiva River at SR 46</u>

Under the current-pumping condition, the FH flooding event (6.6 feet, duration of 30 days) has a probability of 50% (2.0-year return interval), which is the same probability required under the MFLs condition (Figure D-1). Based on the current-pumping elevation and return interval, the FH is met under current conditions, with a river floodplain (i.e., water level) freeboard of 0.0 ft. See below for flow freeboard.

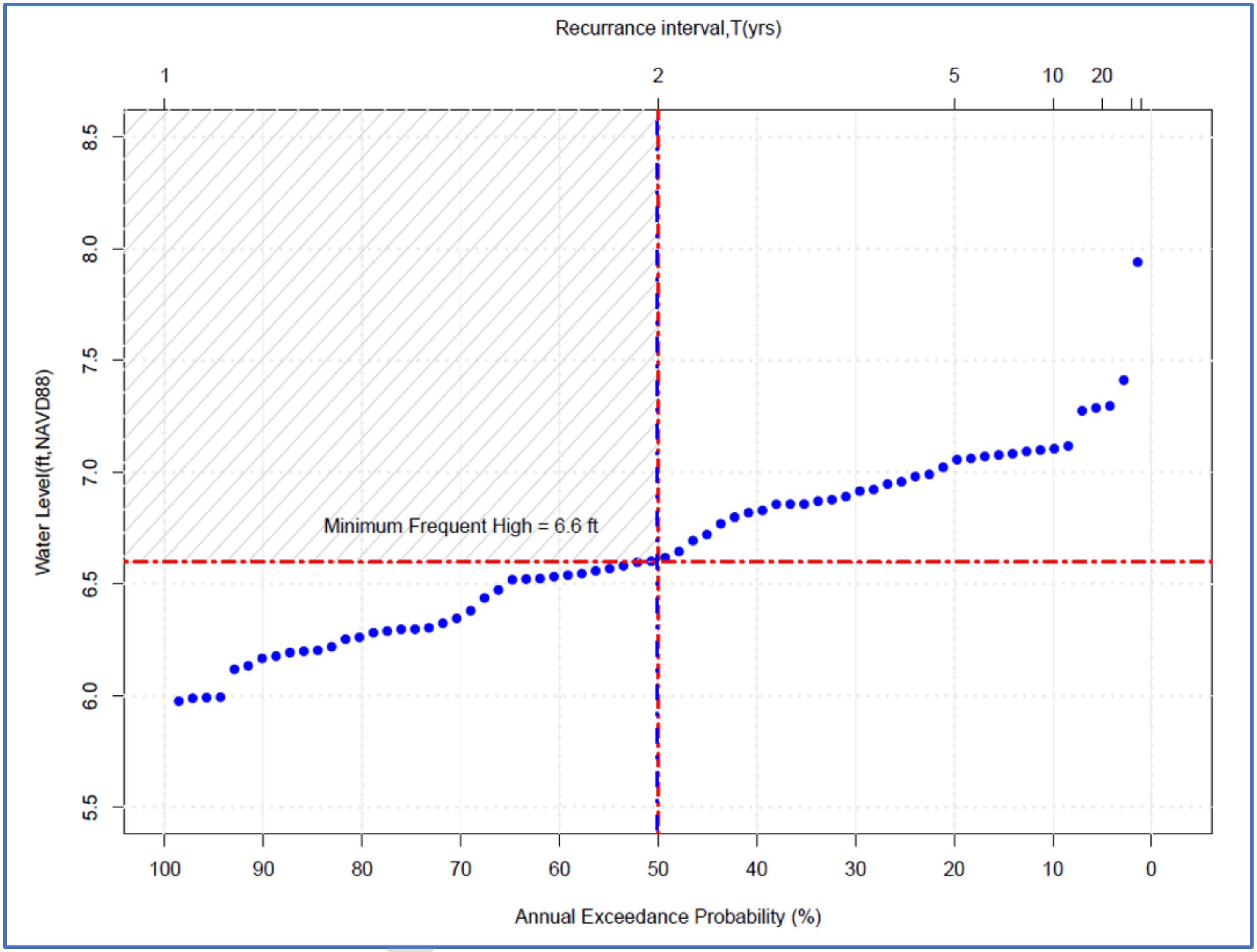

Figure D-1. Frequency analysis plot (i.e., Weibull plot) for the Wekiva River at SR 46 minimum FH, showing MFLs condition return interval and magnitude (vertical and horizontal red dashed lines), current-pumping data (blue data points) and current-pumping return interval (vertical blue dashed line).

Wekiwa Springs

Under the current-pumping condition, the FH flooding event (12.1 feet, duration of 30 days) has a probability of approximately 57% (1.8-year return interval), which is slightly higher than under the MFLs condition (i.e., 50%; 2.0-year return interval; Figure D-2). Although the event frequency under the current-pumping condition is slightly higher than that of the MFL, the difference in magnitude (i.e., elevation) under current-pumping is less than 0.05 ft from the MFL and is therefore considered zero. As such the FH is met under current conditions, with a river floodplain (i.e., water level) freeboard of 0.0 ft.

Rock Springs Run

Under the current-pumping condition, the FH flooding event (25.0 feet, duration of 30 days) has a probability of approximately 94% (~1.1-year return interval), which is a much higher exceedance probability than under the MFLs condition (i.e., 50%; 2.0-year return interval; Figure D-3). Based on the current-pumping elevation and return interval, the FH is met under current conditions, with a water-level freeboard of 0.2 ft. See below for flow freeboard calculation.

Little Wekiva River at Springs Landing Boulevard (SLB)

Under the current-pumping condition, the FH flooding event (18.7 feet, duration of 30 days) has a probability of 0%; all of the current-pumping condition data are below the critical FH elevation; Figure D-4). Further, the FH is also not met under the no-pumping condition (Figure D-4), and so it was deemed inappropriate to assess the FH for the Little Wekiva River at SLB.

Minimum Average (MA)

Calculating the probability of non-exceedance of the MA involved the following three steps:

1. Determine the annual minimum average elevation not exceeded for the specified duration for each water year. The water year for a non-exceedance event is October 1 to September 30.
2. Rank annual minimum averages from step 1 in descending order.
3. Use Weibull plotting position formula to calculate the probability of non-exceedance.

$$P(S < \hat{S}_m) = 1 - \left(\frac{m}{n+1}\right)$$

where $P(S \geq \hat{S}_m)$ = probability of S not exceeding $\hat{S}_m$
m = rank of event
n = number of water years

Wekiva River at SR 46

Under the current-pumping condition, the MA drying event (6.5 feet, duration of 180 days) has a probability of 69% (1.45-year return interval) compared to a probability of 71.4% (1.4-year

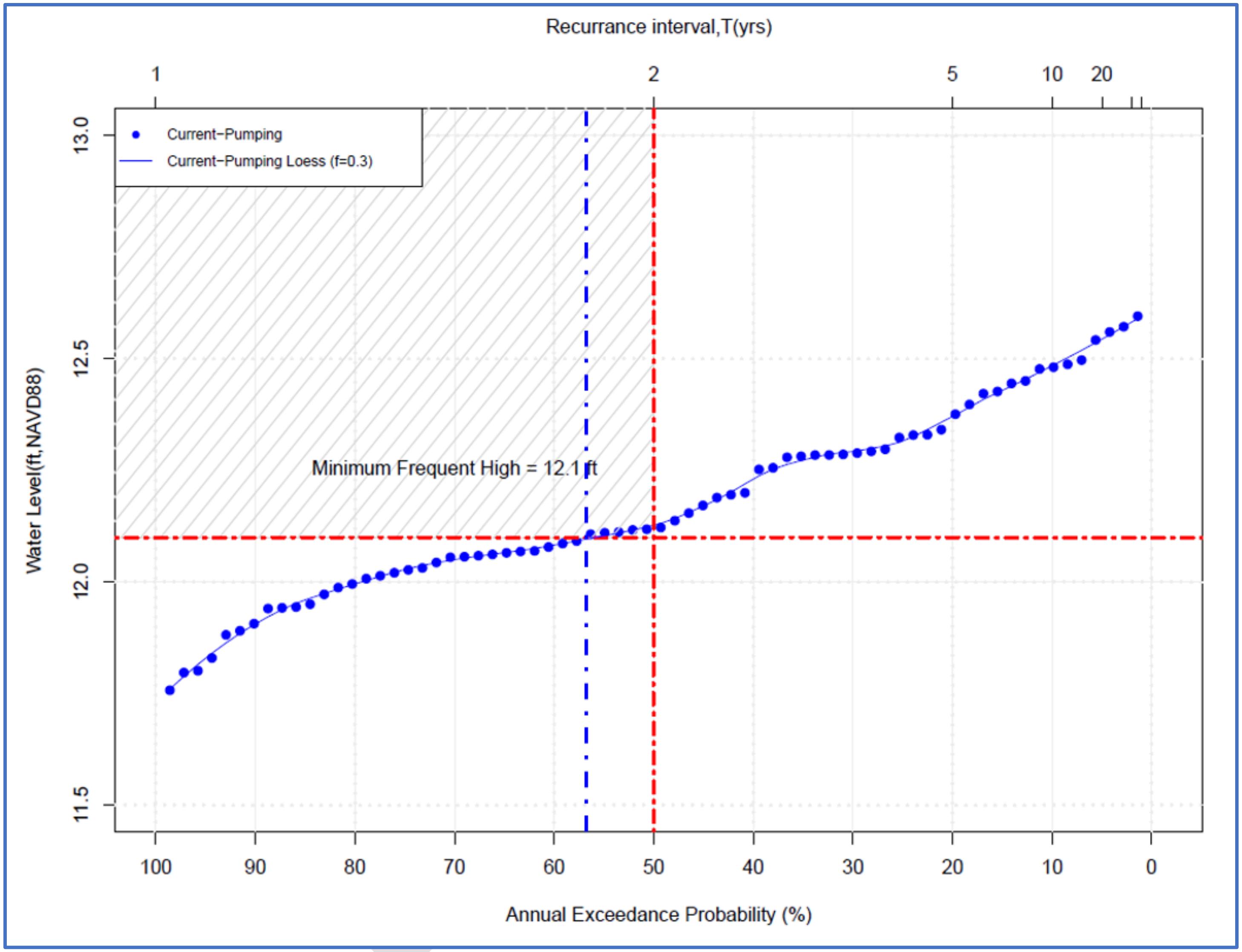

Figure D-2. Frequency analysis plot (i.e., Weibull plot) for the Wekiwa Springs minimum FH, showing MFLs condition return interval and magnitude (vertical and horizontal red dashed lines), current-pumping data (blue data points) and current-pumping return interval (vertical blue dashed line).

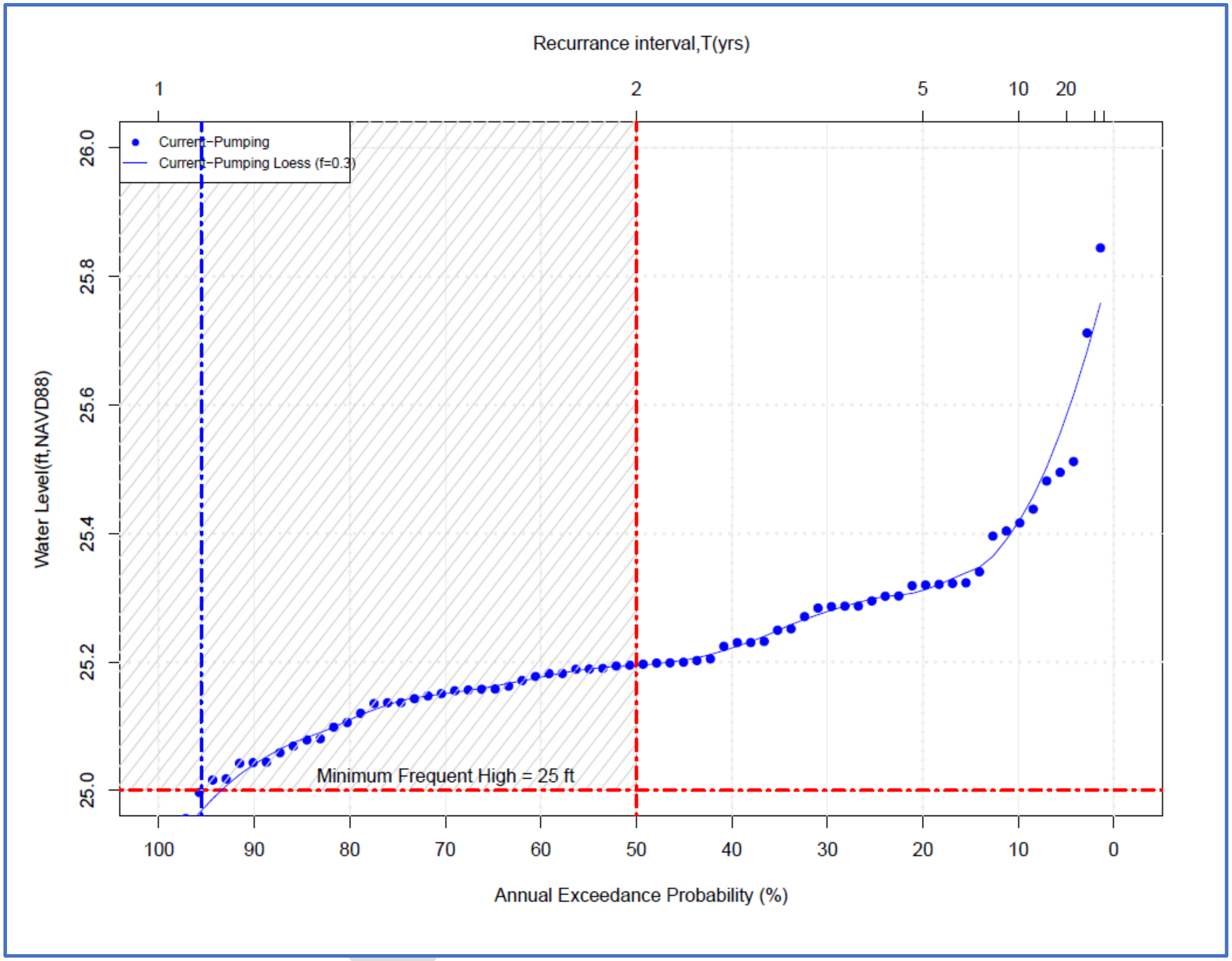

Figure D-3. Frequency analysis plot (i.e., Weibull plot) for the Rock Springs / Run minimum FH, showing MFLs condition return interval and magnitude (vertical and horizontal red dashed lines), current-pumping data (blue data points) and current-pumping return interval (vertical blue dashed line).

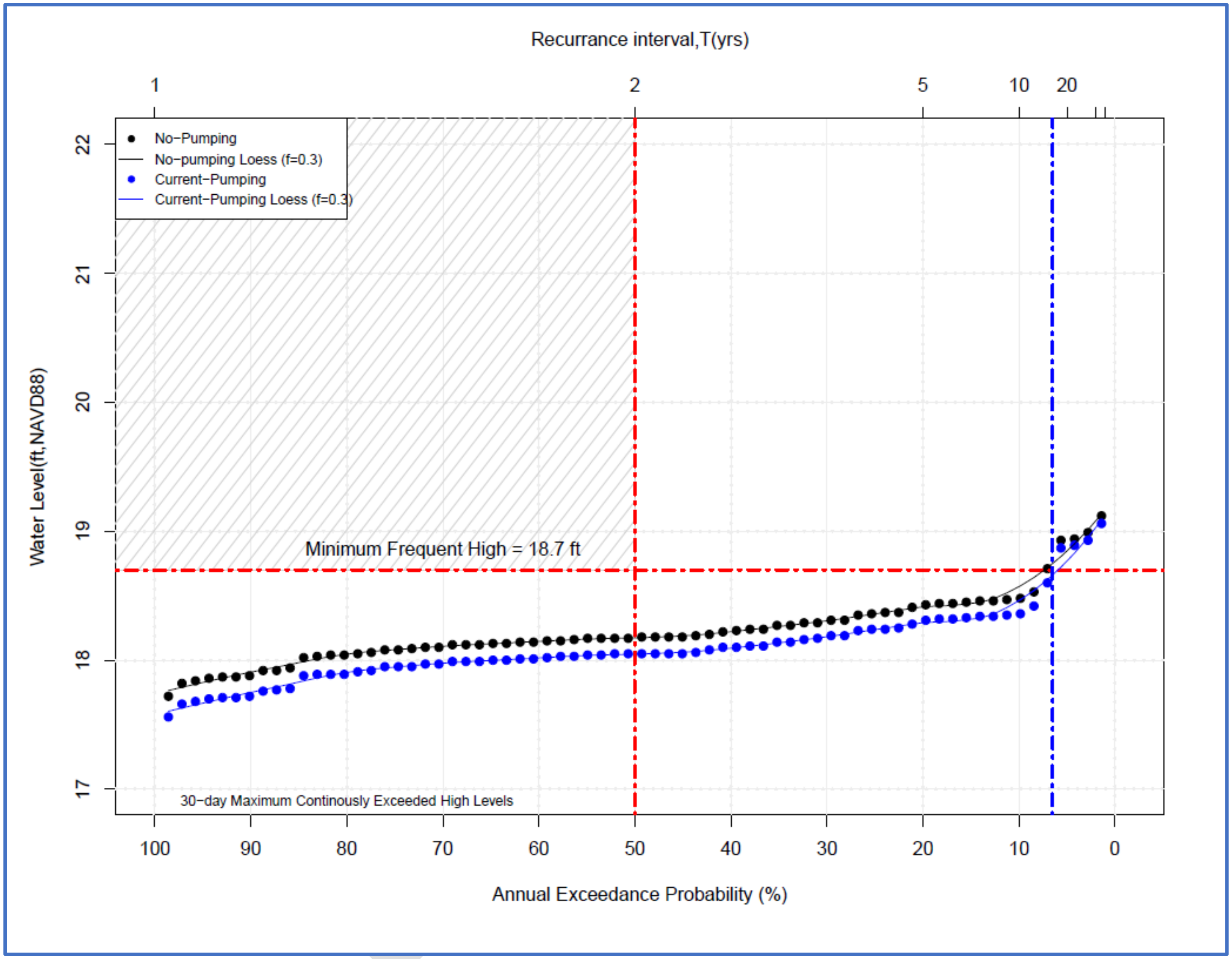

Figure D-4. Frequency analysis plot (i.e., Weibull plot) for the Little Wekiva River at SLB minimum FH, showing MFLs condition return interval and magnitude (vertical and horizontal red dashed lines), current-pumping data (blue data points) and current-pumping return interval (vertical blue dashed line); no-pumping data are black data points.

return interval) under the MFLs condition. Although the event frequency under the current-pumping condition is slightly less than that of the MFL, the difference in magnitude (i.e., elevation) under current-pumping is less than 0.05 ft from the MFL and is therefore considered zero (Figure D-5). As such the MA is met under current conditions, with a river floodplain (i.e., water level) freeboard of 0.0 ft.

Wekiwa Springs

Under the current-pumping condition, the MA drying event (11.9 feet, duration of 180 days) has a probability of 46.5% (2.2-year return interval) compared to a probability of 71.4% (1.4-year return interval) under the MFLs condition. Based on the current-pumping elevation and return interval, the MA is met under current conditions, with a water-level freeboard of approximately 0.1 ft (Figure D-6). See below for flow freeboard calculation.

Rock Springs Run

Under the current-pumping condition, the MA drying event (24.7 feet, duration of 180 days) has a probability of approximately 0% compared to a probability of 71.4% (1.4-year return interval) under the MFLs condition. Based on the current-pumping elevation and return interval, the MA is met under current conditions, with a water level freeboard of approximately 0.5 ft (Figure D-7). See below for flow freeboard calculation.

Little Wekiva River at SLB

Under the current-pumping condition, the MA drying event (18.1 feet, duration of 180 days) has a probability of 97% compared to a probability of 71.4% (1.4-year return interval) under the MFLs condition. However, because the MA was also not met under the no-pumping condition it was deemed inappropriate to assess the MA for the Little Wekiva River at SLB (Figure D-8).

The next step in the current status assessment is to determine the amount of change in spring or river flow required to just meet each event-based metric (i.e., to calculate flow freeboard or deficit).

Flow freeboard / deficit calculations involved the following steps:

1. Springs flows in the surface water model were increased or decreased by small increments (depending on frequency analysis results);
2. The surface water model was then run iteratively after each change to springs flows, to simulate a new water-level time series data representing an increase or decrease in withdrawal, relative to the current-pumping condition;
3. Frequency analysis and Weibull plotting were repeated using the new time series data;
4. Steps 1 through 3 were repeated until the given minimum level was just met (i.e., within 0.1 ft);

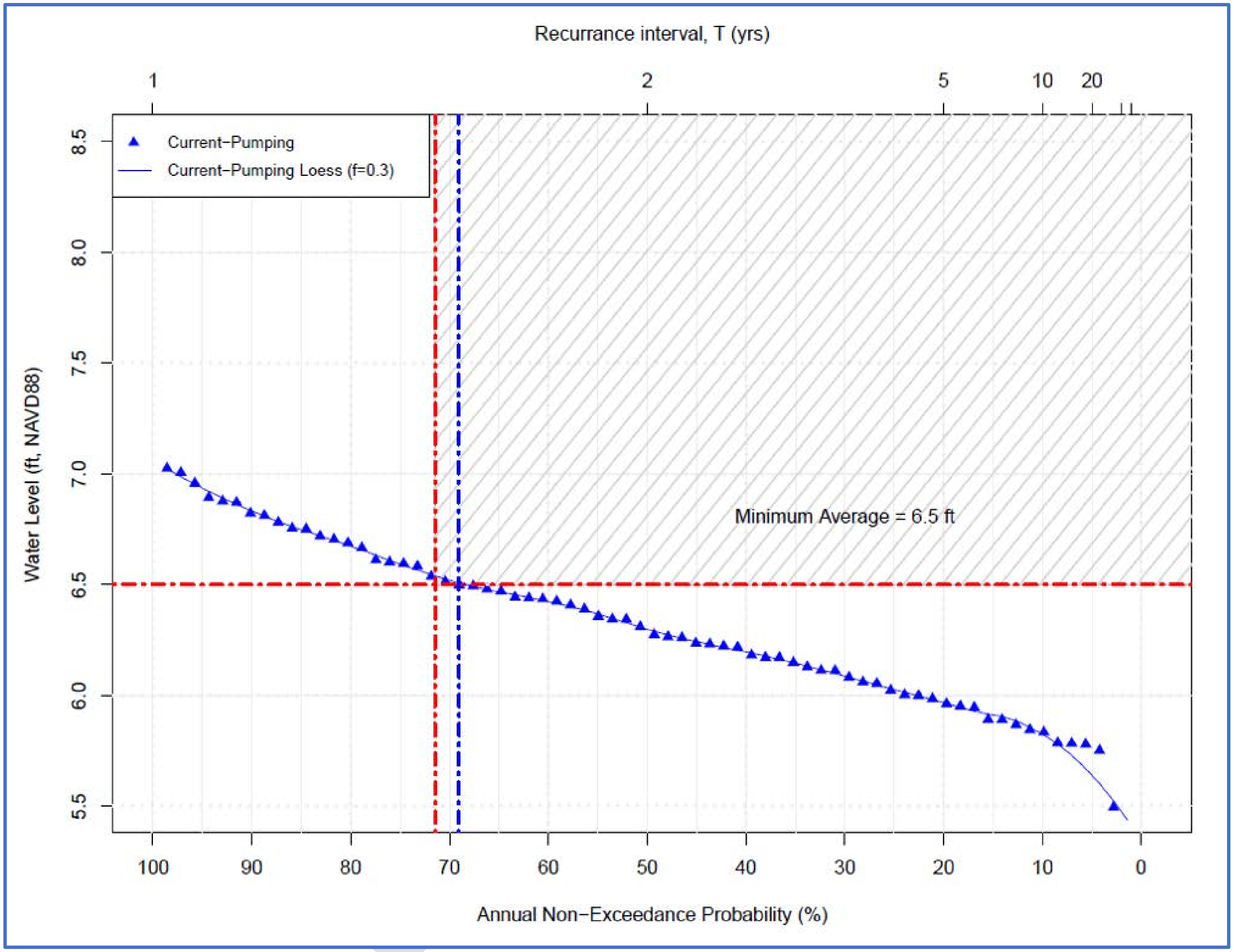

Figure D-5. Frequency analysis plot (i.e., Weibull plot) for the Wekiva River at SR 46 minimum average (MA), showing MFLs condition return interval and magnitude (vertical and horizontal red dashed lines), current-pumping data (blue data points) and current-pumping return interval (vertical blue dashed line).

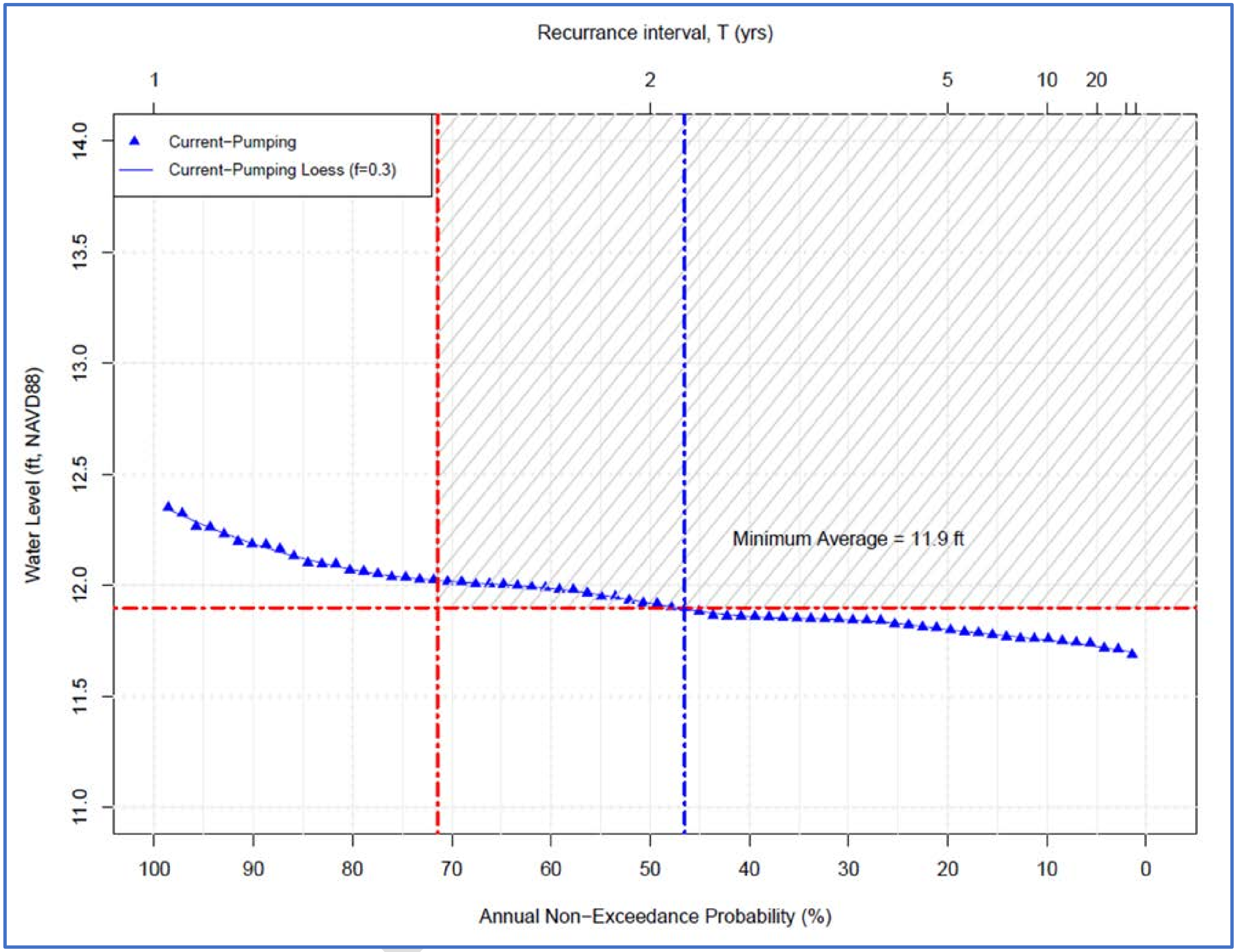

Figure D-6. Frequency analysis plot (i.e., Weibull plot) for the Wekiwa Springs minimum average (MA), showing MFLs condition return interval and magnitude (vertical and horizontal red dashed lines), current-pumping data (blue data points) and current-pumping return interval (vertical blue dashed line).

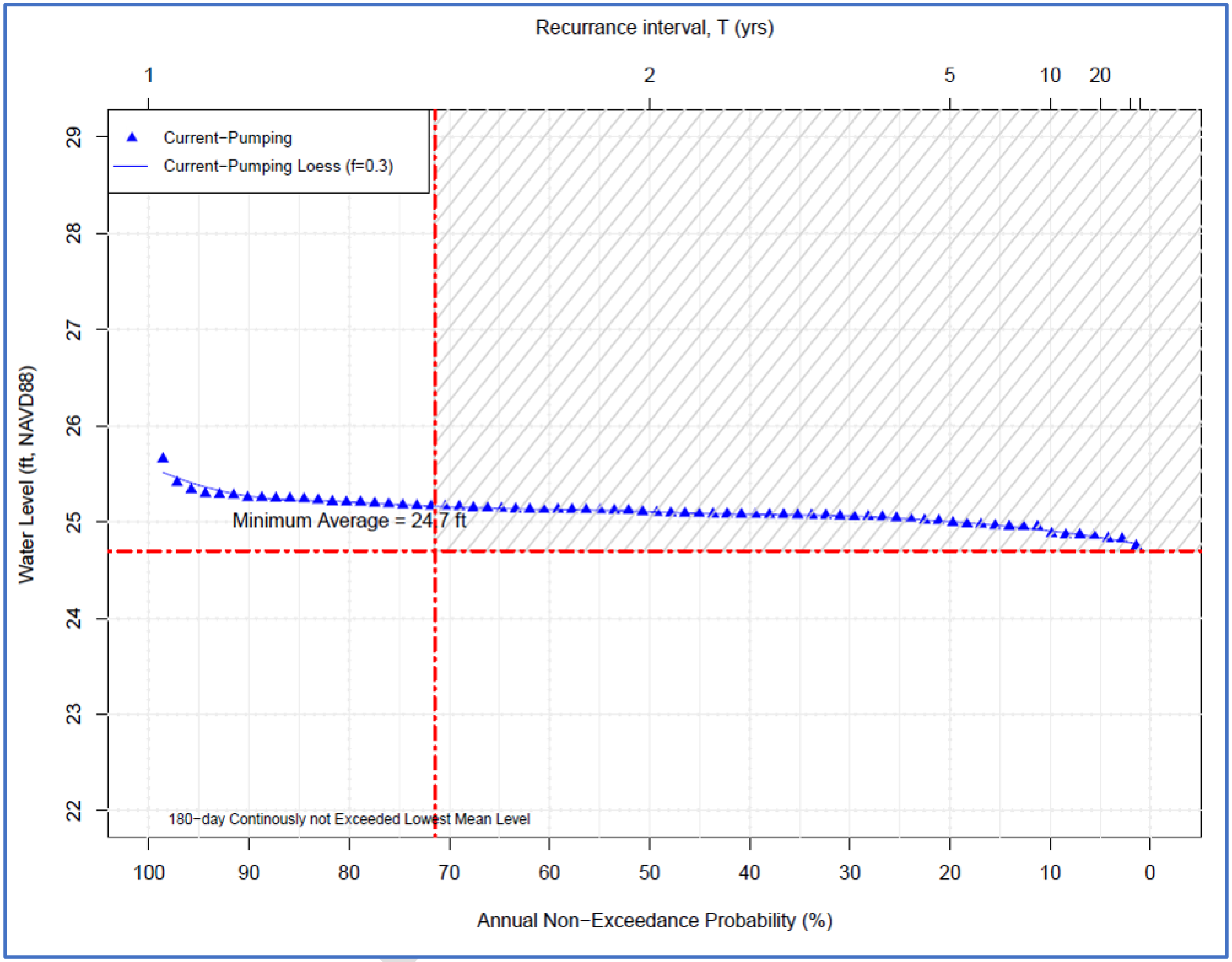

Figure D-7. Frequency analysis plot (i.e., Weibull plot) for the Rock Springs / Run minimum average (MA), showing MFLs condition return interval and magnitude (vertical and horizontal red dashed lines), current-pumping data (blue data points) and current-pumping return interval (vertical blue dashed line).

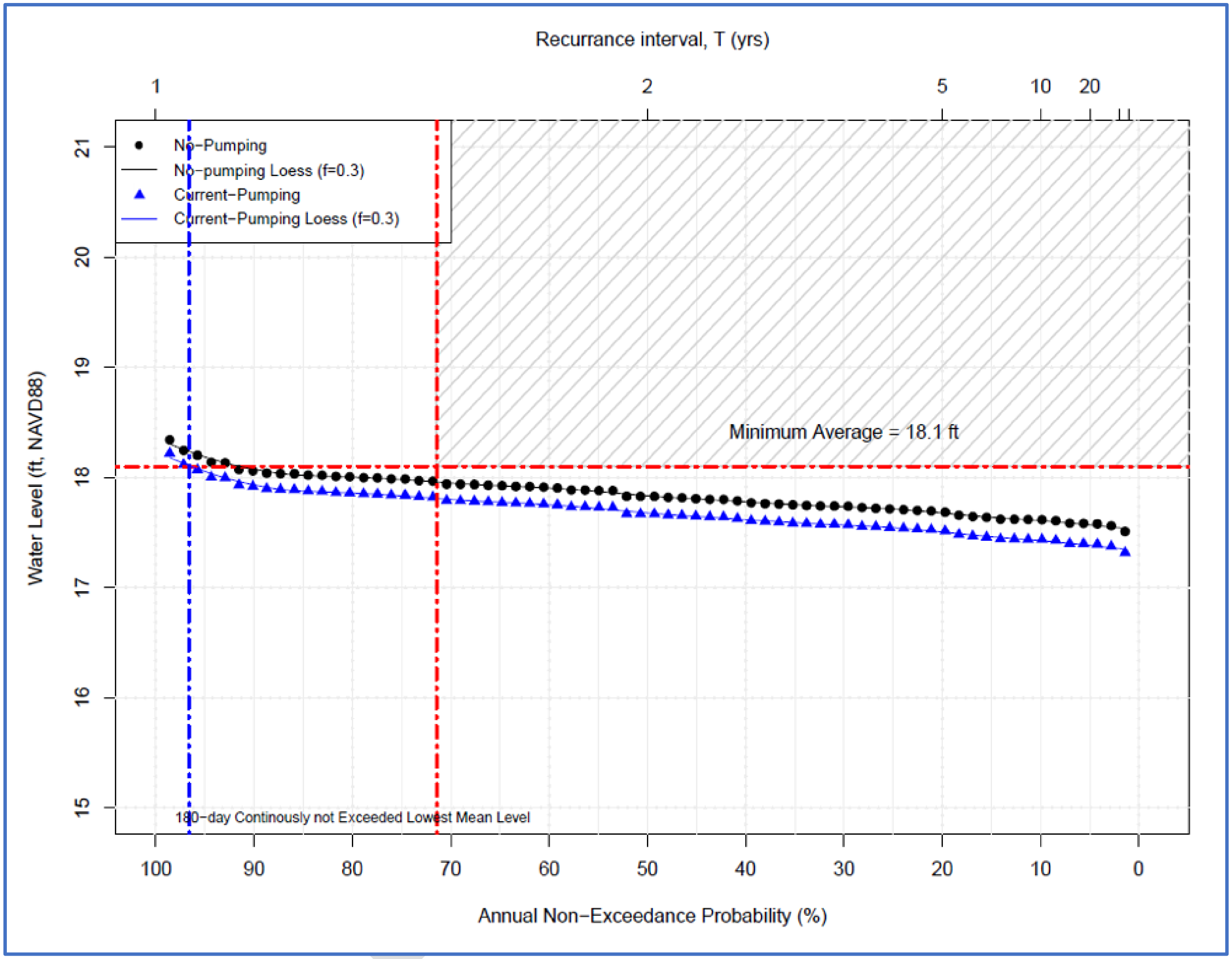

Figure D-8. Frequency analysis plot (i.e., Weibull plot) for the Little Wekiva River at SLB minimum average (MA), showing MFLs condition return interval and magnitude (vertical and horizontal red dashed lines), current-pumping data (blue data points) and current-pumping return interval (vertical blue dashed line); no-pumping data are black data points.

5. The amount of water added (or subtracted) relative to the current-pumping condition represents the amount of water available for consumptive use (i.e., freeboard), or amount of water needed to be recovered (i.e, deficit).

A summary of flow freeboard for event-based metrics is presented below (Table D-1). This represents the allowable reduction in spring flow (or river flow from contributing springs), relative to the current-pumping condition.

Flow freeboard for the Wekiva River at SR 46 is 0.0 cfs because the MFLs condition for the minimum FH and MA is equal to the current-pumping condition (i.e., both minimum levels are just met at the current-pumping condition; Figures D-1 and D-5). For this same reason, the flow freeboard for the Wekiwa Springs FH equals 0.0 cfs (Figure D-2).

The flow freeboard for the Wekiwa Springs MA, and the flow freeboards for both Rock Springs levels are listed as “greater than” a given allowable change in flow (e.g., greater than 2.3 cfs for Wekiwa Springs). This is because the maximum flow change assessed was a 50% increase in the current-pumping impact. Even with this large increase in impact these metrics were not tripped, and so the flow freeboards are shown as “greater than” the flow change associated with this 50% increase in impact. The FH and MA for the Little Wekiva River at SLB are listed as NA, because these metrics were not met under the no-pumping condition, and therefore it is not appropriate to assess them for this system.

Table D-1 Spring freeboards for event-based metrics for Wekiva River basin water bodies; NA = not applicable (see text above)

System	Flow freeboard (cfs)	
	FH	MA
Wekiva River at SR 46	0.0	0.0
Wekiwa Springs	0.0	> 2.3
Rock Springs	> 5.5	> 5.5
Little Wekiva River at SLB	NA	NA

Organic Soils – Protection from Harmful Drying

An organic soil drying event metric was developed to ensure that deep wetland soils are protected at the Little Wekiva River at SLB and Rock Springs, both sites where the standard

MA was not appropriate for use as an MFLs metric, either because the metric was not met under the pre-withdrawal condition or not sensitive to changes in flows. As described in the main MFLs report, evidence suggests that after 8 days oxidation and subsidence may adversely affect organic soils (Osborne et al. 2014). This metric uses a critical elevation equal to the average elevation of deep organic soils (Histosol / histic Epipedon) minus 0.3 ft (i.e., the same critical elevation of the MA); the impact threshold allows no more than a 15% increase in the total duration of harmful drying events, relative to a no-pumping condition. The definition of harmful drying events are those in which water levels are below the critical elevation for ≥ 8 days.

Current-pumping status of this metric was assessed for each system by comparing the total duration of harmful drying events under the current-pumping condition with the MFLs condition. If the total duration of harmful drying events is less under current pumping than the MFL conditions, then the metric is considered met under current conditions.

Under the current-pumping condition, the critical soils elevation for the Little Wekiva River at SLB experienced 416 drying events (≥ 8 days), compared to 436 events under the no-pumping condition. There were *fewer* events under the current-pumping condition because individual events under the no-pumping condition merged to create *fewer but much longer* duration events under current pumping (i.e., fewer events, but longer total duration of harmful conditions).

The length of harmful drying events under the current-pumping condition varied from 8 days to 272 days, with the distribution of events skewed towards low duration events and the average duration of events equaling approximately 44 days (Figure D-9). The average of 44 days is 7 days longer than the average number of days under the no-pumping condition. The total duration of drying events under the current-pumping condition equals 18,486 days. This 12.6% increase in total duration is less than the allowable increase under the MFLs condition (i.e., < 15% increase from no-pumping condition).

Because the MFLs condition was not exceeded, the next step was to test different impact scenarios until the 15% threshold was met. This analysis involved using modeled time series data (i.e., same iterative process as described under event-based assessment) to test the total duration of harmful drying events, until it equaled the MFLs condition.

A 5% increase in current-pumping condition impact was necessary to increase the duration of harmful drying events from the current-pumping to MFLs condition (i.e., from 18,486 to 18,575 days). This increase in allowable impact equates to a flow freeboard of 0.4 cfs for the Little Wekiva River at SLB (Table D-2).

At Rock Springs Run there were zero harmful drying events (≥ 8 days in duration) under the no-pumping condition, and so it was not possible to determine an MFLs condition or flow freeboard for this metric at this site (Table D-2). However, when tested under the current-pumping condition, there were only four events over the POR.

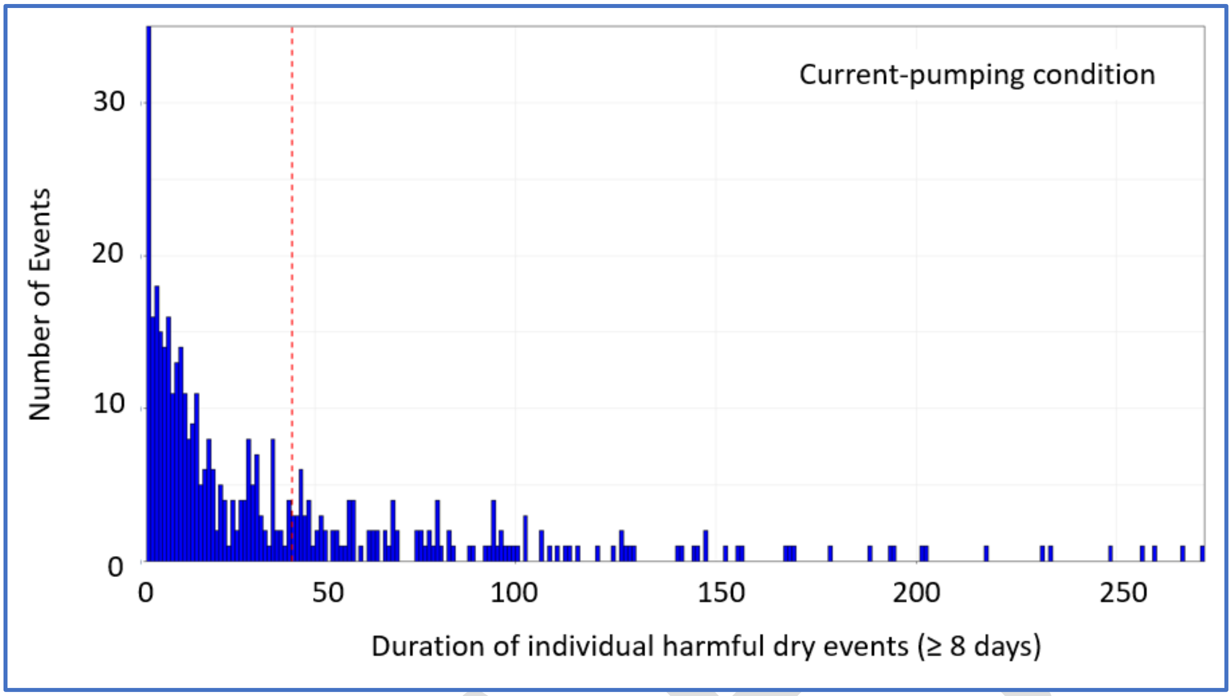

Figure D-9. Distribution showing number of harmful drying events, of varying duration under the current-pumping condition for the Little Wekiva River at SLB; the red dashed line represents the average duration of harmful drying events.

Table D-2 Organic soils drying event summary under no-pumping, MFLs and current-pumping conditions.

	Total Duration of Harmful Drying Events			
	NP Condition	**MFLs Condition**	**CP Condition**	**Flow Freeboard (cfs)**
Little Wekiva River at SLB	16,152	18,575	18,486	0.4
Rock Springs Run	0	NA	4	NA

Floodplain Inundation Protection

As discussed above, the minimum FH was found to be not appropriate at the Little Wekiva River at SLB because it was not met under the pre-withdrawal condition. The FH was also found to be insensitive to flow changes at Rock Springs / Rock Springs Run. Nonetheless, ensuring the floodplains of these two systems being inundated periodically is important. Floodplains require protection from excessive water withdrawal due to the numerous ecosystem benefits they provide, such as maintaining healthy nutrient and carbon exchange, and providing various types of habitat for many fish and wildlife species.

The MFLs-condition inundation exceedance for the Little Wekiva River at SLB average floodplain elevation (18.7 ft NAVD88) is 8.1% (i.e., this equals 15% reduction from the no-pumping condition exceedance of 9.5%). Under the current-pumping condition the exceedance of this elevation is 8.4%, meaning that there is flow freeboard for this metric. Because the MFLs condition was not exceeded, the next step was to test different impact scenarios until the 15% threshold was met.

A 35% increase in current-pumping condition impact was necessary to decrease exceedance of the critical elevation from the current-pumping to MFLs condition (i.e., from 2,200 to 2,099 days). This increase in allowable impact equates to a flow freeboard of 3.1 cfs for the Little Wekiva River at SLB (Table D-3).

The MFLs-condition inundation exceedance for the Rock Springs Run average floodplain elevation (25.0 ft NAVD88) is 83.9% (i.e., this equals 15% reduction from the no-pumping condition exceedance of 98.7%). Under the current-pumping the exceedance of this elevation is 86.3%, meaning that there is flow freeboard for this metric. Because the MFLs condition was not exceeded, the next step was to test different impact scenarios until the 15% threshold was met.

A five percent increase in current-pumping condition impact was necessary to decrease exceedance of the critical elevation from the current-pumping to MFLs condition (i.e., from 22,374 to 21,758 days). This increase in allowable impact equates to a flow freeboard of 0.5 cfs for the Rock Springs Run (Table D-3).

Table D-3 Hardwood swamp average elevation, NP condition exceedance and MFLs condition (NP-15%) exceedance for Wekiva River basin systems.

System	Average Hardwood Swamp Elevation (ft; NAVD88)	MFL Condition Exceedance (%)	CP Condition Exceedance (%)	Flow Freeboard (cfs)
Little Wekiva River at SLB	18.7	8.1	8.4	3.1
Rock Springs Run	25.0	83.9	86.3	0.5

Habitat suitability – System for Environmental Flow Analysis (SEFA)

Current status of fish habitat suitability (i.e., area weighted suitability [AWS]; see MFLs Determination for AWS description) was assessed for each system by comparing the average suitability under the current-pumping condition with the MFLs condition, for each of 32 species, life stages and guilds (see attached for AWS curves for each taxon). The MFLs condition for each SEFA metric is defined as a 15% reduction in average AWS under the no-pumping condition. If the average AWS for a given SEFA metric under the current-pumping condition is greater than or equal to average AWS under the MFL condition, then the metric is considered met under current conditions (i.e., freeboard is ≥ 0 ft or cfs).

A total of 192 SEFA analyses were conducted, equaling the number of taxa/life stages/guilds (i.e., 32) times the following six locations in the Wekiva River basin: three locations on the mainstem Wekiva River, Wekiwa Springs Run, Rock Springs Run and the Little Wekiva River.

Average no-pumping condition AWS (ft^2/ft) for fish taxa with a negative relationship between flow and habitat availability is provided above for all four Wekiva River basin systems (Table D-4). No fish species, life stages or guilds exhibited a 15% or greater reduction in habitat availability (i.e., AWS) from no-pumping to current-pumping conditions (Table D-4). Two locations each exhibited one example each of a greater than 10% change in AWS (Table D-4). One example was for redbreast sunfish fry in the mainstem of the Wekiva River upstream of SR 46. The second example was the deep/fast habitat guild in Rock Springs Run. Both exhibited a 10.5% reduction from no-pumping to current-pumping condition AWS.

In addition to the current-pumping condition, one other withdrawal scenario was evaluated. For Rock Springs and the Little Wekiva River, current-pumping plus 5% impact was evaluated (Table D-4). This scenario represents the most constraining hydrologic regime, based on other primary metrics, for each of these systems. The purpose of testing this other withdrawal scenario was to determine if in-channel habitat suitability is more or less constraining than other primary metrics. No other scenarios were compared for the Wekiva River mainstem or Wekiwa Springs because the current-pumping condition is the constraint for these systems, based on event-based metrics. This withdrawal scenario (current-pumping plus 5%) did not result in a 15% AWS reduction relative to the no-pumping condition for either Rock Springs or the Little Wekiva River (Table D-5).

Habitat suitability (i.e, AWS) under the current-pumping condition and the additional withdrawal scenario tested for Rock Springs and Little Wekiva River, exhibited a minor reduction compared to the no-pumping condition. The largest reduction was less than 15% and was limited to only a few species, life stages or guilds (Table D-4). In only 7.8% of cases (i.e., only 15 of the possible 192 cases) was there a reduction in AWS of greater than 5%. The remaining 177 location/taxa combinations exhibited a reduction in habitat availability that was less than 5%, and for many it was much less; note that taxa with very low no-pumping condition AWS values are not presented in Table D-4.

Table D-4. NP and CP condition AWS (ft^2/ft) for select taxa/life stages and habitat guilds, for six locations in the Wekiva River basin; RM = river mile.

River Reach	Taxon / Life Stage / Guild	NP Condition Average AWS	CP Condition Average AWS	AWS % Reduction (NP - CP) / NP
Wekiva River Mainstem Downstream from SR 46 to RM 2.5	Largemouth Bass Adult	136.9	129.9	5.1
	Channel Catfish Fry	147.5	142.7	3.3
	Generic Darters adult	136.5	132.4	3.0
	Habitat Guilds Deep Slow	147.0	144.0	2.0
	Redbreast Sunfish Adult	147.0	144.0	2.0
	American Shad	119.5	116.9	2.2
	Bluenose Shiner	142.4	140.9	1.1
	Redbreast Sunfish Juvenile	162.9	161.6	0.8
	Largemouth Bass Juvenile	114.8	114.4	0.3
Wekiva River Mainstem Upstream from SR 46 to Railroad	Redbreast Sunfish Fry	99.3	88.9	10.5
	Habitat Guilds Deep Fast	164.5	153.5	6.7
	Largemouth Bass Adult	196.0	186.6	4.8
	Channel Catfish Juvenile Spring	141.6	135.6	4.2
	Channel Catfish Fry	293	284.6	2.9
	Generic Darters adult	270.3	263.7	2.4
	Spotted Sunfish Spawning	152.4	148.8	2.4
	Habitat Guilds Deep Slow	287.6	281.0	2.3
	Redbreast Sunfish Adult	287.6	281.0	2.3
	American Shad	245.8	240.2	2.3
	Spotted Sunfish Juvenile	205.3	201.5	1.9
	Largemouth Bass Juvenile	298.5	294.7	1.3
	Channel Catfish Juvenile	138.4	136.9	1.1
	Channel Catfish Juvenile Summer	154.9	153.5	0.9
	Spotted Sunfish Adult	296.8	294.6	0.7
	Spotted Sunfish Fry	114.5	113.6	0.8
	Redbreast Sunfish Juvenile	342.8	341.6	0.4
	Blackbanded Darter Adult	276.8	275.6	0.4
Wekiva River Mainstem Upstream from Railroad to LWR	Channel Catfish Fry	142.8	133.5	6.5
	Generic Darters adult	127.1	119.6	5.9
	American Shad	118.3	116.1	1.9
	Blackbanded Darter Adult	102.6	101.2	1.4

River Reach	Taxon / Life Stage / Guild	NP Condition Average AWS	CP Condition Average AWS	AWS % Reduction (NP - CP) / NP
Wekiva River Mainstem Upstream from Railroad to LWR, continued	Habitat Guilds Deep Slow	150.4	148.8	1.1
	Redbreast Sunfish Adult	150.4	148.8	1.1
	Spotted Sunfish Adult	101.4	100.6	0.8
	Redbreast Sunfish Juvenile	169.9	169.7	0.1
	Largemouth Bass Adult	154.5	154.3	0.1
	Redbreast Sunfish Spawning	96.9	96.9	0.0
LWR from Wekiva River Upstream to SR434	Habitat Guilds Deep Fast	14.8	14.0	5.4
	American Shad	22.1	21.2	4.1
	Habitat Guilds Deep Slow	17.6	17.2	2.3
	Redbreast Sunfish Adult	17.6	17.2	2.3
	Bluenose Shiner	15.0	14.9	0.7
	Channel Catfish Fry	17.7	17.5	1.1
	Spotted Sunfish Adult	16.6	16.5	0.6
	Generic Darters adult	16.3	16.3	0.0
Wekiwa Springs Run from Gage to RM 14.5	Channel Catfish Spawning	89.2	87.0	2.5
	Largemouth Bass Adult	135.8	134.0	1.3
	Habitat Guilds Deep Slow	135.5	133.9	1.2
	Redbreast Sunfish Adult	135.5	133.9	1.2
	Redbreast Sunfish Juvenile	172.4	170.9	0.9
	Largemouth Bass Spawning	137.7	136.7	0.7
	Bluenose Shiner	134.0	133.2	0.6
	Redbreast Sunfish Fry	88.1	88.1	0.0
Rock Springs Run from Gage to Wekiva River	Habitat Guilds Deep Fast	30.6	27.4	10.5
	Largemouth Bass Adult	26.5	24.2	8.7
	Channel Catfish Juvenile Spring	20.9	19.4	7.2
	American Shad	41.9	39.0	6.9
	Habitat Guilds Deep Slow	43.7	40.8	6.6
	Redbreast Sunfish Adult	43.7	40.8	6.6

River Reach	Taxon / Life Stage / Guild	NP Condition Average AWS	CP Condition Average AWS	AWS % Reduction (NP - CP) / NP
Rock Springs Run from Gage to Wekiva River, continued	Channel Catfish Fry	46.6	43.5	6.7
	Channel Catfish Juvenile Summer	25.6	24.1	5.9
	Generic Darters adult	43.0	40.8	5.1
	Spotted Sunfish Adult	41.9	40.3	3.8
	Blackbanded Darter Adult	42.7	41.1	3.7
	Redbreast Sunfish Juvenile	53.8	51.9	3.5
	Bluenose Shiner	39.2	37.9	3.3
	Largemouth Bass Spawning	18.9	18.4	2.6
	Redbreast Sunfish Spawning	33.7	33.0	2.1
	Channel Catfish Juvenile Fall	17.9	17.6	1.7
	Spotted Sunfish Spawning	21.9	21.6	1.4
	Largemouth Bass Juvenile	35.8	35.5	0.8
	Channel Catfish Juvenile	20.9	20.8	0.5
	Bluegill Spawning	34.3	34.1	0.6
	Spotted Sunfish Juvenile	30.3	30.3	0.0

Table D-5. AWS (ft^2/ft) for NP condition, CP+5% impact for LWR and Rock Springs for select taxa/life stages and habitat guilds; RM = river mile.

River Reach	Taxon / Life Stage / Guild	NP Condition Average AWS	CP+5% Impact Average AWS	AWS % Reduction (NP - [CP+5%]) / NP
LWR from Wekiva River Upstream to SR434	Habitat Guilds Deep Fast	14.8	14.0	4.9
	American Shad	22.1	21.2	4.2
	Habitat Guilds Deep Slow	17.6	17.3	2.1
	Redbreast Sunfish Adult	17.6	17.3	2.1
	Bluenose Shiner	15.0	15.0	0.0
	Channel Catfish Fry	17.7	17.6	0.4
	Spotted Sunfish Adult	16.6	16.6	0.3
	Generic Darters adult	16.3	17.6	0.4
Rock Springs Run from Gage to Wekiva River	Habitat Guilds Deep Fast	30.6	27.2	11.1
	Largemouth Bass Adult	26.5	24.1	9.1
	Channel Catfish Juvenile Spring	20.9	19.3	7.7
	American Shad	41.9	38.9	7.2
	Habitat Guilds Deep Slow	43.7	40.7	7.0
	Redbreast Sunfish Adult	43.7	40.7	7.0
	Channel Catfish Fry	46.6	43.4	6.9
	Channel Catfish Juvenile Summer	25.6	24.0	5.9
	Generic Darters adult	43.0	40.7	5.4
	Spotted Sunfish Adult	41.9	40.2	4.2
	Blackbanded Darter Adult	42.7	41.0	3.8

Rock Springs Run from Gage to Wekiva River, *continued*	Redbreast Sunfish Juvenile	53.8	51.8	3.7
	Bluenose Shiner	39.2	37.9	3.3
	Largemouth Bass Spawning	18.9	18.4	2.6
	Redbreast Sunfish Spawning	33.7	33.0	1.9
	Channel Catfish Juvenile Fall	17.9	17.6	1.8
	Spotted Sunfish Spawning	21.9	21.6	1.2
	Largemouth Bass Juvenile	35.8	35.4	1.1
	Channel Catfish Juvenile	20.9	20.8	0.7
	Bluegill Spawning	34.3	34.1	0.4
	Spotted Sunfish Juvenile	30.3	30.2	0.1

Overall, there was a very small reduction in habitat availability for all species, life stages and guilds under the withdrawal scenarios tested. The largest change was to a single life stage of a ubiquitous generalist species (redbreast sunfish fry).

There was a relatively small reduction in AWS under current-pumping conditions relative to the no-pumping condition for species of special concern like bluenose shiner (0.6 – 3.3% reduction). When weighted by river mile, the total average AWS reduction under the current-pumping condition, for the river system is 1.1%. Rock Springs run exhibited the largest change with a 3.3% reduction. However, the amount of habitat availability under the no-pumping condition was relatively small (39.2 ft^2/ft), and the 3.3% reduction equates to approximately a reduction of 1 ft^2/ft. For most of the rest of the basin the reduction was zero, or less than 1 ft^2/ft. In addition, there was no change to AWS for the bluenose shiner at Rock Spring Run when impact was increased by 5% (Table D-5). This result for the bluenose shiner is reasonable given the use by this species of slow velocity marginal habitat. There is evidence for physical structure being a limiting factor in the success of this species (*personal communication*: Eric Nagid, FWC 2023).

Similar to the bluenose shiner, the greatest reduction in American shad habitat was at Rock Springs run (6.9% reduction), but equated to a small amount of change in habitat suitability (a reduction of 3 ft^2/ft, from 41.9 to 38.9 ft^2/ft). Give the relatively small amount of AWS under the no-pumping condition, and the relatively small reduction to the current-pumping condition, fish habitat suitability, including for imperiled species, is considered protected by other more constraining metrics at all four Wekiva River basin systems.

Current-Status Summary

System Specific Freeboards

Current status for the four Wekiva River basin systems are based on criteria assessments described above. Flow (cfs) freeboard values were determined for the most constraining metric for each Wekiva River basin water body. As described above, spring flows in the Wekiva Basin surface water model were increased or decreased by small increments to determine the change in flow necessary to just meet a particular metric threshold. In some cases if the metric did not exceed a threshold with a certain amount of flow reduction, the freeboard is expresses as “greater than” a given value (Table D-6).

Based on these five primary criteria, none of the four Wekiva River basin systems are in recovery (i.e., all flow freeboards are ≥ zero). Both minimum levels (FH and MA) are equally constraining for the Wekiva River at SR 46 (i.e., flow freeboard equals zero for both metrics). The most constraining metric for Wekiwa Springs is the FH with a flow freeboard of zero. The Little Wekiva River at SLB has a flow freeboard of 0.4 cfs, based on the organic soils drying metric. Rock Springs has a freeboard of 0.5 cfs, based on the floodplain inundation metric (Table D-6). All of these system-specific constraints are more constraining than the SEFA analysis for each water body. This is why the flow freeboards for SEFA are presented as greater than each system-specific freeboard value.

Based on the system-specific MFLs summarized above (Table D-6), the most constraining MFLs water bodies in the Wekiva River basin are the Wekiva River at SR 46 and Wekiwa Springs, both with a freeboard of zero cfs. This means that the allowable impact is equal to that represented by the current-pumping condition (i.e., freeboard is defined as reduction from current-pumping condition). The freeboard for the Little Wekiva River (0.4 cfs) and Rock Springs (0.5 cfs) is equal to the current-pumping condition plus 5% impact (Table D-6).

Table D-6 Flow freeboards for metrics evaluated at all Wekiva River basin water bodies; system-specific freeboards (i.e., most constraining metrics per system) are highlighted.

Environmental Metric	Wekiva River at SR 46	Wekiwa Springs	Rock Springs	Little Wekiva River at SLB
Minimum Frequent High	0.0	0.0	> 5.5	> 4.4
Minimum Average	0.0	> 2.3	> 5.5	NA
Organic Soils - Drying	NA	NA	NA	0.4
Floodplain Inundation	NA	NA	0.5	3.1
In-channel Fish Habitat (SEFA)	>0.0	>0.4	>0.5	>0.4

Basin-wide Freeboard

Rock Springs and the Little Wekiva River at SLB are both less constraining (i.e., have greater freeboards) than Wekiwa Springs and the Wekiva River at State Road (SR) 46. However, both are also upstream of and contribute a large proportion of the flow at SR 46. Because the MFLs constraining metrics at SR 46 (i.e. the minimum FH and MA) are met by the current-pumping condition (which yields a freeboard of zero cfs), it is recommended that all water bodies in the upper portion of the basin also be limited to the current-pumping condition. This is necessary because any further flow reduction in the springs upstream of SR 46 gage (from current-pumping condition) would decrease the flows at SR 46 and result in violation of the MFLs at that location.

This recommendation also stems from the fact that the Wekiva River at SR 46 is an indicator for conditions throughout the basin, and the minimum flow at SR 46 is based on transects (used for the minimum FH and MA) whose locations extend from upstream of the confluence of the Little Wekiva River to downstream of SR 46 (i.e., the SR 46 FH and MA protect floodplain conditions throughout the basin, not only at SR 46; Figure 41 in main report). This recommendation is also supported by the constraint at Wekiwa Springs which has a flow freeboard of zero.

In addition to the four primary waterbodies described above, minimum flows are also recommended for the four smaller Wekiva River basin springs that currently have adopted MFLs. These include Miami Springs, Palm Springs, Sanlando Springs and Starbuck Springs. The recommended minimum flow for these four small (second and third magnitude) springs is equal to the site-specific average flow under the current-pumping condition. This recommendation is for the same reasons described above (i.e., to limit the basin to current pumping to meet the most sensitive and most downstream metric at SR 46). As described in Appendix E, an effort was made to evaluate the effects of withdrawal on swimming and wading, the primary environmental function, at three of these springs (Palm, Sanlando and Starbuck Springs). However, because of the lack of relationship between flow and water level, it was deemed inappropriate to develop a water-level-based swimming or wading metric at these three springs. Flows at these three springs can be reduced by a large amount before a significant change in water level (or swimming depth) will occur (see Appendix E for details). At Miami Springs, swimming depth is not an appropriate metric because of its very small size and the fact that it is not used for swimming. Its primary environmental values are aesthetics and contribution of baseflow to the Wekiwa Springs run. The small reduction in flow under the current-pumping condition (i.e., 0.8 cfs; Table D-7) will protect these values at Miami Springs.

Based on a basin-wide impact equaling the current-pumping condition, the recommended freeboard for each MFLs water body in the Wekiva River basin is zero cfs (i.e., allowable change under current-pumping condition). The resulting minimum flows recommended for these four water bodies are presented below (Table D-7). These minimum flows equate to an allowable flow reduction, relative to the no-pumping condition, of 26.0 cfs for the Wekiva

Table D-7 Average current-pumping (CP) flow for Wekiva River systems, based on setting freeboard equal to SR 46 (i.e., freeboard = 0 cfs), so that impact is limited to current pumping for all systems; also presented are average no-pumping (NP) flow, and the allowable reduction (cfs and percent) from NP to CP average flow.

System	Average NP Flow (cfs)	Average CP (Basin-wide MFL) Flow (cfs)	Flow (cfs) Reduction from NP to CP	Flow (%) Reduction from NP to CP
Wekiva River at SR 46	304.5	278.5	26.0	8.5
Little Wekiva R. at SLB	80.2	71.3	8.9	11.1
Rock Springs	66.9	55.8	11.1	16.6
Wekiwa Springs	69.0	64.4	4.6	6.7
Miami Springs	6.4	5.6	0.8	12.5
Palm Springs	6.7	5.6	1.1	16.4
Sanlando Springs	26.0	21.0	5.0	19.2
Starbuck Springs	15.0	12.8	2.2	14.7

River at SR 46, 8.9 cfs for the Little Wekiva River at SLB, 4.6 cfs at Wekiwa Springs, 11.1 cfs at Rock Springs, 5.0 cfs at Sanlando Springs, 2.2 cfs at Starbuck Springs, 1.1 cfs at Palm Springs, and 0.8 cfs at Miami Springs.

Because the recommended MFLs condition in the basin equals the current-pumping (i.e., defined as the 2014 - 2018 average) condition, the current-pumping condition freeboard (or the allowable change in flow from current pumping) for each MFLs water body in the Wekiva River basin is zero cubic feet per second (cfs).

However, in recent years water use has increased relative to the CP (i.e., 2014 - 2018 average) condition. Therefore, all Wekiva River basin systems are in recovery, and a recovery strategy must be developed concurrently with the MFLs. Consistent with the provisions for establishing and implementing MFLs provided for in section 373.0421, F.S., the recovery strategy identifies a suite of projects and measures that, when implemented, will recover these priority water bodies from impacts due to groundwater pumping withdrawals and prevent the MFLs from not being met due to future consumptive uses of water. The recovery strategy will also provide sufficient water supply options to meet existing and projected reasonable beneficial uses.

UFA Levels - Additional Springs Protection

The relationship between MFLs springs in the Wekiva river basin and groundwater levels in the vicinity were reviewed to determine if any nearby groundwater wells can be used to monitor groundwater level trends in the area. The purpose of monitoring this trend is for early detection of significant impact to MFLs springs from groundwater pumping. The UFA monitoring well OR0548 at Wekiwa springs state park is determined to be the best monitoring well in the Wekiva river groundwater basin for UFA level monitoring and

trend analysis. Comparison of standardized spring flows and the OR0548 water levels show that the OR0548 water levels generally follow a fairly similar trend to the large springs in the Wekiva river basin (Figures D-10 through D-13). Standardization is the process of converting a variable to one with an average of 0 and standard deviation of 1 so that two different variables can be compared on the same scale. A dataset is standardized by subtracting each value from the average and dividing the difference by its standard deviation.

Since uncertainty in groundwater level measurements are much less than those in the spring flow measurements and groundwater model results, monitoring and analyzing groundwater level trends in the Wekiva river basin periodically will provide further assurance that the springs in the basin will not be significantly harmed by groundwater pumping.

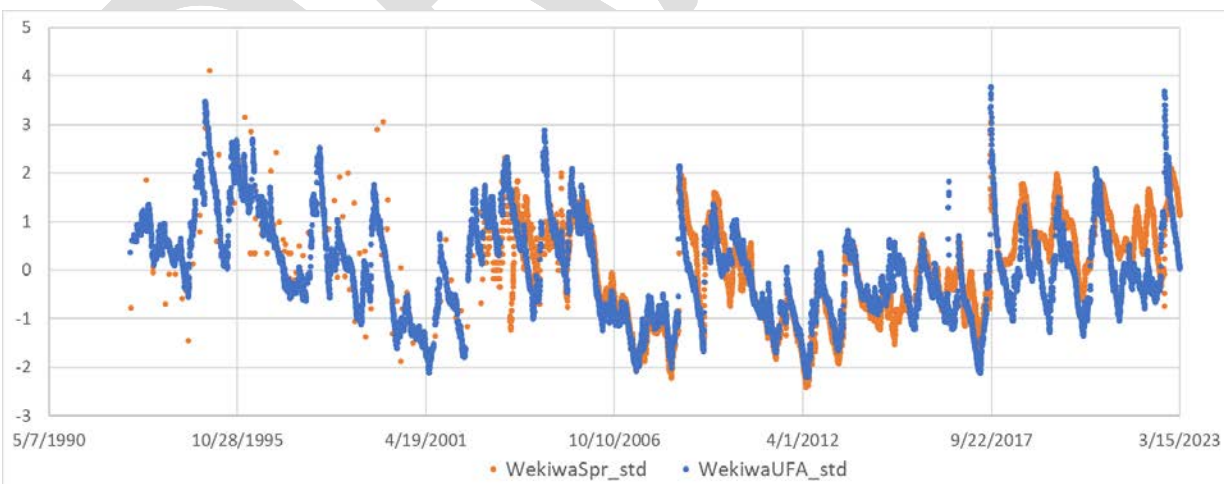

Figure D-10. Standardized Wekiwa springs flows and OR0548 water levels.

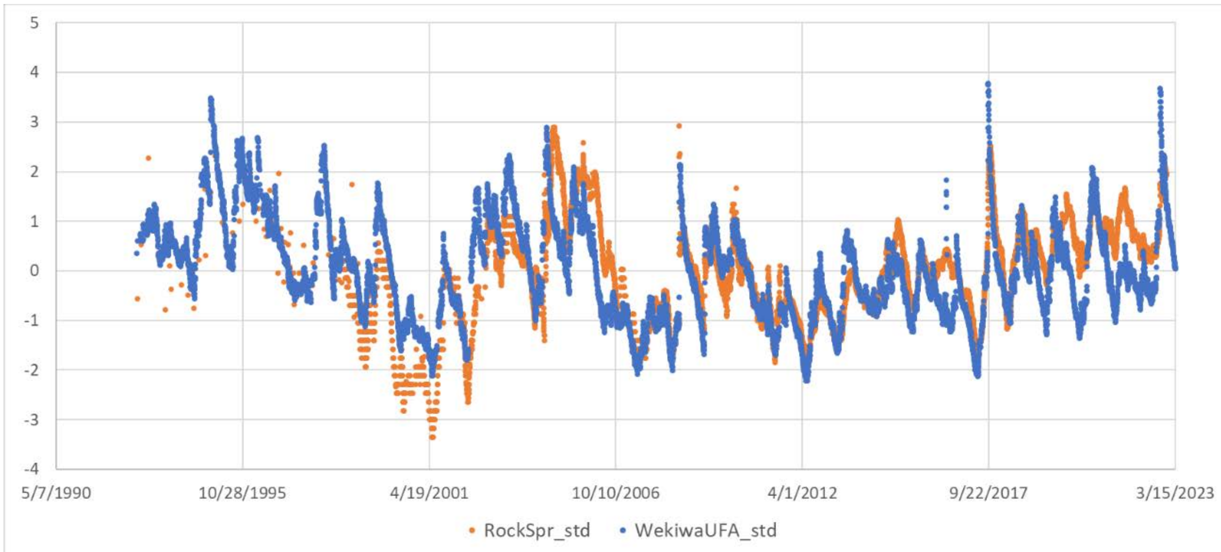

Figure D-11. Standardized Rock springs flows and OR0548 water levels

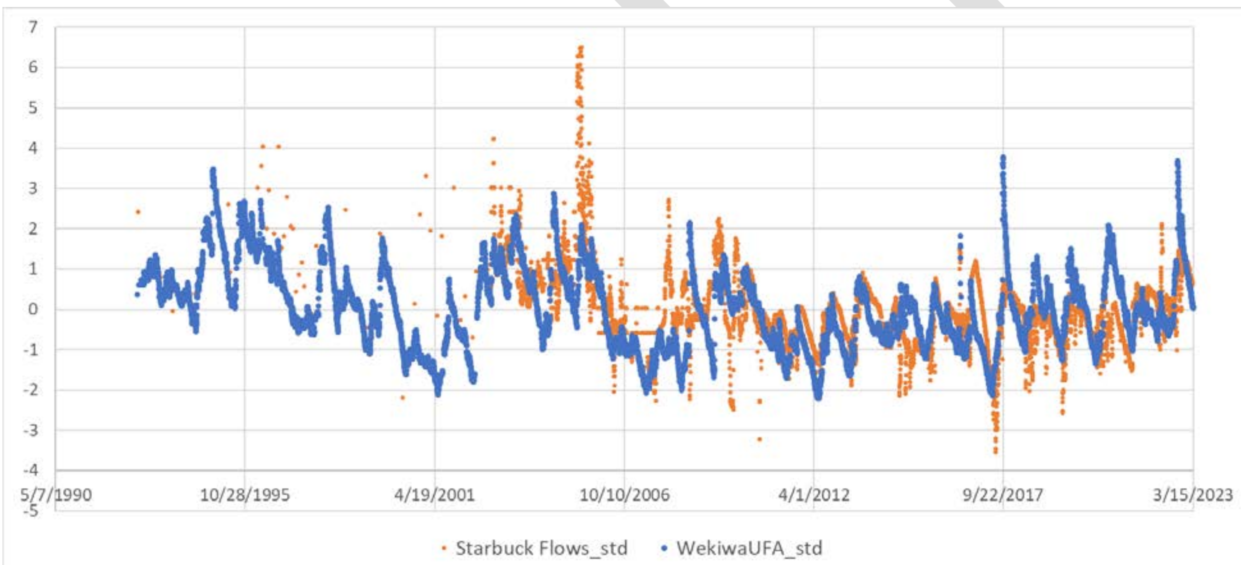

Figure D-12. Standardized Starbuck springs flows and OR0548 water levels

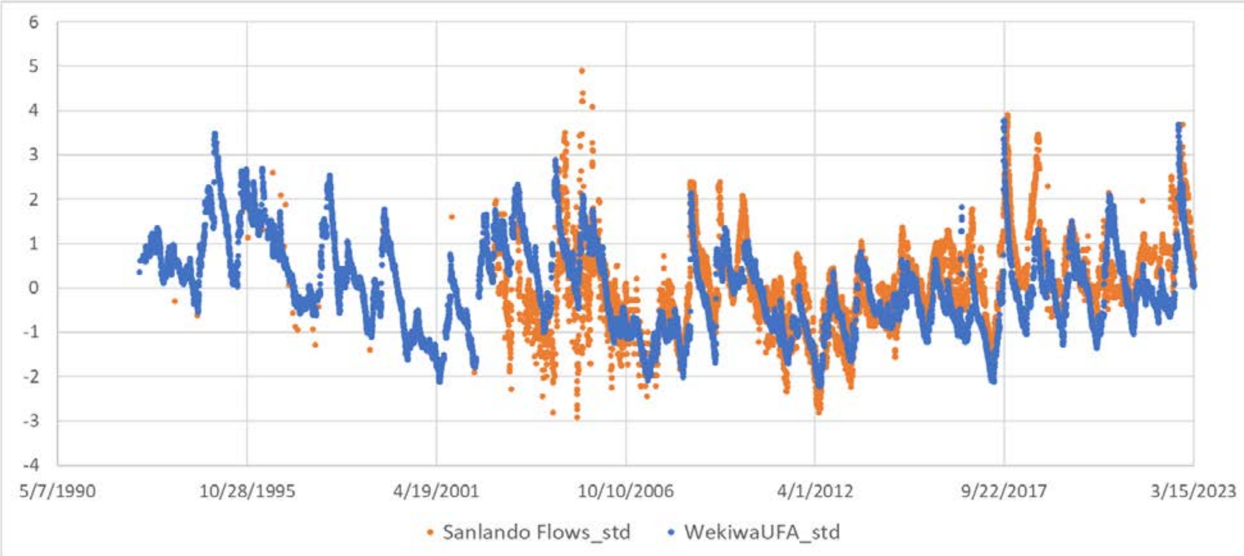

Figure D-13. Standardized Sanlando springs flows and OR0548 water levels

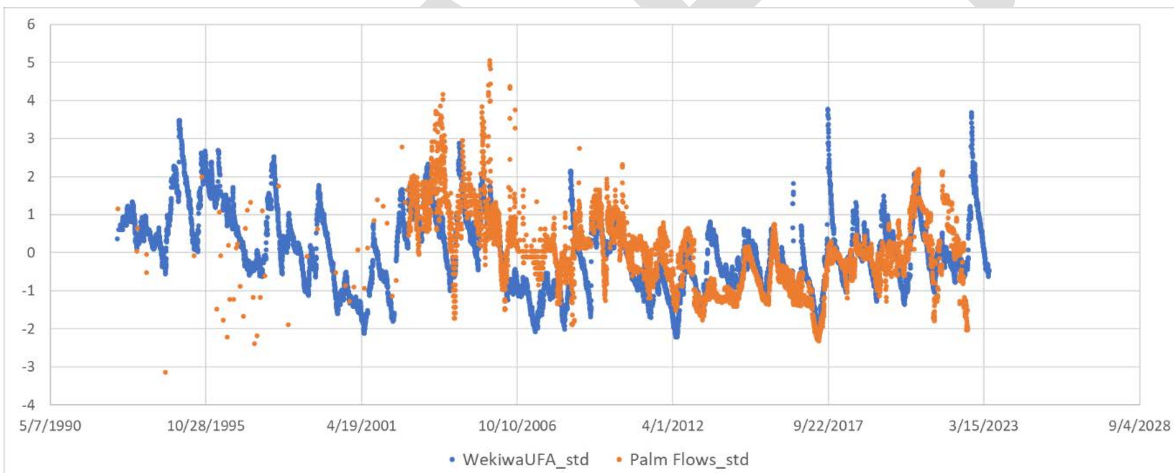

Figure D-14. Standardized Palm springs flows and OR0548 water levels

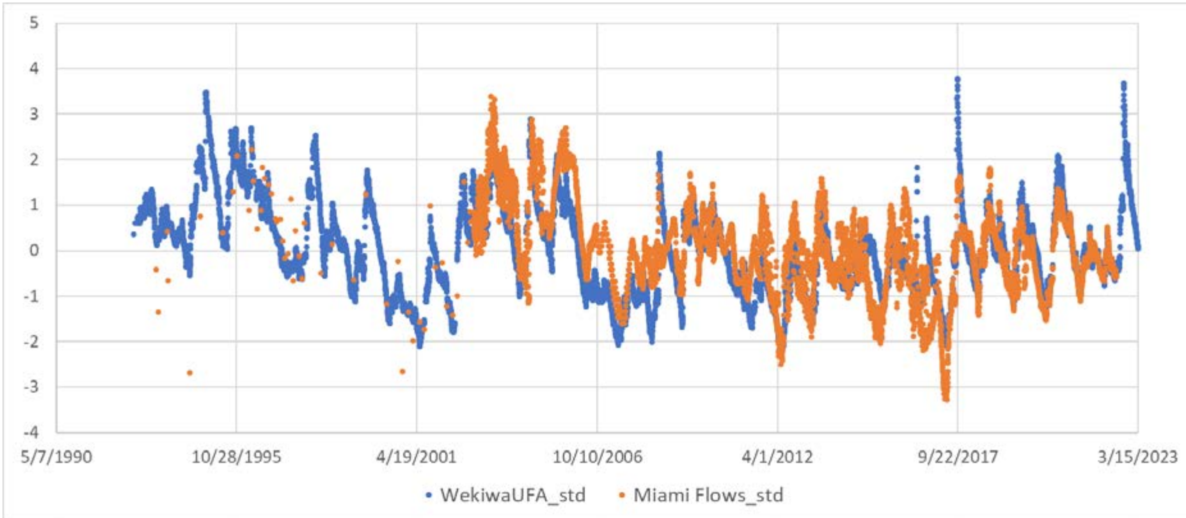

Figure D-15. Standardized Miami springs flows and OR0548 water levels