Naval Facilities Engineering Systems Command Hawaii

Final Report of Findings, Red Hill Shaft Flow Optimization Study, September 19, 2023

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Final Report of Findings, Red Hill Shaft Flow Optimization Study, September 19, 2023

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Executive Summary

This report of findings describes the results of the Red Hill Shaft (RHS) Flow Optimization Study, which seeks to optimize the effective contaminant capture zone around RHS created by pumping at RHS while minimizing the impact on the groundwater resource within the sole-source aquifer. The data-gathering portion of the study was conducted between April 7 and June 20, 2023, in which groundwater levels were recorded at 10-minute intervals throughout the Red Hill monitoring well network and at some offsite wells while different pumping scenarios (trial periods) were implemented at RHS. These data were used to further understanding of geological, hydrogeological, and geochemical aspects of the Red Hill conceptual site model. Optimizing pumping at RHS can help preserve groundwater resources, reduce electrical usage and reduce use of granular activated carbon (GAC) used to treat extracted groundwater prior to discharge to South Hālawa Stream while preventing migration of gross contamination away from RHS as defined in the *Red Hill Shaft Recovery and Monitoring Plan* (RHSRMP) (IDWST 2022).

Data collected for the study were analyzed in a manner consistent with the procedure outlined in EPA documentation entitled *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (EPA 2008). Steps included data review, establishment of site-specific capture zones, interpretations of water levels, capture zone calculations and modeling, evaluation of water quality and concentrations trends, and interpretation of capture.

Multiple lines of evidence were assembled to assess capture of groundwater from the Target Capture Zone located in the immediate vicinity of RHS. (An additional zone near the tank farm was also evaluated, but no final conclusions are being drawn in that area at this time.) Three average pumping rates were evaluated during these three periods: 4.3, 2.9, and 1.7 million gallons per day (mgd). Forward particle tracking methods were used as the main lines of evidence, including water levels interpolated with Groundwater Desktop (GWD) accounting for horizontal anisotropy, an Analytic Element Model (AEM), and the "best available" Groundwater Flow Model (GWFM). Additional consideration was given to several indirect lines of evidence such as 3-point hydraulic gradient calculations, vertical gradients, water quality, stable isotopes of water and nitrate, and analytical data. Results of the particle tracking analysis from all three methods generally indicated that capture of both target areas was sufficient at all pumping rates; however, particle tracking from water level contours alone yielded results that were highly dependent on the assumption of anisotropy.

A key factor in estimating flow directions at the site is the evaluation of horizontal anisotropy. A standard method for evaluating anisotropy depends on the aspect ratio of a drawdown ellipse contour; however, this method uses the assumption of a vertical well. Because RHS is a roughly 1,200-foot-long horizontal shaft, the distances to the drawdown ellipses are greater than the shortest distance to RHS in the secondary direction along the basalt flow strike, resulting in an anisotropy ratio likely to be biased low. From this method, two interpretations arrived at horizontal anisotropy ratio estimates of 5.3 and 10.4. Additional analysis with particle tracking demonstrated flow down ridge with an anisotropy ratio of 15, which is slightly higher than the values presumed to be biased low.

An additional line of evidence that suggests a flow direction down Red Hill ridge is total petroleum hydrocarbons – residual oil range organics (TPH-o) data collected in the weeks and months following the release at Tanks 18 and 20 in May of 2021, which may indicate travel of TPH-o from the release location to RHMW03 to RHMW02 and potentially farther down-ridge. However, the apparent summer 2021 "breakthrough" at RHMW02 may have resulted from a number of alternative mechanisms, such as:

- Local remobilization of residual fuels potentially present at or close to the water table;
- Local remobilization of residual fuels potentially present in the vadose zone; or
- Breakthrough related to the May 2021 release.

Although there is uncertainty about the underlying mechanism, the timing of TPH-o changes at RHMW03 and RHMW02 suggests some migration from the release area down-dip to these monitoring wells, which suggests that the degree of horizontal anisotropy influences the direction of migration in the saturated basalt.

The weight of evidence documented in this report suggests that capture of groundwater in the Target Capture Zone around RHS is likely at all pumping rates evaluated. This conclusion is subject to some uncertainty, given the limitations of the methods applied; estimates of capture could potentially be further investigated using a well-designed tracer study or other technique(s). Because capture of groundwater in the immediate vicinity of RHS is likely at all evaluated pumping rates, it is recommended that the pumping rate of RHS be reduced to 1.7 mgd. Operating the RHS GAC system at this reduced flow rate should remain protective because no recent analytical data have indicated a persistent plume around RHS. It is likely that dissolved-phase contamination has been extracted by RHS and that the risk of contamination migrating farther downgradient away from RHS is low. Also continuing to operate the system, but at a reduced rate, reduces the risk of GAC biofouling when wet GAC sits idle for extended periods.

Decisions to reduce the RHS pumping rate should consider the overall goals of system operation. Capture of the RHS target area may be achieved at the lowest rate of 1.7 mgd, and also may no longer be necessary due to lack of dissolved-phase contamination remaining in the area. Additional capture of groundwater under the tank farm is less certain and would be focused on capturing contamination related to residual petroleum sources in the subsurface. If a future release were to occur, or if residual impacts were to migrate, pumping rates could be raised to increase confidence in capture. Benefits of continuation of pumping to contain residual contamination should be weighed against the drawback of wasted water, electricity, GAC, etc. In case of a future release or evidence of a release such as elevated soil vapor readings, elevated groundwater concentrations of TPH, tank volume discrepancies, or physical observations, the Navy should be prepared to increase pumping back to the full 4.3 mgd as a conservative protective measure.

The study uses multiple lines of inquiry (i.e., a variety of data and interpretive techniques) to converge on these conclusions:

1) Pumping at RHS achieves the purpose set forth in the RHSRMP to capture groundwater in the vicinity of RHS at all three tested pumping rates (1.7 mgd, 2.9 mgd, and 4.3 mgd).
2) Pumping at RHS at 2.9 and 4.3 mgd and greater appears to capture much of the groundwater in the vicinity of the tank farm. Farther up the ridge near the more distant tanks, capture becomes less certain, especially at the lowest pumping rate. Moreover, given the relatively flat gradients at the

site, the extent of capture may not be demonstrable. Small water level differences at this site may be within the margins of measurement error and environmental noise.

In any case, the evaluation of flow in the vicinity of the tank farm in this report is preliminary; further analysis of flow around the tank farm is anticipated over the coming year.

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Charts

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Acronyms and Abbreviations

°	degree
%	percent
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
AECOM	AECOM Technical Services Inc
AEM	analytic element model
AnAqSIM	Analytic Aquifer Simulator
AT	AquaTROLL
bmp	below measurement point
BWS	Board of Water Supply, City and County of Honolulu
CLEAN	Comprehensive Long-Term Environmental Action Navy
COPC	chemical of potential concern
CSM	conceptual site model
DLNR	Department of Land and Natural Resources, State of Hawaiʻi
DOH	Department of Health, State of Hawaiʻi
EAL	Environmental Action Level
EDD	electronic data deliverable
EDMS	Environmental Data Management System
EPA	Environmental Protection Agency, United States
FDOM	fluorescent dissolved organic matter
ft	foot/feet
ft/d	feet per day
ft/ft	feet per foot
ft^2/d	square feet per day
GAC	granular activated carbon
GC/FID	gas chromatography/flame-ionization detection
GC/MS	gas chromatography/mass spectrometry
GHB	general head boundary
GWD	Ground Water Desktop
GWFM	groundwater flow model
HST	Hawaii Standard Time
JBPHH	Joint Base Pearl Harbor-Hickam
JP	Jet Propellant
K_x/K_y	anisotropy ratio
LNAPL	light nonaqueous-phase liquid
LTM	long-term monitoring
MB	method blank
mgd	million gallons per day
msl	mean sea level
NAD	North American Datum
NOI	Notice of Interest

NPDES	National Pollution Discharge Elimination System
NWIS	National Water Information System
OWDF	Oily Waste Disposal Facility
PFAS	per- and polyfluoroalkyl substances
RA	Regulatory Agency
RHS	Red Hill Shaft
RHSRMP	Red Hill Shaft Recovery and Monitoring Plan
RMSE	root mean square error
SPM	Special Purpose Meeting
TIC	tentatively identified compound
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons – diesel range organics
TPH-o	total petroleum hydrocarbons – residual oil range organics
USGS	United States Geological Survey

1.0 Introduction

This report of findings describes the results of the Red Hill Shaft (RHS) Flow Optimization Study, which seeks to optimize the effective contaminant capture zone created by pumping at RHS while minimizing the impact on the groundwater resource. The data-gathering portion of the study was conducted between April 7 and June 20, 2023, in which groundwater levels were recorded at 10-minute intervals throughout the Red Hill monitoring well network and at some offsite wells while different pumping scenarios (trial periods) were implemented at RHS (Figure 1-1). These data were used to further understanding of geological, hydrogeological, and geochemical aspects of the Red Hill conceptual site model (CSM) and allow optimization of RHS pumping. Optimizing pumping at RHS can help preserve groundwater resources, reduce electrical usage and reduce use of granular activated carbon (GAC) used to treat extracted groundwater prior to discharge to South Hālawa Stream) while preventing migration of gross contamination away from RHS as defined in the *Red Hill Shaft Recovery and Monitoring Plan* (RHSRMP) (IDWST 2022). Details of how the study was conducted are described in the *Red Hill Shaft Flow Optimization Work Plan* (DON 2022). The conclusions from this study may be used to support a proposed reduction in water usage from RHS.

The RHS Flow Optimization Study was performed by AECOM Technical Services Inc. (AECOM) as part of the Comprehensive Long-Term Environmental Action Navy (CLEAN) V Program under contract number N62742-17-D-1800, contract task order N6274222F0106.

(b) (3) (A)

[redacted]

[redacted]

Figure 1-1
Site Vicinity Map
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

2.0 Background

On November 20, 2021, a release of Jet Propellant-5 (JP-5) fuel originating from the Adit 3 Tunnel of the Red Hill Bulk Fuel Storage Facility (the Facility) affected the groundwater in the vicinity of RHS. For the first time since environmental investigations began at the Facility, light nonaqueous-phase liquid (LNAPL) was measured at the aquifer surface in the RHS water development tunnel.

In response to this release, the Navy, State of Hawaiʻi Department of Health (DOH), and United States Environmental Protection Agency (EPA) jointly developed and signed the RHSRMP (IDWST 2022) to pump groundwater from RHS through the associated GAC treatment system prior to disposing of the treated water into the cement channelized portion of South Hālawa Stream, in accordance with the National Pollution Discharge Elimination System (NPDES) permit. The purpose of pumping water from RHS was "to remove any fuel contamination" from RHS and "create a contaminant capture zone in the vicinity of the Red Hill Shaft through pumping operations" (IDWST 2022). As part of this urgent and immediate effort during the emergency response, it was agreed that "The first line of defense against migration of fuel away from the Red Hill Shaft well is to establish a 'capture zone' by pumping the well to create a draw-down in the aquifer in the vicinity of the Red Hill Shaft" (IDWST 2022). This initial plan consisting of RHS pumping and treatment through the GAC system was implemented to attempt capture at RHS to mitigate offsite migration of basal-aquifer contaminants from the November 20, 2021 JP-5 release but was *not* selected as the overall site remedy.

The RHSRMP (IDWST 2022) was agreed upon without defining the extent of capture required or anticipated, and without any optimization of the RHS pumping rate. Rather, all signatories recognized the "imperative to create a capture zone as soon as possible to prevent contamination migration" from RHS. Accordingly, the parties agreed on a deterministic approach wherein:

> "**The measure of success for the capture zone will be efficacy in recovery of fuel in the Red Hill Shaft, and prevention of migration of fuel and related contaminants away from the well.**"

While the originally agreed-upon pumping flow rate was approximately 5 million gallons per day (mgd), the RHSRMP provides that "If groundwater quality and level results indicate that the capture zone can be maintained at a lower flow rate, reducing flows may be considered" (IDWST 2022). It was later learned that pumping with one RHS pump 24 hours per day/7 days per week (24/7) actually results in a continuous rate of extraction of about 4.3 mgd.

3.0 Continuous Water Level Study Details

3.1 Trial Periods

Data for the Flow Optimization Study were collected during three successive trial periods under the following pumping scenarios:

- Trial Period #1: RHS pumping 24/7 at a continuous rate of approximately 4.3 mgd. This is the RHS pumping condition that had previously been maintained since installation of the GAC system, which differs from the pump cycling conditions that occurred under normal operating conditions. This was the only constant-rate pumping condition evaluated.
- Trial Period #2: RHS pumping reduced to weekdays only (Monday through Friday) at 4.3 mgd for an average rate of 2.9 mgd (0.1 mgd less than the proposed average rate of 3.0 mgd). This was a roughly 29% reduction from the Trial Period # 1 condition.
- Trial Period #3: RHS pumping reduced to three days per week at 4.3 mgd (Monday, Wednesday, and Friday) for an average pumping rate of 1.7 mgd (0.1 mgd less than the proposed 1.8 mgd). This was a roughly 57% reduction from the Trial Period # 1 condition.

Ideally, the aquifer should fully recover between trial periods to allow each pumping scenario to start at steady-state equilibrium conditions. However, to keep the GAC system functioning properly, the pumps could not remain off for more than 3 days at a time. The pumping schedule is presented in Table 3-1.

Table 3-1: Pumping Schedule

Trial Period	Trial Period Week	RHS	Start [a]	End [a]	Number of Days
#1	Week 1 & 2	Off	Fri, Apr 07, 2023, 09:10	Mon, Apr 10, 2023, 09:12	3
		On	Mon, Apr 10, 2023, 09:12	Fri, Apr 28, 2023, 09:05	18
		Off	Fri, Apr 28, 2023, 09:05	Mon, May 01, 2023, 09:12	3
#2	Week 1	On	Mon, May 01, 2023, 09:12	Sat, May 06, 2023, 09:02	5
		Off	Sat, May 06, 2023, 09:02	Mon, May 08, 2023, 09:09	2
	Week 2	On	Mon, May 08, 2023, 09:09	Sat, May 13, 2023, 09:02	5
		Off	Sat, May 13, 2023, 09:02	Mon, May 15, 2023, 09:03	2
	Week 3	On	Mon, May 15, 2023, 09:03	Sat, May 20, 2023, 09:02	5
		Off	Sat, May 20, 2023, 09:02	Tue, May 23, 2023, 09:17	3
#3	Week 1	On	Tue, May 23, 2023, 09:17	Thu, May 25, 2023, 09:00	2
		Off	Thu, May 25, 2023, 09:00	Fri, May 26, 2023, 09:04	1
		On	Fri, May 26, 2023, 09:04	Sat, May 27, 2023, 09:02	1
		Off	Sat, May 27, 2023, 09:02	Tue, May 30, 2023, 09:02	3
	Week 2	On	Tue, May 30, 2023, 09:02	Thu, Jun 01, 2023, 09:00	2
		Off	Thu, Jun 01, 2023, 09:00	Fri, Jun 02, 2023, 09:00	1
		On	Fri, Jun 02, 2023, 09:00	Sat, Jun 03, 2023, 09:02	1
		Off	Sat, Jun 03, 2023, 09:00	Tue, Jun 06, 2023, 09:04	3
	Week 3	On	Tue, Jun 06, 2023, 09:04	Thu, Jun 08, 2023, 09:00	2
		Off	Thu, Jun 08, 2023, 09:00	Fri, Jun 09, 2023, 09:00	1
		On	Fri, Jun 09, 2023, 09:00	Sat, Jun 10, 2023, 09:02	1
		Off	Sat, Jun 10, 2023, 09:02	Tue, Jun 13, 2023, 09:04	3
	Week 4	On	Tue, Jun 13, 2023, 09:04	Thu, Jun 15, 2023, 09:02	2
		Off	Thu, Jun 15, 2023, 09:02	Fri, Jun 16, 2023, 09:00	1
		On	Fri, Jun 16, 2023, 09:00	Sat, Jun 17, 2023, 09:00	1
		Off	Sat, Jun 17, 2023, 09:00	Tue, June 20, 2023, 09:04	3
Return to 24/7 pumping conditions		On	Tue, June 20, 2023, 09:04	--	--

[a] All times shown are Hawaii Standard Time (HST).

3.2 Monitoring Locations and Transducer Type

Most conventional wells monitored by the Navy were equipped with In-Situ AquaTROLL (AT) 600 transducers. The AT600 vented transducers record pressure, actual conductivity, specific conductivity, salinity, total dissolved solids, resistivity, density, dissolved oxygen (as a percent and as a concentration), oxygen-reduction potential, pH, and barometric pressure. Part-way through the RHS Flow Optimization Study, the University of Hawaiʻi, as part of their Office of Naval Research grant, requested that specialty rhodamine, fluorescein, and fluorescent dissolved organic matter (FDOM) sensors be added to some AT600s to collect background data to inform a potential tracer study that they plan to perform.

The project WP (DON 2022) originally called for conventional monitoring wells to use AT200 transducers. AT200 vented transducers record actual conductivity, specific conductivity, salinity, total dissolved solids, resistivity, and density. This deviation from AT200s to AT600s was requested by the Regulatory Agencies (RAs) in a Special Purpose Meeting (SPM) on January 10, 2023.

Four 2-inch conventional wells, monitored by the Navy (RHMW01R, RHP04B, RHP05, and RHP07) could not be monitored by AT600s because deviations in well profiles were too significant to install AT600s down to the screened intervals. The smaller AT200 transducers were installed instead.

All multilevel wells were equipped with designated MOSDAX transducers that recorded pressure and temperature.

Wells monitored by the United States Geological Survey (USGS) were equipped with Navy-owned Level TROLL 700H transducers that record pressure and temperature. USGS data can be downloaded from their website: https://nwis.waterdata.usgs.gov/nwis. At the time of this report, all USGS data were provisional, and data from two of the monitoring locations were not yet available (Board of Water Supply [BWS] Hālawa Shaft and Ka‘amilo Deep) for the full study period.

All transducers (Navy and USGS) recorded readings at 10-minute intervals. Monitoring locations are depicted on Figure 3-1 and listed in Table 3-2. For comparison, the locations of previous studies (described in Section 4.1) are shown on Figure 3-2.

Table 3-2: Monitoring Locations

Monitoring Location	Transducer Type	Monitoring Entity	Easting (ft msl)	Northing (ft msl)	Measurement Point Elevation (ft msl)	Approximate Transducer Installation	
						Depth (ft bmp)	Elevation (ft msl)
RHMW2254-01	AT200 & AT600	Navy	[redacted]	[redacted]	105.5143	90 & 92	16 & 14
RHMW01R	AT200	Navy	[redacted]	[redacted]	101.757	89	13
RHMW02	AT600	Navy	[redacted]	[redacted]	104.597	94	11
RHMW03	AT600	Navy	[redacted]	[redacted]	120.898	106	15
RHMW04	AT600	Navy	[redacted]	[redacted]	312.1062	303	9
RHMW05	AT600	Navy	[redacted]	[redacted]	101.3012	86	15
RHMW06	AT600	Navy	[redacted]	[redacted]	259.0916	250	9
RHMW08	AT600	Navy	[redacted]	[redacted]	310.4299	304	6
RHMW09	AT600	Navy	[redacted]	[redacted]	395.3749	388	7
RHMW10	AT600	Navy	[redacted]	[redacted]	495.5862	489	7
RHMW11 Zone 5	MOSDAX	Navy	[redacted]	[redacted]	210.1326	n/a	-74.53
RHMW11 Zone 4	MOSDAX	Navy	[redacted]	[redacted]	210.1326	n/a	-119.73
RHMW11 Zone 3	MOSDAX	Navy	[redacted]	[redacted]	210.1326	n/a	-147.03
RHMW11 Zone 2	MOSDAX	Navy	[redacted]	[redacted]	210.1326	n/a	-185.23
RHMW11 Zone 1	MOSDAX	Navy	[redacted]	[redacted]	210.1326	n/a	-258.53
RHMW12A	AT600	Navy	[redacted]	[redacted]	238.4305	428	-190
RHMW13 Zone 5a	MOSDAX	Navy	[redacted]	[redacted]	248.4088	n/a	18.56
RHMW13 Zone 4	MOSDAX	Navy	[redacted]	[redacted]	248.4088	n/a	5.56
RHMW14 Zone 3	MOSDAX	Navy	[redacted]	[redacted]	179.7829	n/a	-144.87
RHMW14 Zone 2	MOSDAX	Navy	[redacted]	[redacted]	179.7829	n/a	-235.07
RHMW14 Zone 1	MOSDAX	Navy	[redacted]	[redacted]	179.7829	n/a	-276.37
RHMW15 Zone 5a	MOSDAX	Navy	[redacted]	[redacted]	310.0000	n/a	13.35
RHMW15 Zone 4	MOSDAX	Navy	[redacted]	[redacted]	310.0000	n/a	-19.65
RHMW15 Zone 3	MOSDAX	Navy	[redacted]	[redacted]	310.0000	n/a	-100.15
RHMW15 Zone 2	MOSDAX	Navy	[redacted]	[redacted]	310.0000	n/a	-153.4
RHMW15 Zone 1	MOSDAX	Navy	[redacted]	[redacted]	310.0000	n/a	-254.65

Monitoring Location	Transducer Type	Monitoring Entity	Easting (ft msl)	Northing (ft msl)	Measurement Point Elevation (ft msl)	Approximate Transducer Installation	
						Depth (ft bmp)	Elevation (ft msl)
RHMW16	AT600	Navy	(b) (3) (A) [redacted]	[redacted]	218.9395	504	-285
RHMW17	AT600	Navy	[redacted]	[redacted]	252.3393	244	8
RHMW19	AT600	Navy	[redacted]	[redacted]	444.5871	438	7
RHMW20	AT600	Navy	[redacted]	[redacted]	444.5871	250	6
NMW24	AT600	Navy	[redacted]	[redacted]	107.1815	98	9
RHP01	AT600	Navy	[redacted]	[redacted]	156.7907	145	12
RHP02	AT600	Navy	[redacted]	[redacted]	140.3633	127	13
RHP03	AT600	Navy	[redacted]	[redacted]	136.7787	130	7
RHP04A	AT600	Navy	[redacted]	[redacted]	157.7037	145	13
RHP04B	AT200	Navy	[redacted]	[redacted]	156.8127	302	-145
RHP04C	AT600	Navy	[redacted]	[redacted]	156.0777	494	-338
RHP05	AT200	Navy	[redacted]	[redacted]	230.2820	220	10
RHP07	AT200	Navy	[redacted]	[redacted]	100.831	86	15
OWDFMW01	AT600	Navy	[redacted]	[redacted]	138.1361	139	-1
OWDFMW02A	AT600	Navy	[redacted]	[redacted]	139.5777	171	-31.5
OWDFMW03A	AT600	Navy	[redacted]	[redacted]	118.6427	156	-37.4
OWDFMW04A	AT600	Navy	[redacted]	[redacted]	166.8387	162	5
OWDFMW05A	AT600	Navy	[redacted]	[redacted]	118.7847	125	-6
OWDFMW06A	AT600	Navy	[redacted]	[redacted]	119.5107	210	-90
OWDFMW07A	AT600	Navy	[redacted]	[redacted]	119.6397	240	-120
OWDFMW08A	AT600	Navy	[redacted]	[redacted]	133.7257	153	-19
BWS Hālawa Shaft	700H	USGS	[redacted]	[redacted]	165 [b]	data not available	
‘Aiea Hālawa Shaft	700H	USGS	[redacted]	[redacted]	28.0481	data not available	
Hālawa TZ	700H	USGS	[redacted]	[redacted]	59.12 [b]	data not available	
‘Aiea Bay	700H	USGS	[redacted]	[redacted]	5.77 [b]	data not available	
TAMC-MW2	700H	USGS	[redacted]	[redacted]	172.1 [b]	data not available	
Ka‘amilo Deep	700H	USGS	[redacted]	[redacted]	491.12 [b]	data not available	

bmp	below measurement point
ft	foot/feet
msl	mean sea level
n/a	not applicable

[a] Coordinates are provided in NAD 83, degrees, minutes, seconds on USGS' NWIS website.

[b] Land surface altitude, provided in low mean sea level on USGS' NWIS website.

3.3 Correction Factors

When deploying and retrieving transducers (to facilitate required groundwater sampling events), the field team collected depth-to-water measurements from a surveyed measurement point with a calibrated water level meter capable of measuring to ±0.01-ft accuracy. Each time transducers were removed to facilitate sampling, field teams attempted to redeploy them to on average within 1 ft of the previous depth. Differences in transducer set depth were accounted for by hand readings collected from the same surveyed measurement point at the same time as transducer placement. The hand measurements were collected with electric water-level probes. While these probes themselves were previously calibrated to a USGS steel tape, it is recognized that there is some uncertainty introduced due to differences among field team members in the manner in which they hold and read the cables. Measurement point elevations were surveyed with a Second Order, Class I Leveling Survey to ±0.0001-ft accuracy. Water levels were also corrected for horizontal displacement based on gyroscopic surveys conducted at each well except for RHP04B, RHP05, and RHMW20, for which the final data are not yet available. Transducer accuracy is generally ±0.01 ft at depths up to 15 ft below the water table, and ±0.1% of the reading for transducers deployed greater than 15 ft below the water table (for In-Situ's 700H). Reduced accuracy also comes from transducer and water level meter cable stretch, flex, and thermal expansion and contraction.

3.4 Transducer Depths

Transducers installed in conventional monitoring wells, monitored by the Navy, were deployed at depths approximately in the middle of each screened interval. Each time a transducer was retrieved and redeployed (to facilitate required groundwater sampling), the transducer was redeployed to approximately the same depth from which it was last retrieved, and a manual water level measurement was then made. Approximate transducer deployment depths are presented in Table 3-2.

3.5 RHS Pumping Data

While the RHS pump was operating, pumping rates were recorded by the Navy at 60-minute intervals for the entirety of the continuous water level study. These data were provided by the Navy's subcontractor Vectrus as part of operating the GAC system outside Adit 3. Pumping rates are plotted on Figure 3-3. The rates shown are reported in millions of gallons per day (mgd). Note however that these are actually instantaneous—not daily average—rates.

3.6 Ongoing Analytical Sampling

During the time of this study, three analytical sampling events were ongoing, including weekly Notice of Interest (NOI) sampling, quarterly long-term monitoring (LTM) sampling, per- and polyfluoroalkyl substances (PFAS) sampling weekly through May 2023 and monthly starting in June 2023, and twice-monthly plume delineation well (P-well) sampling. To facilitate sampling, transducers were removed then redeployed to approximately the same depth from which each was last retrieved.

3.7 Isotope Samples

Isotope samples were collected during Trial Period #3 between June 14 and June 20, 2023. Samples were also collected from June 21 to 23, 2023 and from July 3 to 12, 2023 during continuous pumping conditions that were similar to Trial Period #1. Results were analyzed for hydrogen isotope δ2H of water (‰ vs. V-SMOW) and oxygen isotope δ18O of water (‰ vs. V-SMOW). Samples with nitrate detections were also analyzed for nitrogen isotope δ15N of nitrate (‰ vs. AIR) and oxygen isotope δ18O of nitrate (‰ vs. V-SMOW).

3.8 Groundwater Sample Collection Upon RHS Pump Startup

During each trial period, groundwater samples were collected from the discharge pipeline prior to the GAC system after each time RHS pumping restarted. Groundwater samples were collected within approximately the first 5–10 minutes after RHS restarted and analyzed for NOI groundwater parameters.

3.9 Depth-to-Water Measurements Upon RHS Pump Shut Down

Each time RHS was shut off, depth-to-water measurements were collected from the surveyed measurement point at RHMW2254-01. Four measurements were collected for 1 hour at 15-minute intervals before the pumps shut off, one measurement was collected when the pump shut off, and two readings were collected for 30 minutes at 15-minute intervals after the pump shut off.

(b) (3) (A)

[redacted]

Figure 3-1
Monitoring Locations
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu HI

(b) (3) (A)

[redacted]

Figure 3-2
Monitoring Locations from Previous Synoptic Studies
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

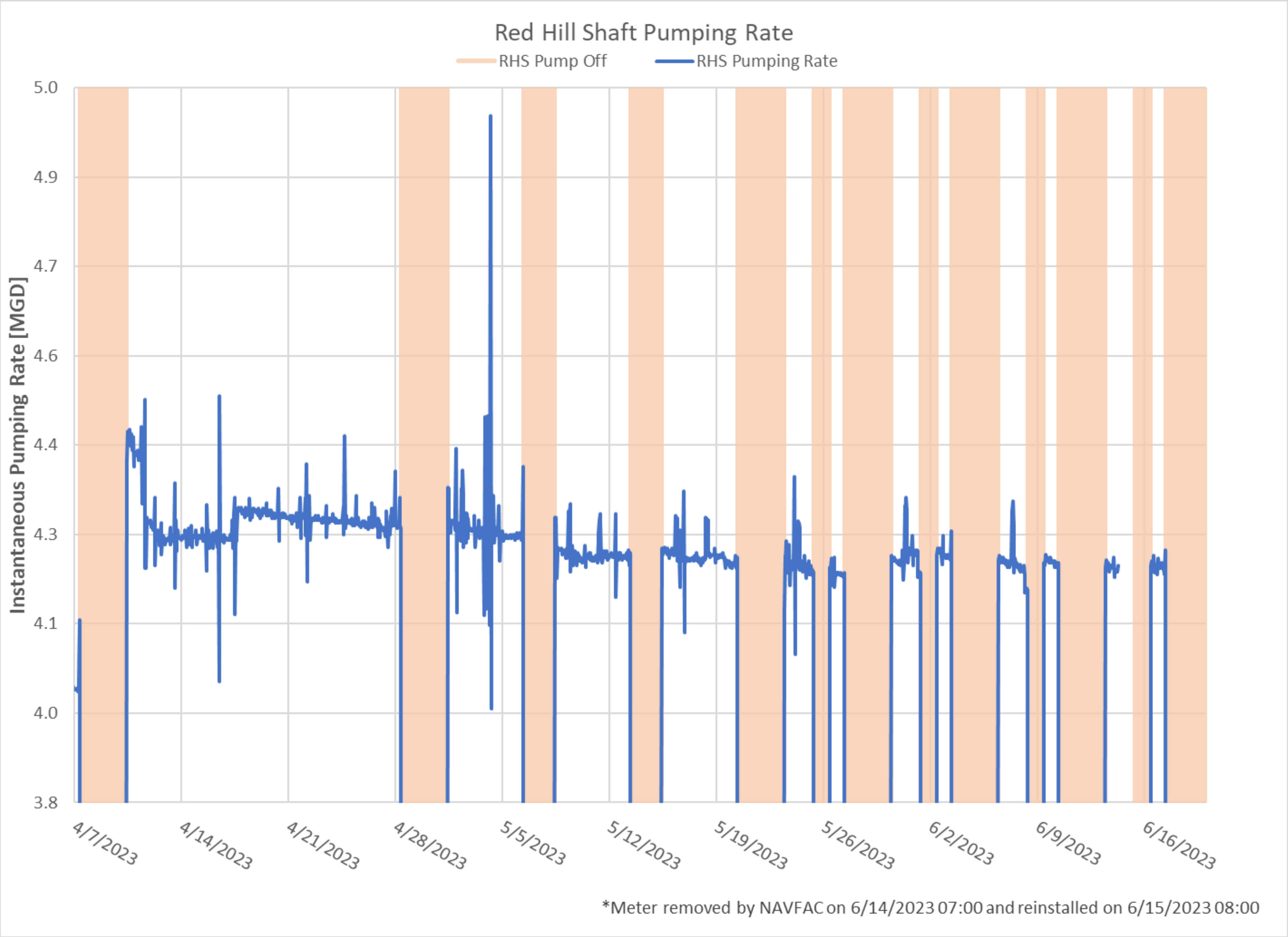


Figure 3-3
Instantaneous Pumping Rates at Red Hill Shaft
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

4.0 Evaluation of a Capture Zone

The scope of this study followed the procedure outlined in EPA documentation entitled *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (EPA 2008). Six steps are outlined in the document:

1. Review site data, CSM, and remedy objectives.
2. Define site-specific Target Capture Zone(s).
3. Interpret water levels.
4. Perform calculations.
5. Evaluate concentration trends.
6. Interpret actual capture based on Steps 1–5, compare to Target Capture Zone(s), assess uncertainties and data gaps.

The methods outlined in EPA (2008) are simplified approaches that require significant interpretation to ensure that important assumptions are accounted for when considering the complex geological conditions such as at the Red Hill Facility. In cases where simplified methods were applied, the implications of simplifying assumptions were discussed. No final conclusions were drawn from any single line of evidence. Throughout this study, multiple lines of evidence were developed and the limitations of each were outlined. A data gap analysis was performed, the uncertainties in the methods were outlined, and suggestions were made for additional data collection that may assist in further refinement of capture zone estimates (Section 4.7).

4.1 Review Site Data, Site Conceptual Model, Remedy Objectives

4.1.1 Site Data, Conceptual Model and Groundwater Models

The Navy's 2019 CSM Report (DON 2019) describes the geologic CSM in Module 5 and the hydrogeologic CSM in Module 6. Previous synoptic studies are summarized below. Additionally, several reports and technical memoranda have been published by the Navy regarding groundwater modeling including the interim groundwater flow modeling study (DON 2018, Appendix A), the 2020 *Groundwater Flow Model* [GWFM] *Report* (DON 2020), and the "best available" *Groundwater Flow Model* and *Contaminant Fate and Transport Technical Memoranda* (DON 2023a; 2023b). Additional groundwater flow and contaminant fate and transport modeling is ongoing.

Previous groundwater level studies are summarized below.

4.1.1.1 CSM 2017/2018 SYNOPTIC STUDY

From July 2017 through March 2018, depths to water in wells depicted on Figure 3-2 were measured during a coordinated synoptic monitoring event conducted by the USGS, BWS, and the Navy. The USGS' *Final Synoptic Water Level Study Work Plan* dated August 10, 2017 lays out this program (USGS 2017). All the conventional monitoring wells used in the study except for RHMW01 were monitored with vented (also known as gauged) In-Situ Level TROLL 700H transducers. Because the diameter of RHMW01 was too small to accommodate a vented transducer, a smaller-diameter non-vented (i.e., absolute, or total) transducer with an accompanying barometric logger was used in that well instead.

The work plan recommended specific controlled pumping scenarios from surrounding water supply wells that withdrew significant water from the aquifer. However, the USGS could not mandate specific withdrawal conditions because the water-purveyor had certain requirements and constraints that had to be met. The actual pumping scenarios carried out during the study were as follows:

1. Withdrawing water from BWS Moanalua Wells 1, 2, and 3 at a high rate while both BWS Hālawa Shaft and Navy RHS withdrew water at typical rates.
2. Allowing RHS to recover (no pumping) for approximately 5 days while BWS Hālawa Shaft pumped at a near-constant rate.
3. Withdrawing water from RHS at a near-constant rate for approximately 4.5 days while BWS Hālawa Shaft withdrew water at a typical near-constant rate.
4. Allowing BWS Hālawa Shaft to recover (no pumping) for approximately 10 days while RHS was pumping under normal conditions (which historically involved cycling on and off in response to water system demands, unlike the current relatively steady operation of the RHS GAC system).
5. Withdrawing water from BWS Hālawa Shaft at a high rate for 10 days while RHS was pumping under normal operational conditions.
6. Withdrawing water from BWS Hālawa Shaft at a normal rate while RHS was pumping under normal operational conditions.

Most groundwater level data collected as part of this effort were made publicly available online through the National Water Information System (NWIS) database: https://nwis.waterdata.usgs.gov/nwis. The USGS issued a non-interpretive report documenting the data collected during the monitoring period (Mitchell and Oki 2018). A more detailed description of the synoptic data evaluation is presented in the Red Hill CSM report (DON 2019).

Notably, significantly fewer wells existed near RHS at the time of the 2017/2018 study than exist now; as shown on Figure 3-2, the only two wells included in the 2017/2018 study near RHS were OWDFMW01 to the west and RHMW05 to the east. Moreover, these three monitoring points (RHMW05, RHS, and OWDFMW01) lie nearly on a straight line, rendering evaluation of flow directions around RHS (and even simple triangulation) challenging at best. As a result, the 2017/2018 data provided limited resolution of conditions in the RHS area impacted by the November 20, 2021 JP-5 release. In contrast, the 2023 Flow Optimization Study includes 41 wells, including 7 wells installed near RHS (plume delineation [P-] wells), including areas north, southwest, and closer to the east and west of RHS, to better characterize aquifer parameters in the vicinity of RHS.

4.1.1.2 2022 RHS STARTUP SYNOPTIC SURVEY

From January to April 2022, depths to water in wells depicted on Figure 3-2 were measured during a synoptic monitoring event conducted by the USGS and the Navy. All conventional wells were monitored with vented (i.e., gauged on differential) In-Situ Level TROLL 700H transducers except for OWDFMW08A and RHMW01, which were monitored with non-vented (i.e., absolute, or total pressure) transducers.

Prior to this 2022 survey, RHS was turned off, on November 28, 2021, and disconnected from the Joint Base Pearl Harbor-Hickam (JBPHH) Water Distribution System in response to the November 2021 Release. BWS Hālawa Shaft was turned off on December 2, 2021. The Navy's ʻAiea Hālawa Shaft was turned off on December 3, 2021. On January 29, 2022, RHS was turned back on after installation of the GAC treatment system and was pumped continuously (except for brief shutdowns) at an average rate of approximately 4.3 mgd. Based on Figure 3-3, it appears that the instantaneous rates declined slightly throughout the study. The reason for this decline is not known. Transducers were installed during the week of January 17, 2022 by both the USGS and the Navy to record water levels from prior to restarting RHS through approximately 6 weeks after resumption of pumping.

Groundwater level data collected by the USGS as part of this effort were made publicly available online through the NWIS database: https://nwis.waterdata.usgs.gov/nwis. Groundwater level data collected by the Navy were provided to the RAs in the Navy's Red Hill Environmental Data Management System (EDMS) and are filed there under Library > Raw Data > Transducer EDDs [electronic data deliverables].

None of the plume delineation (P-) wells surrounding RHS had been installed prior to this study, and several of the other nearby wells were not fitted with transducers, to facilitate continued NOI groundwater sampling (DOH 2021a; 2021b). Additionally, only water levels, drawdown (change in water level), and a smaller set of water quality parameters were monitored during the 2022 study in comparison to the 2023 Flow Optimization Study.

4.1.1.3 RHS FLOW OPTIMIZATION STUDY

The RHS Flow Optimization study was conducted from April 7 through June 20, 2023. Section 1.0 describes the pumping cycle at RHS, the transducers installed at each location (also depicted on Figure 3-1), and other details of how the study was conducted. BWS Hālawa Shaft and the Navy's ʻAiea Hālawa Shaft were not pumping for the duration of the study. Water levels are depicted as hydrographs on Figure 4-1a–Figure 4-1e. Review of these plots reveals that water levels in all monitoring wells responded to pumping changes at RHS, although regional wells such as NMW24 and the wells monitored by USGS had very weak to no response to pumping changes of less than 0.1 ft. In general, wells located nearest the RHS water development tunnel responded the most strongly to pumping stresses. For example, RHP07 showed as much as 0.8 ft of drawdown, compared to approximately 1 ft of drawdown in RHS. Most RHMW locations responded with 0.1 to 0.4 ft of drawdown. RHMW20 was completed on June 8, 2023; a transducer was installed after installation to collect data for the remainder of the Flow Optimization Study. At the time of this writing, USGS has not yet published full data sets for Kaʻamilo Deep and BWS Hālawa Shaft; other USGS data sets are complete but "provisional" and subject to future change by the USGS.

4.1.2 Remedy Objectives

As discussed in Section 2.0, RHS is currently being used as an extraction well to develop a capture zone in the basal aquifer to mitigate potential offsite migration of fuel from the November 2021 Release.

Additionally, concerns remain about the fate of potential releases from the tank farm with respect to further operation and eventual defueling, as well as from residual contaminants from historical releases. If practical, a potential goal of remedial pumping of RHS would be to create a capture zone sufficient to mitigate offsite contaminant migration both in the immediate area around RHS, related to the November 2021 Release, and potential future and historical releases from beneath the tank farm.

After more than a year of GAC operations and weekly groundwater sampling and analyses, the rate of fuel recovery from RHS has become negligible, and weekly data show that concentrations of chemicals of potential concern (COPCs) in groundwater near RHS have substantially decreased, returning to historical levels prior to the November 2021 Release. Observations of field data collected to date and evaluations of hydraulic heads and other parameters indicate successful prevention of migration of gross contamination away from RHS as defined in the RHSRMP (IDWST 2022). This is demonstrated by the overall reduction of chemical concentrations and lack of any measurable LNAPL or other indications of gross contamination in groundwater monitoring points in and around RHS since the GAC operations were established. Specifically, total petroleum hydrocarbons (TPH) – diesel range organics (TPH-d) was last detected above the 400 micrograms per liter (µg/L) DOH Environmental Action Level (EAL) (DOH 2017) in March 2022; since then, detections have been predominantly non-detect with sporadic detections below the EAL. The last TPH-residual oil range organics (TPH-o) EAL exceedance (above 500 µg/L) was reported in November 2022 (potentially associated with installation efforts at RHP04B); after which results have been consistently non-detect with only one detection (below the EAL exceedance). EALs used are promulgated by DOH and apply to all sites in Hawaiʻi (DOH 2017). Based on these conditions, it is appropriate to optimize the rate of pumping RHS to minimize the use of groundwater while still achieving the goals set forth in the RHSRMP (IDWST 2022). The regional freshwater aquifer system is inherently finite due to its island location. Reducing the groundwater extraction rate during remedial activities at RHS could reduce waste, minimize saltwater intrusion and upconing, and make additional groundwater available for other public and private purposes.

4.2 Define Site-Specific Capture Zone

The Target Capture Zone for the Facility is centered around the November 2021 Release location and RHS (Figure 4-2). The GAC system was installed to treat groundwater extracted by RHS that had been affected by the November 2021 Release, and the primary purpose of this Flow Optimization Study was to evaluate capture in the vicinity of RHS. An additional zone of interest encompassing the entirety of the tank farm was also evaluated in a preliminary fashion; more-detailed analyses of flow around the tank farm area is anticipated over the coming year. The Target Capture Zone and a line marking the location where valley fill intersects the water table, based on the geological CSM, are shown on Figure 4-2. Because LNAPL is not anticipated to migrate into the valley fill, the Target Capture Zone around RHS was truncated in this area. Particle tracking evaluations of capture used simulated hypothetical particles distributed over the Target Capture Zone on a 125-ft × 125-ft grid, as shown on Figure 4-2. The tank farm zone of interest also included evenly distributed particles on a similar grid spacing.

4.3 Interpret Groundwater Levels

4.3.1 Potentiometric Surface Maps

Water level contours were developed from measured water levels by interpolation using two-dimensional kriging methods. Kriging was performed using the software package KT3D_H2O Version 3.0, available in Ground Water Desktop (GWD) Version 5.0, developed by S.S. Papadopulos & Associates, Inc. (SSPA 2023). GWD served as a visual interface for evaluating the kriged results generated by KT3D_H2O. The kriging parameters included specifying a regional dip azimuth of 246°, to match the regional basalt dip azimuth agreed to in the January 10, 2023 SPM. The horizontal anisotropy ratio of the kriging algorithm was set to 2, based on trial-and-error and professional judgement. Note that this anisotropy ratio is generally less than the horizontal anisotropy of the basalt aquifer hydraulic conductivity, which may tend to reduce the effect of anisotropy on the interpreted water level surface. The western and eastern segments of the RHS water development tunnel were each simulated by line sink drifts. Line drifts are kriging features that result in near-constant water levels along their length. The strength of a line sink drift determines its relative effect on the nearby potentiometric surface. Approximately 20% of the total strength was assigned to the western segment of the RHS water development tunnel, and 80% was assigned to the eastern end, to account for the more permeable clinker zone in the eastern 200 ft of the water development tunnel as has been previously discussed with RAs.

During all periods, four additional virtual water level points were assigned along the length of RHS. This was done to represent a near consistent water level along the shaft, which was represented as a line drift in the kriging. Water levels were assigned to these virtual points based on the two co-located transducers installed at one location near the western end of RHS. A small difference of approximately 0.01 ft was typically observed between these two transducers. The easternmost virtual point was assigned the higher of the two transducer values, the westernmost virtual point was assigned the lower of the two transducer values, and the intermediate points were assigned intermediate values. This created a small gradient from the upper to the lower end of the shaft, as would be expected in a horizontal well. Gentle movement of water from the eastern to western ends inside the water development tunnel has also been noted by Navy divers during periods of non-pumping of RHS. The impact of this ambient flow has not been well studied to date.

A barrier line drift was tested to represent the transition to lower-permeability valley fill materials adjacent to the basal aquifer; however, the barrier drift resulted in water level contours that were inconsistent with observations and was rejected.

Because the kriging algorithm is two-dimensional, only one water level can be used at any given horizontal location. For nested or multilevel wells, water levels from the shallowest screened basal aquifer interval was used. This included RHMW11 Zone 5, RHMW13 Zone 5a, RHMW14 Zone 3, and RHMW15 Zone 5. Deeper multilevel well zones were not used in kriging.

For Trial Period #2, RHMW11 Zone 5 was excluded due to a transducer malfunction.

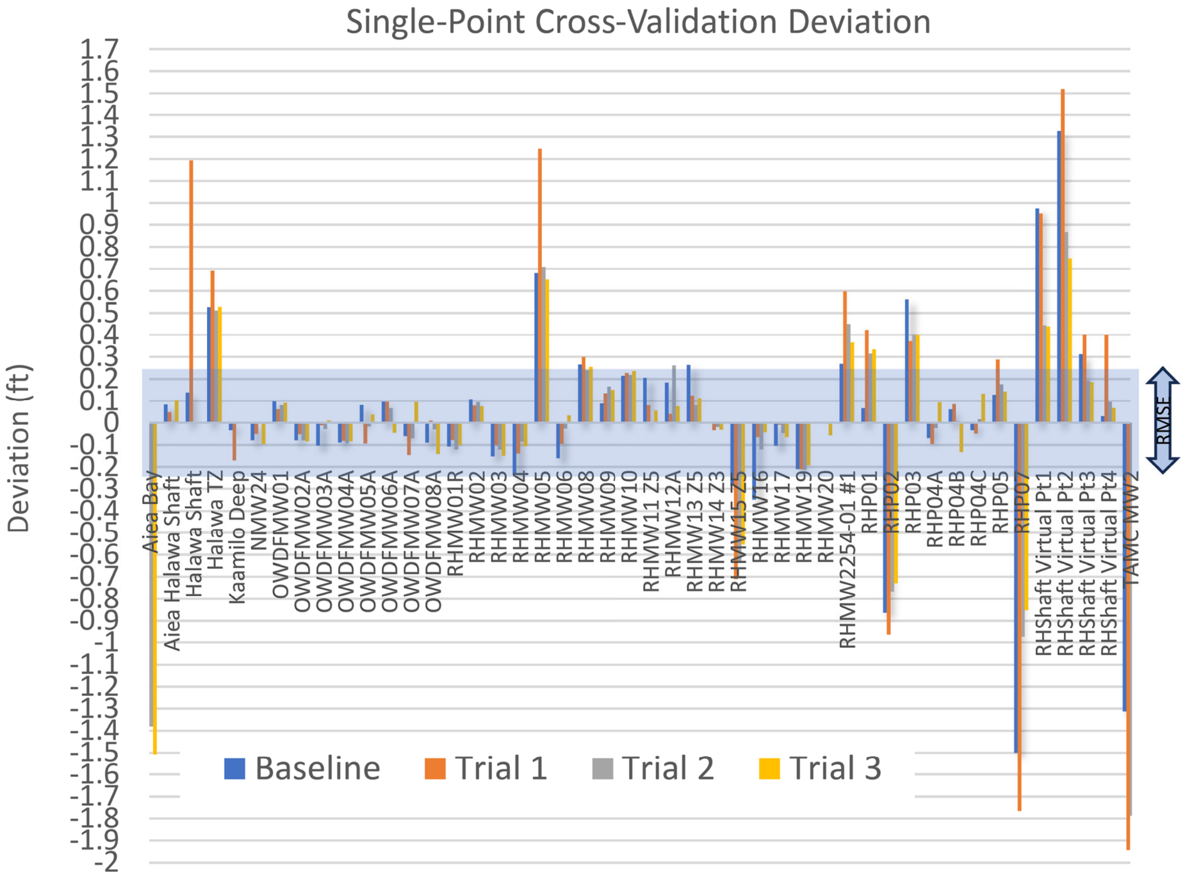
4.3.1.1 *WATER LEVEL CONTOURS*

Four conditions of water level contours were developed using data from the specified wells collected during the following time periods. These water level contours are shown on Figure 4-3a–Figure 4-3b:

- Baseline conditions: water levels after 3 days on non-pumping at the start of the study (4/10/2023 9:00 HST)
- Trial Period #1: water levels at after 18 days of continuous pumping at 4.3 mgd (4/28/2023 9:00 HST)
- Trial Period #2: average water levels over the 22 days of pumping on and off averaging to 2.9 mgd (5/1/2023 9:00 HST to 5/23/2023 9:00 HST)
- Trial Period #3: average water levels over the 28 days of pumping on and off averaging to 1.7 mgd (5/23/2023 9:00 to 6/20/2023 9:00 HST)

Average water levels were used during Trial Periods #2 and #3 to account for the on/off cycling of RHS to arrive at the target average pumping rates. The development of the water level contours is further detailed below.

Upon initial evaluation of the kriged water level contours, it was apparent that relatively small variations in water levels would create localized mounds and depressions in the water level surface. To further evaluate kriging accuracy and the effects of individual wells on the interpolated water level surface, single-point cross validation was conducted. This procedure sequentially removes the measured water level from a single well and re-interpolates the water level surface. The difference between the measured value and the predicted (kriged) value at that location is the kriging deviation. The process is repeated at all data locations. Single-point cross validation results are shown on Chart 4-1.



RMSE root mean square error

Chart 4-1: Single Point Cross-Validation Deviation

As shown on Chart 4-1, most wells exhibit a relatively small deviation, indicating that the water level at that location is generally consistent with nearby wells. Other wells show larger deviations. These can be grouped into two categories:

1) Wells that are relatively isolated, typically near the periphery of the study area. These wells include ‘Aiea Bay, ‘Aiea Hālawa Shaft, Hālawa Shaft, Hālawa TZ, and TAMC MW2. Since there are no other nearby wells to establish the regional potentiometric surface, a large kriging deviation indicates that these wells have a significant impact on the interpolated regional gradient and therefore should not be rejected.
2) Wells located in the central portion of the study area with water levels that are inconsistent with nearby wells. These wells include RHMW05, RHMW15 Zone 5, RHMW2254-01 #1, RHP01, RHP02, RHP07, and the four virtual points along RHS. Each is further discussed below:
    a. The RHS data points (RHMW2254-01 #1 and the four virtual points along the shaft) have water levels that are low relative to nearby wells. This is expected for the water development shaft or for any pumped well where the drawdown near the well is not adequately resolved by neighboring monitoring points.

b. RHMW05 and RHP01 are low relative to nearby wells. Well RHP01 is adjacent to RHS, and well RHMW05 is located between RHS and the tank farm. These wells may be more strongly influenced by the drawdown created by RHS.

c. RHMW15 Zone 5 is elevated compared to other nearby wells. This trend is also observed in other screened zones in this multi-well cluster. The reason for the relatively elevated water levels at this location is unknown.

d. RHP02 and RHP07 are high relative to nearby wells. Both wells are close to RHS. The reason for the relatively elevated water levels at these locations is unknown.

The kriging deviations can be used to derive a root mean square error (RMSE), or an average expected deviation. Since wells with large deviations tend to increase the RMSE, a range of RMSE calculations was explored using different combinations of wells. The results of these calculations are shown below:

	Root Mean Squared Error (RMSE) (ft)				
Wells Used to Calculate RMSE	**Baseline**	**Trial 1**	**Trial 2**	**Trial 3**	**Combined**
No wells excluded	0.47	0.61	0.48	0.45	0.50
Exclude peripheral wells	0.43	0.51	0.33	0.30	0.40
Exclude peripheral wells, RHP02, RHP07	0.34	0.42	0.27	0.24	0.33
Exclude peripheral wells, RHP02, RHP07, and RHS virtual points	0.22	0.30	0.23	0.21	0.24

The RMSE was subsequently used to adjust the kriging algorithm by specifying a “nugget constant” for the variogram. A non-zero nugget indicates that water levels have a degree of variability that is random and unpredictable. In kriging, a larger nugget leads to a smoother interpolated surface.

A nugget of 0.24 was chosen to interpolate the water level surfaces in GWD. This value corresponds to the lowest RMSE among the scenarios considered in the preceding table. This RMSE value is also shown on Chart 4-1. Higher and lower nugget values were explored; although higher values resulted in greater smoothing, some depressions and mounds remained at all tested nugget values. This is to be expected considering the site setting and the methods used. The kriged water level surface represents a simplified two-dimensional rendition of a three-dimensional field. Closed mounds or depressions, which would suggest sources or sinks of water in two dimensions, may simply represent upward or downward flow if the vertical dimension were considered. Rather than eliminate wells to reduce the occurrence of mounds or depressions, all wells shown on Chart 4-1 were used to estimate the potentiometric surface.

These contours were carried forth for the GIS analysis of capture with particle tracking (Section 4.4.1).

4.3.2 Vertical Hydraulic Gradients

Vertical hydraulic gradients were analyzed from the four multilevel wells (RHMW11, RHMW13, RHMW14, and RHMW15) as well as the RHP04 conventional monitoring well cluster (RHP04A, RHP04B, and RHP04C). For each well, comparisons were made between each consecutive transducer as well as between the shallowest and deepest transducers. Only transducers installed in the basal aquifer were considered. Elevations for the transducers are presented in Table 4-1. Figure 4-4a–Figure 4-4e present water levels plotted for each transducer on the primary y-axis and the vertical gradient plotted on the secondary y-axis, along with a chart comparing vertical gradients for each well. Vertical gradients are calculated by dividing the difference in head by the vertical distance between the transducers.

Table 4-1: Transducer Elevations for Vertical Gradient Calculations

Well ID	Distance from Eastern End of RHS (ft)	Zone / Well	Transducer Elevation (ft msl)
RHMW11	2,490	Zone 5	-75.33
		Zone 4	-120.50
		Zone 3	-147.78
		Zone 2	-185.95
		Zone 1	-249.21
RHMW13	4,180	Zone 5a	17.20
		Zone 4	4.55
RHMW14	1,650	Zone 3	-145.20
		Zone 2	-235.30
		Zone 1	-276.55
RHMW15	370	Zone 5a	12.29
		Zone 4	-21.00
		Zone 3	-101.18
		Zone 2	-154.46
		Zone 1	-255.63
RHP04	1,630	RHP04A	10.00
		RHP04B	-145.00
		RHP04C	-348.00

The following pairs of zones exhibited a consistent negative (upward) vertical gradient:

- RHMW11 Zones 2 and 3
- RHMW14 Zones 1 and 2
- RHMW15 Zones 4 and 5a

Previous efforts have been made to confirm that these apparent gradients are not due to error in transducer placement. These gradient directions have persisted for years and are believed to be accurate. All other gradients were positive (vertically downward).

Responses to pumping in vertical gradients were limited in RHMW11, which sits relatively far from RHS. Although water levels at RHMW13 (farthest multilevel well from RHS) did respond to pumping, the gradient responses were relatively muted.

At RHMW14, vertical gradients responded slightly to pumping in all zone pairs except for Zones 2 and 3. Gradients increased slightly during pumping periods and decreased slightly during non-pumping periods. At RHMW15, all gradients responded to pumping; this well also had the greatest changes in gradients in response to pumping and is the closest to RHS.

At the plume delineation (P-) wells, vertical gradients oscillated between positive and negative but remained close to 0 foot per foot (ft/ft). Responses to pumping were slight.

Calculation results are presented in Table 4-2.

Table 4-2: Vertical Gradient Summary

Well ID	Distance from Eastern End of RHS (ft)	Vertical Distance Between Transducers (ft)		Average Vertical Gradients (ft/ft)		
				Trial Period 1	Trial Period 2	Trial Period 3
RHMW11	2,490	Zone 4 & Zone 5	45.17	0.0035	0.0035	0.0034
		Zone 3 & Zone 4	27.28	0.0067	0.0069	0.0070
		Zone 2 & Zone 3	38.17	-0.0013	-0.0012	-0.0019
		Zone 1 & Zone 2	63.26	0.0030	0.0028	0.0017
		Zone 1 & Zone 5	173.88	0.0028	0.0027	0.0022
RHMW13	4,180	Zone 4 & Zone 5a	12.98	0.0088	0.0061	0.0061
RHMW14	1,650	Zone 2 & Zone 3	90.10	0.0090	0.0087	0.0059
		Zone 1 & Zone 2	41.25	-0.0081	-0.0103	-0.0110
		Zone 1 & Zone 3	131.35	0.0029	0.0028	0.0026
RHMW15	370	Zone 4 & Zone 5a	33.29	—	-0.0148	-0.0157
		Zone 3 & Zone 4	80.18	0.0071	0.0077	0.0082
		Zone 2 & Zone 3	53.28	0.0043	0.0047	0.0051
		Zone 1 & Zone 2	101.17	0.0019	0.0021	0.0022
		Zone 1 & Zone 5a	267.92	—	0.0022	0.0023
RHP04	1,630	RHP04A & RHP04B	155.00	-0.0009	-0.0001	0.0007
		RHP04B & RHP04C	203.00	-0.0005	-0.0001	-0.0007
		RHP04A & RHP04C	90.10	-0.0001	-0.0001	-0.0001

— Transducer malfunctioned; no data

4.3.3 *Evaluation of Aquifer Hydraulic Properties*

Drawdown data collected during the Flow Optimization Study were analyzed to estimate hydraulic properties of the aquifer, including hydraulic conductivity and storage. While estimation of hydraulic properties is not in itself a measure of the RHS capture zone, these properties are important in informing the CSM and are used in the equations and modeling described later in this report. The Cooper-Jacob approximation to the Theis method (Cooper and Jacob 1946) for both drawdown vs. time and drawdown vs. distance were applied to obtain an initial evaluation of the aquifer parameters. These solutions apply to homogeneous confined aquifers of infinite areal extent. Because drawdown is very small compared to the thickness of the aquifer, the confined aquifer assumption should not significantly affect the solution. Although the aquifer is not infinite or homogeneous, these assumptions provide reasonable simplifying assumptions to characterize the aquifer as equivalent porous media. After application of these methods, two additional methods that account for areal anisotropy were applied: Hantush and Thomas (1966) and Mutch Jr. (2005).

4.3.3.1 COOPER-JACOB APPROXIMATION TO THE THEIS METHOD – DRAWDOWN VS. TIME

Drawdown was plotted versus the logarithm of pumping time at RHS for each trial period. The slopes of these semi-logarithmic lines and the x-intercepts were recorded. These values were then used to calculate transmissivity using the Cooper-Jacob approximation. To convert transmissivity to hydraulic conductivity, it is first necessary to know the aquifer thickness. The basal aquifer is thousands of feet deep, with a high expected horizontal to vertical anisotropy. Most of the monitoring wells and the water development tunnel are completed at shallow depths. A specified aquifer thickness in the range of 1,000 ft or more would incorrectly assume that flow to RHS was evenly distributed along this entire depth. In the CSM report (DON 2019), three values of thickness were used (20 ft, 50 ft, and 100 ft). In this exercise, a single value of 100 ft was used to approximately convert transmissivity to hydraulic conductivity. This assumes that most of the nearby flow to RHS occurs in the uppermost 100 ft of the basalt aquifer. While the actual aquifer effective thickness is unknown, the resulting hydraulic conductivity values are generally consistent with previously published literature (Hunt Jr. 1996; Nichols, Shade, and Hunt Jr. 1996; Oki 1998; Visher and Mink 1964). Results for the multiple pumping cycles in each trial period are presented on Figure 4-5a–Figure 4-5h and summarized in Table 4-3. Hydraulic conductivity values are presented on Figure 4-6. Detailed results are presented in Appendix A. Parameter values were calculated as follows:

$$T = \frac{2.3 \times Q}{4\pi \times \Delta s}$$

$$K = \frac{T}{b}$$

Where:
Q = extraction rate (L^3/T)
T = transmissivity (L^2/T), or hydraulic conductivity × saturated thickness
Δs = change in drawdown over one log cycle (L)

K = hydraulic conductivity = (L/T)
b = saturated thickness (L)

Table 4-3: Summary of Cooper Jacob Approximation to the Theis Method - Drawdown vs. Time

Trial Period	Drawdown		Recovery	
	Average Effective Transmissivity (ft^2/d)	Average Hydraulic Conductivity (ft/d) if b = 100 ft	Average Effective Transmissivity (ft^2/d)	Average Hydraulic Conductivity (ft/d) if b = 100 ft
1	640,000	6,400	610,000	6,100
2	690,000	6,900	540,000	5,400
3	310,000	3,100	610,000	6,100

ft/d	feet per day
ft^2/d	square feet per day

For this method, the logarithm of distance versus drawdown for each trial period was plotted on a single X:Y scatter plot, and a linear trend was manually fit (Figure 4-7) for each trial period. Distance to each of these wells was computed from the center of the clinker zone of the water development tunnel. The slope of the trend lines and the x-intercept were recorded and used in the Cooper-Jacob distance-drawdown method (Cooper and Jacob 1946). Calculated parameters, derived from the formulas listed below are presented in Table 4-4.

$$T = \frac{2.3 \times Q}{2\pi \times \Delta s}$$

$$K = \frac{T}{b}$$

Where:
Q = extraction rate (L^3/T)
T = transmissivity (L^2/T), or hydraulic conductivity × saturated thickness
Δs = change in drawdown over one log cycle (L)
K = hydraulic conductivity = (L/T)
b = saturated thickness (L)

Table 4-4: Summary of Cooper Jacob Approximation to the Theis Method – Drawdown vs. Distance

Trial Period	Δ s (ft)	r0 (ft)	Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) if b = 100 ft
#1	0.58	4,000	360,000	3,600
#2	0.40	3,000	360,000	3,600
#3	0.26	5,000	320,000	3,200

RHP01, RHP02, and RHP07 are the closest wells to the water development tunnel and consequently had the largest drawdowns. However, they do not fit with the general trend line because their distances are measured to the center of the 200-ft clinker zone at the eastern end of the water development tunnel, as opposed to their shortest distance to any point along RHS, which would shorten their distances. The distance-drawdown method does not account for a horizontally oriented line-sink such as the water development tunnel because it assumes a vertically oriented point-sink source from a single pumping well. The shortest distances from these locations to the water development tunnel were plotted and considered as an approximation to the method. The resulting plots show some significant deviations from the linear trendline, which indicate that anisotropy needs to be accounted for when applying such a solution. Further analysis with incorporation of anisotropy with the distance-drawdown method as described by Mutch Jr. (2005) is documented in Section 4.3.3.3.

In general, transmissivity and hydraulic conductivity was the same order of magnitude and within historical ranges for both the drawdown versus time and drawdown versus distance methods.

4.3.3.2 EVALUATION OF ANISOTROPY

Drawdown data can be used to estimate the anisotropy of an aquifer based on the shape and orientation of the drawdown cone. In an infinite and anisotropic aquifer with homogeneous hydraulic conductivities in the primary (K_x) and secondary (K_y) directions, the drawdown cone will form an ellipse oriented along the axis of K_x with an aspect ratio equivalent to the square root of K_x divided by the square root of K_y (Freeze and Cherry 1979; Mutch, Jr. 2005).

Initially, GWD was used to contour drawdown data for Trial Period #1, when the drawdown was most pronounced. The drawdown plots are shown on Figure 4-8a–Figure 4-8b. The kriging algorithm used in GWD does produce an elongated drawdown cone, but a lack of monitoring wells to the north/northeast of RHS and to the south of RHS results in drawdown contours that are not well constrained and spread more widely than if the drawdown cone was presumed to form an ellipse.

To provide an estimate of anisotropy, an idealized ellipse was fit to the 0.3-ft drawdown contour with the ellipse oriented at the dip azimuth of 246° (agreed-upon regional basalt dip azimuth). Ellipses at various other drawdowns (0.1, 0.2, 0.4 ft) were attempted at multiple orientations; however, drawdown ellipses below 0.3 ft were not as well constrained, and the 0.4 drawdown ellipse contained several wells that violated the contour value. This methodology is intended for vertical pumping wells where the center of the ellipse is at the pumping well. The RHS water development tunnel, however, is approximately 1,200 ft long; therefore, placement of the ellipse center point is subject to interpretation. For this analysis, it was oriented at the approximate center of the clinker bed on the eastern end, which is theorized to feed most of the water to the water development tunnel. This orientation likely widens the ellipse due to a greater distance from that location to the plume delineation (P-) wells and Oily Waste Disposal Facility (OWDF) wells, compared to their closest distance to RHS, which reduce the aspect ratio of the ellipse and the resulting estimated anisotropy ratio of the aquifer.

Figure 4-9 shows the ellipse fit to the 0.3-ft drawdown data oriented with the 246° dip azimuth. The resulting aspect ratio was approximately 2.30, corresponding to an anisotropy ratio (K_x/K_y) of 5.3.

Additional attempts were made to fit an ellipse to the 0.3-ft drawdown contour by making slight adjustments to the dip azimuth assumption. The apparent visual best fit used a dip azimuth of 252°, with an aspect ratio of 3.23, resulting in an aquifer anisotropy of 10.4, also shown on Figure 4-9. Although wells are not distributed around RHS evenly enough to depict a symmetric drawdown ellipse in all directions, the analysis does provide some confidence that anisotropy does generally occur along the assumed dip azimuth of 246, with some potential local variation. Centering of the ellipse on the eastern clinker zone of RHS also potentially introduces the bias of a widened ellipse and reduced aquifer anisotropy. The resulting anisotropy factors of 5.3 and 10.2 should likely be viewed as lower bounds on the potential anisotropy. A reduced anisotropy is conservative with respect to the capture zone of RHS because it will result in groundwater flow trajectories closer to the direction of the hydraulic gradient from the tank farm to the northwest, rather than along dip toward RHS. Other factors which are not accounted for in the analysis include the effects of valley fill, dipping lava flows, and local heterogeneity. Estimates of the drawdown ellipse orientation and anisotropy ratios were carried forward to use in aquifer test analysis.

4.3.3.3 ANISOTROPIC HYDRAULIC CONDUCTIVITY EVALUATION

Two methods of aquifer test evaluation which account for areal anisotropy of the aquifer: Hantush and Thomas (1966) and Mutch Jr. (2005). Both methods rely on the assumption that an elliptical drawdown contour can be clearly delineated to make a determination of the major and minor axes as well as the aspect ratio of the ellipse. Estimation of drawdown ellipse from the Flow Optimization Study drawdown data was discussed previously in Section 4.3.3.2. The two alternative interpretations of the drawdown ellipse and their corresponding anisotropy values, 246° azimuth with an anisotropy of 5.3 and a 252° azimuth with an anisotropy of 10.4, were included in the analysis by each method. These calculations were only carried out for Trial Period 1 since it was the only period with consistent pumping.

The Hantush and Thomas method uses transmissivity (T_r) along a ray estimated through the Cooper-Jacob distance-time method and the aspect ratio of the drawdown ellipse to calculate the transmissivity in the major and minor axis directions. The calculations are:

$$T_e = \frac{T_r \times a \times b}{r^2}$$

$$T_x = \frac{a}{b} T_e$$

$$T_y = \frac{b}{a} T_e$$

Where:
T_e = Effective transmissivity (ft^2/day), estimated from distance drawdown
T_r = Transmissivity along a ray (ft^2/day)
r = the distance between each monitoring well and the last 200 ft of the RHS water development tunnel
a/b = Aspect ratio of the drawdown ellipse along the major axis, equivalent to $\sqrt{K_x / K_y}$

b/a = Aspect ratio of the drawdown ellipse along the minor axis, equivalent to $\sqrt{K_y / K_x}$

T_x = Transmissivity along the major axis (ft^2/day)

T_y = Transmissivity along the minor axis (ft^2/day)

The Mutch method applies a coordinate transformation technique to the distance drawdown method, allowing for estimation of transmissivity along the major and minor axes as an equivalent isotropic aquifer. In this method, x and y distance from the pumping well are calculated with respect to the orientation of the major axis. The y distance is then expanded by the aspect ratio of the drawdown ellipse along the major axis (a/b). The Cooper-Jacob distance drawdown analysis is then applied to estimate the effective transmissivity, and the transmissivity along each axis is calculated using the same method as applied above.

Calculation results are presented in Table 4-5.

Table 4-5: Summary of Anisotropy Evaluation

	Major Axis		Minor Axis	
Azimuth / Anisotropy Ratio	**Transmissivity (ft^2/d)**	**Hydraulic Conductivity (ft/d) if b = 100 ft**	**Transmissivity (ft^2/d)**	**Hydraulic Conductivity (ft/d) if b = 100 ft**
Hantush and Thomas (1966)				
246° / 5.3	1,500,000	15,000	290,000	2,900
252° / 10.4	2,200,000	22,000	210,000	2,100
Mutch Jr. (2005)				
246° / 5.3	930,000	9,300	180,000	1,700
252° / 10.4	1,300,000	13,000	130,000	1,300

4.3.4 Hydraulic Gradient Calculations with 3-Point Solution

Traditional 3-point solutions were completed for each trial period using the EPA's 3PE spreadsheet tool (EPA 2014). Triangles were developed between monitoring locations, and the 3PE tool enabled calculation of groundwater velocity and direction at each triangle. Rather than include all possible triangles that could be created, triangles with roughly equal angles and side lengths (i.e., roughly equilateral) were selected. Results are presented on Figure 4-10. As has been observed historically at the site, gradients are very low (generally on the order of 0.0001 to 0.001 ft/ft) vectors can therefore point in differing directions. It is thought that despite significant effort by the Navy to reduce measurement error (e.g., in hand measurements, among water level meters, as a result of well deviation, in elevation surveys, and in transducer readings), there is likely still irreducible error that may be the primary source of uncertainty in the gradient azimuths and magnitudes. This unresolvable spatial variability in the water levels, coupled with the very low gradients, renders the use and interpretation of the 3-point method challenging at this site.

4.3.5 Evaluation of Capture from Water Levels

A typical procedure for drawing a capture zone around a pumping well is to interpretively draw a flow net perpendicular to the water level contours, where the flow net converges on the pumping well. However, when horizontal anisotropy is introduced, flow paths will deviate from perpendicular to water level contours. Evaluation of two-dimensional flow paths in anisotropic conditions requires a coordinate transformation where the coordinates are stretched in the direction of secondary hydraulic conductivity K_y by the square root of K_x divided by the square root of K_y (Freeze and Cherry 1979).

To apply this methodology to the water levels, a GIS based approach was developed using ESRI ArcGIS Pro 3.1.0 and ArcPy software. The transformation process is as follows:

1. Interpolate water level contours to a raster
2. Rotate the raster so that the direction of secondary anisotropy aligns with the y axis (north-south)
3. Multiply Y coordinates by the aspect ratio $\sqrt{K_x}/\sqrt{K_y}$.
4. Rotate the raster to the original angle.
5. Calculate flow direction at each raster cell
6. Reverse the transformation by rotating, shrinking by the aspect ratio, and rotating back to its original orientation.
7. Run forward particle tracks with the transformed flow directions.

Forward particle tracks were run based on the GWD contouring of select wells, as discussed in Section 4.3.1.1 for each of three trial periods under several assumptions of anisotropy including baseline assumption of a 246° dip azimuth with an anisotropy ratio of 5.3 (Figure 4-11a), 252° dip azimuth with an anisotropy ratio of 10.4 (Figure 4-11b), and a 246° dip azimuth with an anisotropy ratio of 15 (Figure 4-11c). The third set of particle tracks using an anisotropy ratio of 15 was included to demonstrate the effects of a higher anisotropy ratio than the estimates based on the interpreted drawdown ellipses, which is a likely scenario given the limitations of the method, as discussed in Section 4.3.3.

Particle tracks for the initial dip azimuth of 246 and anisotropy ratio of 5.3 generally show results with decreasing capture as the average pumping rate of RHS decreases. At 4.3 mgd, 97% of particles were captured, compared to 63% and 14% at the pumping rates of 2.9 and 1.7 mgd. The particle tracking results from the analysis using a dip azimuth of 252° and anisotropy ratio of 10.4 yielded very similar results, with the rotated azimuth, but higher anisotropy ratio likely negating one another. At 4.3 mgd, 86% of particles were captured, compared to 63% and 14% at the pumping rates of 2.9 and 1.7 mgd, respectively. Slight differences in water levels between monitoring wells result in larger changes to particle tracks than changes to the pumping rates. This conclusion casts significant uncertainty on the application of this method and use of water levels for evaluating capture.

The third set of particle tracks with a dip azimuth of 246 and an anisotropy of 15 shows significantly different patterns, where flow paths are more closely aligned with the dip azimuth rather than the hydraulic gradient. For the reasons discussed in Section 4.3.3, the values of anisotropy estimated from the drawdown ellipse method of 5.3 and 10.4 for this site are likely biased low. While the true anisotropy may be challenging to estimate, the forward particle tracks with an anisotropy ratio of 15 demonstrate that the uncertainty in this estimate significantly affects the conclusions of the analysis because all particles were captured regardless of pumping rate. The combination of the small effects on water levels variations on flow paths, combined with the uncertainty in anisotropy, results in significant uncertainty in the estimated capture of RHS under all three pumping scenarios when evaluated solely using water levels and particle tracking. The results do, however, indicate that if the horizontal anisotropy ratio can be reasonably bound to a value of greater than 15, greater confidence in flow direction is implied.

4.4 Perform Capture Zone Calculations

To supplement the interpretation of capture from measured water levels, analytical capture zone calculations are typically performed to estimate the size of a capture zone based on a simple two-dimensional analytical calculation as outlined in EPA (2008) guidance. If additional calculations are necessary, analytic element or numerical models may be employed to account for more complex settings. For this study, a simple analytical solution was applied as a first step toward estimating a capture zone; however, it is acknowledged that geologic heterogeneity, structural features such as the strike/dip and presence of valley fill, and horizontal anisotropy exhibit significant influence on capture and render the analytical solution inapplicable for a determination of capture. The purpose of the analytical solution is to demonstrate a baseline understanding of the potential capture zone width under the most simplified conditions. The next step taken was development of a quasi-3D analytic element model (AEM), which can account for some more complex features such as the valley fill barriers and horizontal anisotropy, but cannot fully account for complexities associated with vertical heterogeneity or vertical flow components. The AEM was used to simulate capture zones with average pumping rates from the three trial periods. Finally to better account for complexities at the site, the 3-D “best available” numerical GWFM (DON 2023a) was used to simulate capture in the RHS Target Capture Zone and the Red Hill tank farm evaluation area with average pumping rates from the three trial periods.

4.4.1 Analytical Solution for Capture Zone Width

The analytical calculation presented by EPA (2008) to estimate the maximum capture zone width was applied to the Facility assuming a single equivalent vertical pumping well to represent the RHS water development tunnel. The calculation assumes a homogeneous, isotropic confined aquifer, fully penetrating well, uniform thickness, steady-state flow, negligible vertical gradients, no net recharge, and no other water sources. While most of these assumptions are violated at the Facility, it provides some general information about what may be expected for the approximate width of hydraulic capture. Most notably, the isotropic aquifer assumption has been demonstrated to be untrue. The conservative assumption for the capture zone width calculation is to assume the hydraulic conductivity in the primary direction along dip is applied in all directions.

The formula for the maximum capture zone on each side of the axis is:

$$Y_{max} = \frac{Q}{2 \times T \times i}$$

Where:
Q = extraction rate (L^3/T)
T = transmissivity (L^2/T), or hydraulic conductivity × saturated thickness
i = hydraulic gradient

Input values and results are shown in Table 4-6.

Table 4-6: Analytical Capture Zone Width Calculation

Parameter	Extraction Rate (mgd)			Unit	Source
	4.3	2.9	1.7		
Hydraulic Conductivity (Kx, Ky)	9,300, 1,700			ft/d	Estimate from Mutch Jr. (2005) with 246° azimuth in Section 4.3.3.
Aquifer Thickness	100			ft/d	Assumed vertical extent from which majority of flow occurs.
Regional Hydraulic Gradient	0.00057			ft/ft	Calculated from linear trend of baseline water levels from Flow Optimization Study data in ArcGIS Software (ESRI 2020).
RHS Target Capture Zone Length and Width	730 × 320			ft × ft	Measured shapefile in ArcGIS Software (ESRI 2020).
Tank Farm Additional Evaluation Zone Length and Width	1,190 × 480			ft × ft	Measured shapefile in ArcGIS Software (ESRI 2020).
Calculated Capture Zone Width	1,115	752	441	ft	Calculated (2*Ymax).
Greater than RHS Target Capture Zone Width?	Yes	Yes	Yes	n/a	Compared to RHS Target Capture Zone Width of 320 ft.
Greater than Tank Farm Additional Evaluation Zone Width?	Yes	Yes	No	n/a	Compared to Tank Farm Additional Evaluation Zone Width of 480 ft.

n/a not applicable

The results indicate that the two higher flow rates of 4.3 and 2.9 mgd would have a wider capture zone than the Target Capture Zone associated with the tank farm, under the given assumptions, while the lowest rate of 1.7 mgd has a width slightly smaller than the Target Capture Zone (Figure 4-2). Orientation of the capture zone is not certain to be aligned with the tank farm but may be if the true anisotropy ratio of the aquifer is approximately 15 or greater.

4.4.2 Analytical Element Model

Next in the process of progressively increasing the detail and complexity of the capture analysis, an AEM was developed using AnAqSIM (Analytic Aquifer Simulator) software (Fitts Geosolutions 2022) to account for some additional complexities beyond the analytical calculations, including horizontal anisotropy, vertical anisotropy, configuration of RHS, and presence of valley fill. The model was set up with three layers of basalt, which were each 100 ft, 100 ft, and 600 ft thick from top to bottom. Within the first layer, the valley fill was implemented with a 50-ft-thick interdomain boundary, leaving half of the layer 1 thickness below the valley fill where groundwater can flow within the basalt. The extent of valley fill was derived from the Earth Volumetric Studio model where the valley fill was present below 18 ft msl. The RHS water development tunnel was simulated as a line sink with 80% of the flow rate specified in the eastern wing and 20% in the western wing. A head-specified external hydraulic gradient of 0.0005678 ft/ft oriented at 44° west of north (e.g., north-northwest), based on average trend of the baseline water levels prior to pumping was used. The valley fill was assigned a hydraulic conductivity of 0.1 ft/d in all directions. The hydraulic conductivity of the basalt in the primary direction, oriented with the dip azimuth of 246°, was set to 9,300 ft/d along dip and 1,700 ft/d in the secondary direction along strike, normal to dip. A second set of simulations were performed with the dip azimuth set to 252° with hydraulic conductivities in the primary and secondary directions of 13,000 ft/d and 1,300 ft/d, respectively.

A steady-state simulation was performed with the average flow rate of each trial period. The simulation results with the 246° dip azimuth are shown on Figure 4-12a, and the simulation results with the 252° dip azimuth are shown on Figure 4-12b. For both sets of simulations, all three pumping rates (4.3, 2.9, and 1.7 mgd) showed all particles from both Target Capture Zones flowing to RHS. While these simulations are not intended to represent all hydrogeological processes, they provide additional information beyond what can be estimated from water levels and particle tracking or analytical calculations, particularly accounting for the effects of horizonal anisotropy and the presence of the valley fill barriers. The AEM simulations show that presence of the valley fill is another mechanism that may promote groundwater flow from the tank farm toward RHS. Even under the assumptions of lower anisotropy values such as the 5.3 and 10.4 used in these simulations, where it would be expected that some particles may flow to the northwest, the valley fill impacts the hydraulic gradients enough to divert flow along dip.

4.4.3 "Best Available" Groundwater Flow Model

The 'best available' GWFM documented in DON (2023a) was used as an additional line of evidence to the capture evaluation. Initially, the GWFM was modified to simulate the pumping schedule that occurred during this study. Wells other than RHS were set to steady state and assigned the most recent pumping data, which had been previously provided by the Hawaiʻi Department of Land and Natural Resources (DLNR). The only additional change was to modify the general head boundary (GHB) values to account for changes to regional water levels. The model stress period setup is shown in Table 4-7.

Table 4-7: GWFM Stress Period Setup for Flow Optimization Study Simulation

Stress Period	Type	Description	Start Date	End Date	Dura-tion (days)	RHS Rate (mgd)
1	Steady State	RHS – 4.5 mgd, Hālawa Shaft off	4/6/23 9:00	4/7/23 9:00	1.00	4.5
2	Transient	RHS off, mgd, Hālawa Shaft off	4/7/23 9:00	4/10/23 9:00	3.00	0
3	Transient	RHS – 4.3 mgd, Hālawa Shaft off (Trial Period #1)	4/10/23 9:00	4/28/2023 9:00	18.00	4.3
4	Transient	RHS off, mgd, Hālawa Shaft off	4/28/23 9:00	5/1/2023 9:00	3.00	0
5	Transient	RHS – 4.3 mgd, Hālawa Shaft off (Trial Period #2, Week #1)	5/1/23 9:00	5/6/2023 9:00	5.00	4.3
6	Transient	RHS off, mgd, Hālawa Shaft off	5/6/23 9:00	5/8/2023 9:00	2.00	0
7	Transient	RHS – 4.2 mgd, Hālawa Shaft off (Trial Period #2, Week #2)	5/8/23 9:00	5/13/2023 9:00	5.00	4.2
8	Transient	RHS off, mgd, Hālawa Shaft off	5/13/23 9:00	5/15/2023 9:00	2.00	0
9	Transient	RHS – 4.2 mgd, Hālawa Shaft off (Trial Period #2, Week #3)	5/15/23 9:00	5/20/2023 9:00	5.00	4.2
10	Transient	RHS off, mgd, Hālawa Shaft off	5/20/23 9:00	5/23/2023 9:00	3.00	0
11	Transient	RHS – 4.2 mgd, Hālawa Shaft off (Trial Period #3, Week #1)	5/23/23 9:00	5/25/2023 9:00	2.00	4.2
12	Transient	RHS off, mgd, Hālawa Shaft off	5/25/23 9:00	5/26/2023 9:00	1.00	0
13	Transient	RHS – 4.2 mgd, Hālawa Shaft off (Trial Period #3, Week #1)	5/26/23 9:00	5/27/2023 9:00	1.00	4.2
14	Transient	RHS off, mgd, Hālawa Shaft off	5/27/23 9:00	5/30/2023 9:00	3.00	0
15	Transient	RHS – 4.2 mgd, Hālawa Shaft off (Trial Period #3, Week #2)	5/30/23 9:00	6/1/2023 9:00	2.00	4.2
16	Transient	RHS off, mgd, Hālawa Shaft off	6/1/23 9:00	6/2/2023 9:00	1.00	0
17	Transient	RHS – 4.2 mgd, Hālawa Shaft off (Trial Period #3, Week #2)	6/2/23 9:00	6/3/2023 9:00	1.00	4.2
18	Transient	RHS off, mgd, Hālawa Shaft off	6/3/23 9:00	6/6/2023 9:00	3.00	0
19	Transient	RHS – 4.3 mgd, Hālawa Shaft off (Trial Period #3, Week #3)	6/6/23 9:00	6/8/2023 9:00	2.00	4.2
20	Transient	RHS off, mgd, Hālawa Shaft off	6/8/23 9:00	6/9/2023 9:00	1.00	0
21	Transient	RHS – 4.3 mgd, Hālawa Shaft off (Trial Period #3, Week #3)	6/9/23 9:00	6/10/2023 9:00	1.00	4.2
22	Transient	RHS off, mgd, Hālawa Shaft off	6/10/23 9:00	6/13/2023 9:00	3.00	0
23	Transient	RHS – 4.1 mgd, Hālawa Shaft off (Trial Period #3, Week #4)	6/13/23 9:00	6/15/2023 9:00	2.00	4.1
24	Transient	RHS off, mgd, Hālawa Shaft off	6/15/23 9:00	6/16/2023 9:00	1.00	0
25	Transient	RHS – 4.2 mgd, Hālawa Shaft off (Trial Period #3, Week #4)	6/16/23 9:00	6/17/2023 9:00	1.00	4.2
26	Transient	RHS off, mgd, Hālawa Shaft off	6/17/23 9:00	6/20/2023 9:00	3.00	0

Simulated heads and drawdowns were compared to those measured by transducers during the study. Table 4-8 shows head and drawdown statistics from the original "best available" model calibration which included data from the 2017/2018 synoptic survey and the 2022 restart of RHS, as well as for the current flow optimization study. The RMSE of the observed versus simulated heads for the flow optimization study model simulation increased compared to the "best available" model calibration period, increasing from 0.28 to 0.30 ft, and the drawdown error (RMSE) increased from 0.18 to 0.19 ft. A much smaller range of observations in head data—2.95 ft—was available from the flow optimization study given the focus on wells proximate to RHS, compared to 7.19 ft over the previous data sets. Scaling the RMSE by the range of observation is typically done to provide context of the RMSE with respect to the observation. The scaled RMSE for the flow optimization study to 10.0%, which is the upper limit of typically acceptable groundwater flow model calibration standards, while the "best available" model calibration-scaled RMSE was 3.9%, due primarily to the larger range of observations. Although bulk calibration statistics are not all-encompassing measures of model acceptability, this is one measure to demonstrate that there is generally little degradation of the calibration when simulating the flow optimization study conditions and comparing to an independent dataset.

Table 4-8: GWFM Calibration Statistics

	Head		**Drawdown**	
Calibration Statistic	**"Best Available" Model**	**Flow Optimization Study**	**"Best Available" Model**	**Flow Optimization Study**
Residual Mean (ft)	-0.05	0.00	0.01	0.12
Absolute Residual Mean (ft)	0.20	0.21	0.08	0.13
Residual Standard Deviation (ft)	0.28	0.30	0.18	0.14
Sum of Squared Residuals (ft^2)	803.87	45,043.87	281.55	17,634.93
RMSE Error (ft)	0.28	0.30	0.18	0.19
Minimum Residual (ft)	-2.36	-1.01	-1.79	-1.31
Maximum Residual (ft)	2.08	1.24	2.30	2.52
Number of Observations	9,928	512,339	8,926	499,116
Range in Observations	7.19	2.95	4.76	1.65
Scaled Residual Standard Deviation (%)	3.9%	10.0%	3.7%	8.6%
Scaled Absolute Residual Mean (%)	2.8%	7.0%	1.7%	8.1%
Scaled RMSE Error (%)	4.0%	10.0%	3.7%	11.4%
Scaled Residual Mean (%)	-0.6%	0.0%	0.3%	7.5%
Correlation Coefficient	0.96	0.82	0.85	0.51

Additional calibration data including a scatter plot and hydrographs of head and drawdown are presented in Appendix B. The scatter plot of simulated and observed heads shows most points distributed evenly around the perfect match line; however, low simulated values compared to values measured at the plume delineation (P-) wells show the appearance of a flatter slope compared to the perfect match line. Data points on the scatter plots were thinned to every 100th point to show more clarity on the distribution and density.

Additionally, background wells with the highest and lowest water levels, to the southeast and northwest of the Facility, respectively, show opposite slop^{es} than observed, indicating that effects of external factors that are not accounted for in the model, such as short-term variations in recharge to the basal aquifer.

Each of the three average pumping rates from the trial periods (4.3, 2.9, and 1.7 mgd) were simulated in steady-state predictive GWFM, based on the "best available" model calibration, to show forward particle tracking from the Target Capture Zones. At the pumping rates of 4.3 and 2.9 mgd, all particles from both target areas were captured by RHS; however, at 1.7 mgd, one particle escaped capture to the northwest from each target area. Results from the "Best Available Model" particle tracking simulations are shown on Figure 4-13.

4.5 Evaluate Concentration Trends

4.5.1 Water Quality Parameters

Water quality parameters were monitored along with water levels by AT600s, AT200s, and MOSDAX transducers, as described in Section 3.2. Figure 4-14a–Figure 4-14s present water quality parameters from each well plotted on a secondary y-axis, with water levels on the primary y-axis for comparison. At least one parameter per transducer sensor is plotted, specifically temperature, specific conductivity, dissolved oxygen, pH, oxygen reduction potential and one of the following specialty sensors: FDOM, fluorescein, or rhodamine. Other recorded parameters are calculated from the same sensors listed above, and so are not plotted herein. Plots of parameters that responded to pumping are outlined in black. Figure 4-15 indicates the number of parameters that responded to pumping in wells (per sensor) throughout the Facility.

Based on the number of wells that had responses in at least one parameter, the primary influence appears to be near RHS and in the vicinity of Red Hill ridge. Fewer responses were observed in the confined wells in South Hālawa Valley as well as on the edge of the OWDF.

Plan view plots of specific conductivity at the end of each trial period are depicted on Figure 4-16; results are consistent with historical trends for the area. Wells around OWDF show the highest specific conductivity values, as well as RHMW06. Water on the Moanalua side of Red Hill ridge has the lowest specific conductivity values. Most of the newly installed plume delineation wells had specific conductivity values between 500 and 1,000 microsiemens per centimeter (µS/cm).

4.5.2 Isotope Samples

At the time of this writing, not all the nitrate isotope sample analytical results are available. Water isotope sample analytical results are available in the Navy's Red Hill EDMS. Isotopes are saved under Library > Laboratory Reports > Wells: show all coverages pull-down menu > Flow Optimization. Because Isotech and the University of Hawaiʻi do not have EDMS access, only laboratory reports are available. Furthermore, because EDDs are not available in EDMS, data are unable to be queried. Nitrate/nitrite sample results are found in EDMS under Reports > Environmental Data > Chemistry Results by Location Type (JBPHE) or Reports > Environmental Data > Validated Data Export with Rejects, Approved (Excel), Project = RHS Flow Optimization Study, Event = 2023 Monitoring Wells.

The water isotope sample results indicate limited variability in isotopic composition between Trial Period #3 and continuous pumping conditions, aside from a few outliers. No correlation was observed between isotopic composition and sample elevation, which agrees with the 2020 island-wide study of O‘ahu (Dores et al. 2020). This contrasts with clear correlations observed on the islands of Hawai‘i and Maui, which both have much higher elevation ranges. The data may also be inconclusive due to significant variability observed between primary and duplicate samples. Samples collected during RHS pumping and non-pumping periods did not show significantly varied isotopic signatures. Results to date are presented on Figure 4-17. Based on the currently incomplete data set no conclusions can be drawn regarding capture during any of the three test periods. Results will be reevaluated when the complete data set is available.

4.5.3 Analytical Data from Sampling Programs

Groundwater samples were collected and analyzed for fuel-related compounds during this study as part of the ongoing NOI, LTM, and plume delineation (P-) well sampling programs. At the time of this writing, select validated data are available for a full round of sampling. Data will be provided on the Navy’s Red Hill EDMS as they become validated under Reports > Environmental Data > Chemistry Results by Location Type (JBPHE) or Reports > Environmental Data > Validated Data Export with Rejects, Approved (Excel). Results will be incorporated into the “heat maps” as they become validated.

Validated Heat Maps. Fully validated data sets from the following four events are available at the time of this writing:

1) NOI Week of April 3, 2023 & P-Wells – Baseline prior to the start of the Flow Optimization Study
2) Q2 2023 LTM (April 11 to April 21, 2023) & P-wells – during Trial Period 1
3) NOI Week of April 24, 2023 – during Trial Period 1
4) NOI Week of May 1, 2023 & P-wells – during Trial Period 2.

TPH-d results are presented on Figure 4-18a. TPH-d was generally not detected or was at low concentrations, below the EAL (400 µg/L) inside and outside of the Tank Farm area for the week of April 3rd and for the Q2 2023 LTM event. During the week of April 24th, a sporadic TPH-d EAL exceedance was detected at RHMW04. During the week of May 1st, a sporadic TPH-d EAL exceedance was detected at RHMW06. An EAL exceedance remained at RHMW02 throughout all evaluated weeks, which is within historical levels, as was the case prior to 2021. All TPH-d results in locations at and around RHS (delineation [P-]wells, OWDF wells) are consistently non-detects or low concentrations below the EAL.

TPH-o results are presented on Figure 4-18b. TPH-o was not detected or was at low concentrations, below the EAL (500 µg/L) inside and outside of the Tank Farm area for the week of April 3rd and the Q2 2023 LTM event at all monitoring locations. During the week of April 24th, a sporadic TPH-o EAL exceedance as detected at RHMW04. During the week of May 1st, a sporadic TPH-o EAL exceedance was detected at RHMW06. All TPH-o results in locations at and around RHS (P-wells, OWDF wells) are consistently non-detects or low concentrations below the EAL.

1-Methylnpathelene, 2-methylnapthalene, naphthalene, and total xylenes results are presented on Figure 4-18c–Figure 4-18f. Unlike TPH, the laboratory method for these analytes is specific and identifies actual chemical constituents of fuel. Results are consistent with the range of historical detections for the site.

For the week of April 3rd and the Q2 2023 LTM event, 1-methylnpahtlene was detected only at RHMW02 and RHMW2254-01; all other locations had non-detect results. At RHMW02, 1-methylnpahtlene was detected one order of magnitude below the EAL (10 µg/L). At RHMW2254-01, 1-methylnpahtlene was three orders of magnitude below the EAL as an estimated concentration. 1-methylnpathalene was not detected at most locations except for RHMW02 for the week of April 24th, where 1-methylnaphthlene was detected below the EAL. For the week of May 1st, 1-methylnaphthalene was not detected at most locations except for RHMW02, which exceeded the EAL.

2-Methylnaphthalene and naphthalene were not detected at any location except RHMW02 for each of these three events. All results at RHMW02 were one order of magnitude below EALs (10 µg/L for 2-methlynapthalene and 17 µg/L for naphthalene). For the week of May 1st, 2-methylnapthalene at RHMW02 exceeded the EAL.

Total xylenes were not detected at any location for the week of April 3rd and the week of May 1st. Total xylenes were estimated at four orders of magnitude below the EAL (20 µg/L) in RHMW02 for the Q2 2023 LTM event, and were detected at three orders of magnitude below the EAL in RHMW02 for the week of April 24th.

Based on these partial results, no pattern was detected that indicates any evidence of remaining fuel constituents in RHS (i.e., the goal of current RHS pumping per the RHSRMP).

4.5.4 RHS Pump Start Up Influent Samples

During each trial period, samples were collected from between the discharge pipeline and the GAC system after each time RHS restarted. At the time of this writing, validated data are available for most but not all influent samples. Validated results are presented in Table 4-9. Data are provided on the Navy's EDMS as they become validated and are filed under Reports > Environmental Data > Chemistry Results by Location Type (JBPHE) or Reports > Environmental Data > Validated Data Export with Rejects, Approved (Excel).

Table 4-9: Validated TPH Influent Samples

Sample ID	Sample Type	Sampling Date and Time (HST)	TPH-d (µg/L)	TPH-o (µg/L)
RHS-IF-TRAIN-01-040523-(1)-N	Duplicate	4/5/2023 12:05:00 PM	ND	ND
RHS-IF-TRAIN-01-040523-N	Primary	4/5/2023 12:05:00 PM	ND	ND
RHS-IF-TRAIN-02-041023-N	Primary	4/10/2023 10:45:00 AM	ND	ND
RHS-IF-TRAIN-03-041923-N	Primary	4/19/2023 11:25:00 AM	ND	ND
RHS-IF-TRAIN-01-042623-N	Primary	4/26/2023 11:25:00 AM	ND	ND
RHS-IF-TRAIN-02-050123-(01)-N	Duplicate	5/1/2023 10:50:00 AM	ND	ND
RHS-IF-TRAIN-02-050123-N	Primary	5/1/2023 10:50:00 AM	ND	ND
RHS-IF-TRAIN-03-050823-N	Primary	5/8/2023 10:25:00 AM	ND	ND
RHS-IF-TRAIN-01-051523-N	Primary	5/15/2023 10:30:00 AM	ND	ND
RHS-IF-TRAIN-02-052323-N	Primary	5/23/2023 10:20:00 AM	ND	ND
RHS-IF-TRAIN-03-052623-N	Primary	5/26/2023 10:35:00 AM	ND	ND
RHS-IF-TRAIN-01-053023-N	Primary	5/30/2023 10:30:00 AM	ND	ND
RHS-IF-TRAIN-02-060223-(01)-N	Duplicate	6/2/2023 10:05:00 AM	ND	ND
RHS-IF-TRAIN-02-060223-N	Primary	6/2/2023 10:05:00 AM	ND	ND
RHS-IF-TRAIN-03-060623-N	Primary	6/6/2023 9:55:00 AM	ND	ND
RHS-IF-TRAIN-01-060923-N	Primary	6/9/2023 10:00:00 AM	ND	ND
RHS-IF-TRAIN-02-061323-N	Primary	6/13/2023 9:35:00 AM	ND	ND
RHS-IF-TRAIN-03-061623-N	Primary	6/16/2023 9:15:00 AM	ND	ND
RHS-IF-TRAIN-01-062023-N	Primary	6/20/2023 9:50:00 AM	ND	ND

ND non detect

Based on these non-detected results, there is no evidence of remaining fuel constituents in RHS (i.e., the goal of current RHS pumping per the RHSRMP), and there was no evidence of rebound after the non-pumping periods.

4.5.5 Evaluation of Groundwater Flow Direction Based on May 2021 Release

The degree to which horizontal anisotropy affects groundwater flow directions is an important factor in the consideration of capture zone evaluation. Because the previously described methods for evaluating anisotropy have associated uncertainty that can affect the outcome of the evaluation, TPH-o analytical data collected after the May 2021 Release are considered. These data provide a line of evidence that anisotropy of the aquifer if high enough to create flow conditions generally along dip rather than in the direction of hydraulic gradients.

On May 6, 2021, a pipeline carrying JP-5 near Red Hill Tanks 18 and 20 was damaged during a fuel transfer procedure. Fuel was released to the tunnel floor, and attempts were made to recover the fuel. Some of the fuel that was not recovered was pumped from a fire suppression retention system (sump) into a fire recovery drain line. The fuel remained in the fire suppression drain line within the lower access tunnel until the drain line was damaged on November 20, 2021. The fire suppression drain line was damaged, resulting in fuel release to the tunnel floor. The fuel traveled along the tunnel floor to an Adit 3 storm water sump. The fuel was pumped via float automated pump from the Adit 3 Sump to a holding tank and leach tank located outside the Adit 3 Tunnel.

To characterize the TPH-o detects for samples collected on July 15, 2021 from RHMW03 (610 µg/L), the RHS pre-chlorination spigot (480 µg/L), and the associated method blank (MB), the samples were extracted using the EPA 3520 continuous liquid-liquid extraction method and analyzed for possible identification of the unknown peaks via the EPA 8015 gas chromatography/flame-ionization detection (GC/FID) method along with the EPA 8270 gas chromatography/mass spectrometry (GC/MS) scan for tentatively identified compounds (TICs). The peaks were not a match to any of the materials in the library of spectra. In general, compounds identified in the MB were present in the RHMW03 and RHS pre-chlorination spigot sample, which includes phthalates, surfactants, and non-hydrocarbon compounds, and is not related to the fuel stored within the tanks.

Some of the broad and “hump-like” peaks of interest in past samples have been late-eluting compounds, primarily in the TPH-o range. RHMW03 has consistently exhibited low-level TPH-o concentrations with a pattern of fuel degradation byproducts and dissolved fuel constituents in groundwater that are largely removed by silica gel. These peaks were most likely indicators of polar metabolites or laboratory artifacts; one peak is indicative of a polyvinyl chloride stabilizer, another is a urea type compound, and the other two are an alcohol and a glycol; however, the actual identity of the peaks could not be confirmed.

Although TPH-d is more closely related to JP-5 than TPH-o is, the TPH-o data appear to show a more distinct response to the May 2021 Release, suggesting potential mobilization of residual petroleum contamination during the release or subsequent cleanup efforts. Timing of the initial breakthrough and the peak TPH-o concentration are shown for the various wells on Chart 4-2 through Chart 4-7. RHMW03 shows an apparent breakthrough curve, while RHMW02 may show a breakthrough curve but is weaker and further obscured by higher background concentrations compared to RHMW03. RHMW05 and RHMW01R had only one detection or exceedance during this period; therefore, dates are the same for initial apparent breakthrough and apparent peak. Neither of these wells exhibit breakthrough appears to be consistent with groundwater flow through the saturated zone originating from the release location. Several detections and exceedances also occurred at the RHS pre-chlorination spigot; however, no detections occurred from RHS (RHMW2254-01) at those corresponding time periods. Estimated groundwater velocities ranged from 2.5 to 52.4 ft/d, as shown in Table 4-10.

Table 4-10: Estimated Groundwater Velocities After May 6, 2021 Release

Parameter	RHMW03	RHMW02	RHMW01R	RHMW05	RHS (pre-chlorination spigot)
Date of breakthrough	6/4/2021	6/4/2021	11/10/2021	9/29/2021	7/8/2021
Date of peak concentration	8/26/2021	9/8/2021	11/10/2021	9/29/2021	8/5/2021
Distance from release (ft)	275	1,105	1,725	2,580	3,300
Total travel time for arrival (days)	29	29	188	146	63
Total travel time to apparent peak (days)	112	125	188	146	91
Average groundwater velocity to apparent breakthrough from release (ft/d)	9.5	38.1	9.2	17.7	52.4
Average groundwater velocity to apparent peak from release (ft/d)	2.5	8.8	9.2	17.7	36.3

Note: Breakthrough refers to the first data point above background values at each well.

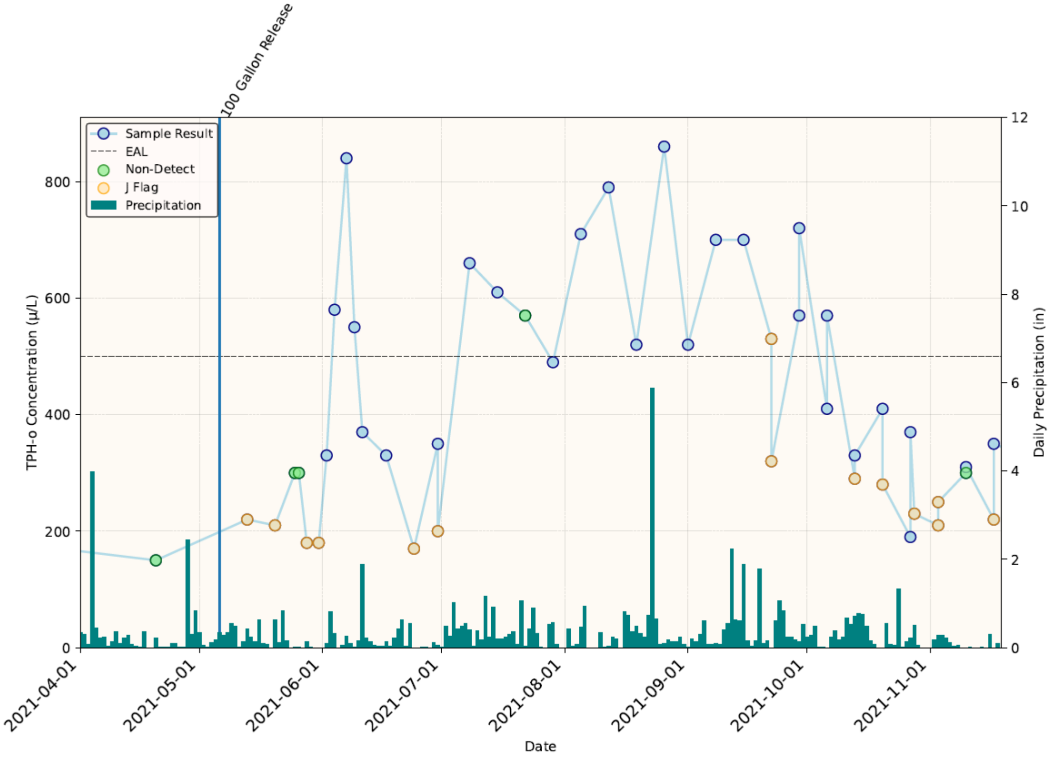


Chart 4-2: TPH-o Concentrations at RHMW03 following the May 6, 2021 Release

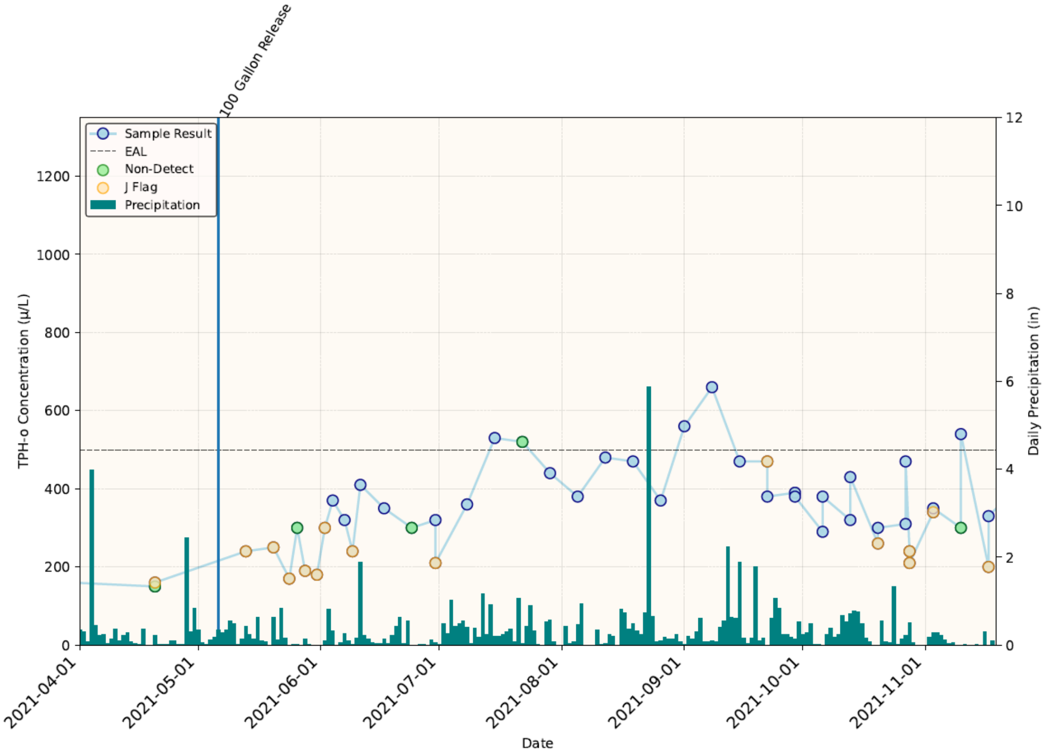


Chart 4-3: TPH-o Concentrations at RHMW02 following the May 6, 2021 Release

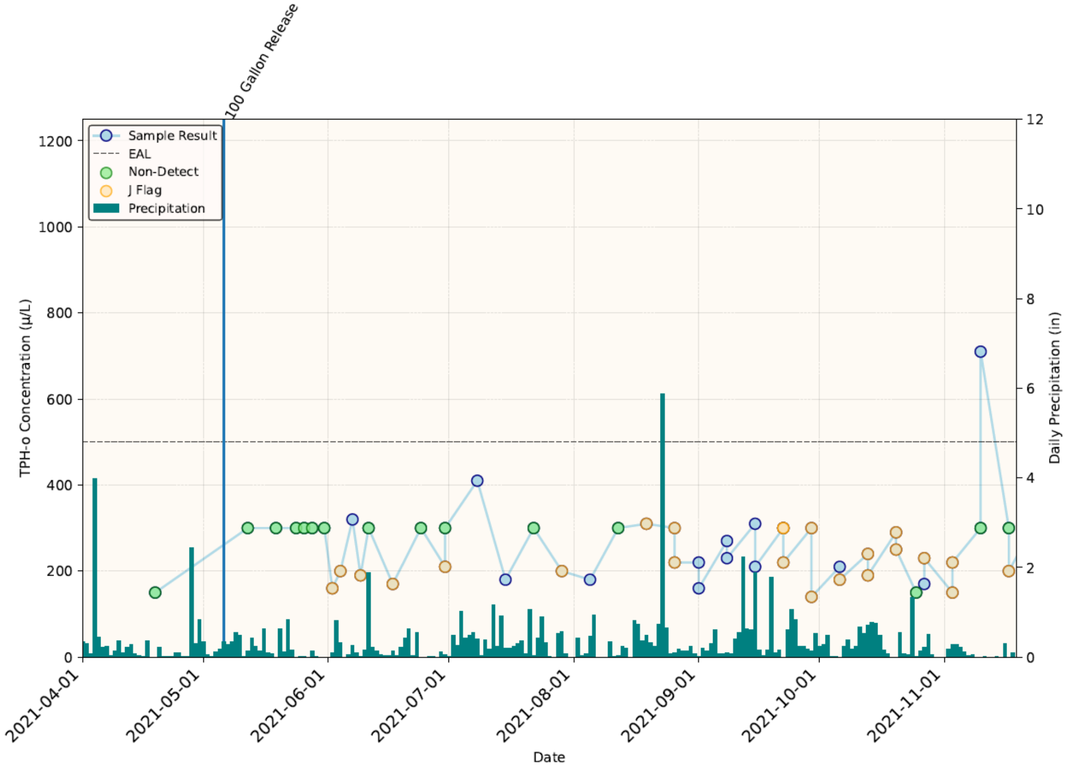


Chart 4-4: TPH-o Concentrations at RHMW01R following the May 6, 2021 Release

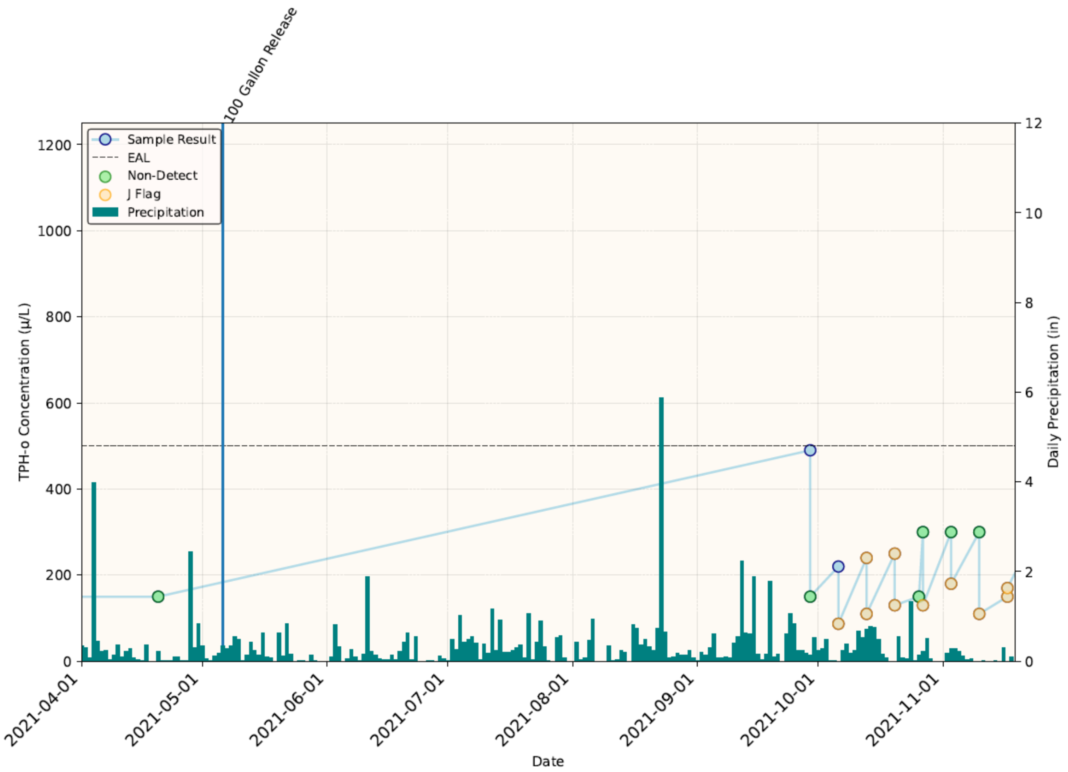


Chart 4-5: TPH-o Concentrations at RHMW05 following the May 6, 2021 Release

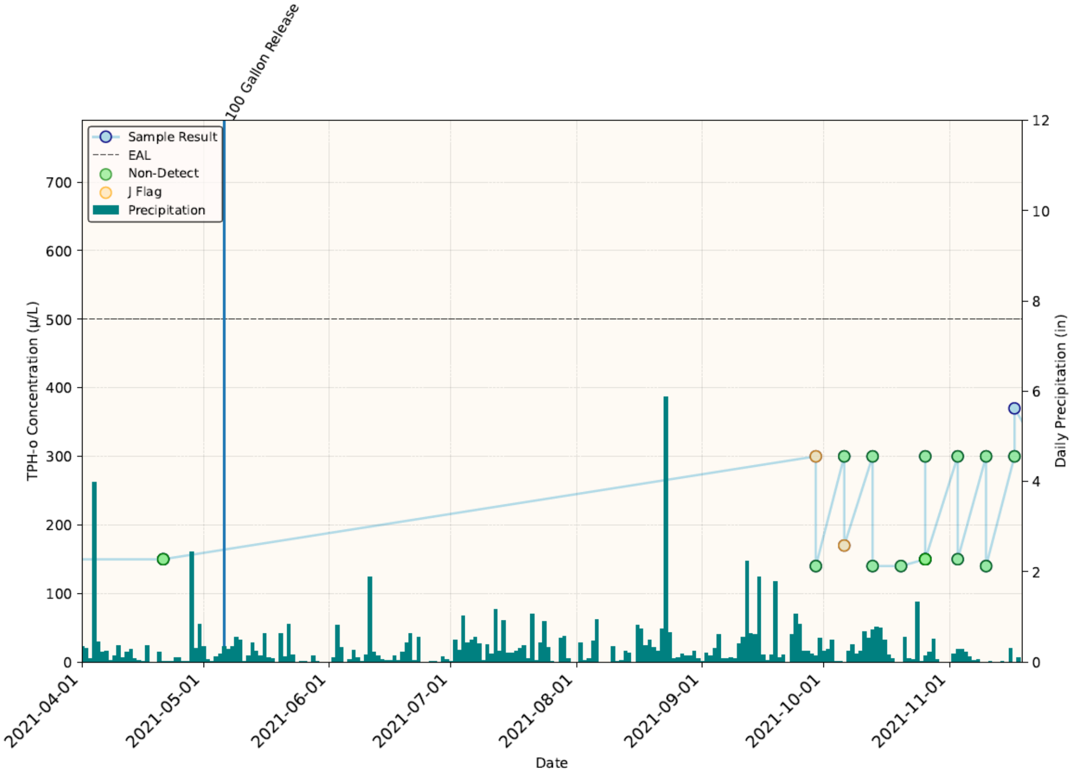


Chart 4-6: TPH-o Concentrations at RHS (RHMW2254-01) following the May 6, 2021 Release

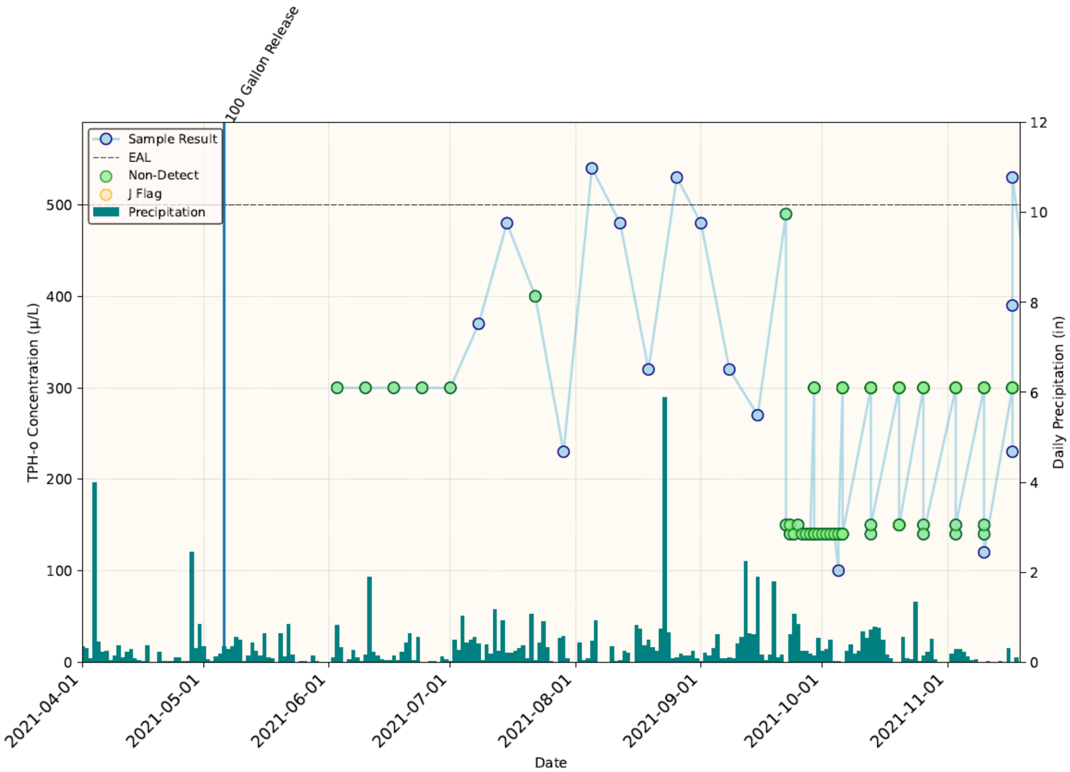


Chart 4-7: TPH-o Concentrations at RHS Pre-Chlorination Spigot following the May 6, 2021 Release

Although it is expected that groundwater velocity is variable along the travel paths between the release location and RHS, the timing of the detections and high variability in velocity do not lead to a clear sequence of breakthrough curves down the Red Hill ridge, particularly when considering the timing of TPH-o occurrence at the RHS pre-chlorination spigot that occurred well before detections occurred at RHMW05 and RHMW01R. Peak TPH concentration at the RHS pre-chlorination spigot also occurred prior to the peak at RHMW03 and RHMW02. Based on the available data, concentrations at RHMW03 are most likely related to the May 2021 Release, followed by RHMW02, which may be also related to the May 2021 Release. Other sporadic hits at RHMW01R and RHMW05 may be related but do not exhibit clear enough behavior to draw any specific conclusions. Because concentrations at the RHS pre-chlorination spigot occur around the same times as those at RHMW02 and RHMW03, it presents a conceptual inconsistency in the groundwater flow path that is currently unexplained. It is possible either that the detections are not related to the same source, or that some portion of the TPH-o plume reached a preferential pathway that migrated to RHS much faster than the remainder of the plume.

The apparent breakthrough curves at RHMW03 and RHMW02 following the release, however, do present a line of evidence indicating that groundwater flows along Red Hill ridge. It is possible that the other TPH-o detections are related to the release, which would provide further evidence of the flow path. It may be that a TPH-o plume was diluted enough by the time it reached RHS to not create a clear breakthrough curve. The interpretation of all these data along the entirety of the flow path is uncertain, but there is some reasonable confidence that dissolved phase TPH-o moved from the release location to RHMW03, then to

RHMW02. This is consistent with the estimated magnitude and direction of anisotropy and is suggestive of a higher degree of aquifer anisotropy than was estimated by the methods described in Section 4.3.3. However, the apparent summer 2021 “breakthrough” at RHMW02 may have resulted from a number of alternative causes, such as:

- Local remobilization of residual fuels potentially present at or close to the water table;
- Local remobilization of residual fuels potentially present in the vadose zone; or
- Breakthrough related to the May 2021 release.

4.6 Interpretation of Capture

Many lines of evidence were compiled to estimate capture of the target areas under the three pumping scenarios used during the Flow Optimization Study trial periods. Three methods of particle tracking were applied: running particle tracks on contoured 2-D water level data, a quas-3-D analytic element model, and the “best available” 3-D GWFM. The methods were intended to progressively add complexity to account for additional site conditions. The major underlying assumptions associated with each method are summarized in Table 4-11. Comparison of contours and particle tracking results for different methods are presented on Figure 4-19a–Figure 4-19c.

Table 4-11: Methodology Assumptions and Specifications

Assumptions	GWD Water Level Particle Tracks	Analytical Element Model	“Best Available” GWFM
Dimensions	2D	Quasi-3D	3D
Horizontal Anisotropy	Yes	Yes	Yes
Vertical Gradients	No	Limited	Yes
Geologic Heterogeneity	No	Limited (differentiates between confined and unconfined units)	Limited (differentiates between geologic units but not basalt sub-types)
RHS Represented as Line Sink	Approximate (kriging line drift)	Yes	Yes
Recharge	No	No	Yes
Additional Water Sources and Sinks	No	No	Yes
Transient or Steady-State Flow	Steady-State	Steady-State	Transient
Hydraulic Properties Adjusted via Calibration	No	No	Yes

Figure 4-20a–Figure 4-20c show the forward particle tracks for each respective trial period with all three particle tracking methods overlaid. For methods where multiple dip azimuth and anisotropy assumptions were applied, the particle tracks shown on these figures correspond to the dip azimuth of 246° and an aquifer anisotropy of 5.3. Results were not significantly different with a dip azimuth of 252° and aquifer anisotropy of 10.4. A summary of the particle tracking results is shown in Table 4-12.

The water level mapping under various pumping conditions straddles the threshold of complete capture. The AnAqSim and MODFLOW models indicate full capture (of particles released from both the RHS Target Capture Zone and the Tank Farm Evaluation Area) under all scenarios because they account for additional factors such as the presence of valley fill. These results use forward particle tracking. If reverse particle tracking was performed releasing particles from RHS, it would likely show differences in capture zone extent as the pumping rate changes. In addition, the models have varying capabilities to adequately represent three-dimensional flow, heterogeneity, and anisotropic behavior, all of which likely factor into the actual field conditions, as previously described.

Table 4-12: Summary of Particle Tracking Results

	% Capture of Particles from RHS Target Area			% Capture of Particles from Tank Farm Target Area		
Method	**1.7 mgd**	**2.9 mgd**	**4.3 mgd**	**1.7 mgd**	**2.9 mgd**	**4.3 mgd**
GWD Water Level Particle Tracks (Azimuth 246°, Anisotropy 5.3)	100%	100%	100%	14%	63%	97%
GWD Water Level Particle Tracks (Azimuth 252°, Anisotropy 10.4)	100%	100%	100%	14%	63%	86%
GWD Water Level Particle Tracks (Azimuth 246°, Anisotropy 15)	100%	100%	100%	100%	100%	100%
AEM (Azimuth 246°, Anisotropy 5.3)	100%	100%	100%	100%	100%	100%
AEM (Azimuth 252°, Anisotropy 10.4)	100%	100%	100%	100%	100%	100%
"Best Available" GWFM	94%	100%	100%	98%	100%	100%

The methods outlined above indicate that capture of the target area around RHS is likely to be sufficient under all three pumping scenarios. Capture of the entirety of the tank farm has increased uncertainty. Particle tracking results from the water level contours yield conclusions that are highly variable based on the degree of anisotropy assumed, while the AEM and GWFM both indicate that capture is likely at all three pumping rates for both target areas.

Each method produces a different estimated percent capture with forward particle tracking, which best represents transport of groundwater particles originating at the water table. This differs from the total extent of capture, which would be best evaluated through reverse particle tracking (Table 4-12). The method that used field-measured water levels that were interpolated using kriging, combined with particle tracks based on these interpolated gradients, predicted increased percent capture with increased pumping rate. This was the only method that in certain scenarios predicted incomplete capture of the tank farm at lower pumping rates. The other two methods (AEM and GWFM) indicated complete capture at all pumping rates. The actual capture zone of RHS with each of these methods would likely expand proportionally to the pumping rate if the evaluations were done with reverse particle tracking; however, in each case, the threshold of full capture was not crossed, therefore the forward particle tracking results were similar regardless of pumping rate. Additional differences are likely due to the 2-D nature of the water level method, in contrast with the AEM and GWFM methods, which can account for flow in the vertical dimension as well as the effects of different geologic materials (Table 4-11). All the methods suggest substantial capture of groundwater in the Target Capture Zone near RHS at all tested pumping rates.

Analytical capture zone width calculations also support the conclusion that 4.3, 2.9, 1.7 mgd may capture releases from the RHS target area. However, a pumping rate of only 1.7 mgd may be too low to establish confidence in full hydraulic capture of the tank farm, but that was not the purpose for which RHS pumping was re-established, and this will be further evaluated over the coming year.

Additional lines of evidence were considered to support capture determinations, though many were inconclusive. Evaluation of vertical gradients showed mostly downward gradients for the four multilevel wells. Calculation of hydraulic gradients by 3-point solutions demonstrated that the small water level differences within the Facility make inferences of flow direction based on 3-point solutions problematic. Analysis of trends in water quality parameters across the Red Hill monitoring network generally support a broad area of parameter changes across the network, but is not diagnostic of capture. Stable isotope data and COPC heat maps are partially pending and will be evaluated at a later time. Available COPC heat map and RHS start-up sampling results do not indicate the presence of fuel constituents in RHS.

A potentially important line of evidence to support the flow direction down Red Hill ridge is the TPH-o analytical data following the May 2021 Release near Tanks 18 and 20, which showed an apparent breakthrough curve traveling from the release location through RHMW03 and potentially to RHMW02. The strengths and limitations of this line of evidence are discussed in Section 4.5.5. This line of evidence supports the concept of a relatively high degree of anisotropy, resulting in groundwater flow directions along dip when pumping is introduced; however, there is significant uncertainty regarding interpretation of these results, and it should not be taken as a standalone case for groundwater flow directions. These potential flow conditions and estimates of capture can be further evaluated through the successful completion of a well-designed tracer study or other techniques, as discussed in Section 4.7.

4.7 Data Gaps and Uncertainty

Evaluation of capture at the Red Hill Facility carries significant uncertainties and challenges in verifying capture of the target areas. Due to the complex geology (highly heterogeneous and anisotropic), small differences in water levels, likely measurement error, and other factors, simplified methods that are typically applied to groundwater remediation projects as documented by EPA (2008) do not adequately account for various features such as horizontal anisotropy and presence of valley fill/confining unit. More complex methods such as numerical groundwater models require significant efforts to construct, calibrate, and constrain predictive results to plausible outcomes. While the results from the “best available” numerical model are valuable and inform decision making, without direct field verification of the results, capture is not certain, even if the simulations and field conditions indicate it is likely.

The very small relative differences in water levels measured at the Facility make interpretations of hydraulic gradients challenging. The single-point cross-validation indicates measurement error/uncertainty on the order of 0.2 to 0.3 ft. Small measurement errors and water level differences due to local-scale heterogeneity of the basaltic formation can obscure hydraulic gradient evaluation as demonstrated by both the water level contours discussed in Section 4.3.1 and the 3-point hydraulic gradient calculations discussed in Section 4.3.4. The sparseness of the monitoring well network also leaves spatial gaps where hydraulic gradients are unknown.

An additional compounding factor is the role that horizontal anisotropy plays in the groundwater flow directions. Estimating anisotropy requires a well-distributed monitoring network to understand the spatial distribution of drawdown. Additionally, classical methods of estimating horizontal anisotropy are based on the assumption of a vertical pumping well. Because the RHS water development tunnel is a long horizontal tunnel, anisotropy estimates are likely biased low because any given monitoring well is located nearer to the tunnel than is assumed by the center point of the drawdown ellipse. Bias in the anisotropy estimates is important because the predicted extent of hydraulic capture is somewhat sensitive to this parameter. If the estimated anisotropy is biased low, RHS will capture more of the tank farm than predicted. Conversely, if the estimated anisotropy is biased high, RHS will capture less of the tank farm than predicted.

In addition, efforts are currently underway to attempt to model the significant heterogeneity known to exist within the basalt aquifer at the site. These effects have not been modeled using the tools described in this report, but will be the subject of future modeling work.

A significant amount of water level and drawdown data have been compiled over the course of several years. Data collected during this study will provide valuable insights into future GWFM recalibration. While expansion of the monitoring well network is ongoing, other forms of data collection may be valuable to understanding groundwater flow directions at the Facility including in-well testing and intra-well tracer testing. A tracer test that starts at the tank farm and reaches RHS may be useful to verify capture of groundwater from the tank farm area by RHS.

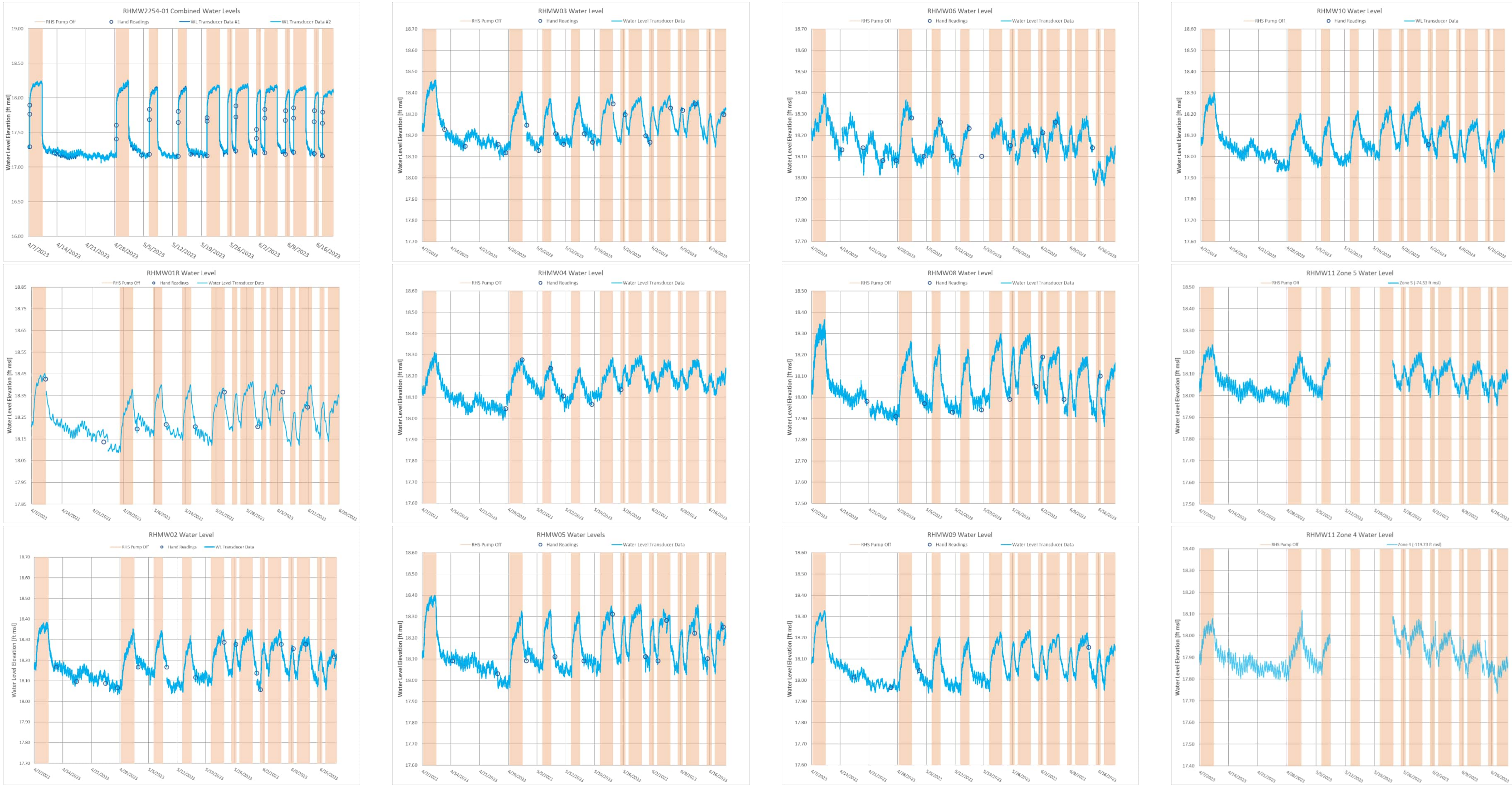


Figure 4-1a
Water Level Plots
(RHMW2254-01, RHMW01R, RHMW02, RHMW03,
RHMW04, RHMW05, RHMW06, RHMW08, RHMW09,
RHMW10, RHMW11 Zone 5 and RHMW11 Zone 4)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, Oʻahu, HI

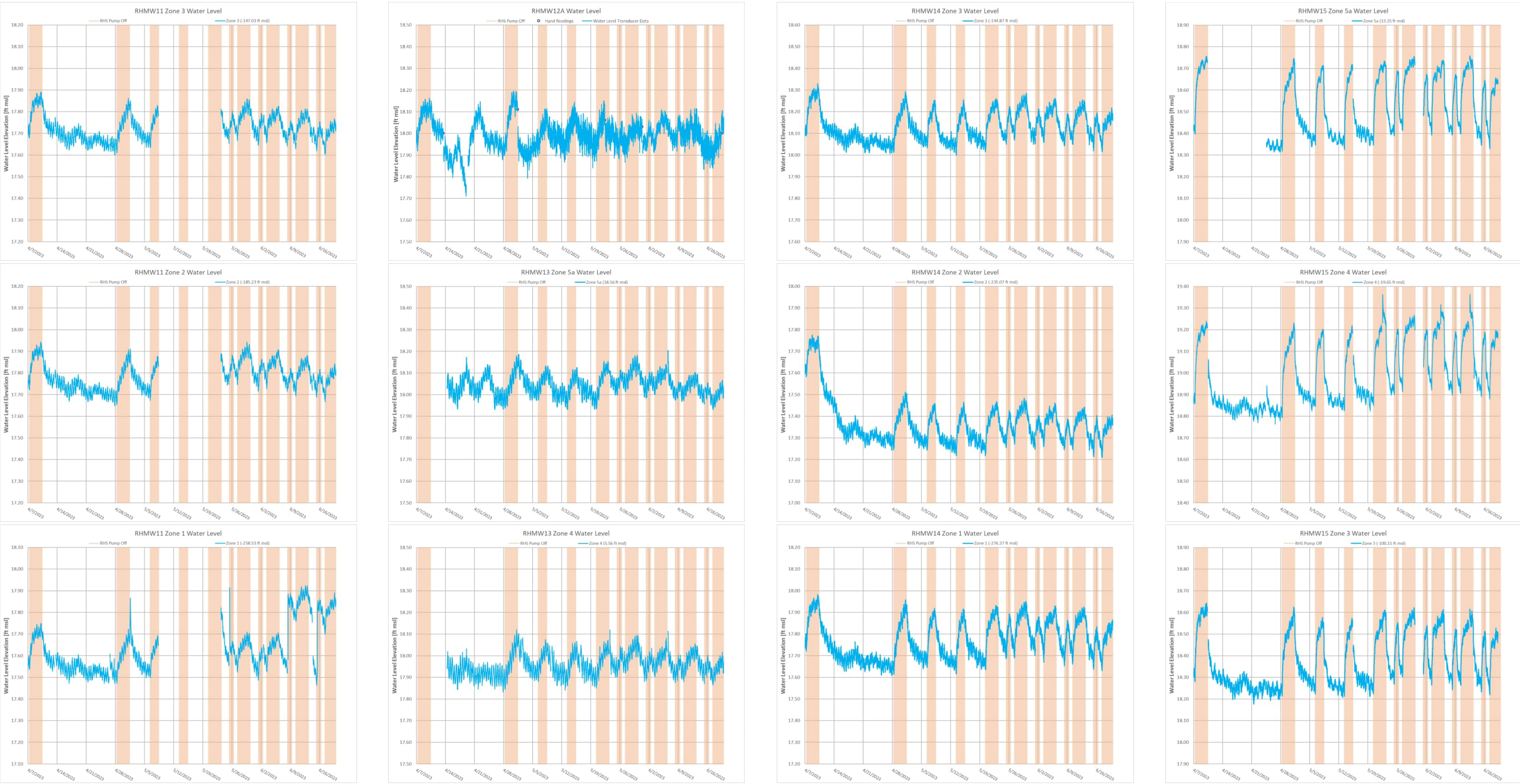


Figure 4-1b
Water Level Plots
(RHMW11 Zone 1, RHMW11 Zone 2, RHMW11 Zone 3,
RHMW12A, RHMW13 Zone 4, RHMW13 Zone 5a,
RHMW14 Zone 1, RHMW14 Zone 2, RHMW14 Zone3,
RHMW 15 Zone, 3, RHMW15 Zone 4, and RHMW15 Zone 5a)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

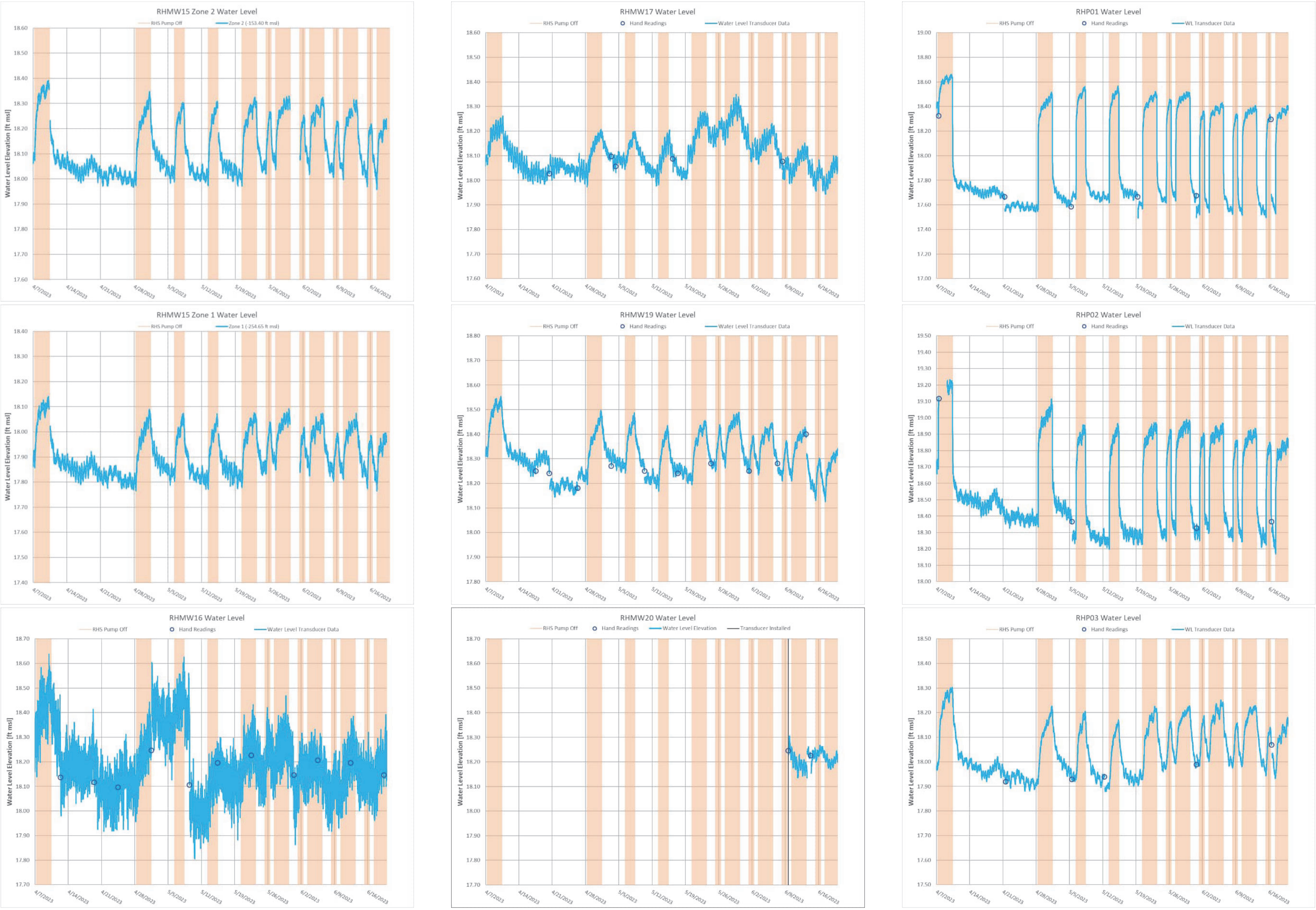
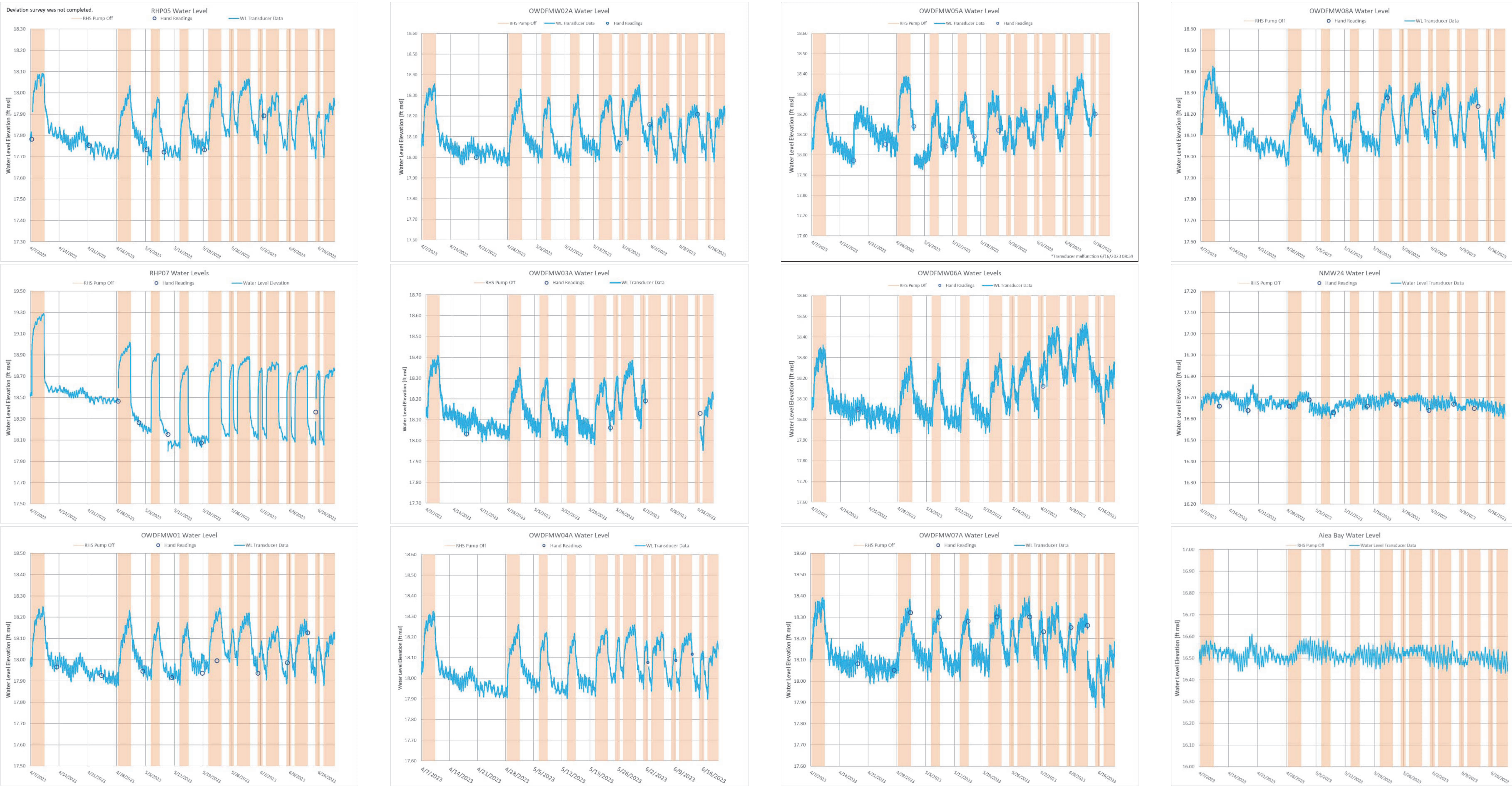


Figure 4-1c
Water Level Plots
(RHMW15 Zone 1, RHMW15 Zone 2, RHMW16, RHMW17,
RHMW19, RHMW 20, RHP01, RHP02, RHP03,
RHO04A, RHP04B and RHP40C)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI



Deviation survey was not completed.

*Transducer malfunction 6/16/2023 08:39

Figure 4-1d
Water Level Plots
(RHP05, RHP07, OWDFMW01, OWDFMW02A,
OWDFMW03A, OWDFMW04A, OWDFMW05A, OWDFMW06A,
OWDFMW07A, OWDFMW08A, NMW24, and Aiea Bay)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

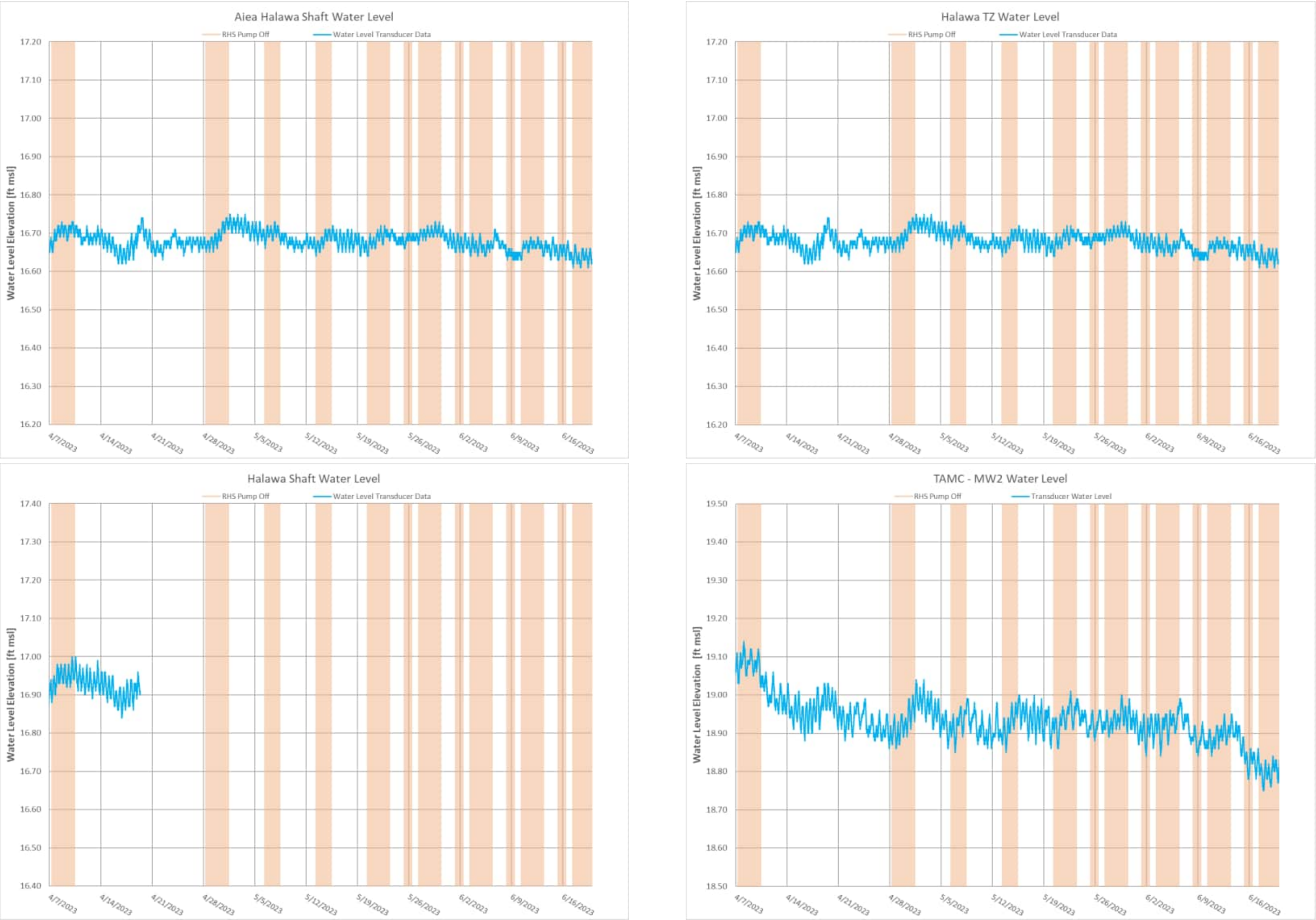


Figure 4-1e
Water Level Plots
(Aiea Halawa Shaft, Halawa T2,
Halawa Shaft and TAMC)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

Figure 4-2
Target Capture Zones
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu HI

(b) (3) (A)

[redacted]

Figure 4-3a
Water Level Contours - All Wells
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu HI

(b) (3) (A)

[redacted]

Figure 4-3b
Water Level Contours - All Wells, Zoomed Extent
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu HI

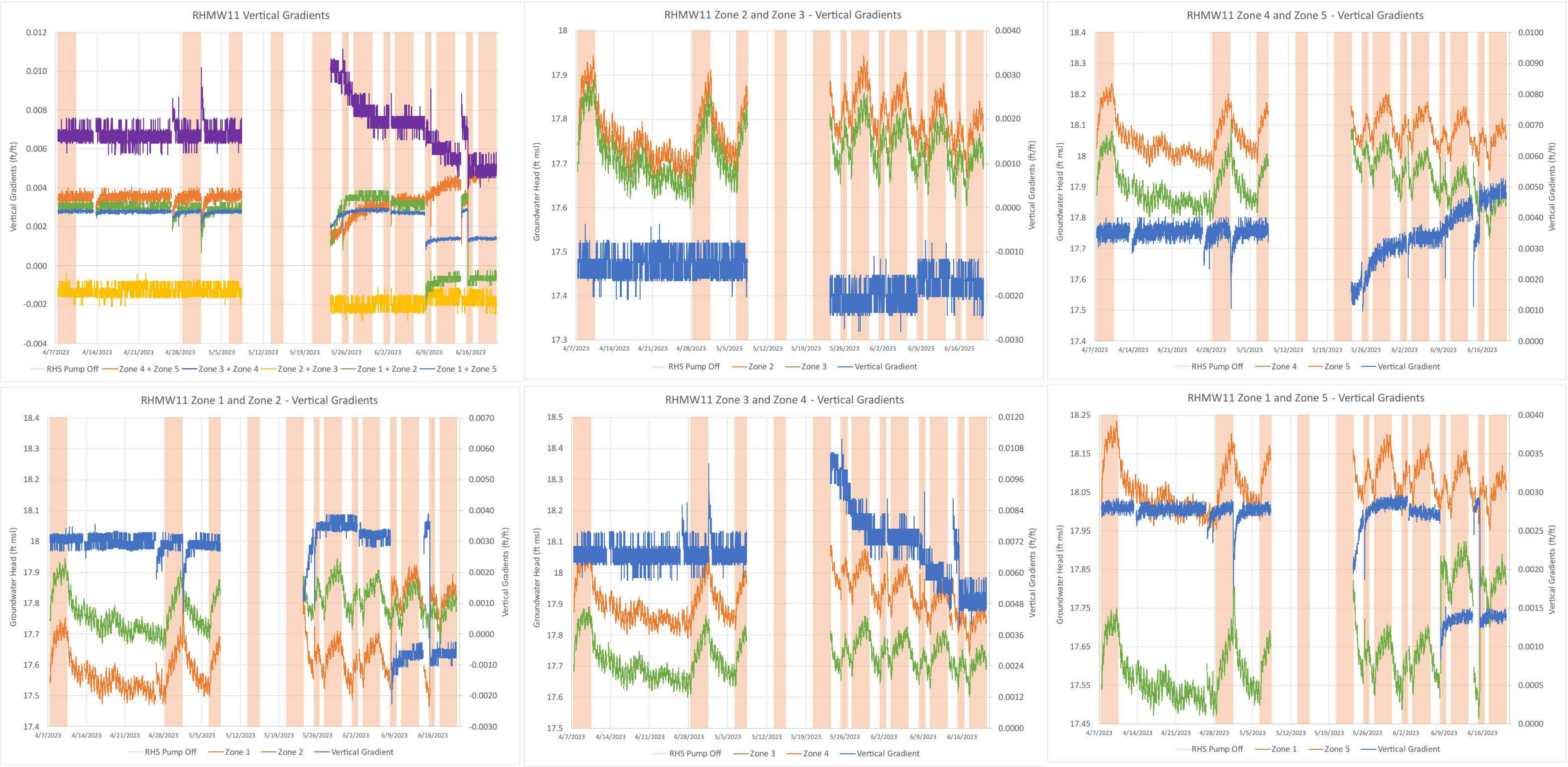


Figure 4-4a
Vertical Gradients RHMW11
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

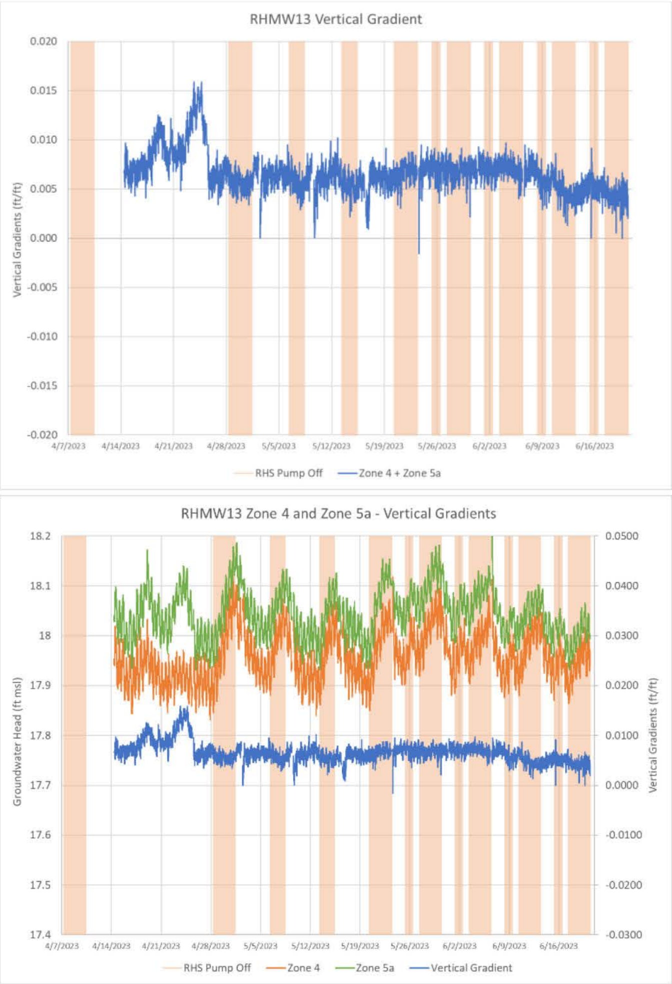


Figure 4-4b
Vertical Gradients RHMW13
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

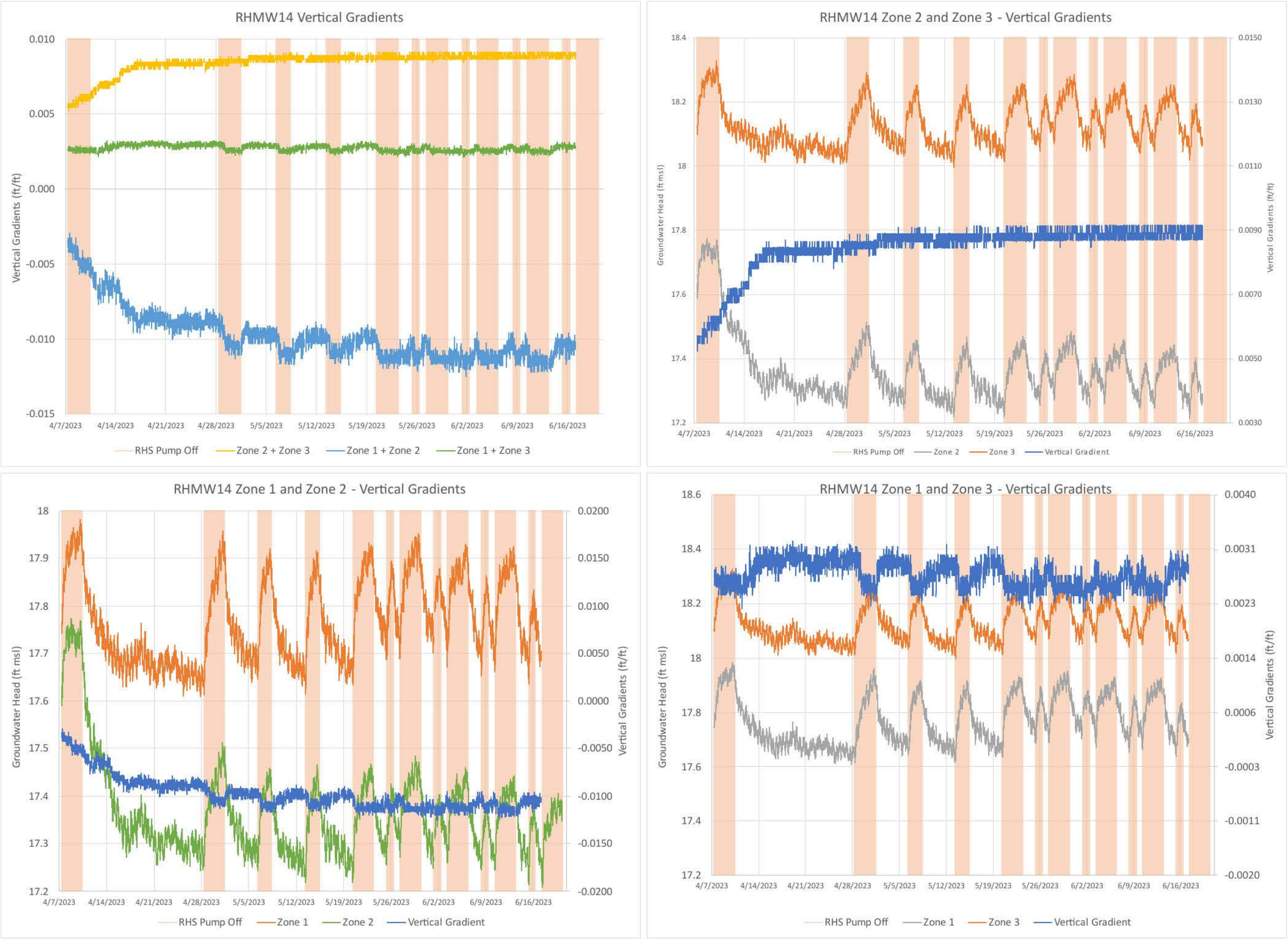
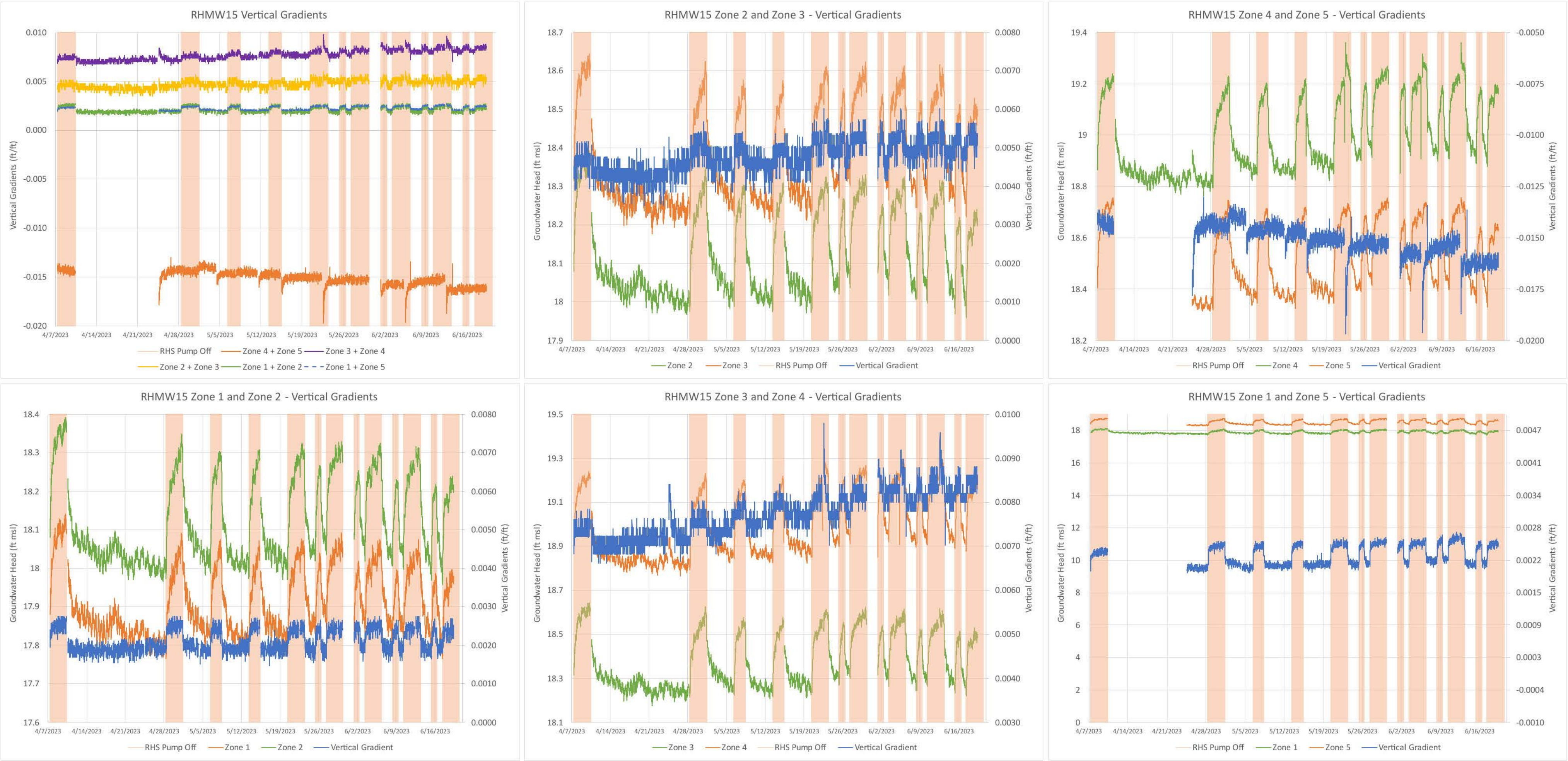


Figure 4-4c
Vertical Gradients RHMW14
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI



RHMW15 Vertical Gradients

RHMW15 Zone 2 and Zone 3 - Vertical Gradients

RHMW15 Zone 4 and Zone 5 - Vertical Gradients

RHMW15 Zone 1 and Zone 2 - Vertical Gradients

RHMW15 Zone 3 and Zone 4 - Vertical Gradients

RHMW15 Zone 1 and Zone 5 - Vertical Gradients

Figure 4-4d
Vertical Gradients RHMW15
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

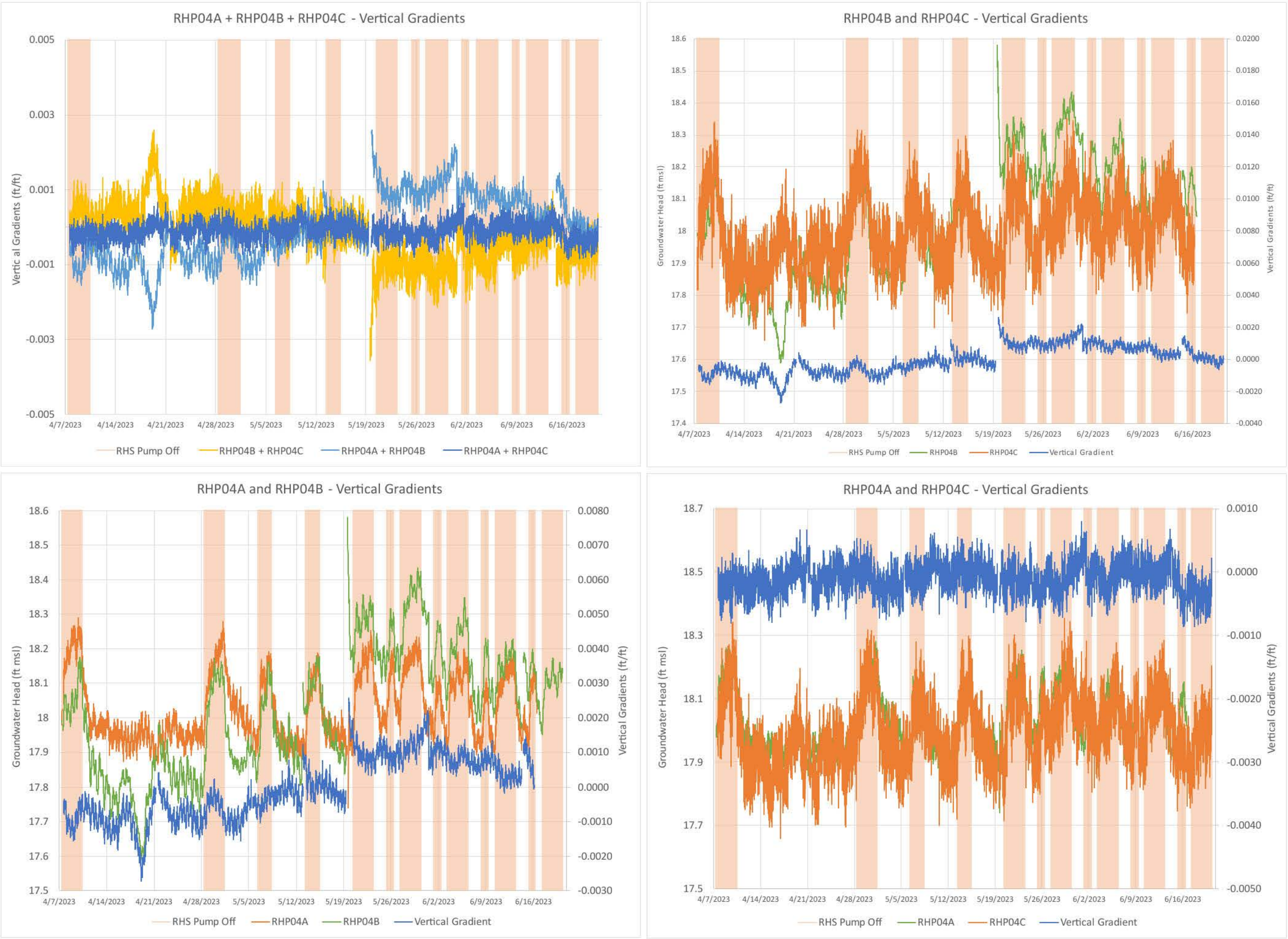
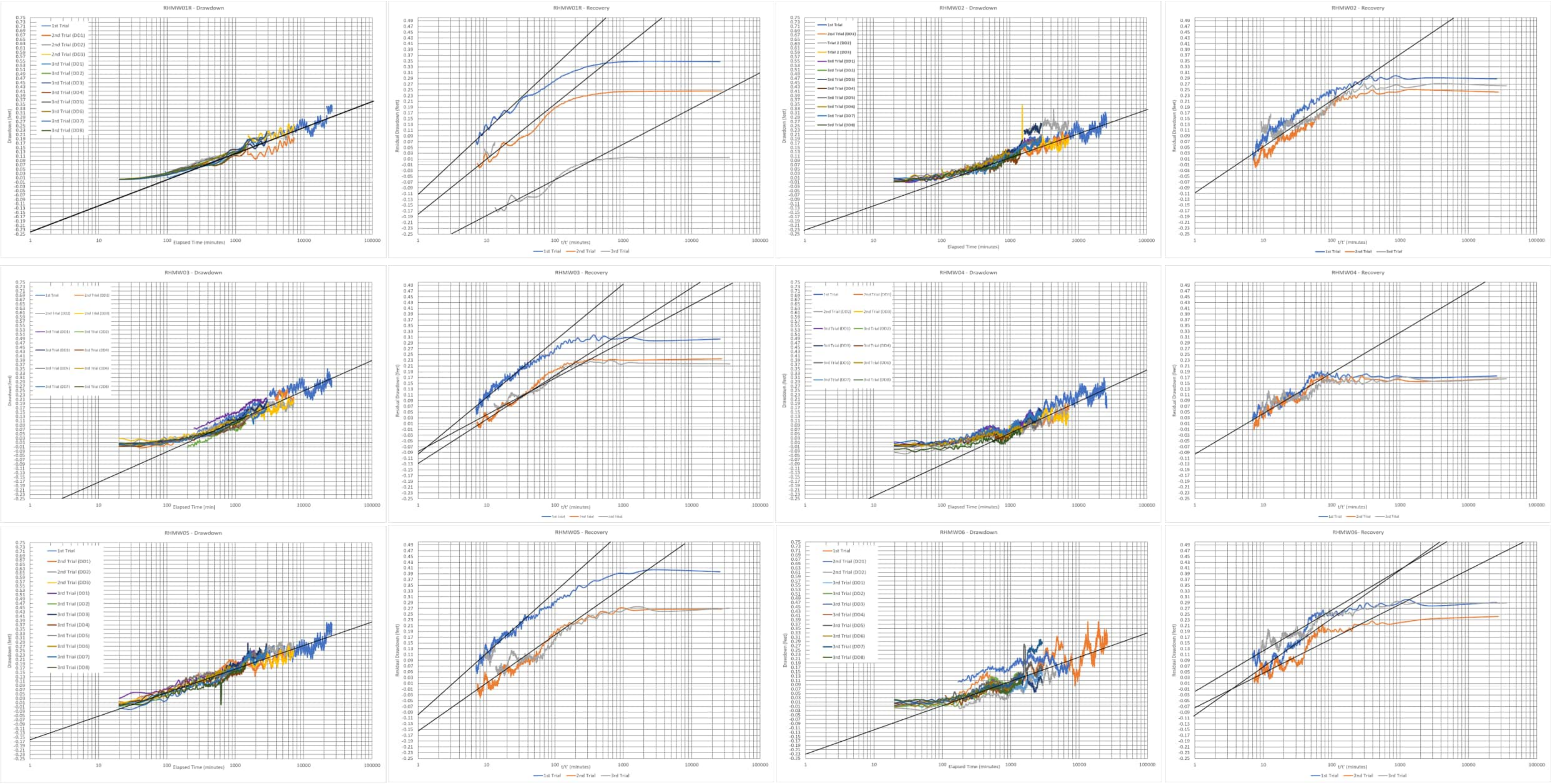


Figure 4-4e
Vertical Gradients RHP04
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI


RHMW01R - Drawdown

RHMW01R - Recovery

RHMW02 - Drawdown

RHMW02 - Recovery

RHMW03 - Drawdown

RHMW03 - Recovery

RHMW04 - Drawdown

RHMW04 - Recovery

RHMW05 - Drawdown

RHMW05 - Recovery

RHMW06 - Drawdown

RHMW06- Recovery

Figure 4-5a
Cooper-Jacob Drawdown and Recovery Plots
(RHMW01R, RHMW02, RHMW03, RHMW04, RHMW05, RHMW06)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

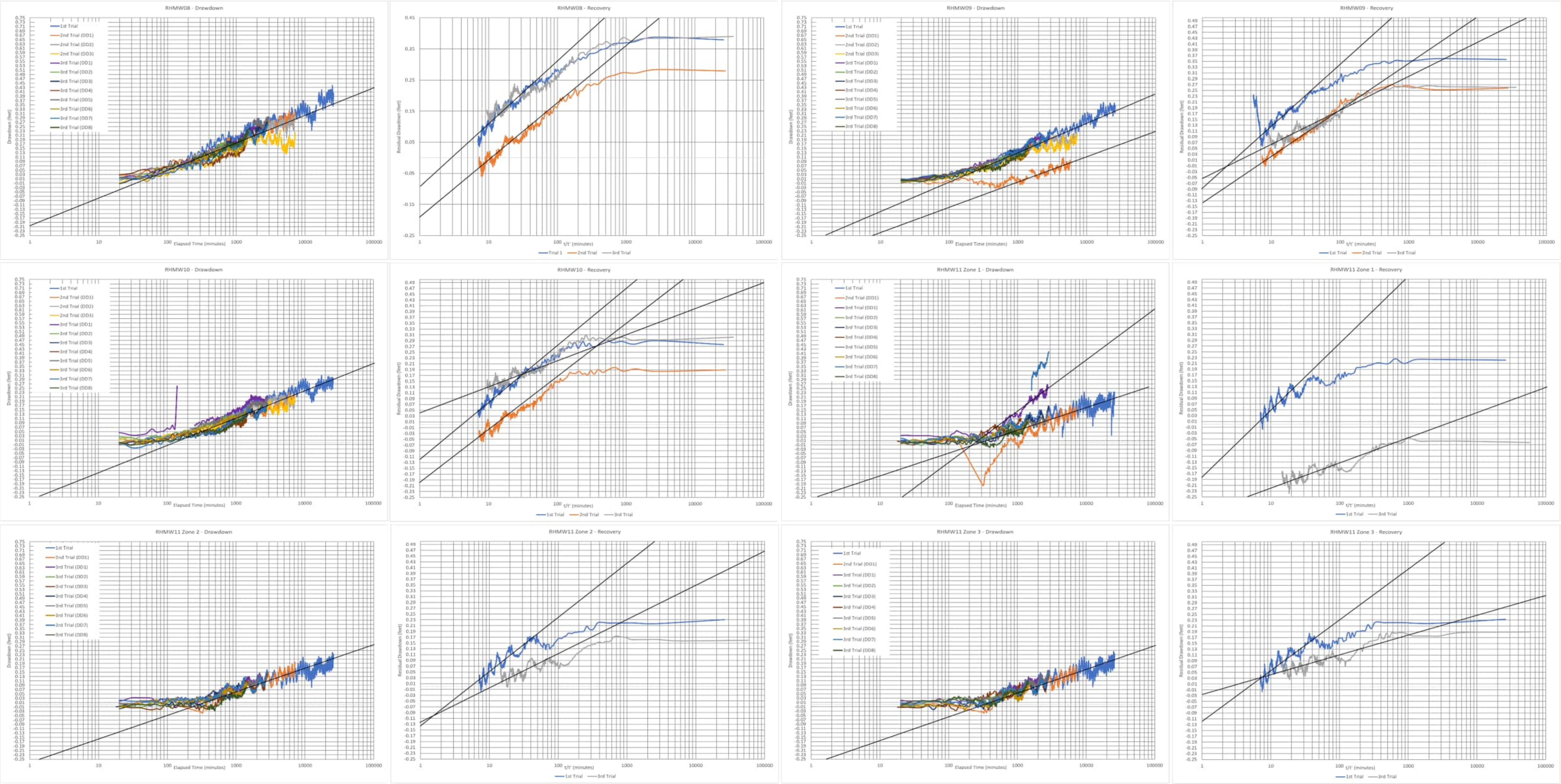


Figure 4-5b
Cooper-Jacob Drawdown and Recovery Plots
(RHMW08, RHMW09, RHMW10, RHMW11 Zone 1, RHMW11 Zone 2, RHMW11 Zone 3)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, Oʻahu, Hawaiʻi

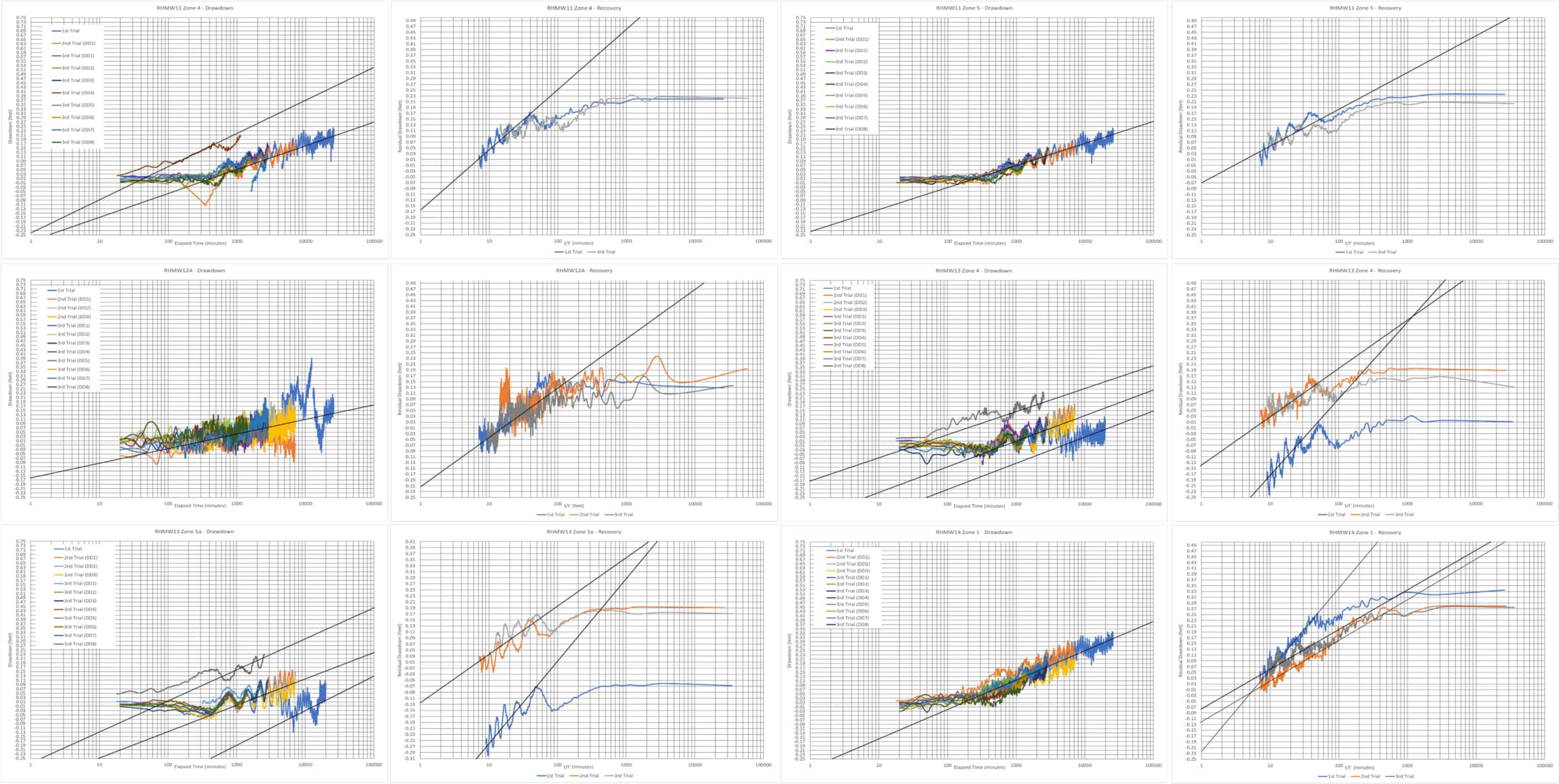


Figure 4-5c
Cooper-Jacob Drawdown and Recovery Plots
(RHMW11 Zone 4, RHMW11 Zone 5, RHMW12A, RHMW13 Zone 4, RHMW13 Zone 5a, RHMW14 Zone 1)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

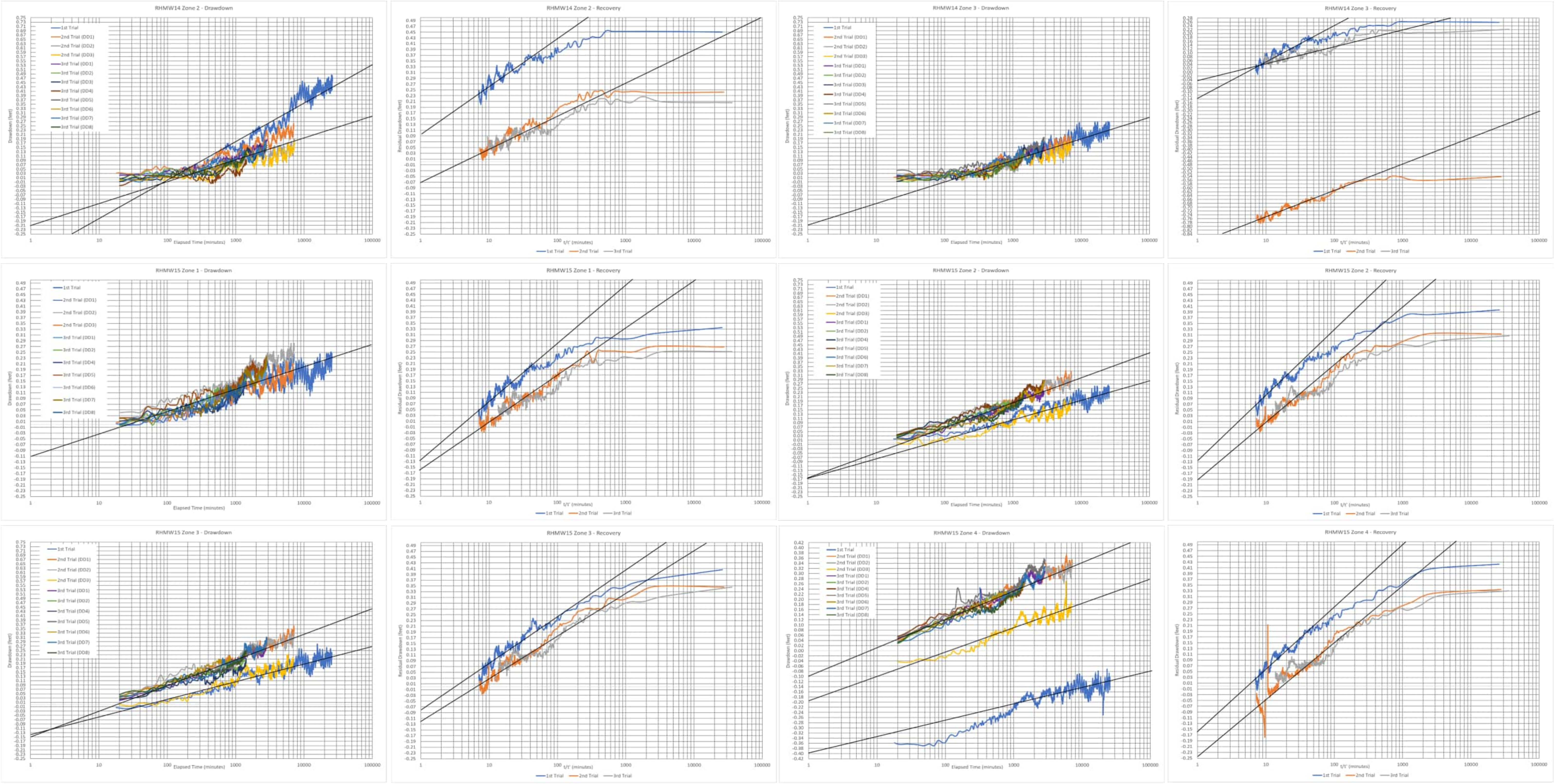


Figure 4-5d
Cooper-Jacob Drawdown and Recovery Plots
(RHMW14 Zone 2, RHMW14 Zone 3, RHMW15 Zone 1, RHMW15 Zone 2, RHMW15 Zone 3, RHMW15 Zone 4)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

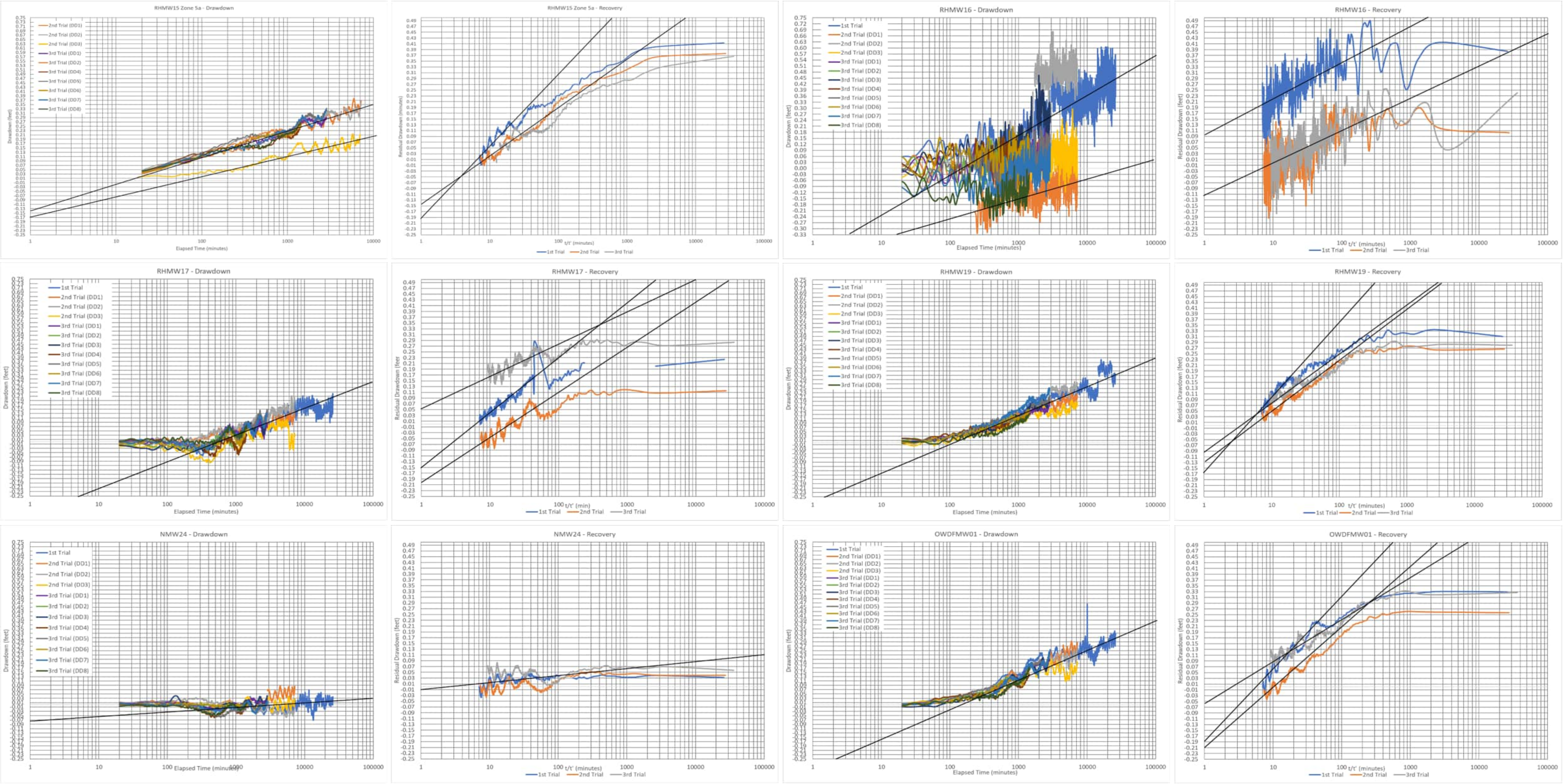


Figure 4-5e
Cooper-Jacob Drawdown and Recovery Plots
(RHMW15 Zone 4, RHMW16, RHMW17, RHMW19, NMW24, OWDFMW01)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

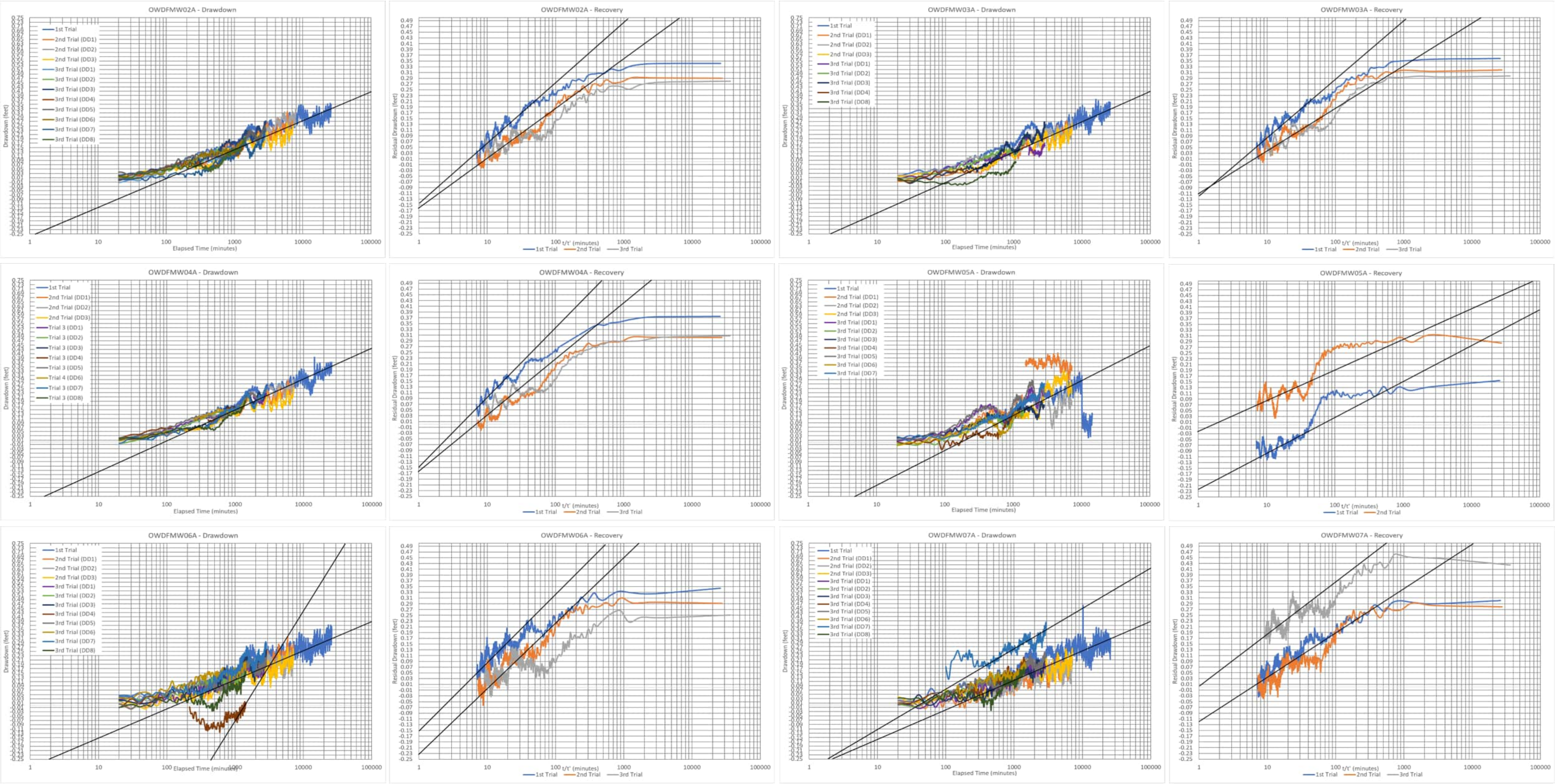


Figure 4-5f
Cooper-Jacob Drawdown and Recovery Plots
(OWDFMW02A, OWDFMW03A, OWDFMW04A, OWDFMW05A, OWDFMW06A, OWDFMW07A)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

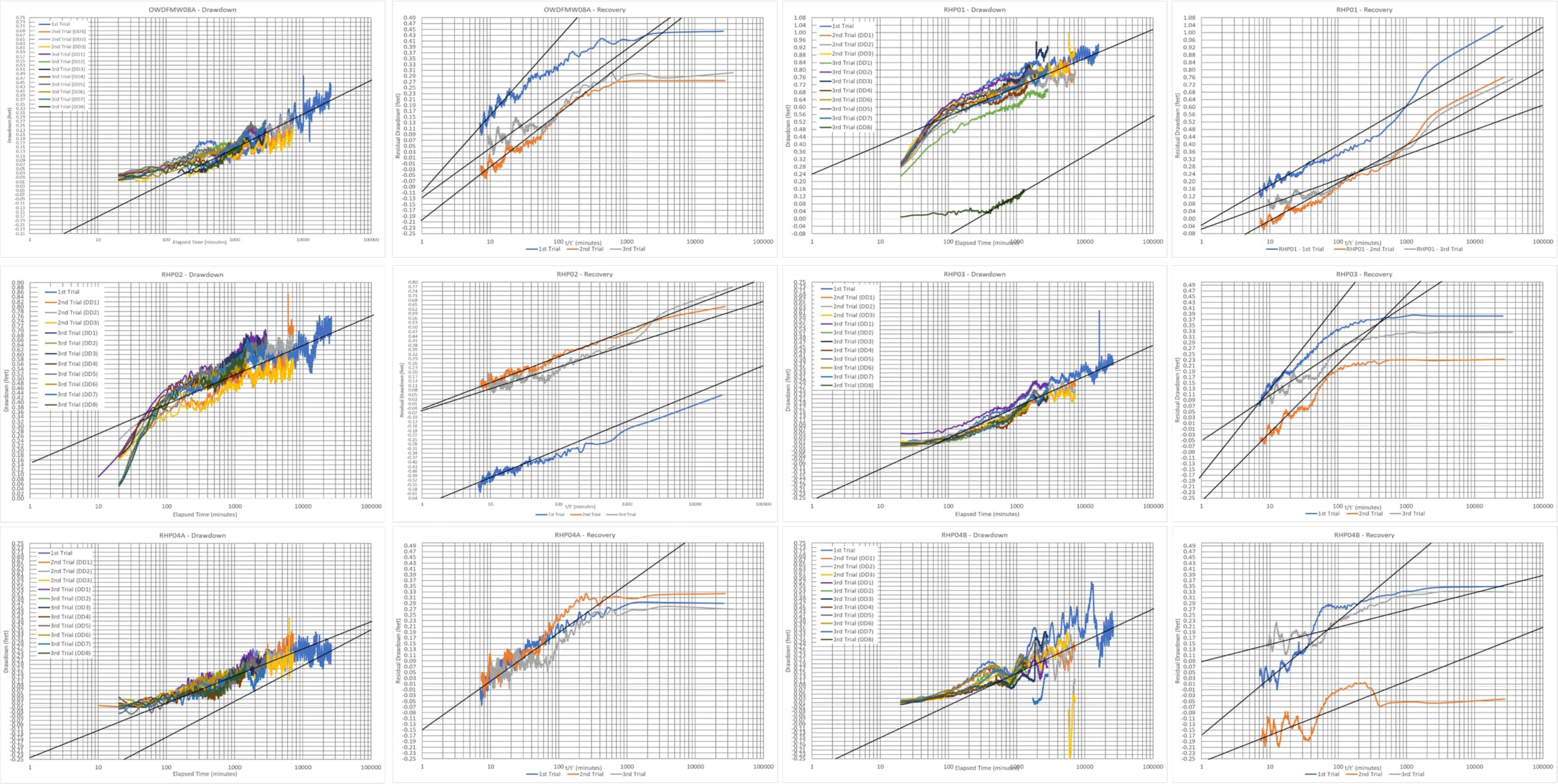


Figure 4-5g
Cooper-Jacob Drawdown and Recovery Plots
(OWDFMW08A, RHP01, RHP02, RHP03, RHP04A, RHP04B)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

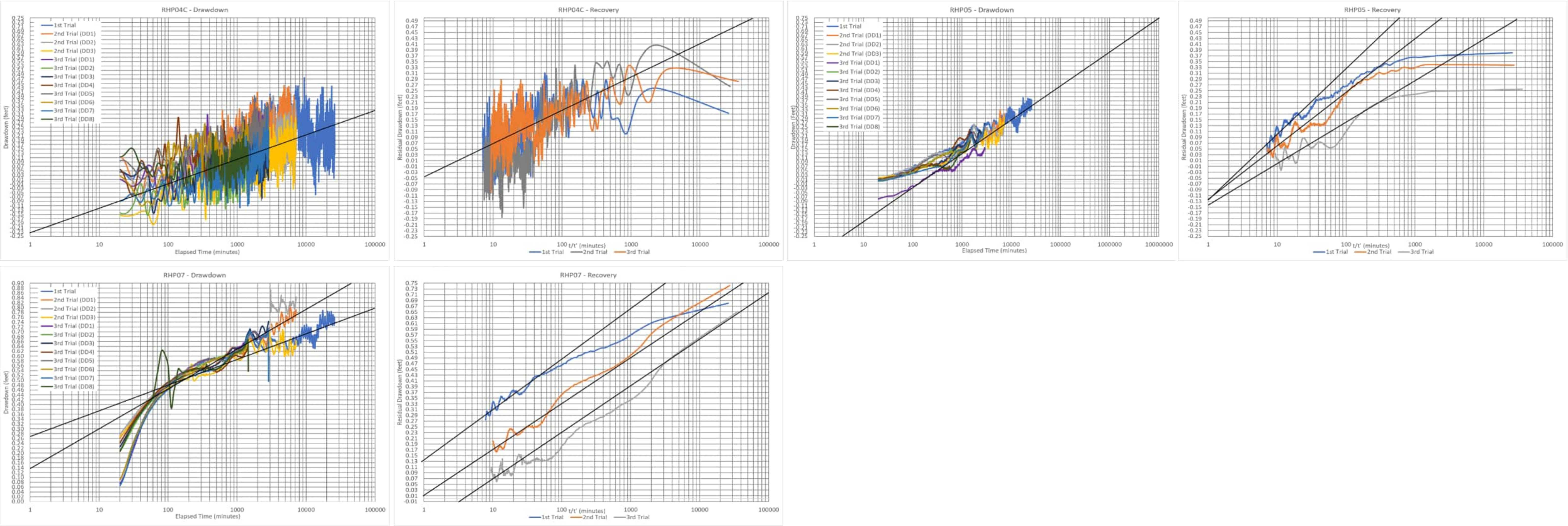


Figure 4-5h
Cooper-Jacob Drawdown and Recovery Plots
(RHP04C, RHP05, RHP07)
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

(b) (3) (A)

[redacted]

[redacted]

Figure 4-6
Hydraulic Conductivity Values Derived from
Cooper-Jacob Drawdown vs Time Analysis
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

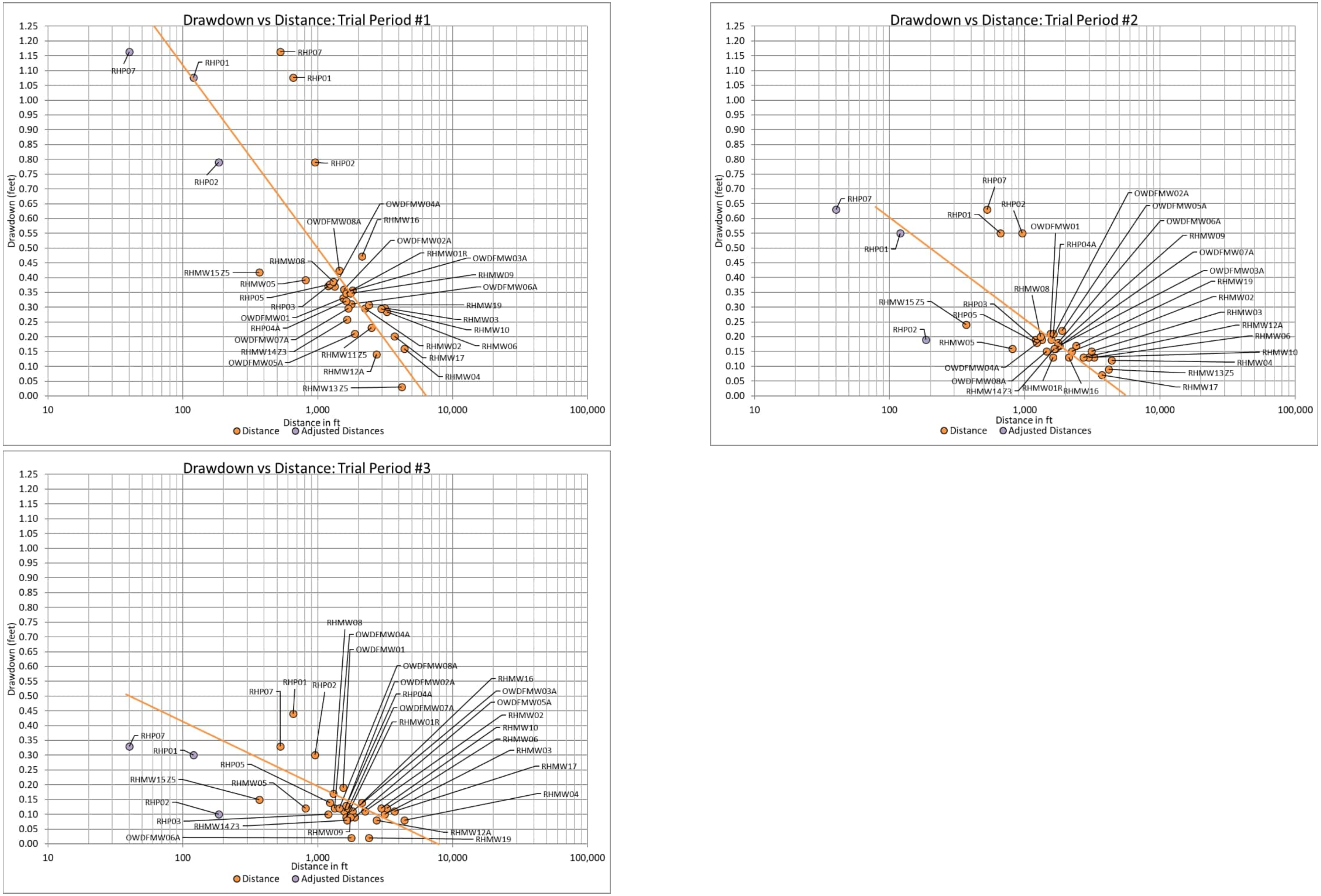


Figure 4-7
Cooper-Jacob Drawdown vs. Distance for Trial Period #1, for Trial Period #2, for Trial Period #3
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

[redacted]

Figure 4-8a
Drawdown Contours - All Wells
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu HI

(b) (3) (A)

[redacted]

[redacted]

Figure 4-8b
Drawdown Contours - All Wells, Zoomed Extent
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu HI

(b) (3) (A)

[redacted]

Figure 4-9
Ellipses of Equal Drawdown
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu HI

(b) (3) (A)

[redacted]

[redacted]

Figure 4-10
3-point Solutions
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

Figure 4-11a
GWD Particle Tracks:
246° Azimuth, 5.3 Anisotropy
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

Figure 4-11b
GWD Particle Tracks:
252° Azimuth, 10.4 Anisotropy
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

[redacted]

Figure 4-11c
GWD Particle Tracks:
246° Azimuth, 15 Anisotropy
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

Figure 4-12a
AnAqSIM Particle Tracks:
246° Azimuth, 5.3 Anisotropy
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

Figure 4-12b
AnAqSIM Particle Tracks:
252° Azimuth, 10.4 Anisotropy
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

[redacted]

Figure 4-13
Particle Tracks from the
"Best Available Model"
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

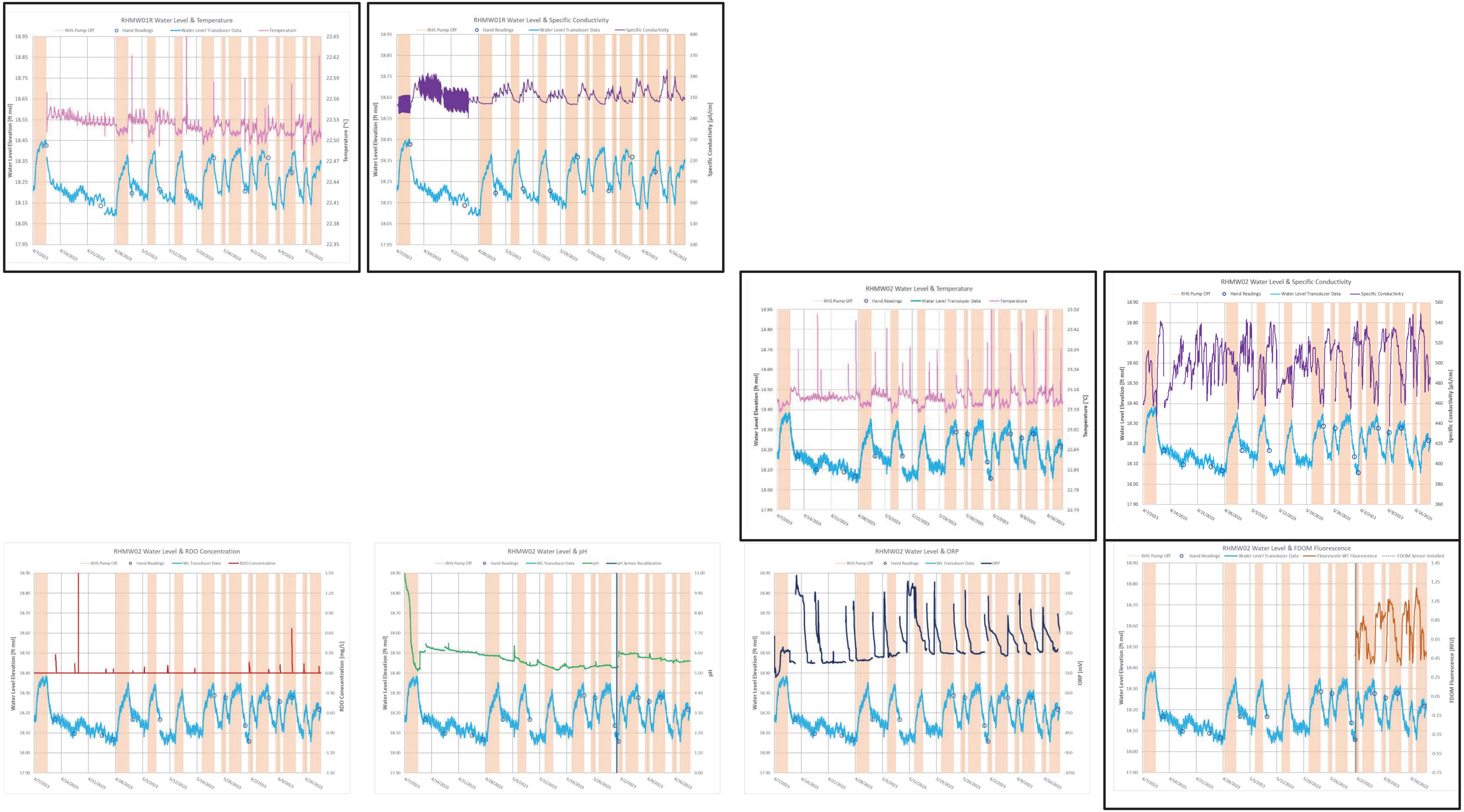


Figure 4-14a
Water Quality Parameters (RHMW01R and RHMW02)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

Legend

☐ Parameter responded to pumping

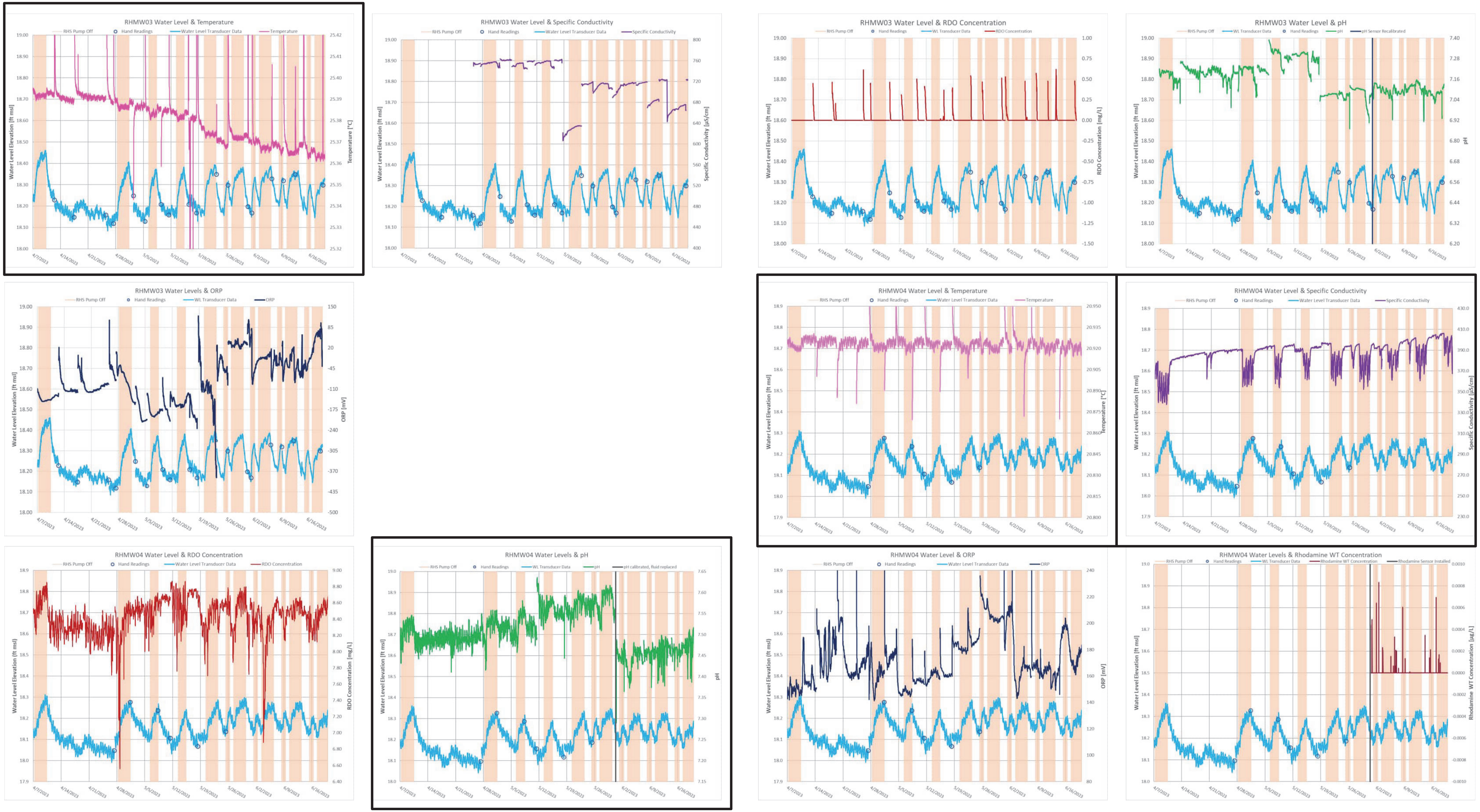


Figure 4-14b
Water Quality Parameters (RHMW03 and RHMW04)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

▭ Parameter responded to pumping

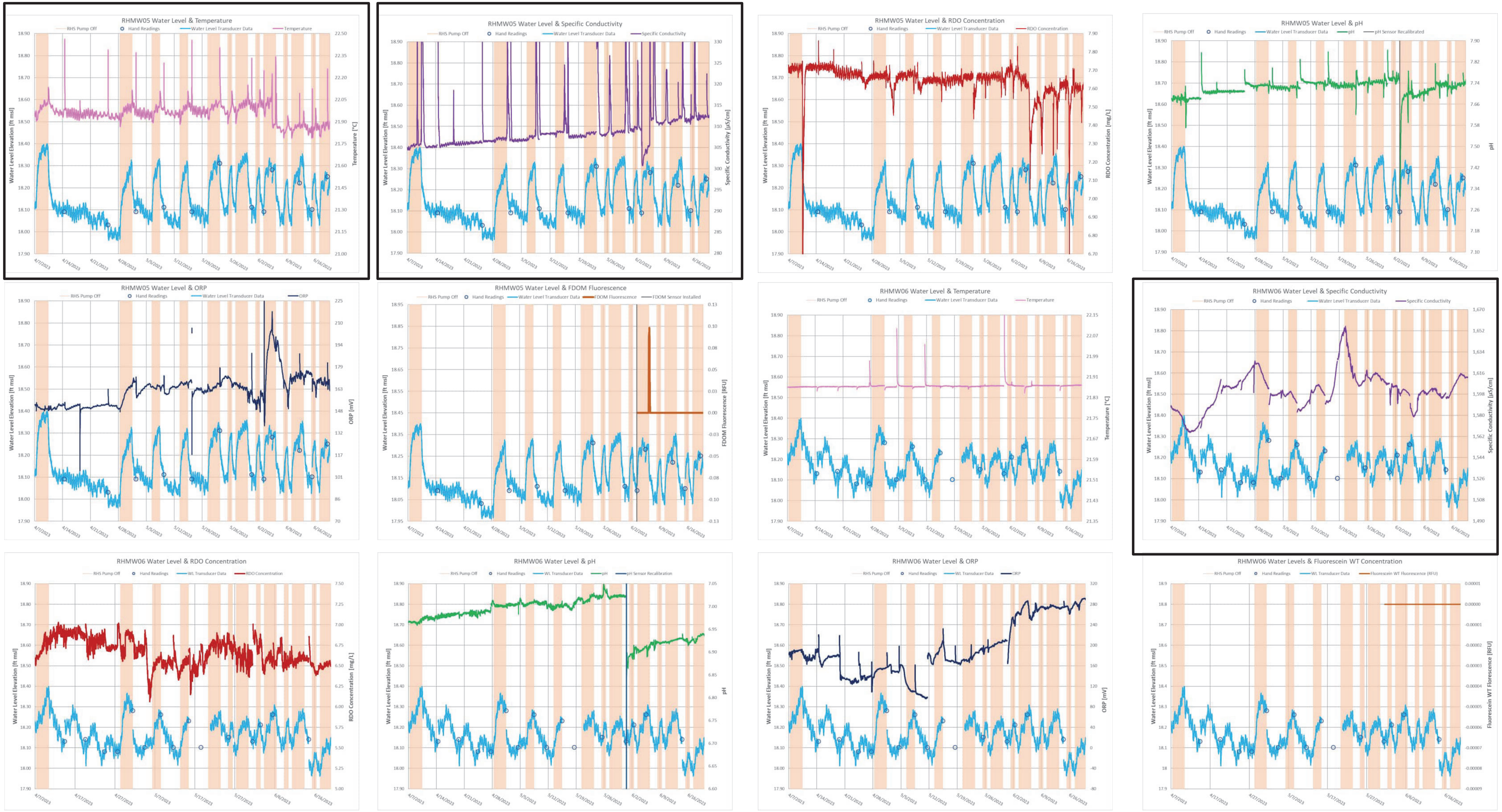


Figure 4-14c
Water Quality Parameters (RHMW05 and RHMW06)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

☐ Parameter responded to pumping

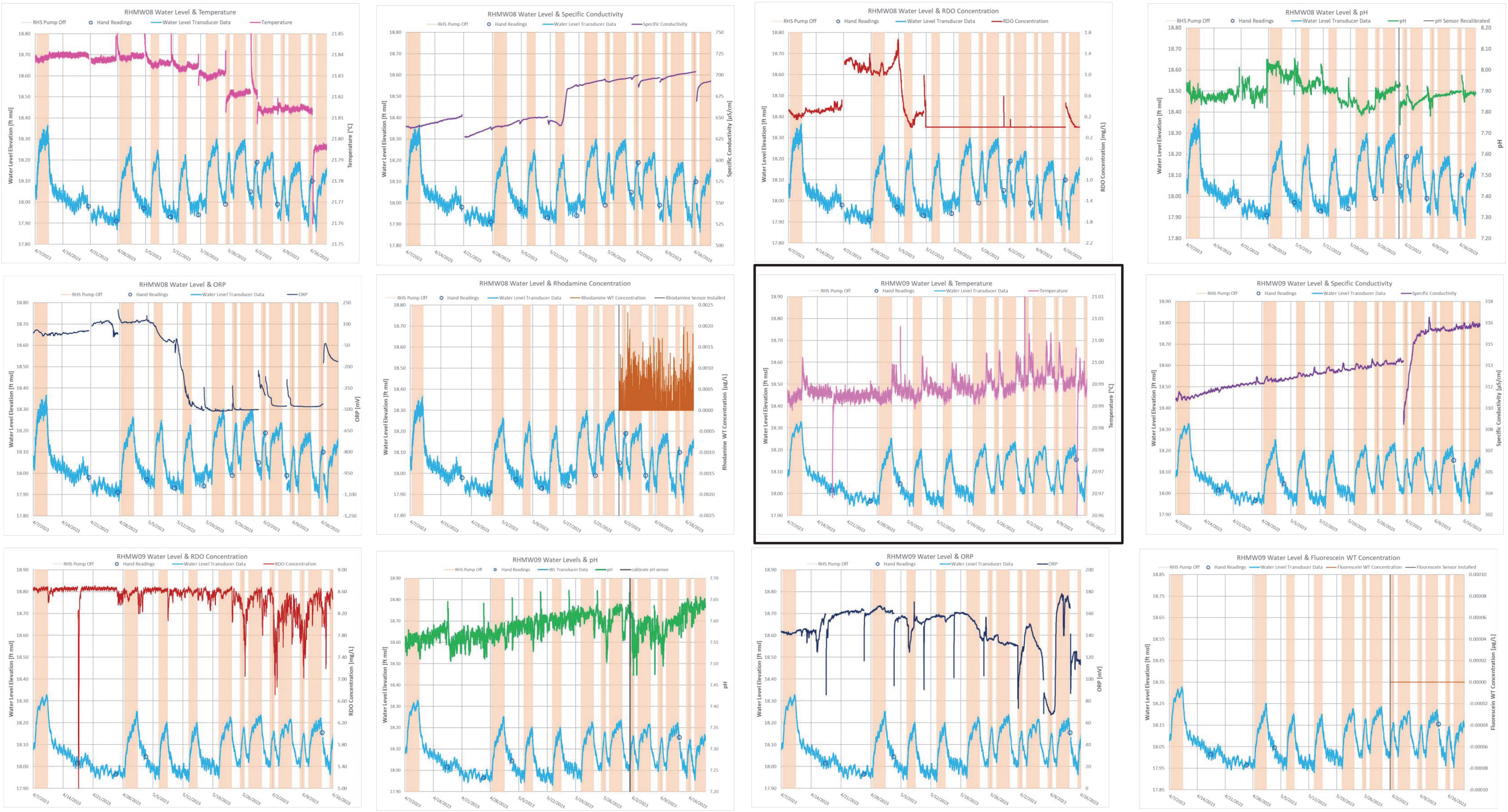


Figure 4-14d
Water Quality Parameters (RHMW08 and RHMW09)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

☐ Parameter responded to pumping

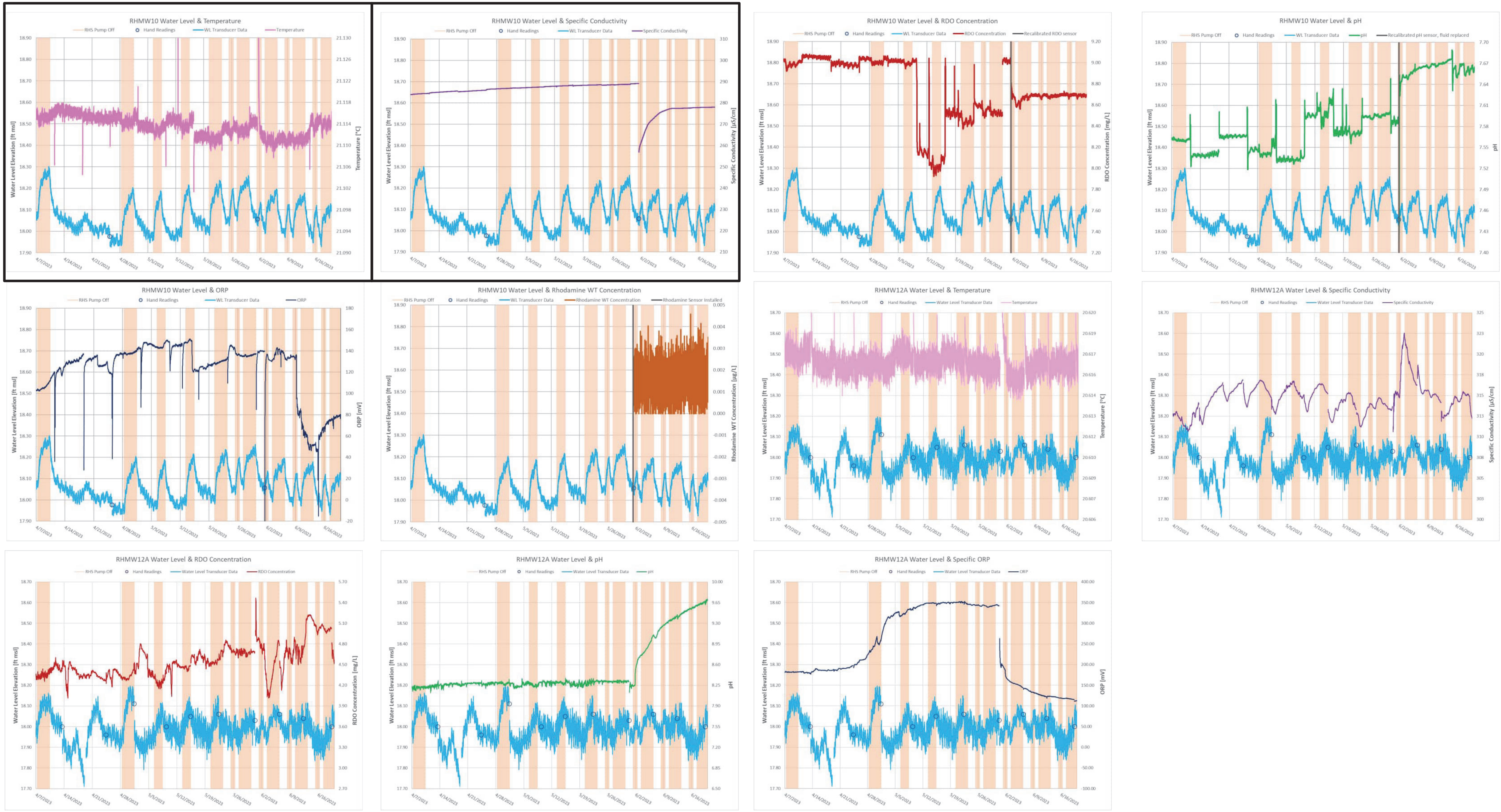


Figure 4-14e
Water Quality Parameters (RHMW10 and RHMW12A)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, Oʻahu, HI

Legend

▭ Parameter responded to pumping

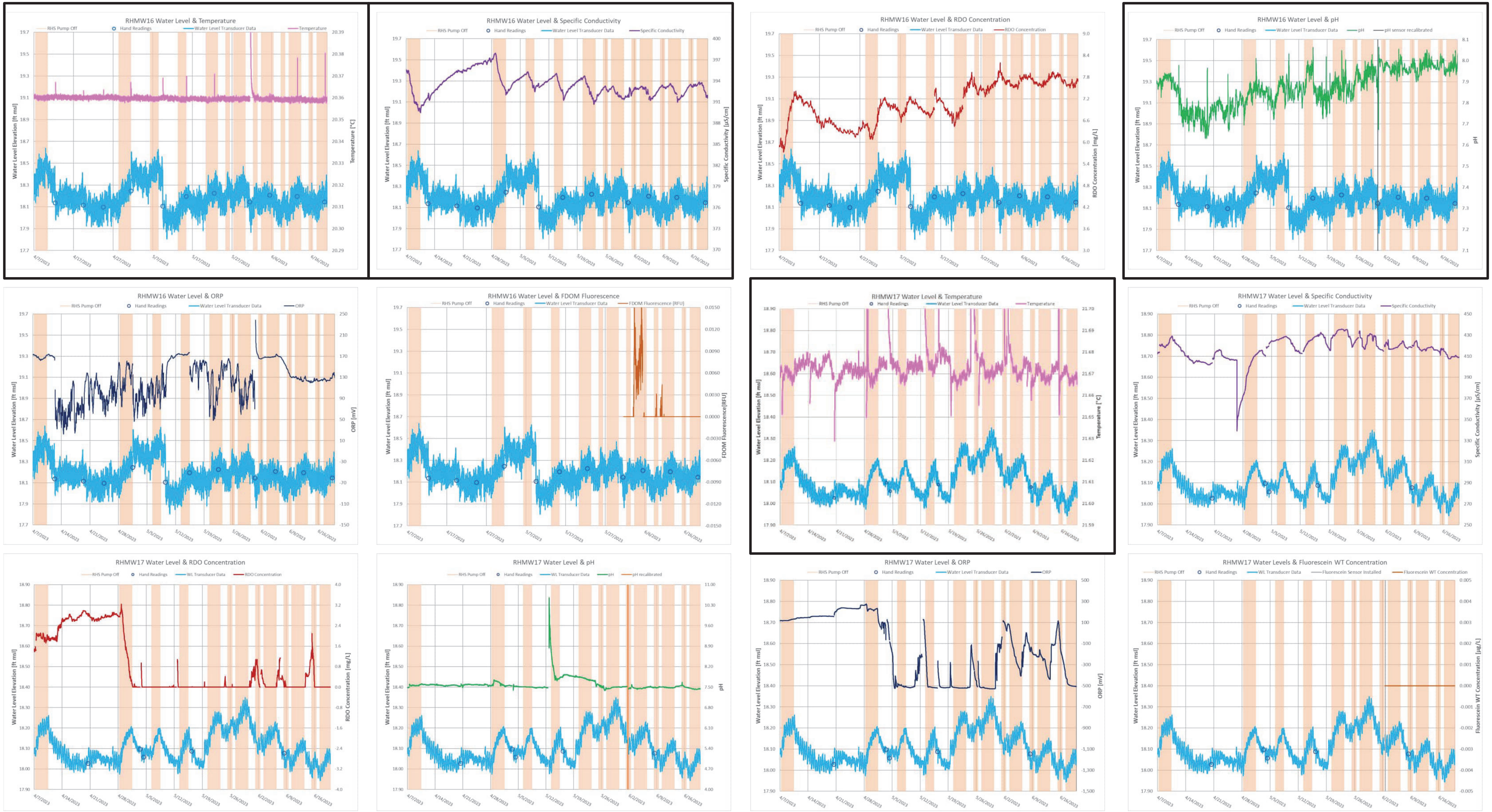


Figure 4-14f
Water Quality Parameters (RHMW16 and RHMW17)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

☐ Parameter responded to pumping

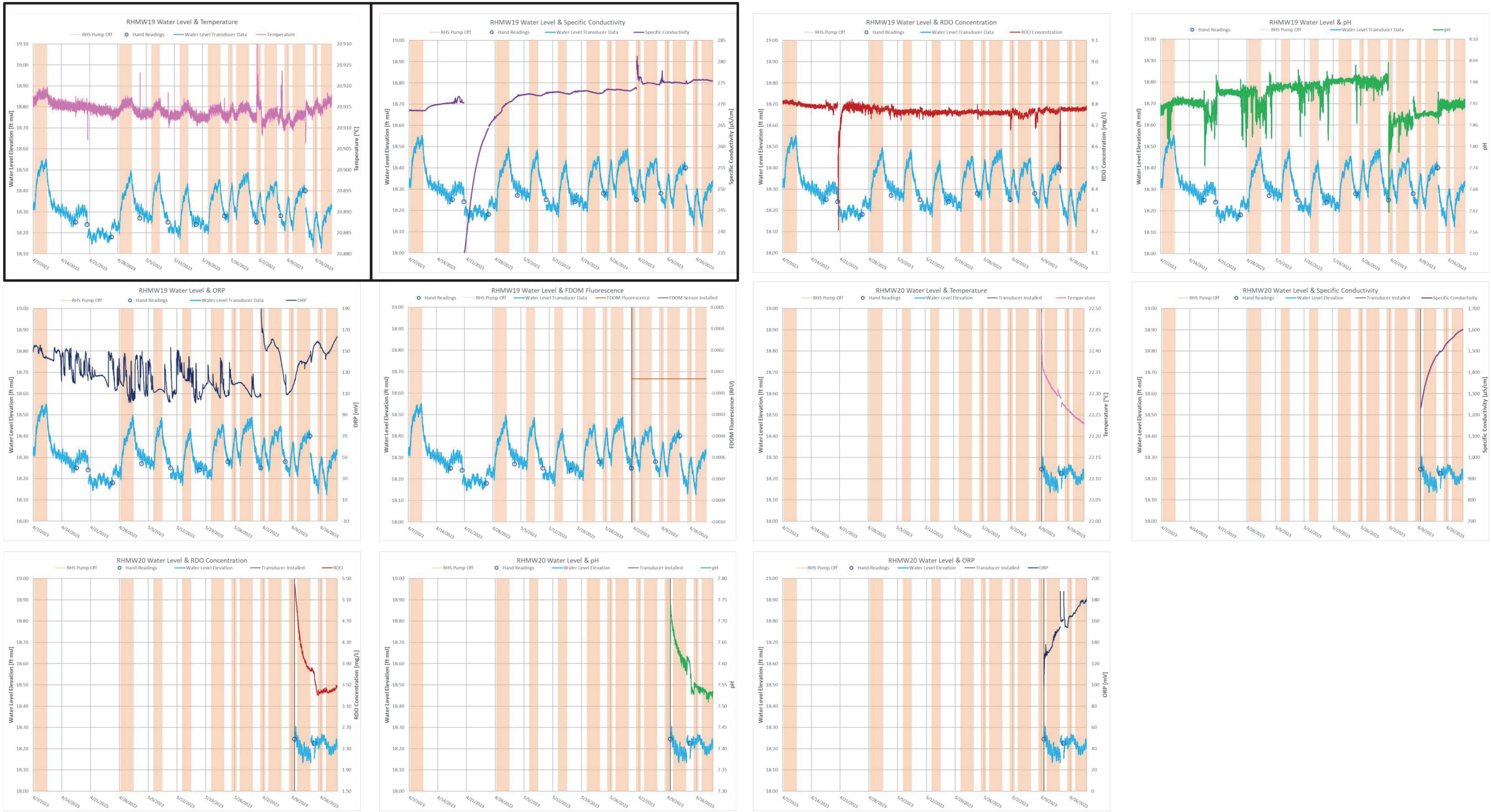


Figure 4-14g
Water Quality Parameters (RHMW19 and RHMW20)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

▭ Parameter responded to pumping

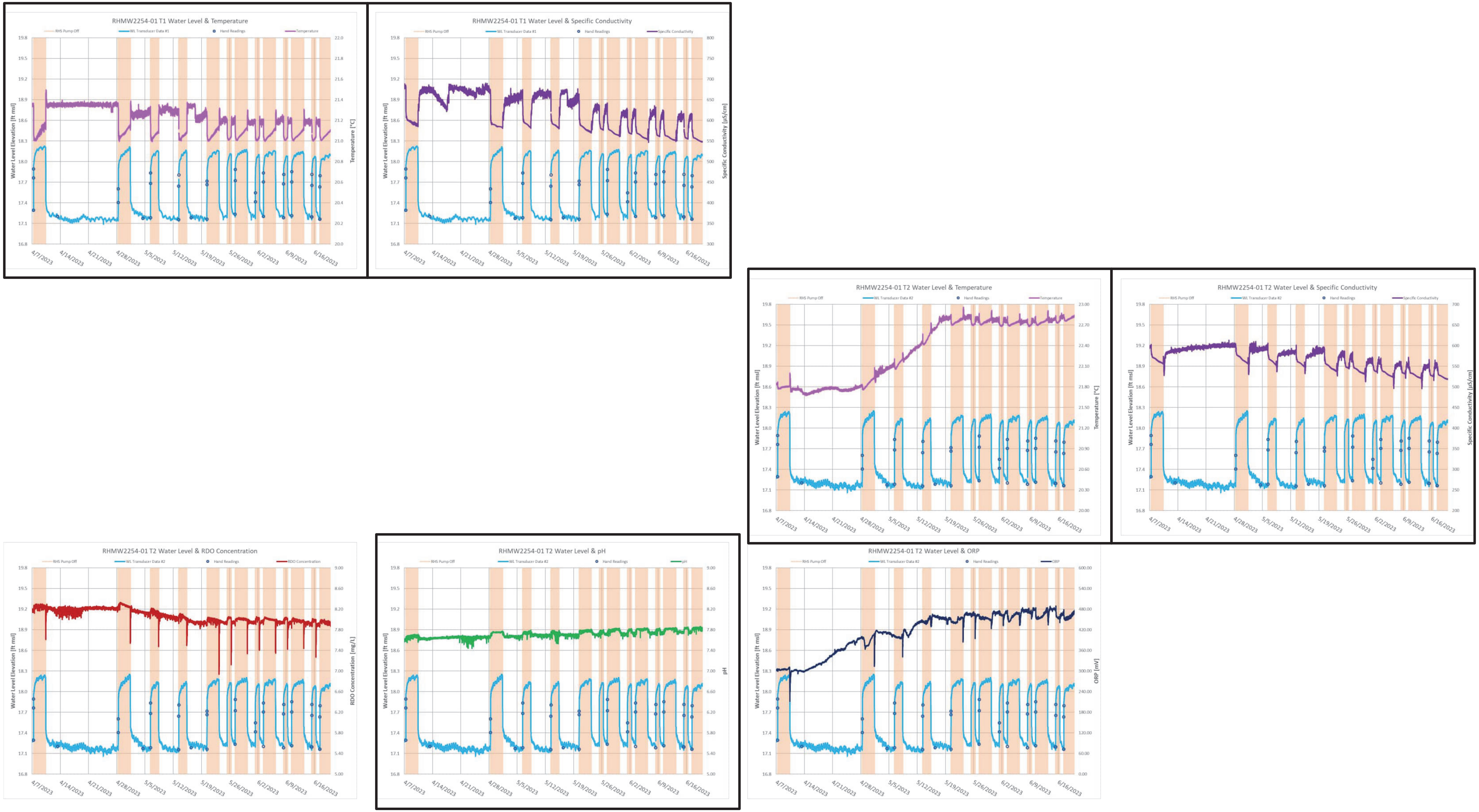


Figure 4-14h
Water Quality Parameters (RHMW2254-01 T1 and T2)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

▭ Parameter responded to pumping

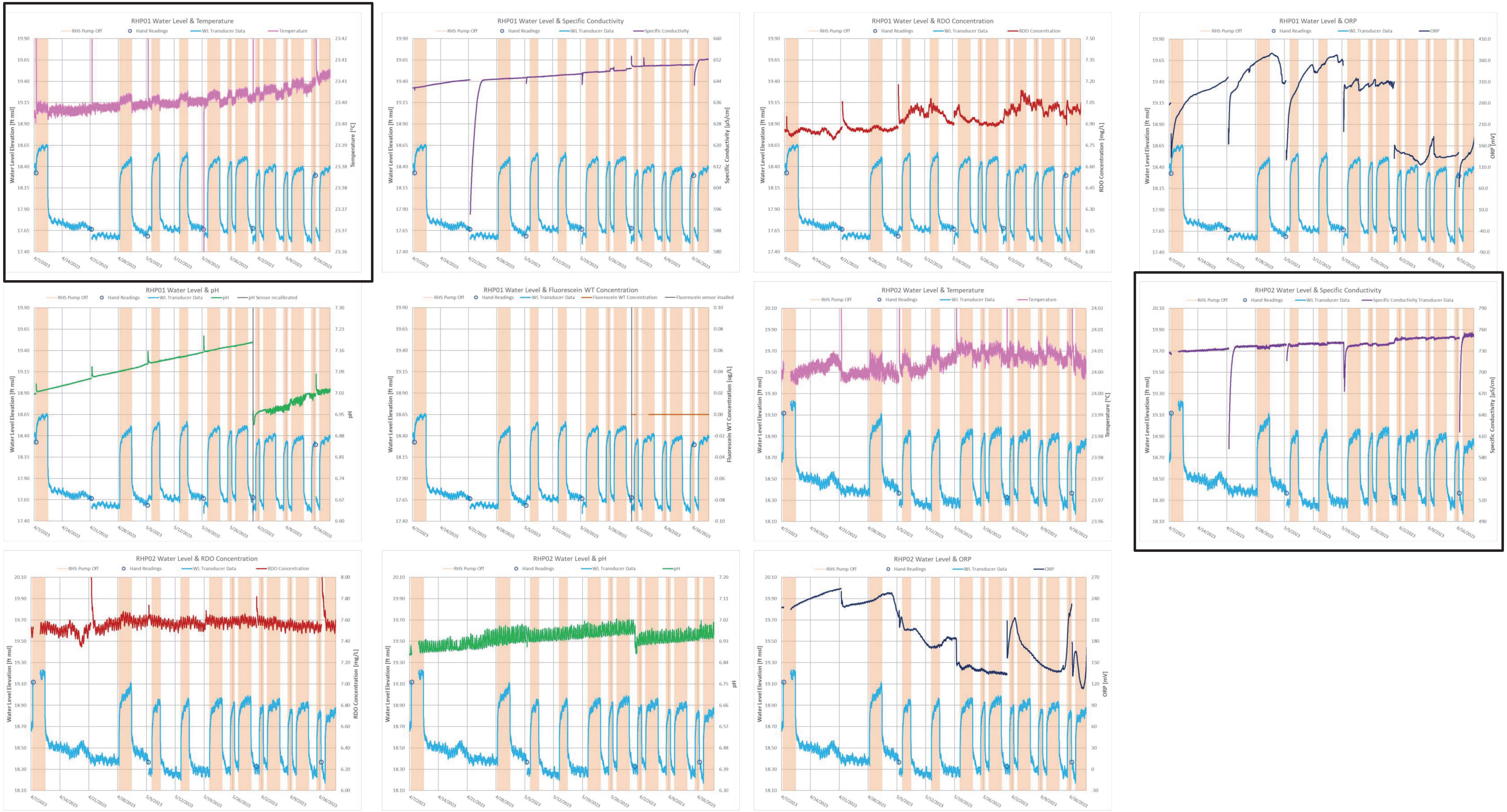
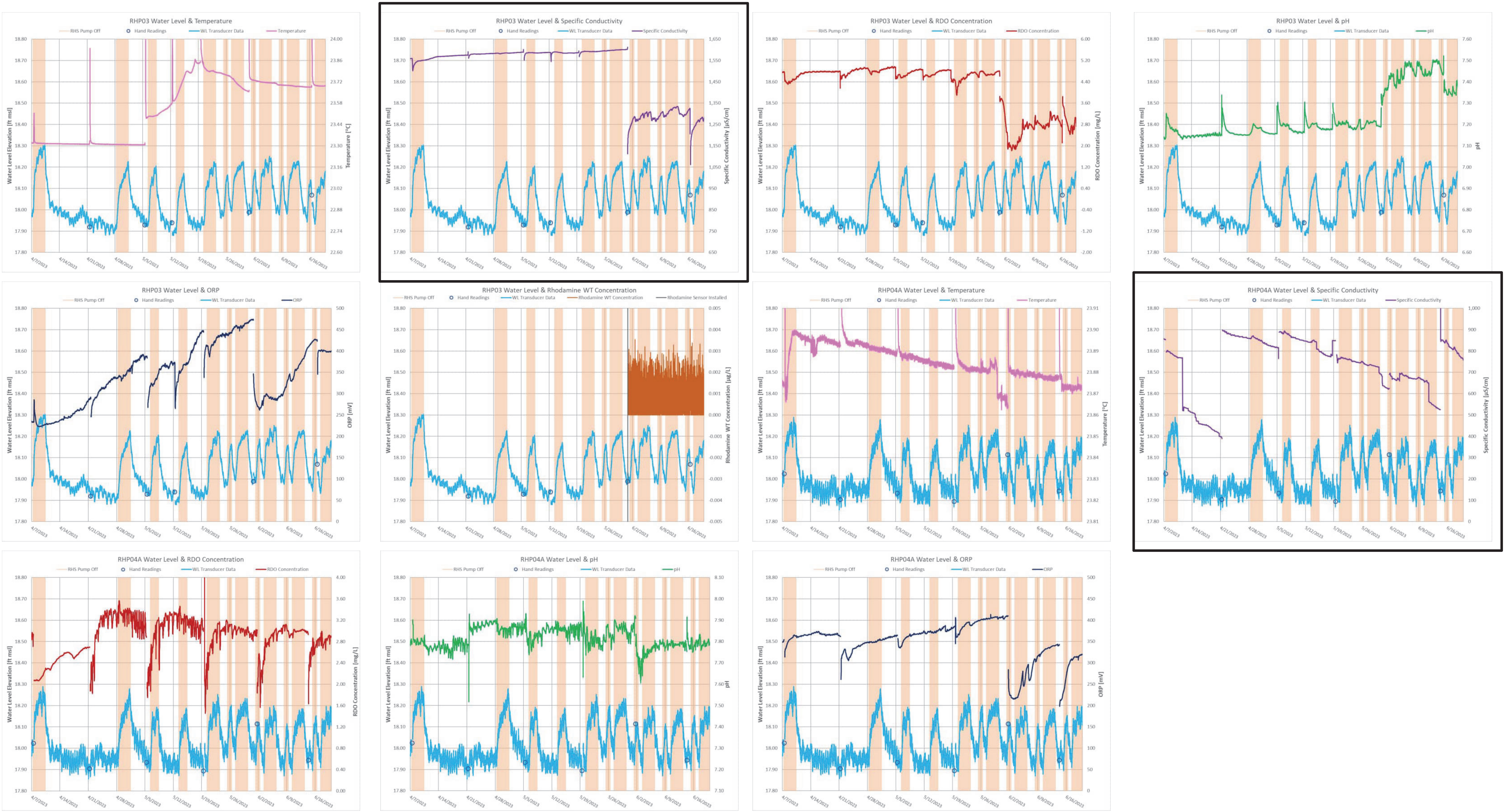


Figure 4-14i
Water Quality Parameters (RHP01 and RHP02)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

▭ Parameter responded to pumping



RHP03 Water Level & Temperature

RHP03 Water Level & Specific Conductivity

RHP03 Water Level & RDO Concentration

RHP03 Water Level & pH

RHP03 Water Level & ORP

RHP03 Water Level & Rhodamine WT Concentration

RHP04A Water Level & Temperature

RHP04A Water Level & Specific Conductivity

RHP04A Water Level & RDO Concentration

RHP04A Water Level & pH

RHP04A Water Level & ORP

Figure 4-14j
Water Quality Parameters (RHP03 and RHP04A)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

☐ Parameter responded to pumping

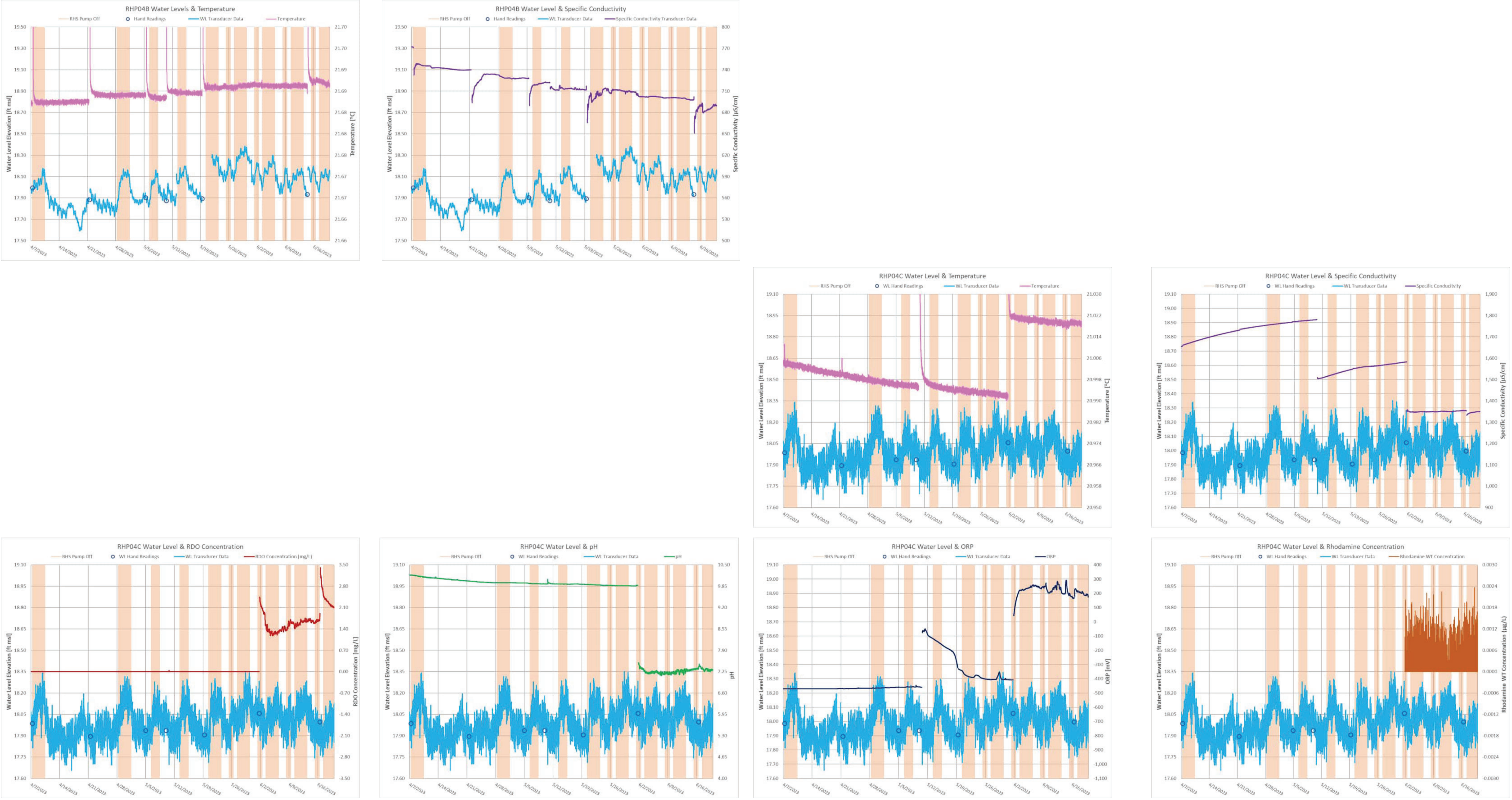


Figure 4-14k
Water Quality Parameters (RHP04B and RHP04C)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

▭ Parameter responded to pumping

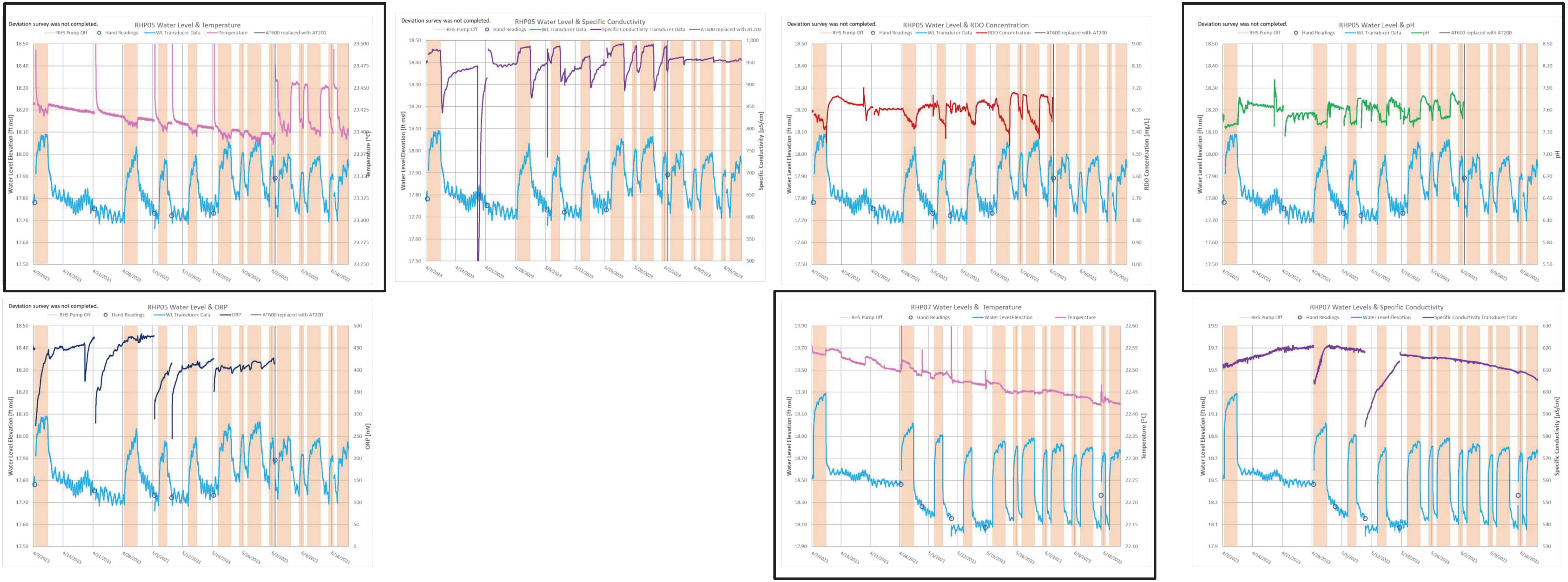


Figure 4-14I
Water Quality Parameters (RHP05 and RHP07)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

☐ Parameter responded to pumping

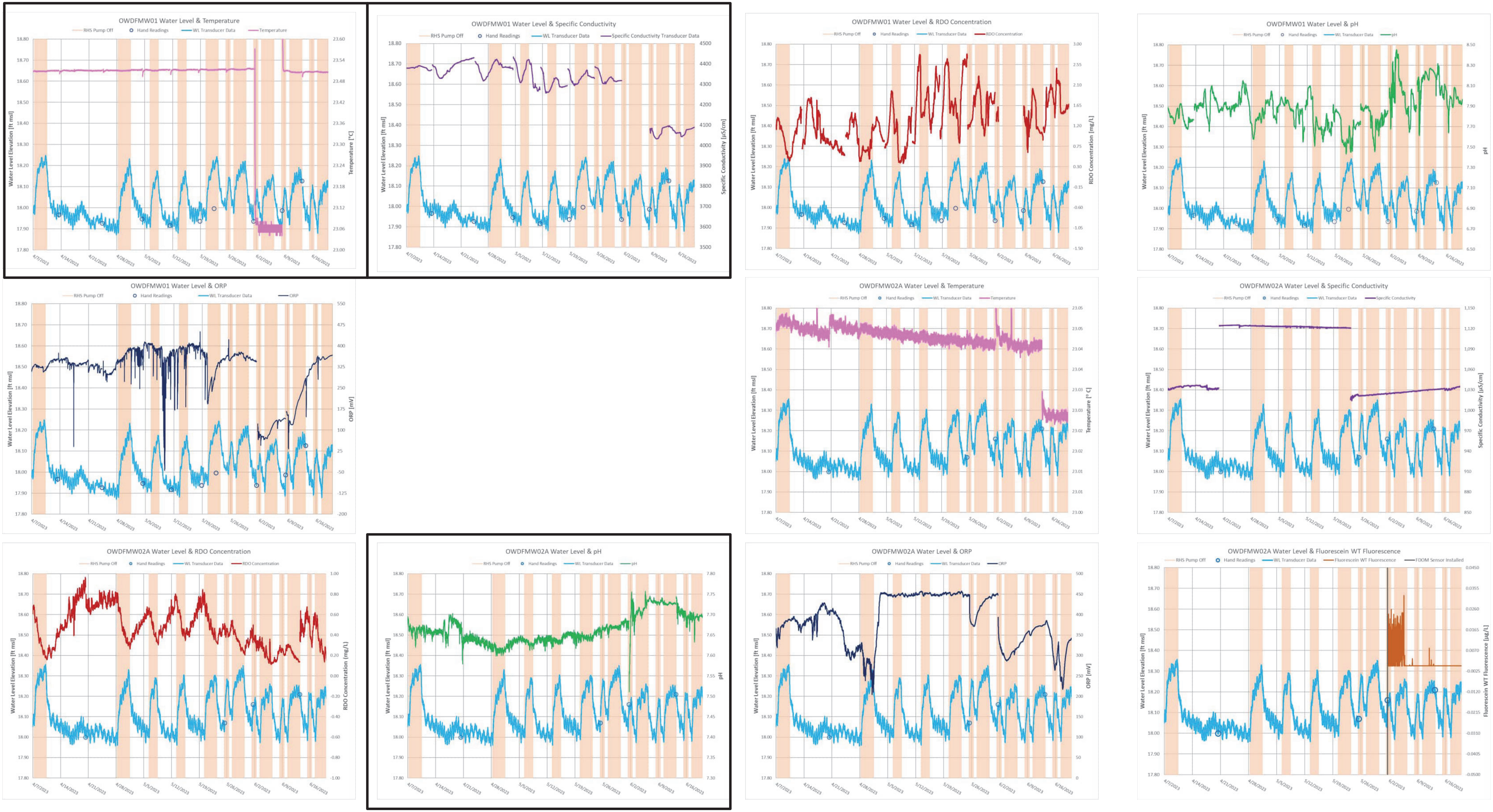


Figure 4-14m
Water Quality Parameters (OWDFMW01 and OWDFMW02A)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

☐ Parameter responded to pumping

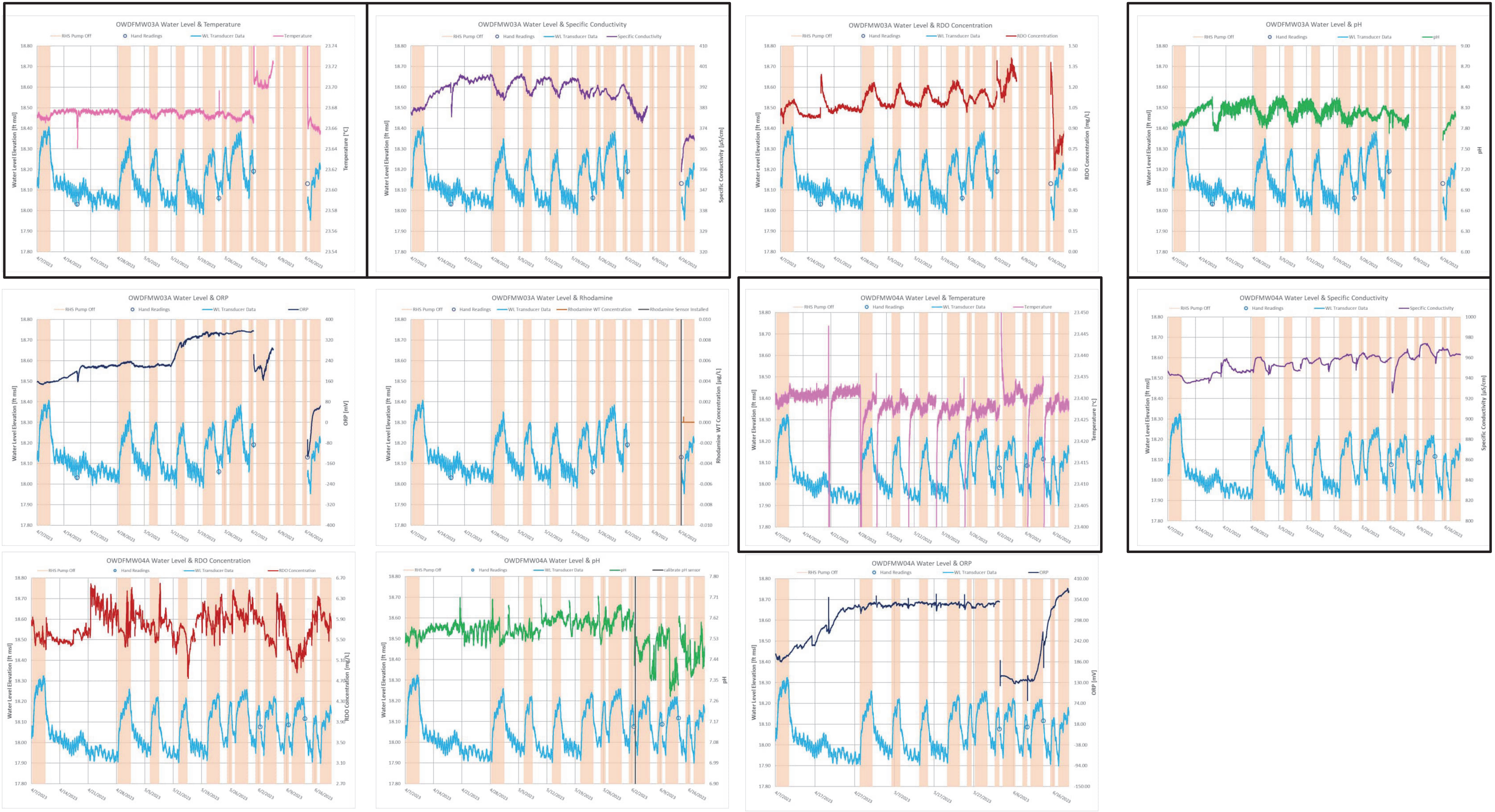


Figure 4-14n
Water Quality Parameters (OWDFMW03A and OWDFMW04A)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

☐ Parameter responded to pumping

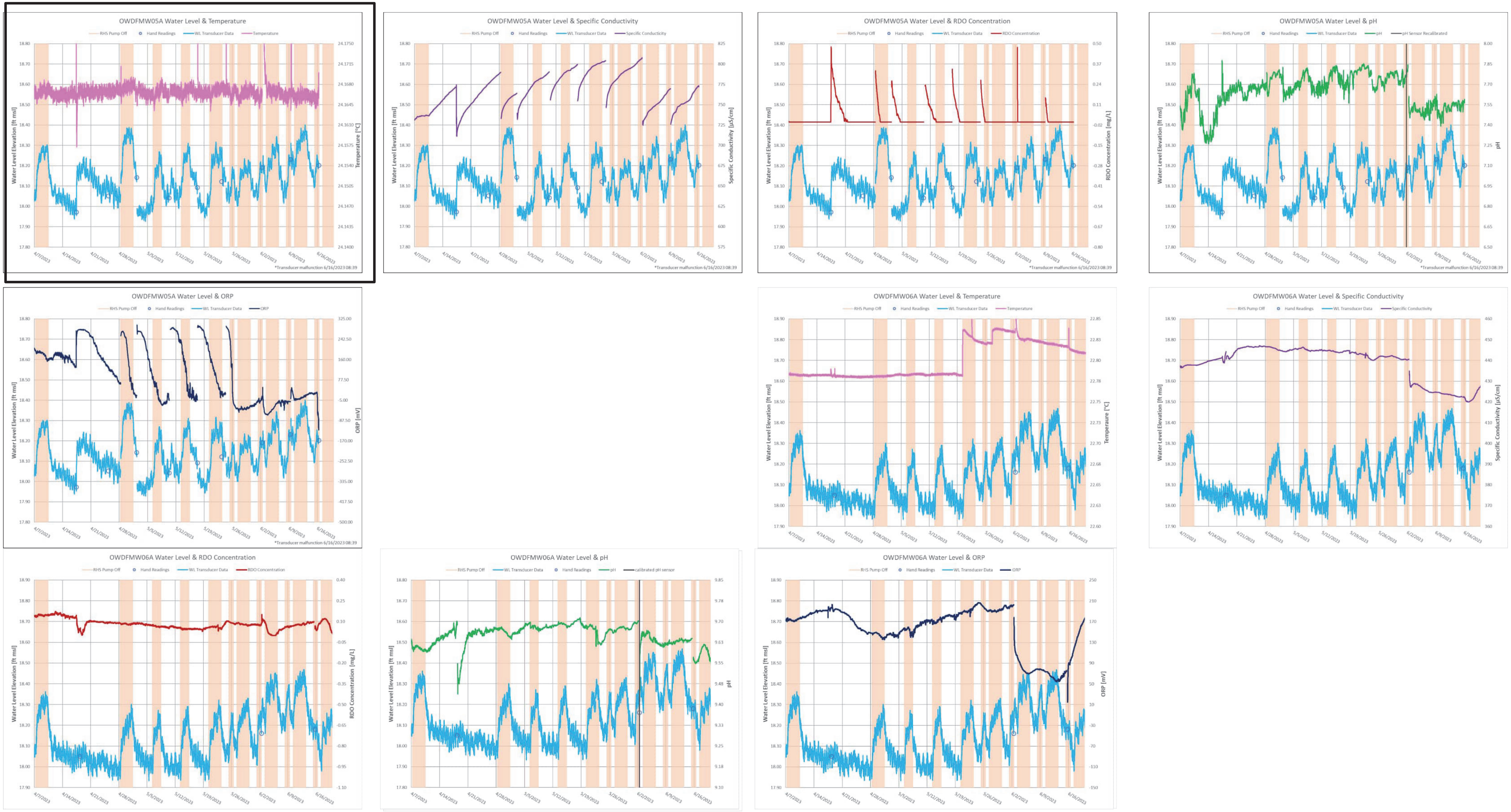


Figure 4-14o
Water Quality Parameters (OWDFMW05A and OWDFMW06A)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

▭ Parameter responded to pumping

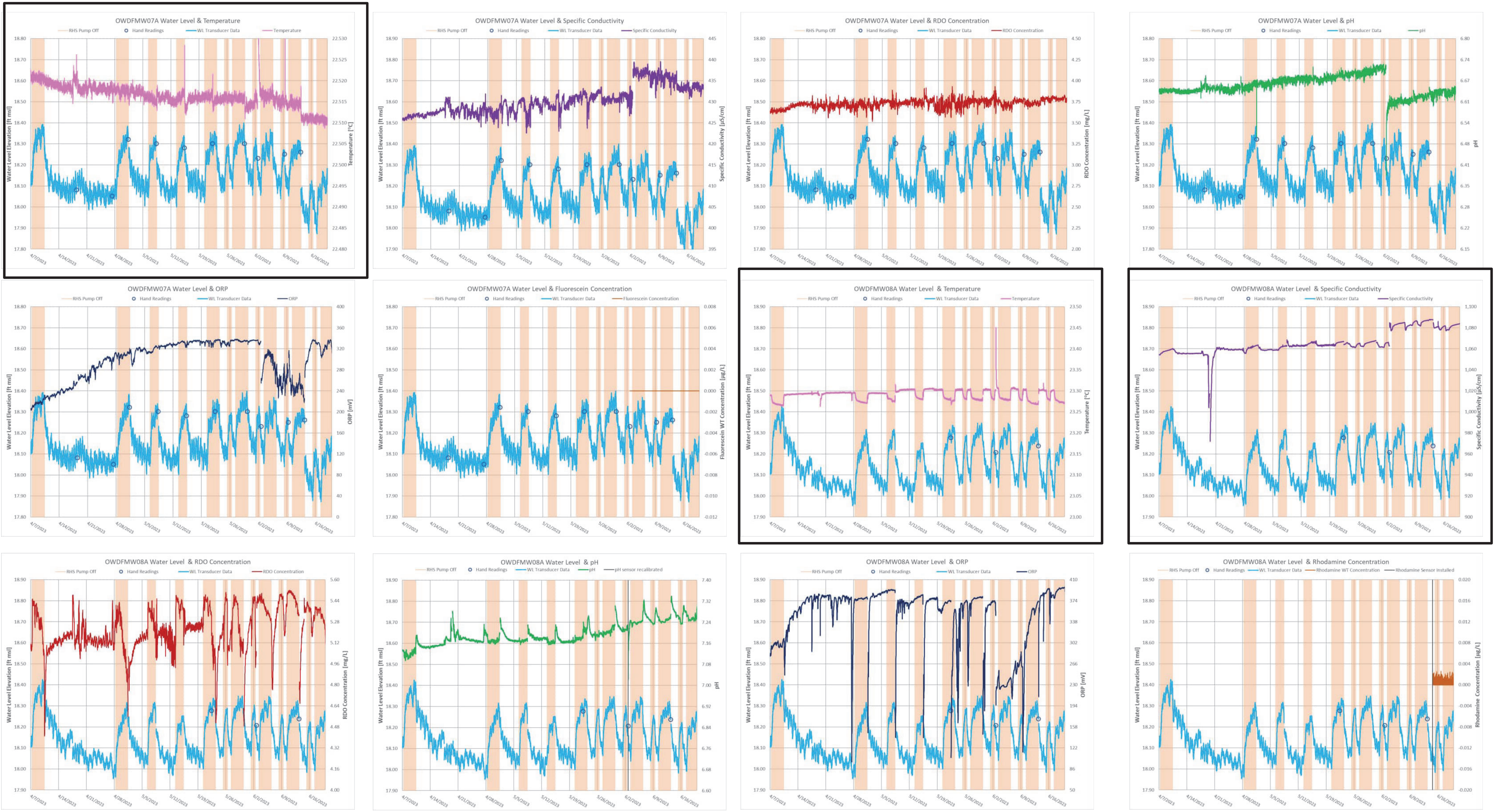


Figure 4-14p
Water Quality Parameters (OWDFMW07A and OWDFMW08A)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

☐ Parameter responded to pumping

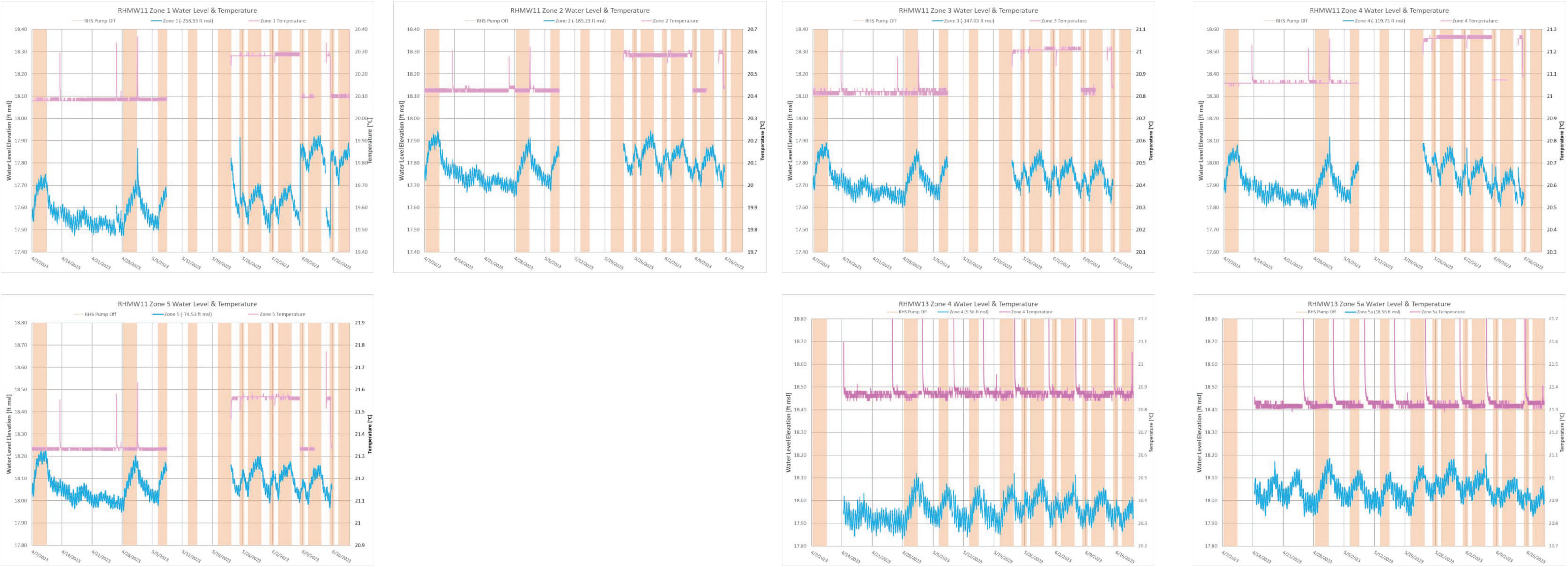


Figure 4-14q
Water Quality Parameters (Multilevel – RHMW11 and RHMW13)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

□ Parameter responded to pumping

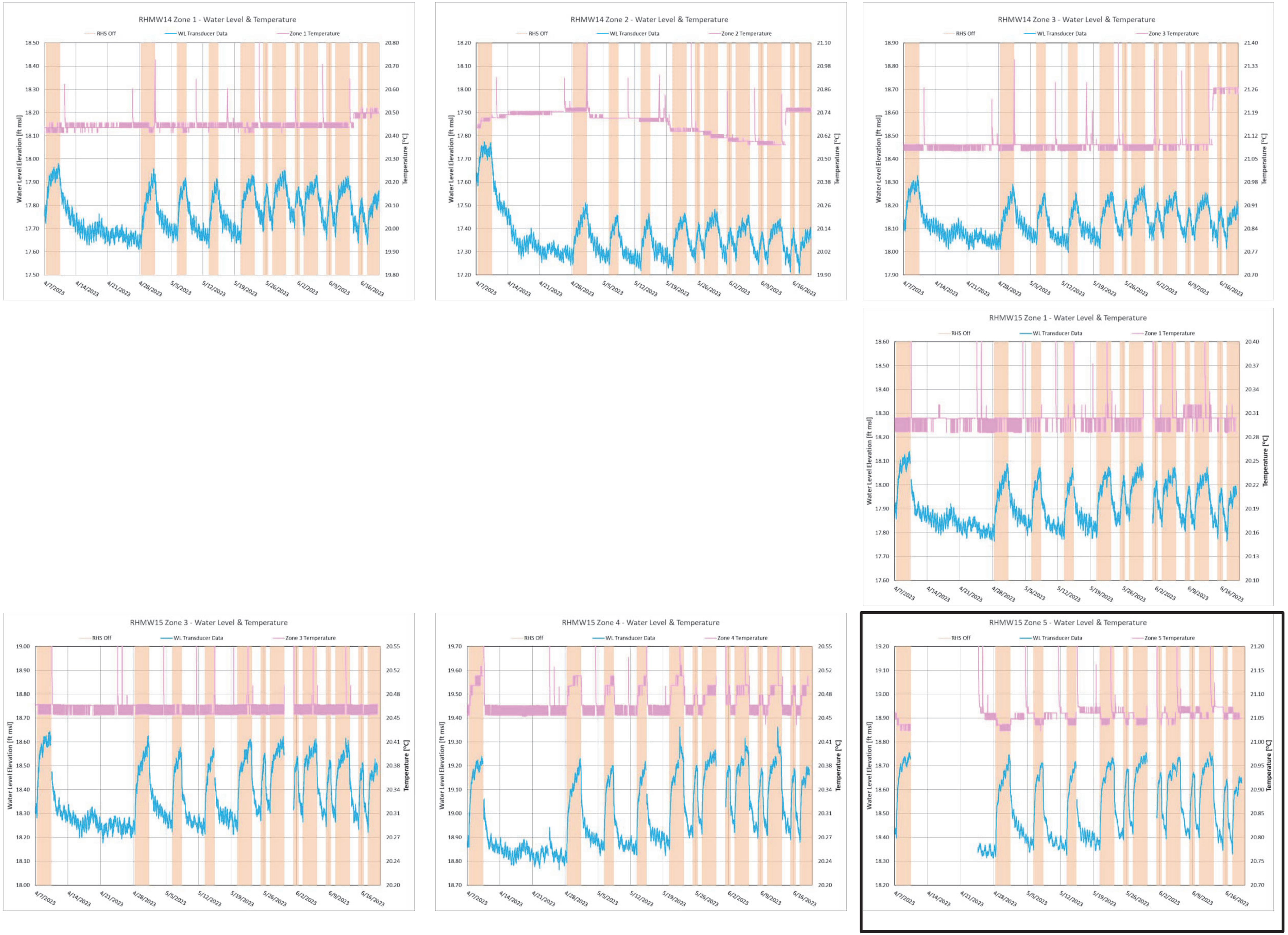


Figure 4-14r
Water Quality Parameters (Multilevel – RHMW14 and RHMW15)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

▭ Parameter responded to pumping

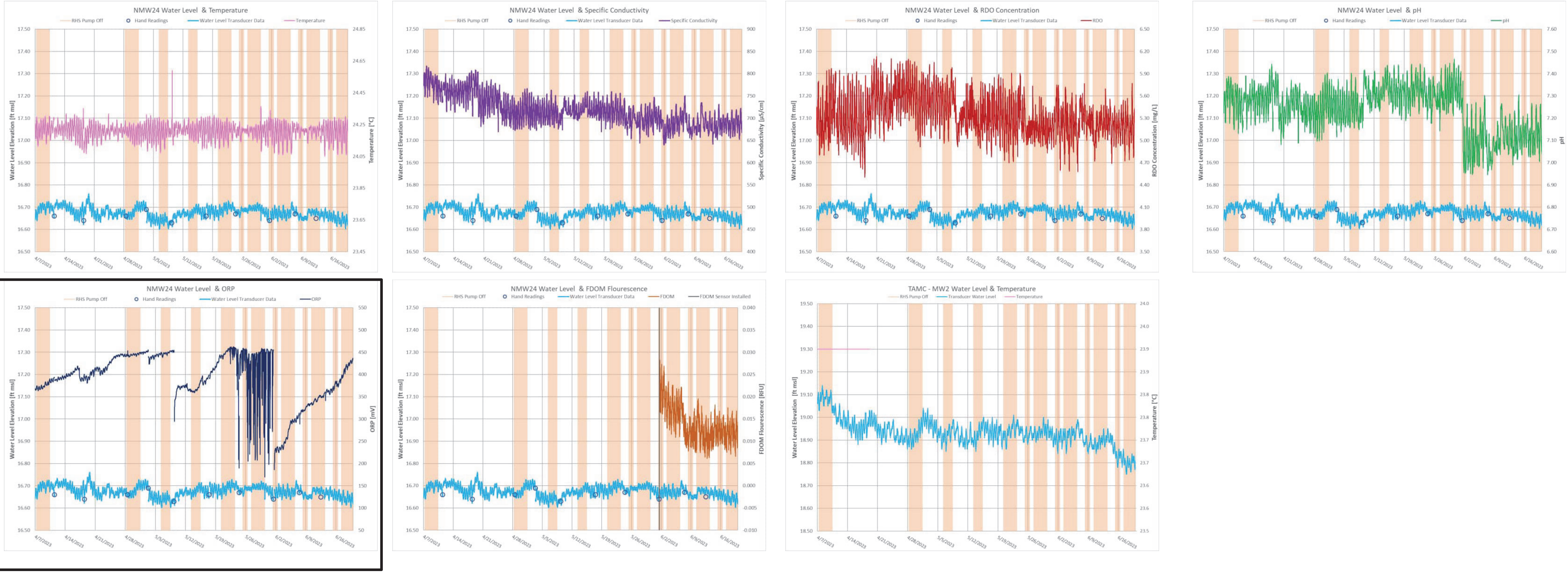


Figure 4-14s
Water Quality Parameters (NMW24 and TAMC – MW2)
Red Hill Shaft Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, HI

Legend

▭ Parameter responded to pumping

(b) (3) (A)

[redacted]

Figure 4-15
Parameter Trend Summary
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu HI

(b) (3) (A)

[redacted]

Figure 4-16
Specific Conductivity Results
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

[redacted]

Figure 4-17
Isotopes of Water
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

Figure 4-18a
TPH-d Results
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O’ahu, HI

(b) (3) (A)

[redacted]

Figure 4-18b
TPH-o Results
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

Figure 4-18c
1-Methylnaphthalene Results
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

[redacted]

Figure 4-18d
2-Methylnaphthalene Results
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

[redacted]

Figure 4-18e
Naphthalene Results
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

Figure 4-18f
Total Xylenes Results
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

Figure 4-19a
Trial Period #1: Results from Each Method
Pumping Rate = 4.3 mgd
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

Figure 4-19b
Trial Period #2: Results from Each Method
Pumping Rate = 2.9 mgd
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

[redacted]

Figure 4-19c
Trial Period #3: Results from Each Method
Pumping Rate = 1.7 mgd
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, HI

(b) (3) (A)

[redacted]

Figure 4-20a
Trial Period #1: Particle Track Results
Pumping Rate = 4.3 mgd
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu HI

(b) (3) (A)

[redacted]

Figure 4-20b
Trial Period #2: Particle Track Results
Pumping Rate = 2.9 mgd
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu HI

(b) (3) (A)

[redacted]

Figure 4-20c
Trial Period #3: Particle Track Results
Pumping Rate = 1.7 mgd
RHS Flow Optimization Study
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu HI

5.0 Conclusions

Multiple lines of evidence were assembled to assess capture of groundwater from one target zone by RHS located in the immediate vicinity of RHS. An additional zone was also evaluated encompassing the entirety of the tank farm. Three average pumping rates were evaluated: 4.3, 2.9, and 1.7 mgd. Forward particle tracking methods based on kriged water levels, an AEM, and the "best available" GWFM were used as the main lines of evidence. Additional consideration was given to several indirect lines of evidence, such as 3-point hydraulic gradient calculations, vertical gradients, water quality, isotopes, and analytical data. Results of the particle tracking analysis from the three methods generally indicated that capture of both target areas was sufficient at all pumping rates; however, particle tracking from water level contours alone yielded results that were more difficult to interpret and highly dependent on the assumption of anisotropy.

A key factor in estimating flow directions at the site is the evaluation of horizontal anisotropy. A standard method for evaluating anisotropy depends on the aspect ratio of a drawdown ellipse contour; however, this method uses the assumption of a vertical well. Because RHS is a 1,200-ft-long shaft, the distances to the drawdown ellipses are greater than the shortest distance to RHS in the secondary direction along strike, resulting in an anisotropy ratio likely to be biased low. From this method, two interpretations arrived at horizontal anisotropy ratio estimates of 5.3 and 10.4. Additional analysis with particle tracking demonstrated flow down ridge with an anisotropy ratio of 15, which is slightly higher than the values presumed to be biased low. An additional line of evidence that suggests a flow direction down Red Hill ridge is TPH-o data collected in the weeks and months following the release at Tanks 18 and 20 in May of 2021, which showed travel of TPH-o from the release location to RHMW03 to RHMW02 and potentially farther down-ridge. It is noted that the apparent summer 2021 breakthrough at RHMW02 may arise from several causes, including:

- Local remobilization of residual fuels already present at/close to the water table
- Local remobilization of residual fuels already present in the vadose zone
- Actual breakthrough related to the release

The weight of evidence documented in this report suggests that capture of the target area in the immediate vicinity of RHS is likely at all evaluated pumping rates. Capture at the tank farm is likely when pumping RHS at 2.9 mgd and greater. These findings are still subject to uncertainty given the limitations of the methods applied. Estimates of capture are best verified through the successful completion of a well-designed tracer study and possibly other field testing techniques.

The study uses multiple lines of inquiry (i.e., a variety of data and interpretive techniques) to converge on the following conclusions:

1) Pumping at RHS achieves the purpose set forth in the RHSRMP to capture groundwater in the vicinity of RHS at all three tested pumping rates (1.7 mgd, 2.9 mgd, and 4.3 mgd).
2) Pumping at RHS at 2.9 and 4.3 mgd and greater appears to capture much of the groundwater in the vicinity of the tank farm. Farther up the ridge near the more distal tanks, capture becomes less certain, especially at the lowest pumping rate. Moreover, given the relatively flat gradients at the

site, the extent of capture may not be 100 percent demonstrable. Small water level differences can be significant, and at this site, such differences may be within the margins of measurement error and environmental noise. Further analysis of flow around the Tank Farm is anticipated over the coming year.

6.0 Recommendations

Based on the findings from this study, it is suggested that the pumping rate of RHS may be reduced to 2.9 mgd and capture of groundwater in the tank farm target area will still be likely, but further reduction to 1.7 mgd will lead to greater potential for escape of groundwater under the tank farm. Capture of the area in the immediate vicinity of RHS is likely at all evaluated pumping rates. Additionally, no recent analytical data have indicated a persistent plume around RHS. It is likely that dissolved-phase contamination has been extracted by RHS and that the risk of contamination migrating farther downgradient away from RHS is low.

Decisions to reduce the RHS pumping rate should consider the overall goals of system operation. Capture of the RHS target area may be achieved at the lowest rate of 1.7 mgd, and also may no longer be necessary due to lack of dissolved-phase contamination remaining in the area. Capture of groundwater under the tank farm is less certain and would be focused on capturing contamination related to residual petroleum sources in the subsurface. If a future release were to occur, or if residual impacts were to migrate, pumping rates could be increased to increase confidence in capture. Benefits of continuation of pumping to contain residual contamination should be weighed against the drawback of wasted water, electricity, GAC, etc. In case of a future release or evidence of a release such as elevated soil vapor readings, elevated groundwater concentrations of TPH, tank volume discrepancies, or physical observations, the Navy should be prepared to increase pumping back to the full 4.3 mgd as a conservative protective measure.

7.0 References

Cooper, H. H., and C. E. Jacob. 1946. “A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History.” *Transactions, American Geophysical Union* 27 (4): 526. https://doi.org/10.1029/TR027i004p00526.

Department of Health, State of Hawaii (DOH). 2017. *Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater, Hawai‘i Edition*. Hazard Evaluation and Emergency Response. Revised 2017. Fall.

———. 2021a. *Notice of Interest in a Release or Threatened Release of Hazardous Substances: Red Hill Bulk Fuel Storage Facility, Pearl Harbor, HI. Case No.: 20210507-0852 JP-5 Spill That Occurred on 6 May 2021.* Letter from: Keith Kawaoka, Hawaii DOH Deputy Director for Environmental Health; to: Admiral R. B. Chadwick II, Navy Region Hawaii. May 10.

———. 2021b. *Notice of Interest in a Release or Threatened Release of Hazardous Substances: Red Hill Bulk Fuel Storage Facility, Pearl Harbor, HI. HEER Incident Release Case No.: 20211120-2330*. Letter from: K. Ho, Hawaii DOH Deputy Director for Environmental Health; to: Rear Admiral T. Kott, Navy Region Hawaii. November 24.

Department of the Navy (DON). 2018. *Groundwater Protection and Evaluation Considerations for the Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O‘ahu, Hawai‘i; July 27, 2018, Revision 00*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2019. *Conceptual Site Model, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O‘ahu, Hawai‘i; June 30, 2019, Revision 01*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2020. *Groundwater Flow Model Report, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O‘ahu, Hawai‘i; March 25, 2020, Revision 00*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2022. *Red Hill Shaft Flow Optimization, Work Plan, Red Hill Bulk Fuel Storage Facility, JBPHH, O‘ahu, Hawai‘i*. Prepared for NAVFAC Hawaii by AECOM Technical Services Inc. October 26.

———. 2023a. *Groundwater Flow Model Technical Memorandum, Red Hill Bulk Fuel Storage Facility. JBPHH, O‘ahu, Hawai‘i*. Prepared for NAVFAC Hawaii by AECOM Technical Services Inc. May 17.

———. 2023b. *Contaminant Fate and Transport Model Technical Memorandum, Red Hill Bulk Fuel Storage Facility. JBPHH, O'ahu, Hawai'i*. Prepared for NAVFAC Hawaii by AECOM Technical Services Inc. June 26.

Dores, D., C. R. Glenn, G. Torri, R. B. Whittier, and B. N. Popp. 2000. "Implications for Groundwater Recharge from Stable Isotopic Composition of Precipitation in Hawai'i during the 2017–2018 La Niña." *Hydrological Processes* 34 (24): 4675–96. https://doi.org/doi.org/10.1002/hyp.13907.

Environmental Protection Agency, United States (EPA). 2008. *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems - Final Project Report*. EPA 600/R-08/003. Office of Research and Development: National Risk Management Research Laboratory | Ground Water and Ecosystems Restoration Division. January.

———. 2014. *3PE: A Tool for Estimating Groundwater Flow Vectors*. 600/R-14/273. Office of Research and Development | National Risk Management Research Laboratory | Ground Water and Ecosystems Restoration Division. Beljin, M., R. Ross, and S. AcreeBeljin, M., R. Ross, and S. Acree. September.

ESRI. 2020. *ArcGIS Desktop: Release 10.8*. Redlands, CA: Environmental Systems Research Institute.

Fitts Geosolutions. 2022. *AnAqSIM (Analytic Aquifer Simulator)*. Release 2022-2, June 8. www.fittsgeosolutions.com.

Freeze, R. A., and J. A. Cherry. 1979. *Groundwater*. Englewood Cliffs, NJ: Prentice Hall.

Hantush, M. S., and R. G. Thomas. 1966. "A Method for Analyzing a Drawdown Test in Anisotropic Aquifers." *Water Resources Research* 2 (2): 281–85. https://doi.org/10.1029/WR002i002p00281.

Hunt Jr., C. D. 1996. *Geohydrology of the Island of Oahu, Hawaii*. Professional Paper 1412-B. Regional Aquifer-System Analysis—Oahu, Hawaii. U.S. Geological Survey.

Interagency Drinking Water System Team (IDWST). 2022. *Red Hill Shaft Recovery and Monitoring Plan (RHSRMP), JBPHH, O'ahu, Hawai'i*. Navy, Army, State of Hawaii Department of Health, and United States Environmental Protection Agency. January.

Mitchell, J. N., and D. S. Oki. 2018. *Groundwater-Level, Groundwater-Temperature, and Barometric-Pressure Data, July 2017 to February 2018, Hālawa Area, O'ahu, Hawai'i*. USGS Open-File Report 2018–1147. Prepared in Cooperation with the U.S. Navy. Reston, VA: U.S. Geological Survey.

Mutch, Jr., R. D. 2005. "A Distance-Drawdown Aquifer Test Method for Aquifers with Areal Anisotropy." *Ground Water* 43 (6): 935–38. https://doi.org/10.1111/j.1745-6584.2005.00105.x.

Nichols, W. D., P. J. Shade, and C. D. Hunt Jr. 1996. *Summary of the Oahu, Hawaii, Regional Aquifer-System Analysis*. Professional Paper 1412-A. Regional Aquifer-System Analysis—Oahu, Hawaii. U.S. Geological Survey.

Oki, D. S. 1998. *Geohydrology of the Central Oahu, Hawaii, Ground-Water Flow System and Numerical Simulation of the Effects of Additional Pumping*. Water-Resources Investigations Report 97–4276. Prepared in Cooperation with the Honolulu Board of Water Supply. U.S. Geological Survey.

S.S. Papadopulos & Associates, Inc. (SSPA). 2023. *Groundwater Desktop*. Rockville MD.

United States Geological Survey (USGS). 2017. *Final Synoptic Water Level Study Work Plan, Hālawa Area, Oʻahu, Hawaiʻi*. Honolulu, HI: Pacific Islands Water Science Center. August 10.

Visher, F. N., and J. F. Mink. 1964. *Ground-Water Resources in Southern Oahu, Hawaii*. Geological Survey Water Supply Paper 1778. Prepared in Cooperation with the State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development. U.S. Geological Survey.

Appendix A: Detailed Summary of Cooper-Jacob Approximation to the Theis Method - Drawdown vs. Time

Cooper-Jacob vs. Time Parameters

Well	Trial Period #1										
	Drawdown						Recovery				
	Δ s (ft)	t_0 (min)	t_0 (day)	Effective Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield	Δ s (ft)	Residual Drawdown	Effective Transmissivity (ft2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield
RHMW01R	0.12	30	0.02	877000	8770	0.02	0.1	0	752000	7520	0
RHMW02	0.12	75	0.05	877000	8770	0.02	0.2	0	601000	6010	0
RHMW03	0.13	75	0.05	809000	8090	0.01	0.1	0	779000	7790	0
RHMW04	0.16	200	0.14	658000	6580	0.01	0.2	0	658000	6580	0
RHMW05	0.13	20	0.01	809000	8090	0.04	0.2	0	585000	5850	0
RHMW06	0.45	3500	2.43	234000	2340	0.12	0.3	0	376000	3760	0
RHMW08	0.13	25	0.02	809000	8090	0.02	0.2	0	501000	5010	0
RHMW09	0.14	80	0.06	752000	7520	0.03	0.2	0	526000	5260	0
RHMW10	0.12	50	0.03	877000	8770	0.01	—	—	—	—	—
RHMW11-01	0.28	900	0.63	376000	3760	0.09	0.1	0	957000	9570	0
RHMW11-02	0.24	20	0.01	438000	4380	0.00	0.2	0	658000	6580	0
RHMW11-03	0.27	100	0.07	390000	3900	0.01	0.1	0	957000	9570	0
RHMW11-04	0.33	300	0.21	319000	3190	0.02	0.1	0	957000	9570	0
RHMW11-05	0.36	950	0.66	292000	2920	0.07	0.1	0	915000	9150	0
RHMW12A	0.19	180	0.13	554000	5540	0.02	0.3	0	376000	3760	0
RHMW13-04	0.10	450	0.31	1108000	11080	0.04	0.2	0	438000	4380	0
RHMW13-05	0.82	950	0.66	128000	1280	0.01	0.2	0	448000	4480	0
RHMW14-01	0.24	300	0.21	448000	4480	0.08	0.3	0	413000	4130	0
RHMW14-02	0.24	450	0.31	438000	4380	0.11	0.3	0	405000	4050	0
RHMW14-03	0.14	650	0.45	752000	7520	0.28	0.2	0	489000	4890	0
RHMW15-01	0.56	900	0.63	188000	1880	2.0	0.1	0	1403000	14030	0
RHMW15-02	0.15	150	0.10	726000	7260	1.3	0.3	0	390000	3900	0
RHMW15-03	0.18	50	0.03	601000	6010	0.35	0.3	0	357000	3570	0
RHMW15-04	0.30	200	0.14	351000	3510	0.81	0.2	0	438000	4380	0
RHMW15-05	—	—	—	—	—	—	0.2	0	526000	5260	0
RHMW16	0.26	150	0.10	413000	4130	0.02	0.2	0.02	619000	6190	0.01
RHMW17	0.22	150	0.10	478000	4780	0.01	0.2	0	526000	5260	0
RHMW19	0.16	400	0.28	679000	6790	0.07	0.2	0	429000	4290	0
NMW24	0.08	900	0.63	1403000	14030	0.03	0.1	0	809000	8090	0
OWDFMW01	0.14	80	0.06	752000	7520	0.04	0.3	0	421000	4210	0
OWDFMW02A	0.11	35	0.02	957000	9570	0.02	0.2	0	457000	4570	0
OWDFMW03A	0.13	35	0.02	809000	8090	0.01	0.2	0	478000	4780	0
OWDFMW04A	0.13	50	0.03	809000	8090	0.04	0.1	0	877000	8770	0
OWDFMW05A	0.13	65	0.05	809000	8090	0.02	0.2	0	478000	4780	0
OWDFMW06A	0.12	20	0.01	877000	8770	0.01	0.2	0	701000	7010	0
OWDFMW07A	0.17	9	0.01	619000	6190	0.00	0.1	0	752000	7520	0
OWDFMW08A	0.19	150	0.10	554000	5540	0.06	0.2	0	585000	5850	0
RHP01	0.14	0	0.00	752000	7520	0.00	0.2	0	526000	5260	0
RHP02	0.15	0	0.00	701000	7010	0.00	0.2	0	619000	6190	0
RHP03	0.16	65	0.05	658000	6580	0.05	0.2	0	501000	5010	0
RHP04A	0.10	10	0.01	1052000	10520	0.01	0.1	0	809000	8090	0
RHP04B	0.20	65	0.05	526000	5260	0.02	0.3	0	351000	3510	0
RHP04C	0.16	48	0.03	658000	6580	0.02	0.4	0	292000	2920	0
RHP05	0.13	10	0.01	809000	8090	0.01	0.1	0	1503000	15030	0
RHP07	0.37	200	0.14	284000	2840	0.32	0.23	0	457000	4570	0

Well	Trial Period #2																						
	Drawdown 1						Drawdown 2						Drawdown 3						Recovery				
	Δ s (ft)	t_0 (min)	t_0 (day)	Effective Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield	Δ s (ft)	t_0 (min)	t_0 (day)	Effective Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield	Δ s (ft)	t_0 (min)	t_0 (day)	Effective Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield	Δ s (ft)	Residual Drawdown	Effective Transmissivity (ft2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield
RHMW01R	0.17	250	0.17	619000	6190	0.09	0.11	10	0.01	934000	9340	0.01	0.13	35	0.02	791000	7910	0.02	0.18	0	579000	5790	0
RHMW02	0.09	35	0.02	1169000	11690	0.01	0.18	175	0.12	571000	5710	0.03	0.10	50	0.03	1028000	10280	0.02	0.18	0	571000	5710	0
RHMW03	0.14	175	0.12	752000	7520	0.02	0.12	100	0.07	856000	8560	0.01	0.12	150	0.10	856000	8560	0.02	0.16	0	653000	6530	0
RHMW04	0.15	250	0.17	701000	7010	0.01	0.14	200	0.14	761000	7610	0.01	0.12	90	0.06	856000	8560	0.01	0.16	0	642000	6420	0
RHMW05	0.19	250	0.17	554000	5540	0.33	0.10	25	0.02	1028000	10280	0.06	0.13	80	0.06	791000	7910	0.15	0.17	0	605000	6050	0
RHMW06	0.23	800	0.56	457000	4570	0.05	0.17	350	0.24	605000	6050	0.03	1.71	800	0.56	60000	600	0.01	0.31	0	332000	3320	0
RHMW08	0.16	83	0.06	658000	6580	0.05	0.11	20	0.01	934000	9340	0.02	0.21	85	0.06	489000	4890	0.04	0.32	0	321000	3210	0
RHMW09	0.10	275	0.19	1027000	10270	0.14	0.12	50	0.03	856000	8560	0.02	0.12	90	0.06	875000	8750	0.04	0.18	0	571000	5710	0
RHMW10	0.15	160	0.11	701000	7010	0.02	0.12	80	0.06	856000	8560	0.01	0.13	150	0.10	806000	8060	0.02	0.25	0	411000	4110	0
RHMW11-01	0.20	150	0.10	526000	5260	0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
RHMW11-02	0.24	20	0.01	438000	4380	0.00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
RHMW11-03	0.18	45	0.03	585000	5850	0.01	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
RHMW11-04	0.23	175	0.12	457000	4570	0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
RHMW11-05	0.24	85	0.06	438000	4380	0.01	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
RHMW12A	0.14	160	0.11	752000	7520	0.03	0.14	150	0.10	761000	7610	0.02	0.17	450	0.31	605000	6050	0.06	0.10	0	1028000	10280	0
RHMW13-04	0.19	500	0.35	554000	5540	0.02	0.18	650	0.45	571000	5710	0.03	0.16	550	0.38	642000	6420	0.03	0.19	0	541000	5410	0
RHMW13-05	0.19	400	0.28	554000	5540	0.02	0.17	550	0.38	605000	6050	0.03	0.15	400	0.28	685000	6850	0.02	0.22	0	467000	4670	0
RHMW14-01	0.18	200	0.14	601000	6010	0.07	0.17	200	0.14	623000	6230	0.07	0.15	150	0.10	685000	6850	0.06	0.16	0	642000	6420	0
RHMW14-02	0.17	200	0.14	619000	6190	0.07	0.12	200	0.14	894000	8940	0.10	0.13	350	0.24	791000	7910	0.16	0.20	0	514000	5140	0
RHMW14-03	0.14	300	0.21	752000	7520	0.13	0.15	300	0.21	685000	6850	0.12	0.12	450	0.31	856000	8560	0.22	0.18	0	571000	5710	0
RHMW15-01	0.56	900	0.63	188000	1880	1.95	0.28	70	0.05	374000	3740	0.30	0.11	150	0.10	934000	9340	1.62	0.22	0	478000	4780	0
RHMW15-02	0.19	175	0.12	569000	5690	1.15	0.52	950	0.66	198000	1980	2.17	0.17	85	0.06	605000	6050	0.59	0.23	0	447000	4470	0
RHMW15-03	0.15	40	0.03	701000	7010	0.32	0.12	15	0.01	894000	8940	0.15	0.09	30	0.02	1142000	11420	0.40	0.20	0	514000	5140	0
RHMW15-04	0.18	85	0.06	585000	5850	0.57	0.19	150	0.10	556000	5560	0.96	0.14	100	0.07	734000	7340	0.85	0.41	0	251000	2510	0
RHMW15-05	0.18	65	0.00	479000	4790	0.02	0.14	20	0.01	761000	7610	0.18	0.07	65	0.05	1581000	15810	1.19	0.20	0	514000	5140	0
RHMW16	0.21	150	0.10	501000	5010	0.03	0.13	0	0.00	791000	7910	0.00	0.12	45	0.03	894000	8940	0.01	0.42	0	248000	2480	0
RHMW17	0.10	350	0.24	1052000	10520	0.04	0.14	225	0.16	734000	7340	0.02	0.11	60	0.04	979000	9790	0.01	0.16	0	642000	6420	0
RHMW19	0.16	175	0.12	679000	6790	0.03	0.12	125	0.09	856000	8560	0.03	0.12	85	0.06	894000	8940	0.02	0.20	0	514000	5140	0
NMW24	0.09	350	0.24	1238000	12380	0.01	0.14	200	0.14	761000	7610	0.00	0.09	25	0.02	1142000	11420	0.00	0.14	0	761000	7610	0
OWDFMW01	0.16	300	0.21	658000	6580	0.13	0.15	150	0.10	709000	7090	0.07	0.47	250	0.17	219000	2190	0.04	0.20	0	514000	5140	0
OWDFMW02A	0.17	175	0.12	619000	6190	0.07	0.17	150	0.10	605000	6050	0.06	0.15	150	0.10	685000	6850	0.07	0.19	0	556000	5560	0
OWDFMW03A	0.15	175	0.12	701000	7010	0.06	0.13	100	0.07	791000	7910	0.04	0.12	100	0.07	856000	8560	0.05	0.21	0	489000	4890	0
OWDFMW04A	0.17	200	0.14	638000	6380	0.11	0.14	80	0.06	734000	7340	0.05	0.11	25	0.02	934000	9340	0.01	0.18	0	571000	5710	0
OWDFMW05A	0.53	500	0.35	199000	1990	0.04	0.72	550	0.38	143000	1430	0.03	0.61	225	0.16	168000	1680	0.03	0.18	0	571000	5710	0
OWDFMW06A	0.16	65	0.05	679000	6790	0.02	0.15	175	0.12	685000	6850	0.06	0.16	17	0.01	642000	6420	0.00	0.22	0	467000	4670	0
OWDFMW07A	0.14	100	0.07	779000	7790	0.04	0.10	35	0.02	1028000	10280	0.02	0.10	15	0.01	1028000	10280	0.01	0.15	0	685000	6850	0
OWDFMW08A	0.17	150	0.10	619000	6190	0.07	0.18	115	0.08	571000	5710	0.05	0.12	60	0.04	856000	8560	0.03	0.18	0	571000	5710	0
RHP01	0.12	0	0.00	877000	8770	0.00	0.13	0	0.00	791000	7910	0.00	0.12	0	0.00	856000	8560	0.00	0.19	0	541000	5410	0
RHP02	0.18	35	0.02	585000	5850	0.04	0.16	0	0.00	642000	6420	0.00	0.11	0	0.00	934000	9340	0.00	0.29	0	354000	3540	0
RHP03	0.19	225	0.16	554000	5540	0.14	0.18	125	0.09	571000	5710	0.08	0.18	150	0.10	571000	5710	0.15	0.21	0	489000	4890	0
RHP04A	0.23	250	0.17	457000	4570	0.07	0.09	15	0.01	1142000	11420	0.01	0.09	7	0.00	1209000	12090	0.01	0.21	0	501000	5010	0
RHP04B	1.85	400	0.28	57000	570	0.01	0.68	425	0.30	151000	1510	0.04	0.61	12	0.01	168000	1680	0.00	0.14	0	734000	7340	0
RHP04C	0.13	6	0.00	809000	8090	0.00	0.51	850	0.59	202000	2020	0.10	0.29	200	0.14	354000	3540	0.04	0.20	0	514000	5140	0
RHP05	0.20	150	0.10	526000	5260	0.08	0.16	20	0.01	642000	6420	0.01	0.15	20	0.01	685000	6850	0.01	0.20	0	527000	5270	0
RHP07	0.25	5	0.00	429000	4290	0.01	0.26	5	0.00	395000	3950	0.01	0.23	15	0.01	447000	4470	0.01	0.21	0	489000	4890	0

Well	Trial Period #3																							
	Drawdown 1						Drawdown 2						Drawdown 3						Drawdown 4					
	Δ s (ft)	t_0 (min)	t_0 (day)	Effective Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield	Δ s (ft)	t_0 (min)	t_0 (day)	Effective Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield	Δ s (ft)	t_0 (min)	t_0 (day)	Effective Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield	Δ s (ft)	t_0 (min)	t_0 (day)	Effective Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield
RHMW01R	0.48	300	0.21	214000	2140	0.04	0.32	55	0.04	321000	3210	0.01	0.16	35	0.02	642000	6420	0.01	0.17	4	0.00	605000	6050	0.00
RHMW02	0.24	75	0.05	437000	4370	0.01	0.33	35	0.02	311000	3110	0.00	0.25	40	0.03	411000	4110	0.01	0.17	20	0.01	605000	6050	0.00
RHMW03	0.77	95	0.07	133000	1330	0.00	0.29	25	0.02	354000	3540	0.00	0.29	25	0.02	354000	3540	0.00	0.30	25	0.02	348000	3480	0.00
RHMW04	0.51	150	0.10	202000	2020	0.00	0.52	85	0.06	200000	2000	0.00	0.73	350	0.24	141000	1410	0.00	0.48	70	0.05	214000	2140	0.00
RHMW05	0.28	50	0.03	367000	3670	0.04	0.25	40	0.03	411000	4110	0.04	0.46	90	0.06	223000	2230	0.05	0.46	80	0.06	223000	2230	0.04
RHMW06	0.59	225	0.16	174000	1740	0.01	0.59	95	0.07	174000	1740	0.00	0.40	35	0.02	257000	2570	0.00	0.40	35	0.02	257000	2570	0.00
RHMW08	0.27	65	0.05	381000	3810	0.02	0.27	55	0.04	381000	3810	0.02	0.24	20	0.01	437000	4370	0.01	18.00	15	0.01	6000	60	0.00
RHMW09	0.27	60	0.04	381000	3810	0.01	0.50	25	0.02	206000	2060	0.00	0.50	15	0.01	206000	2060	0.00	0.48	25	0.02	214000	2140	0.00
RHMW10	0.38	80	0.06	270000	2700	0.00	0.24	20	0.01	437000	4370	0.00	0.26	40	0.03	403000	4030	0.00	0.26	35	0.02	403000	4030	0.00
RHMW11-01	0.18	7.5	0.01	571000	5710	0.00	0.55	175	0.12	187000	1870	0.01	0.33	175	0.12	311000	3110	0.01	0.46	85	0.06	223000	2230	0.00
RHMW11-02	0.16	4.5	0.00	642000	6420	0.00	0.56	80	0.06	185000	1850	0.00	0.38	20	0.01	270000	2700	0.00	0.48	35	0.02	216000	2160	0.00
RHMW11-03	0.26	25	0.02	395000	3950	0.00	0.81	150	0.10	127000	1270	0.00	0.35	85	0.06	294000	2940	0.01	0.81	100	0.07	127000	1270	0.00
RHMW11-04	0.20	300	0.21	527000	5270	0.04	0.16	150	0.10	663000	6630	0.03	0.20	300	0.21	527000	5270	0.04	0.36	90	0.06	285000	2850	0.01
RHMW11-05	0.19	500	0.35	541000	5410	0.07	0.21	250	0.17	501000	5010	0.03	0.23	450	0.31	457000	4570	0.05	0.50	250	0.17	206000	2060	0.01
RHMW12A	0.45	300	0.21	231000	2310	0.01	0.35	90	0.06	298000	2980	0.01	0.32	125	0.09	326000	3260	0.01	0.32	60	0.04	321000	3210	0.00
RHMW13-04	0.13	60	0.04	822000	8220	0.00	0.10	40	0.03	1028000	10280	0.00	0.41	400	0.28	251000	2510	0.01	0.33	35	0.02	311000	3110	0.00
RHMW13-05	0.29	250	0.17	354000	3540	0.01	0.16	35	0.02	642000	6420	0.00	0.29	300	0.21	354000	3540	0.01	0.17	40	0.03	623000	6230	0.00
RHMW14-01	0.28	25	0.02	367000	3670	0.01	0.39	55	0.04	264000	2640	0.01	0.31	40	0.03	332000	3320	0.01	0.39	60	0.04	264000	2640	0.01
RHMW14-02	0.25	60	0.04	419000	4190	0.01	0.55	95	0.07	187000	1870	0.01	0.30	15	0.01	343000	3430	0.00	0.63	70	0.05	163000	1630	0.01
RHMW14-03	0.17	20	0.01	623000	6230	0.01	0.60	65	0.05	171000	1710	0.01	0.38	15	0.01	270000	2700	0.00	0.60	65	0.05	171000	1710	0.01
RHMW15-01	0.11	75	0.05	934000	9340	0.81	0.11	35	0.02	914000	9140	0.37	—	—	—	—	—	—	0.23	300	0.21	457000	4570	1.58
RHMW15-02	0.29	150	0.10	354000	3540	0.61	0.35	90	0.06	294000	2940	0.31	—	—	—	—	—	—	0.53	95	0.07	194000	1940	0.21
RHMW15-03	0.13	30	0.02	791000	7910	0.27	0.34	45	0.03	307000	3070	0.16	—	—	—	—	—	—	0.31	38	0.03	332000	3320	0.14
RHMW15-04	0.29	150	0.10	354000	3540	0.61	0.45	350	0.24	228000	2280	0.92	—	—	—	—	—	—	0.64	750	0.52	161000	1610	1.39
RHMW15-05	0.31	55	0.04	332000	3320	0.21	0.35	65	0.05	298000	2980	0.22	—	—	—	—	—	—	0.40	40	0.03	257000	2570	0.12
RHMW16	0.28	225	0.16	367000	3670	0.03	0.71	500	0.35	145000	1450	0.03	0.75	500	0.35	137000	1370	0.02	0.38	550	0.38	270000	2700	0.05
RHMW17	0.44	65	0.05	234000	2340	0.00	0.56	225	0.16	184000	1840	0.00	0.32	50	0.03	321000	3210	0.00	0.70	350	0.24	147000	1470	0.01
RHMW19	0.94	700	0.49	109000	1090	0.02	0.44	80	0.06	234000	2340	0.01	0.37	150	0.10	282000	2820	0.01	0.52	150	0.10	198000	1980	0.01
NMW24	0.12	10	0.01	856000	8560	0.00	0.16	700	0.49	642000	6420	0.01	0.28	450	0.31	367000	3670	0.00	0.16	55	0.04	642000	6420	0.00
OWDFMW01	1.22	725	0.50	84000	840	0.04	1.09	125	0.09	94000	940	0.01	1.08	125	0.09	95000	950	0.01	1.06	150	0.10	97000	970	0.01
OWDFMW02A	0.25	275	0.19	411000	4110	0.07	0.12	45	0.03	894000	8940	0.03	0.315	100	0.07	326000	3260	0.02	0.25	95	0.07	419000	4190	0.03
OWDFMW03A	0.35	450	0.31	294000	2940	0.06	0.57	650	0.45	180000	1800	0.06	0.57	650	0.45	180000	1800	0.06	—	—	—	—	—	—
OWDFMW04A	0.28	250	0.17	374000	3740	0.08	0.42	500	0.35	245000	2450	0.11	0.24	250	0.17	428000	4280	0.09	0.41	150	0.10	251000	2510	0.03
OWDFMW05A	0.38	75	0.05	270000	2700	0.01	0.79	80	0.06	130000	1300	0.00	0.49	50	0.03	212000	2120	0.00	0.27	65	0.05	381000	3810	0.01
OWDFMW06A	0.20	250	0.17	514000	5140	0.06	0.40	400	0.28	257000	2570	0.05	0.56	500	0.35	184000	1840	0.05	0.52	375	0.26	198000	1980	0.04
OWDFMW07A	0.25	100	0.07	411000	4110	0.02	0.25	100	0.07	411000	4110	0.02	0.22	200	0.14	467000	4670	0.05	0.30	250	0.17	343000	3430	0.05
OWDFMW08A	0.32	225	0.16	326000	3260	0.05	0.49	400	0.28	210000	2100	0.06	0.49	475	0.33	210000	2100	0.07	0.53	475	0.33	196000	1960	0.07
RHP01	0.39	30	0.02	264000	2640	0.03	0.44	25	0.02	234000	2340	0.02	—	—	—	—	—	—	0.60	90	0.06	171000	1710	0.06
RHP02	0.38	20	0.01	274000	2740	0.01	0.38	30	0.02	274000	2740	0.01	0.30	4	0.00	348000	3480	0.00	0.34	100	0.07	302000	3020	0.05
RHP03	0.49	70	0.05	212000	2120	0.02	0.22	27	0.02	467000	4670	0.01	0.25	60	0.04	419000	4190	0.03	0.25	50	0.03	411000	4110	0.02
RHP04A	0.11	30	0.02	934000	9340	0.02	0.11	40	0.03	934000	9340	0.02	0.32	95	0.07	326000	3260	0.02	0.73	95	0.07	141000	1410	0.01
RHP04B	0.34	55	0.04	307000	3070	0.01	0.85	45	0.03	121000	1210	0.00	—	—	—	—	—	—	0.80	100	0.07	128000	1280	0.01
RHP04C	0.81	90	0.06	127000	1270	0.01	0.76	70	0.05	135000	1350	0.01	0.76	95	0.07	135000	1350	0.01	0.77	35	0.02	133000	1330	0.00
RHP05	0.33	95	0.07	311000	3110	0.03	0.47	500	0.35	219000	2190	0.11	0.51	350	0.24	202000	2020	0.07	0.24	25	0.02	428000	4280	0.01
RHP07	0.56	60	0.04	184000	1840	0.06	0.50	25	0.02	206000	2060	0.03	0.28	8	0.01	367000	3670	0.02	0.60	60	0.04	171000	1710	0.06

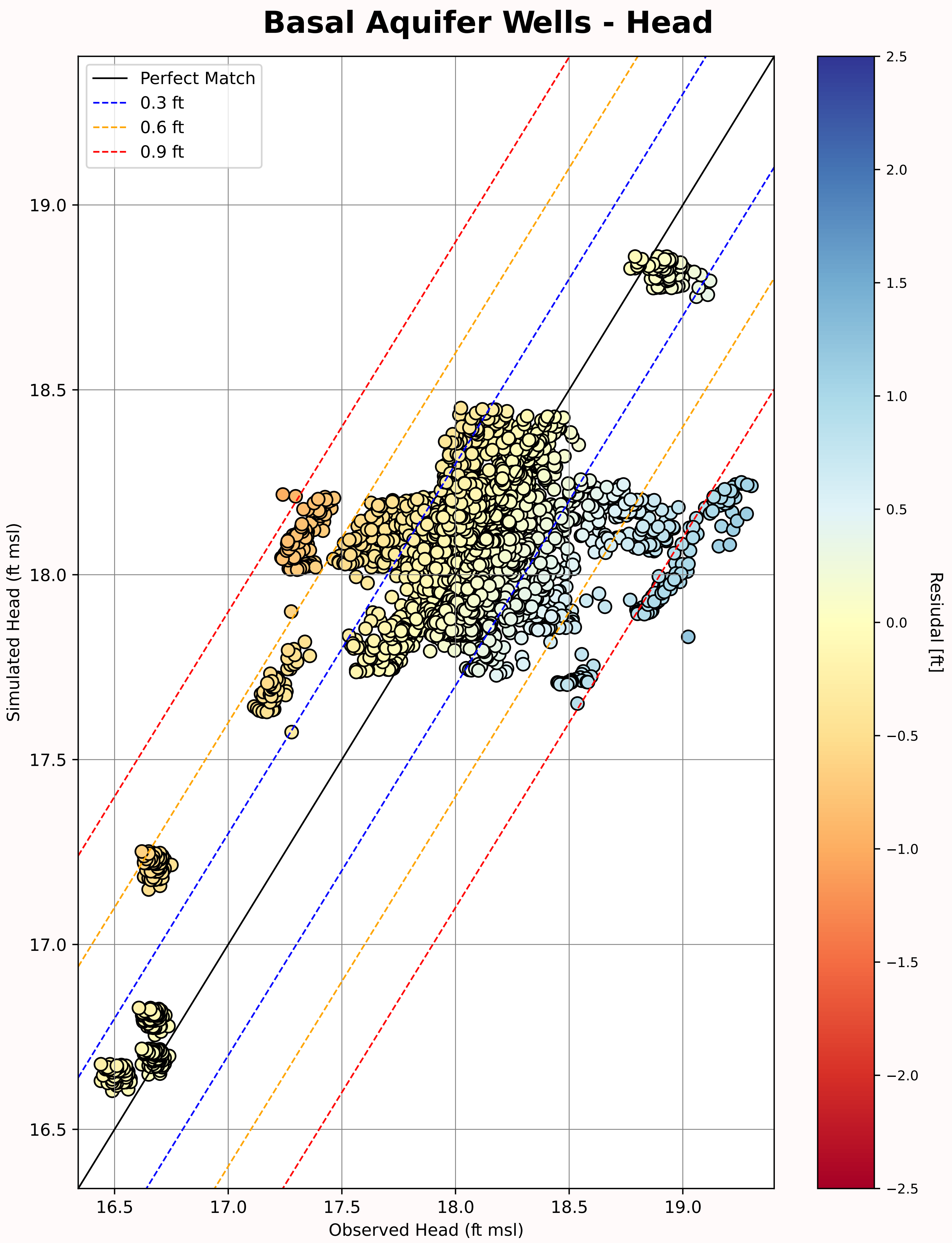
Well	Trial Period #3																												
	Drawdown 5						Drawdown 6						Drawdown 7						Drawdown 8						Recovery				
	Δ s (ft)	t_0 (min)	t_0 (day)	Effective Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield	Δ s (ft)	t_0 (min)	t_0 (day)	Effective Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield	Δ s (ft)	t_0 (min)	t_0 (day)	Effective Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield	Δ s (ft)	t_0 (min)	t_0 (day)	Effective Transmissivity (ft^2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield	Δ s (ft)	Residual Drawdown	Effective Transmissivity (ft2/d)	Hydraulic Conductivity (ft/d) [b = 100 ft]	Specific Yield
RHMW01R	0.18	5	0.00	571000	5710	0.00	0.26	30	0.02	395000	3950	0.01	0.47	125	0.09	213000	2130	0.02	0.23	15	0.01	457000	4570	0.00	0.17	0.0	623000	6230	0
RHMW02	0.21	25	0.02	489000	4890	0.00	0.22	40	0.03	467000	4670	0.01	0.30	90	0.06	340000	3400	0.01	0.26	40	0.03	403000	4030	0.01	0.19	0.0	541000	5410	0
RHMW03	0.28	25	0.02	367000	3670	0.00	0.28	15	0.01	374000	3740	0.00	0.30	30	0.02	340000	3400	0.00	0.18	2	0.00	571000	5710	0.00	0.18	0.0	587000	5870	0
RHMW04	0.48	100	0.07	214000	2140	0.00	0.45	60	0.04	228000	2280	0.00	0.68	550	0.38	148000	1480	0.01	0.51	175	0.12	202000	2020	0.00	0.12	0.0	856000	8560	0
RHMW05	0.53	100	0.07	194000	1940	0.05	0.42	45	0.03	245000	2450	0.03	0.41	65	0.05	245000	2450	0.04	0.44	60	0.04	234000	2340	0.03	0.14	0.0	761000	7610	0
RHMW06	0.37	25	0.02	278000	2780	0.00	0.42	40	0.03	245000	2450	0.00	0.43	40	0.03	236000	2360	0.00	0.43	45	0.03	239000	2390	0.00	0.13	0.0	791000	7910	0
RHMW08	0.29	60	0.04	354000	3540	0.02	0.36	90	0.06	285000	2850	0.02	0.43	80	0.06	233000	2330	0.02	0.66	95	0.07	156000	1560	0.01	0.19	0.0	556000	5560	0
RHMW09	0.48	25	0.02	214000	2140	0.00	0.48	25	0.02	214000	2140	0.00	0.44	20	0.01	231000	2310	0.00	0.42	50	0.03	248000	2480	0.01	0.29	0.0	361000	3610	0
RHMW10	0.36	80	0.06	289000	2890	0.00	0.36	80	0.06	289000	2890	0.00	0.34	80	0.06	295000	2950	0.00	0.33	70	0.05	311000	3110	0.00	0.16	0.0	642000	6420	0
RHMW11-01	0.32	175	0.12	321000	3210	0.01	0.33	550	0.38	311000	3110	0.04	0.56	400	0.28	179000	1790	0.02	0.58	700	0.49	177000	1770	0.03	0.20	0.0	514000	5140	0
RHMW11-02	0.26	8	0.01	395000	3950	0.00	0.43	55	0.04	239000	2390	0.00	0.43	80	0.06	233000	2330	0.00	0.43	60	0.04	242000	2420	0.00	0.11	0.0	979000	9790	0
RHMW11-03	0.35	80	0.06	294000	2940	0.01	0.60	200	0.14	171000	1710	0.01	0.46	200	0.14	218000	2180	0.01	0.66	250	0.17	156000	1560	0.01	0.11	0.0	934000	9340	0
RHMW11-04	0.27	150	0.10	381000	3810	0.01	0.32	200	0.14	326000	3260	0.02	0.64	850	0.59	157000	1570	0.03	0.43	300	0.21	239000	2390	0.02	0.14	0.0	734000	7340	0
RHMW11-05	0.23	550	0.38	457000	4570	0.06	0.65	800	0.56	158000	1580	0.03	0.54	850	0.59	186000	1860	0.04	0.44	300	0.21	234000	2340	0.02	0.14	0.0	761000	7610	0
RHMW12A	0.33	150	0.10	316000	3160	0.01	0.31	75	0.05	332000	3320	0.01	0.23	35	0.02	446000	4460	0.00	0.22	25	0.02	467000	4670	0.00	0.22	0.0	478000	4780	0
RHMW13-04	0.36	45	0.03	285000	2850	0.00	0.34	40	0.03	302000	3020	0.00	0.52	65	0.05	193000	1930	0.00	0.46	225	0.16	226000	2260	0.00	0.13	0.0	822000	8220	0
RHMW13-05	0.23	35	0.02	447000	4470	0.00	0.11	10	0.01	934000	9340	0.00	0.23	150	0.10	446000	4460	0.01	0.14	20	0.01	761000	7610	0.00	0.25	0.0	419000	4190	0
RHMW14-01	0.66	95	0.07	156000	1560	0.01	0.51	50	0.03	202000	2020	0.01	0.46	45	0.03	218000	2180	0.01	0.55	75	0.05	187000	1870	0.01	0.14	0.0	734000	7340	0
RHMW14-02	0.47	150	0.10	219000	2190	0.02	0.64	60	0.04	162000	1620	0.01	0.49	35	0.02	205000	2050	0.00	0.47	75	0.05	219000	2190	0.01	0.13	0.0	791000	7910	0
RHMW14-03	0.42	15	0.01	245000	2450	0.00	0.41	15	0.01	254000	2540	0.00	0.44	25	0.02	228000	2280	0.00	0.61	50	0.03	168000	1680	0.00	0.16	0.0	642000	6420	0
RHMW15-01	0.22	225	0.16	467000	4670	1.21	0.30	350	0.24	348000	3480	1.41	0.58	750	0.52	173000	1730	1.50	0.25	300	0.21	411000	4110	1.42	0.24	0.0	428000	4280	0
RHMW15-02	0.56	95	0.07	184000	1840	0.20	0.56	95	0.07	184000	1840	0.20	0.42	55	0.04	239000	2390	0.15	0.35	18	0.01	294000	2940	0.06	0.20	0.0	514000	5140	0
RHMW15-03	0.34	40	0.03	302000	3020	0.14	0.39	55	0.04	264000	2640	0.17	0.50	70	0.05	201000	2010	0.16	0.50	0	0.00	206000	2060	0.00	0.23	0.0	447000	4470	0
RHMW15-04	0.58	250	0.17	177000	1770	0.51	0.27	15	0.01	381000	3810	0.07	0.38	70	0.05	264000	2640	0.21	0.55	25	0.02	187000	1870	0.05	0.17	0.0	605000	6050	0
RHMW15-05	0.38	75	0.05	270000	2700	0.23	0.28	7	0.00	367000	3670	0.03	0.41	45	0.03	245000	2450	0.13	0.14	30	0.02	734000	7340	0.25	0.13	0.0	791000	7910	0
RHMW16	0.38	375	0.26	270000	2700	0.04	0.36	90	0.06	285000	2850	0.01	0.10	5	0.00	1003000	10030	0.00	0.11	50	0.03	934000	9340	0.02	0.14	0.0	734000	7340	0
RHMW17	0.24	20	0.01	428000	4280	0.00	70.00	325	0.23	1000	10	0.00	0.22	12	0.01	467000	4670	0.00	0.44	150	0.10	236000	2360	0.00	0.15	0.0	685000	6850	0
RHMW19	0.54	225	0.16	190000	1900	0.01	0.44	75	0.05	236000	2360	0.00	0.41	75	0.05	245000	2450	0.01	0.41	75	0.05	251000	2510	0.01	0.30	0.0	343000	3430	0
NMW24	0.23	350	0.24	447000	4470	0.00	0.14	55	0.04	734000	7340	0.00	0.19	150	0.10	528000	5280	0.00	0.35	350	0.24	294000	2940	0.00	0.21	0.0	489000	4890	0
OWDFMW01	0.72	275	0.19	144000	1440	0.03	0.72	175	0.12	143000	1430	0.02	0.74	250	0.17	136000	1360	0.02	0.69	35	0.02	150000	1500	0.00	0.26	0.0	395000	3950	0
OWDFMW02A	0.38	90	0.06	270000	2700	0.02	0.24	60	0.04	428000	4280	0.02	0.20	40	0.03	514000	5140	0.01	0.32	100	0.07	321000	3210	0.02	0.26	0.0	395000	3950	0
OWDFMW03A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.42	400	0.28	245000	2450	0.05	0.27	0.0	381000	3810	0
OWDFMW04A	0.30	300	0.21	343000	3430	0.09	0.32	350	0.24	321000	3210	0.10	0.42	750	0.52	239000	2390	0.16	0.55	650	0.45	187000	1870	0.11	0.30	0.0	343000	3430	0
OWDFMW05A	0.12	22	0.02	856000	8560	0.01	0.71	95	0.07	146000	1460	0.01	0.27	25	0.02	372000	3720	0.00	—	—	—	—	—	—	—	—	—	—	—
OWDFMW06A	0.35	85	0.06	294000	2940	0.01	0.31	55	0.04	332000	3320	0.01	0.49	250	0.17	207000	2070	0.03	0.47	225	0.16	219000	2190	0.02	0.33	0.0	316000	3160	0
OWDFMW07A	0.41	650	0.45	254000	2540	0.09	0.41	375	0.26	251000	2510	0.05	0.64	85	0.06	158000	1580	0.01	0.47	85	0.06	221000	2210	0.01	0.24	0.0	428000	4280	0
OWDFMW08A	0.47	375	0.26	219000	2190	0.06	0.47	350	0.24	219000	2190	0.06	42.00	800	0.56	2000	20	0.00	0.34	250	0.17	307000	3070	0.06	0.23	0.0	447000	4470	0
RHP01	0.55	50	0.03	189000	1890	0.03	0.62	80	0.06	167000	1670	0.05	0.52	80	0.06	193000	1930	0.06	0.21	95	0.07	489000	4890	0.17	0.19	0.0	541000	5410	0
RHP02	0.43	80	0.06	239000	2390	0.03	0.35	95	0.07	294000	2940	0.05	0.59	70	0.05	170000	1700	0.02	0.34	20	0.01	307000	3070	0.01	0.14	0.0	734000	7340	0
RHP03	0.43	50	0.03	239000	2390	0.01	0.26	20	0.01	395000	3950	0.01	0.56	80	0.06	179000	1790	0.02	0.36	80	0.06	285000	2850	0.02	0.15	0.0	685000	6850	0
RHP04A	0.46	85	0.06	223000	2230	0.01	0.26	50	0.03	395000	3950	0.01	0.67	75	0.05	150000	1500	0.01	0.23	40	0.03	457000	4570	0.01	0.10	0.0	1028000	10280	0
RHP04B	0.96	95	0.07	107000	1070	0.01	0.58	70	0.05	177000	1770	0.01	0.45	7	0.00	223000	2230	0.00	0.40	4	0.00	257000	2570	0.00	0.36	0.0	285000	2850	0
RHP04C	0.76	60	0.04	135000	1350	0.00	0.76	40	0.03	135000	1350	0.00	0.92	60	0.04	109000	1090	0.00	0.55	10	0.01	187000	1870	0.00	0.10	0.0	1028000	10280	0
RHP05	0.50	400	0.28	206000	2060	0.09	0.30	75	0.05	343000	3430	0.03	0.54	350	0.24	186000	1860	0.07	0.56	300	0.21	184000	1840	0.06	0.13	0.0	791000	7910	0
RHP07	0.44	25	0.02	236000	2360	0.03	—	—	—	—	—	—	0.52	50	0.03	193000	1930	0.05	0.52	30	0.02	198000	1980	0.03	0.17	0.0	605000	6050	0

Appendix B: Flow Optimization Study Groundwater Flow Model Calibration Evaluation Documentation

Flow Optimization Study Groundwater Flow Model Calibration Evaluation Documents

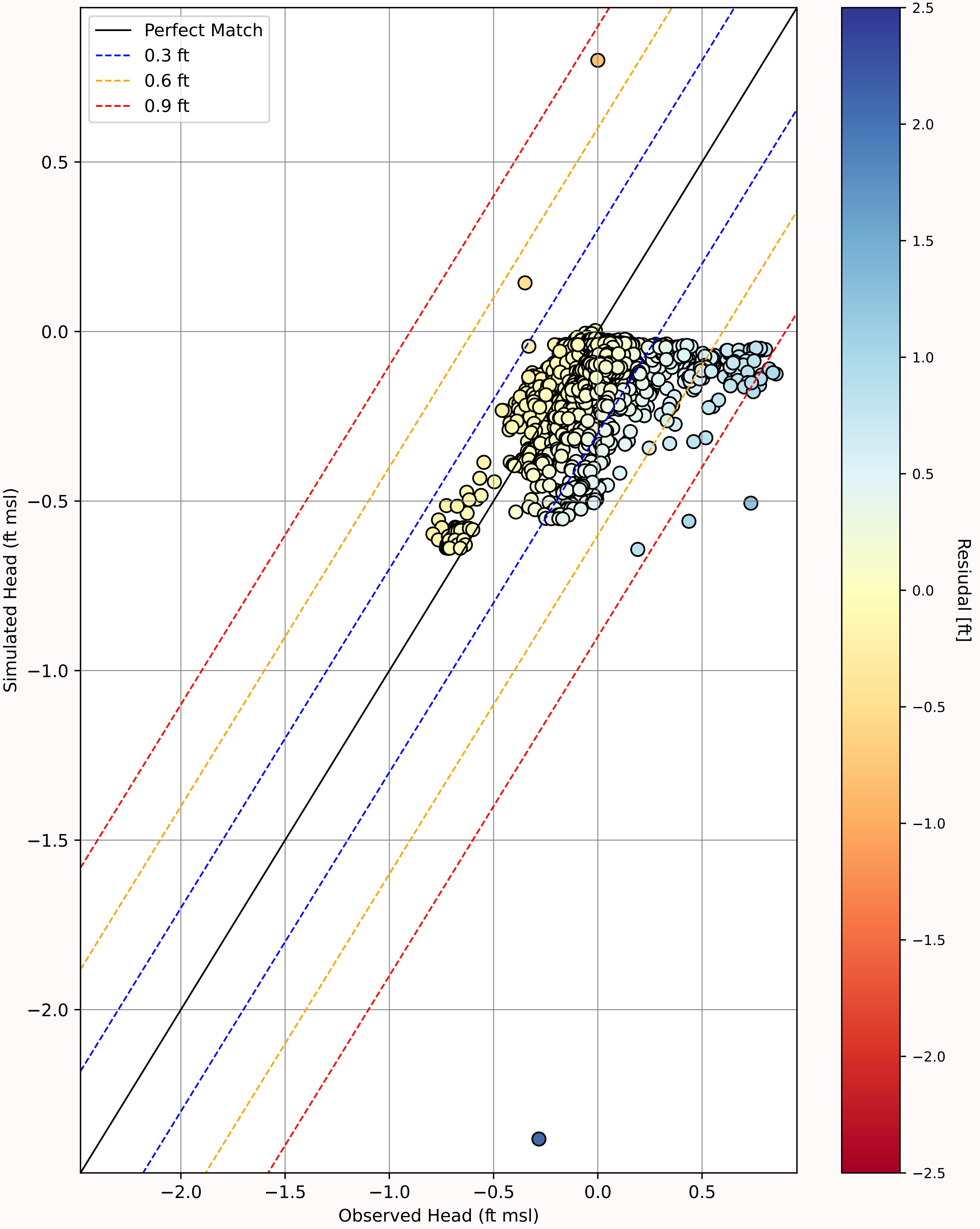
Calibration Statistics

	Head				Drawdown			
Time Period	**2017/2018**	**2021/2022**	**"Best Available" Model Calibration**	**Flow Optimization Study**	**2017/2018**	**2021/2022**	**"Best Available" Model Calibration**	**Flow Optimization Study**
Residual Mean (ft)	-0.06	-0.01	-0.05	0.00	0.00	0.04	0.01	0.12
Absolute Residual Mean (ft)	0.17	0.21	0.20	0.21	0.09	0.06	0.08	0.13
Residual Standard Deviation (ft)	0.24	0.28	0.28	0.30	0.21	0.09	0.18	0.14
Sum of Squared Residuals (ft2)	336.40	298.68	803.87	45043.87	246.29	35.26	281.55	17634.93
RMSE Error (ft)	0.25	0.28	0.28	0.30	0.21	0.10	0.18	0.19
Minimum Residual (ft)	-2.36	-0.78	-2.36	-1.01	-1.79	-0.27	-1.79	-1.31
Maximum Residual (ft)	0.85	0.64	2.08	1.24	2.30	0.49	2.30	2.52
Number of Observations	5459	3915	9928	512339	5393	3533	8926	499116
Range in Observations	7.14	3.26	7.19	2.95	4.76	0.68	4.76	1.65
Scaled Residual Standard Deviation (%)	3.4%	8.5%	3.9%	10.0%	4.5%	13.5%	3.7%	8.6%
Scaled Absolute Residual Mean (%)	2.3%	6.5%	2.8%	7.0%	2.0%	9.2%	1.7%	8.1%
Scaled RMSE Error (%)	3.5%	8.5%	4.0%	10.0%	4.5%	14.8%	3.7%	11.4%
Scaled Residual Mean (%)	-0.8%	-0.2%	-0.6%	0.0%	-0.1%	6.1%	0.3%	7.5%
Correlation Coefficient	0.98	0.93	0.96	0.82	0.83	0.72	0.85	0.51

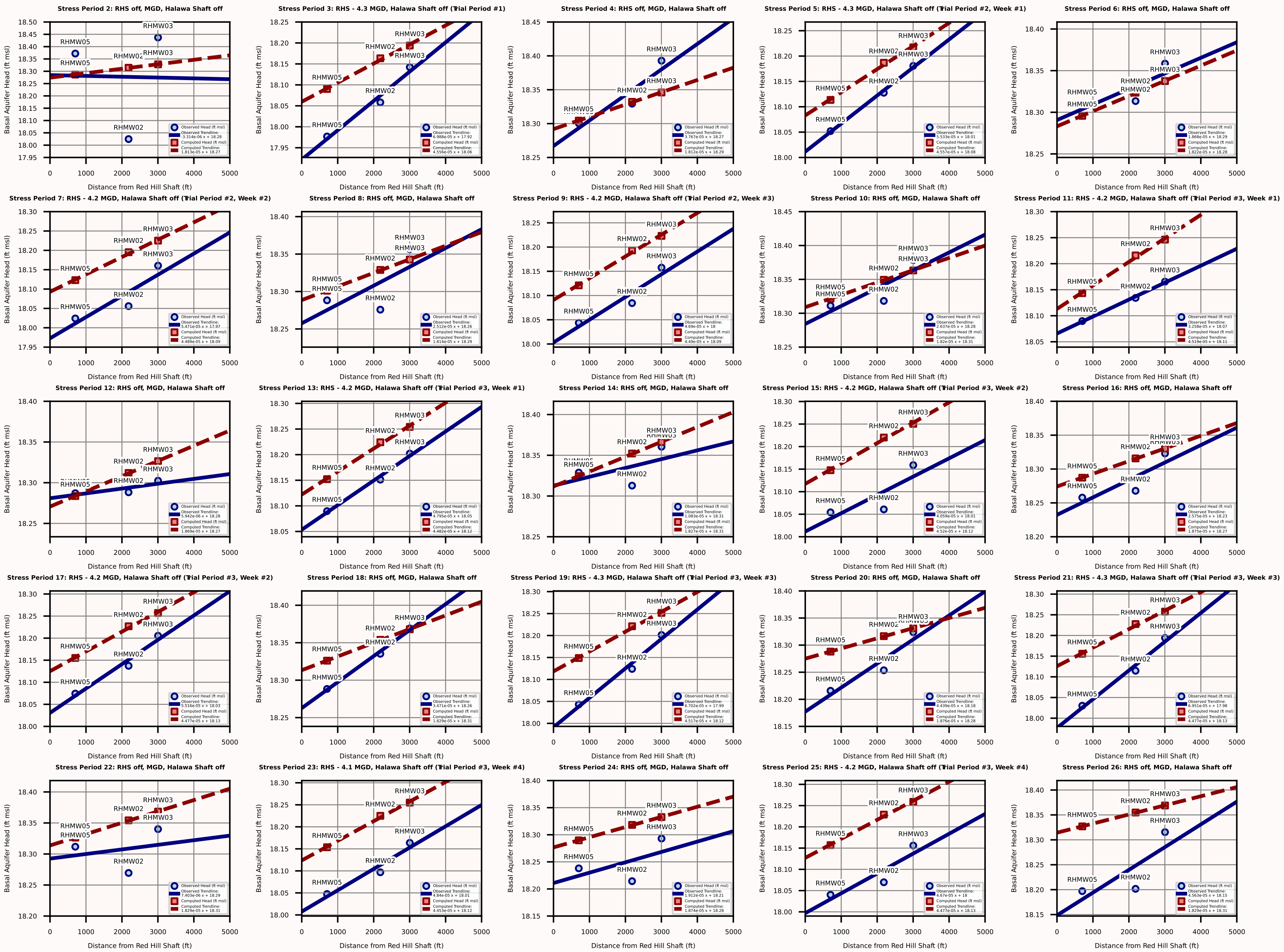


Basal Aquifer Wells - Head
Perfect Match
0.3 ft
0.6 ft
0.9 ft
Simulated Head (ft msl)
Observed Head (ft msl)
16.5
17.0
17.5
18.0
18.5
19.0
Residual [ft]
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.5

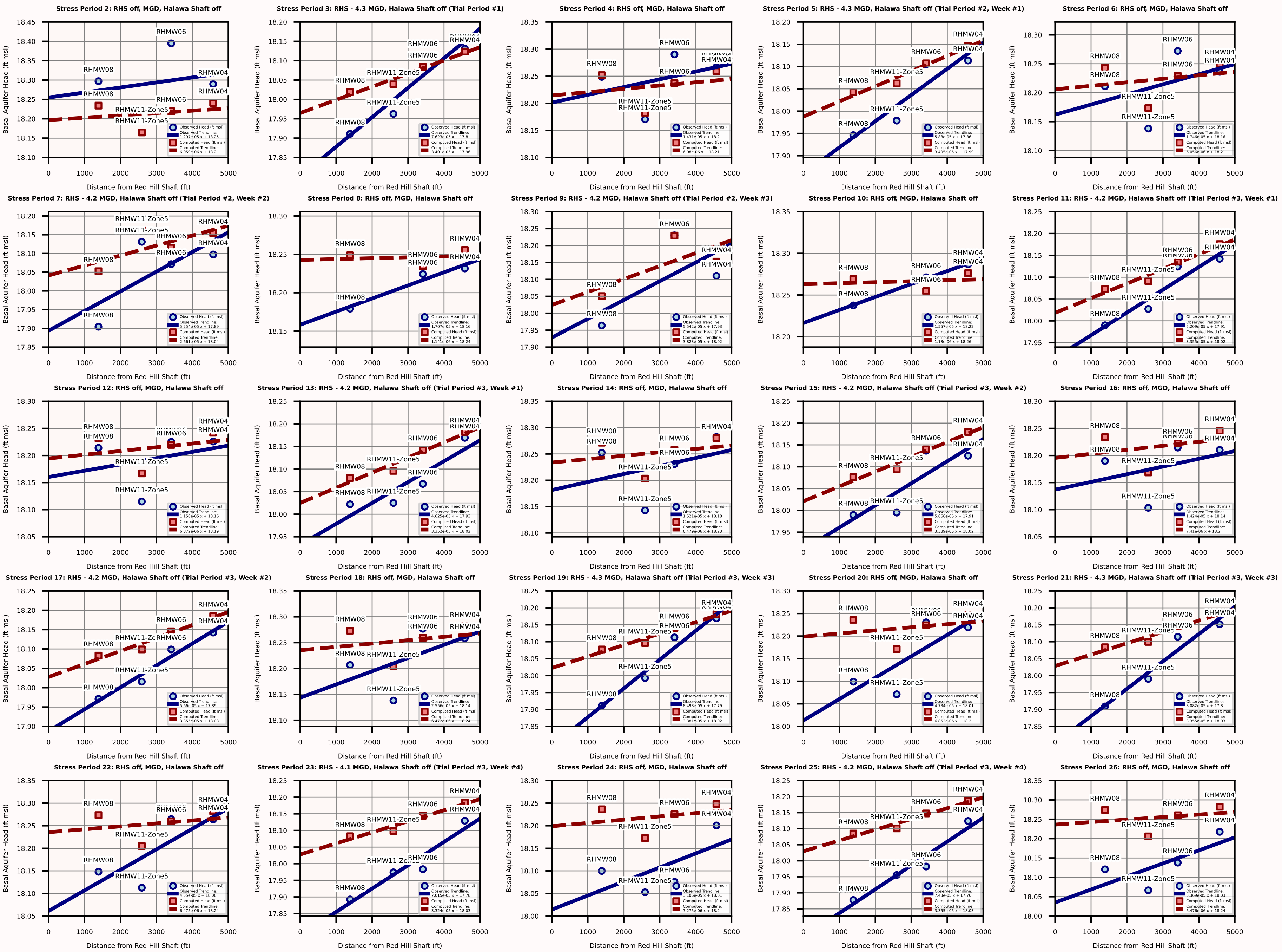
Basal Aquifer Wells - Drawdown

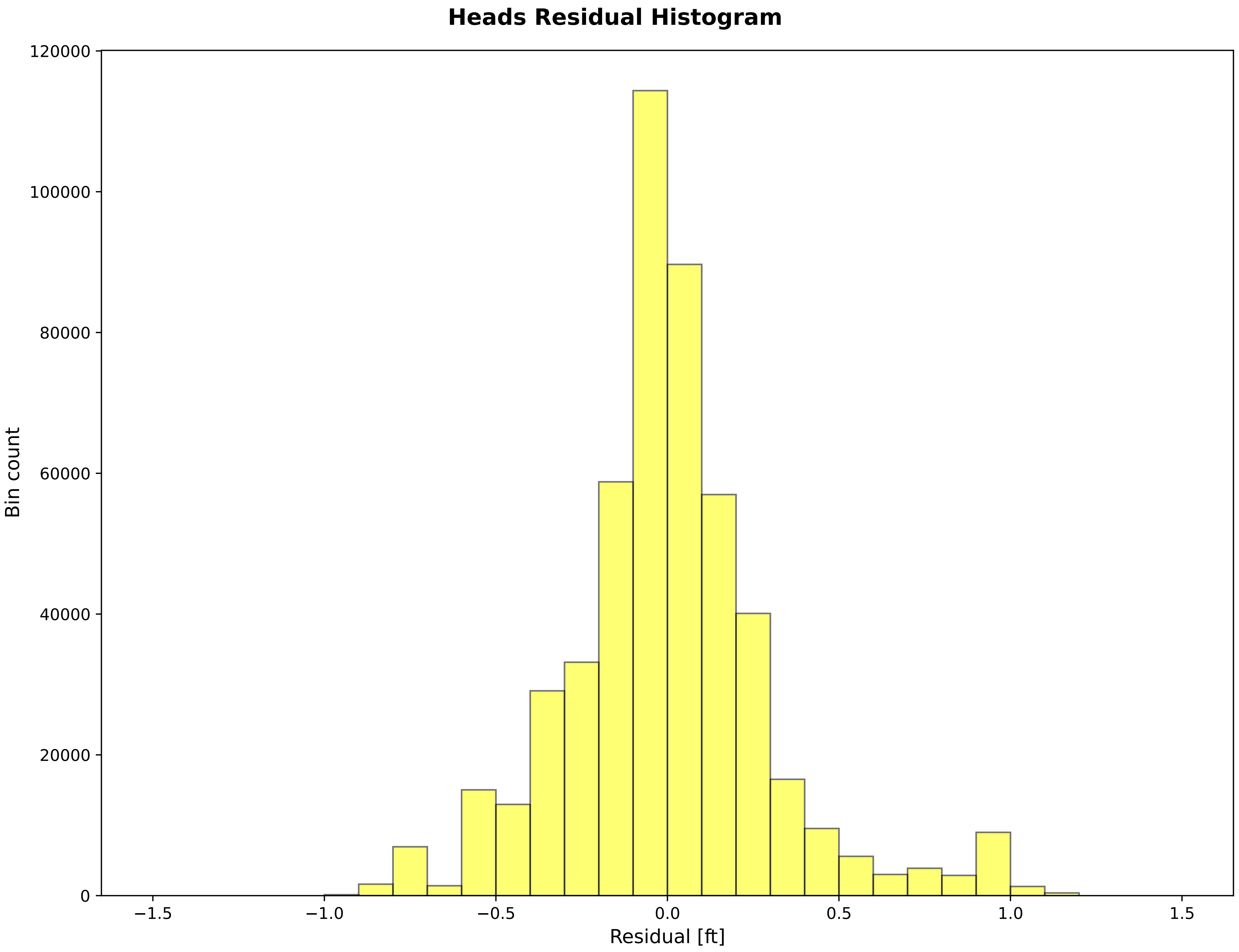


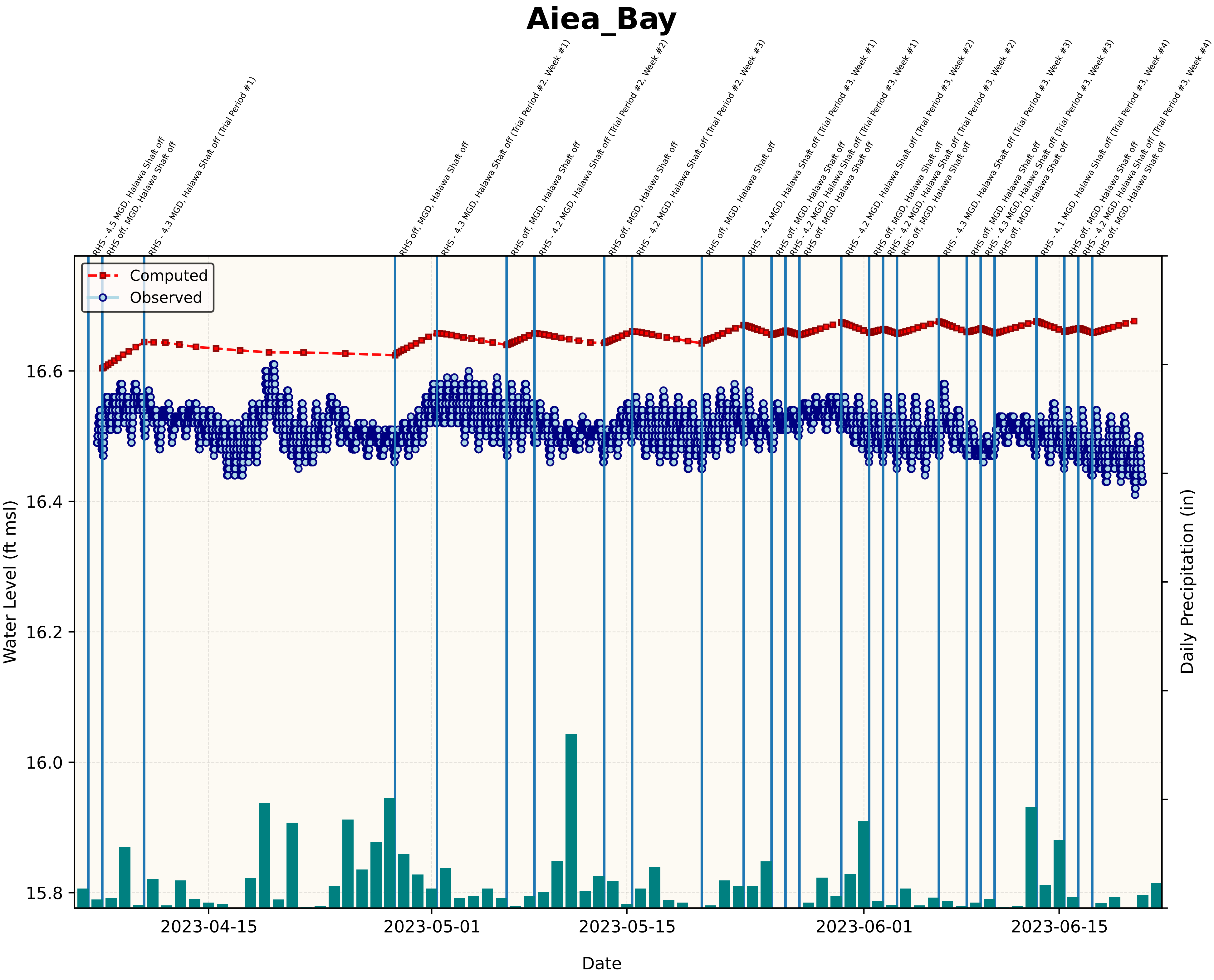
Gradients Along Red Hill Ridge



Gradients Northwest of Red Hill Ridge




Heads Residual Histogram
Bin count
Residual [ft]
0
20000
40000
60000
80000
100000
120000
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
RHS off, MGD, Halawa Shaft off
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RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
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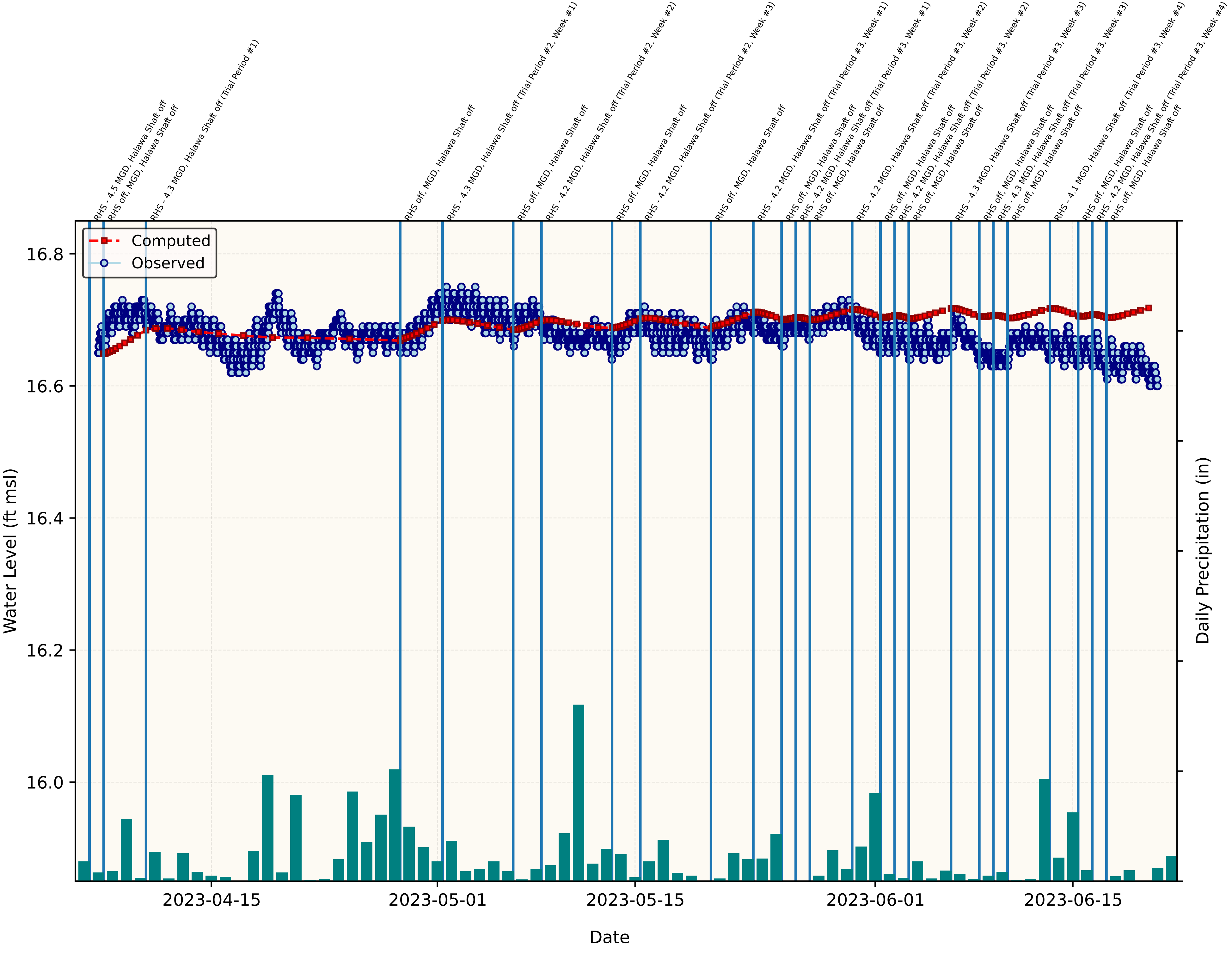
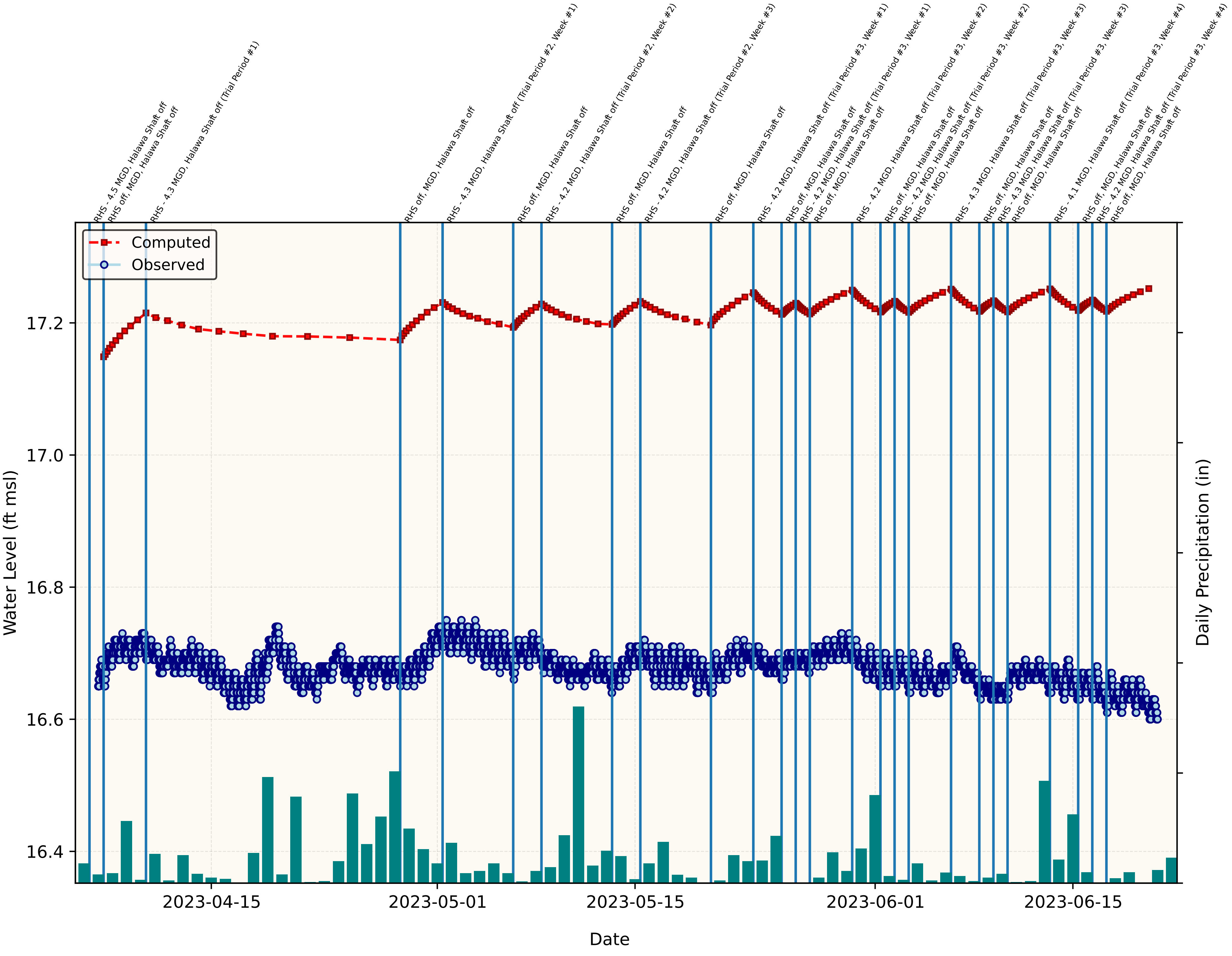
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
16.6
16.4
16.2
16.0
15.8
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

Aiea_Halawa_Shaft



Halawa_TZ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RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
17.2
17.0
16.8
16.6
16.4
Daily Precipitation (in)
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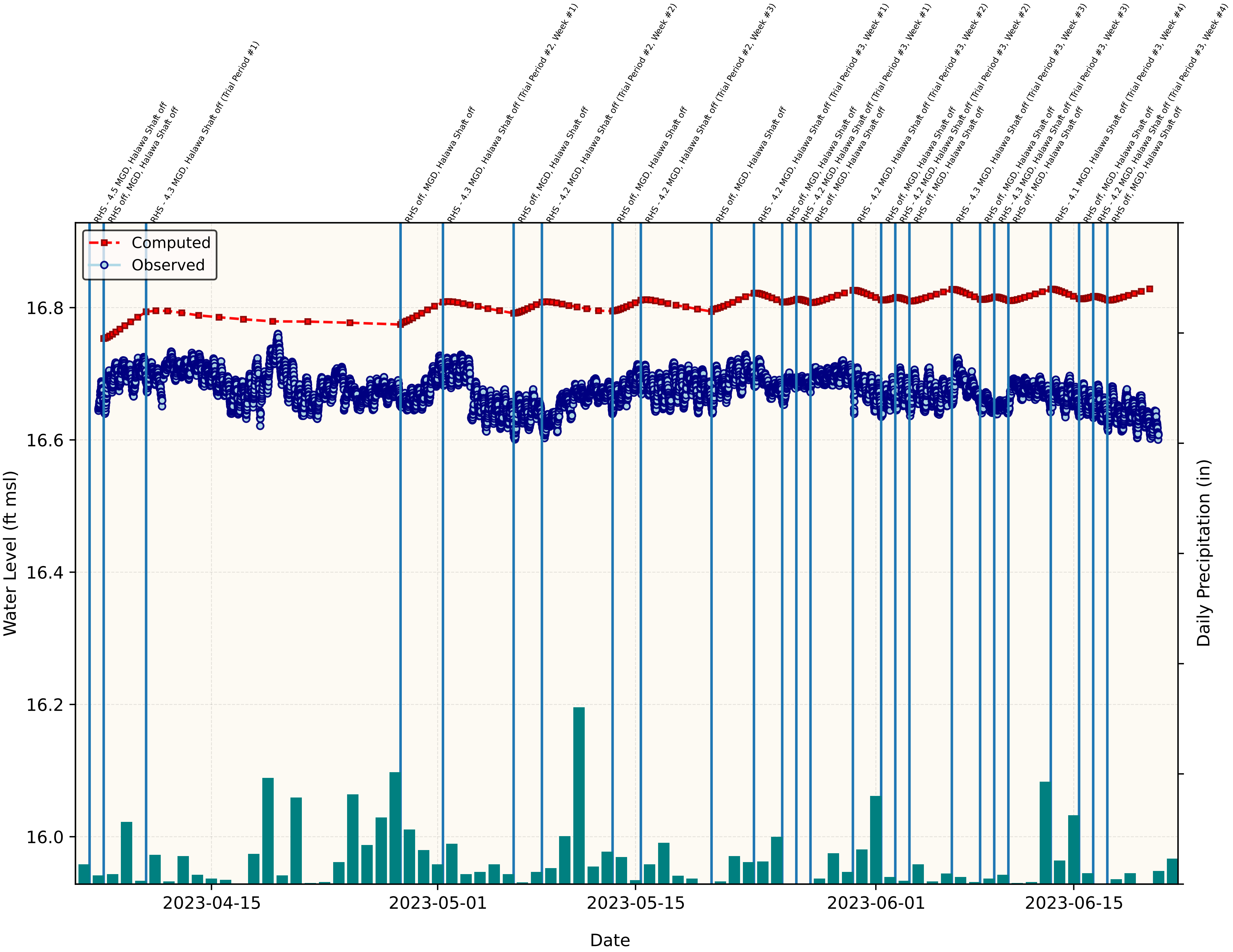
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

NMW24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RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
16.8
16.6
16.4
16.2
16.0
Daily Precipitation (in)
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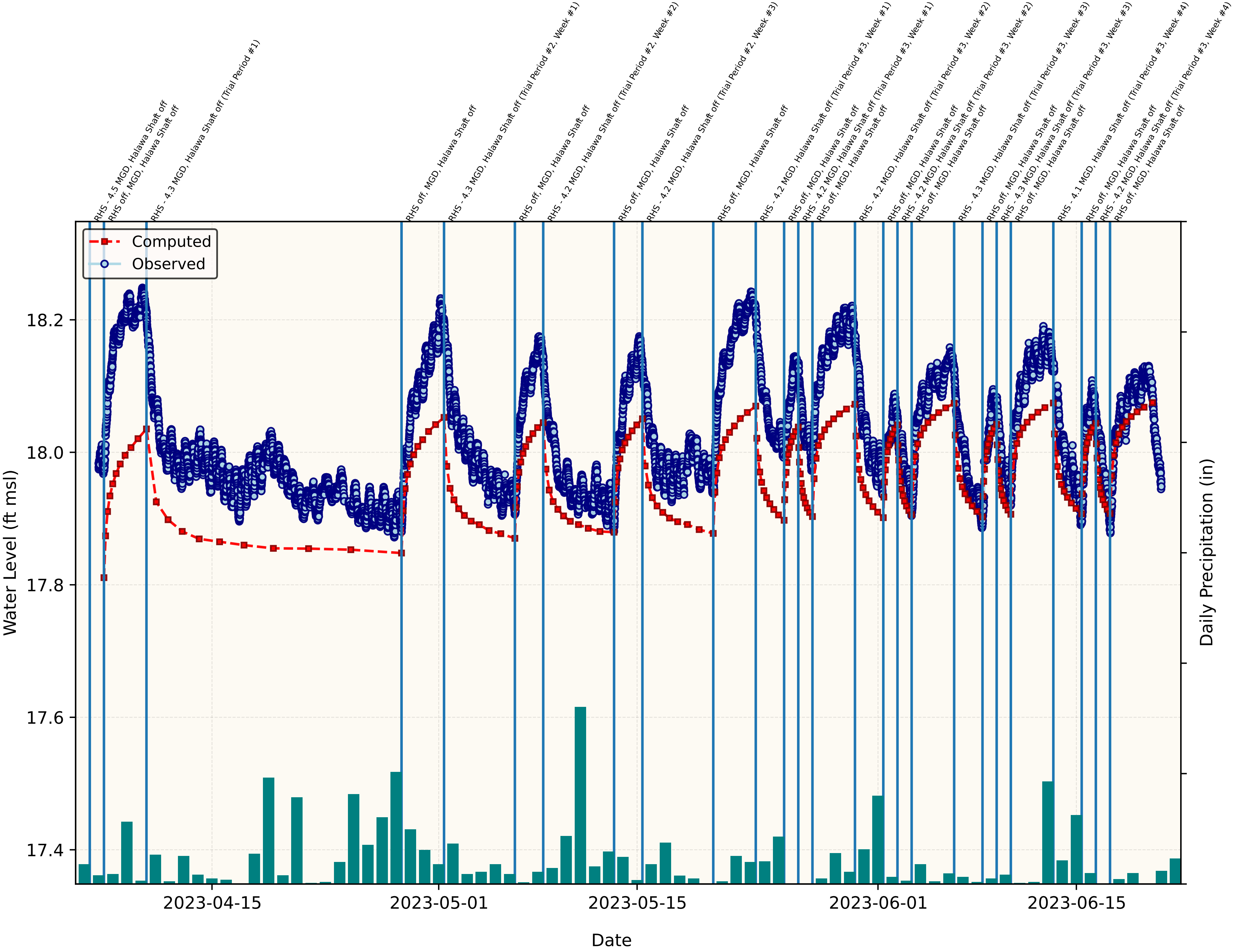
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

OWDFMW01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RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.2
18.0
17.8
17.6
17.4
Daily Precipitation (in)
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2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

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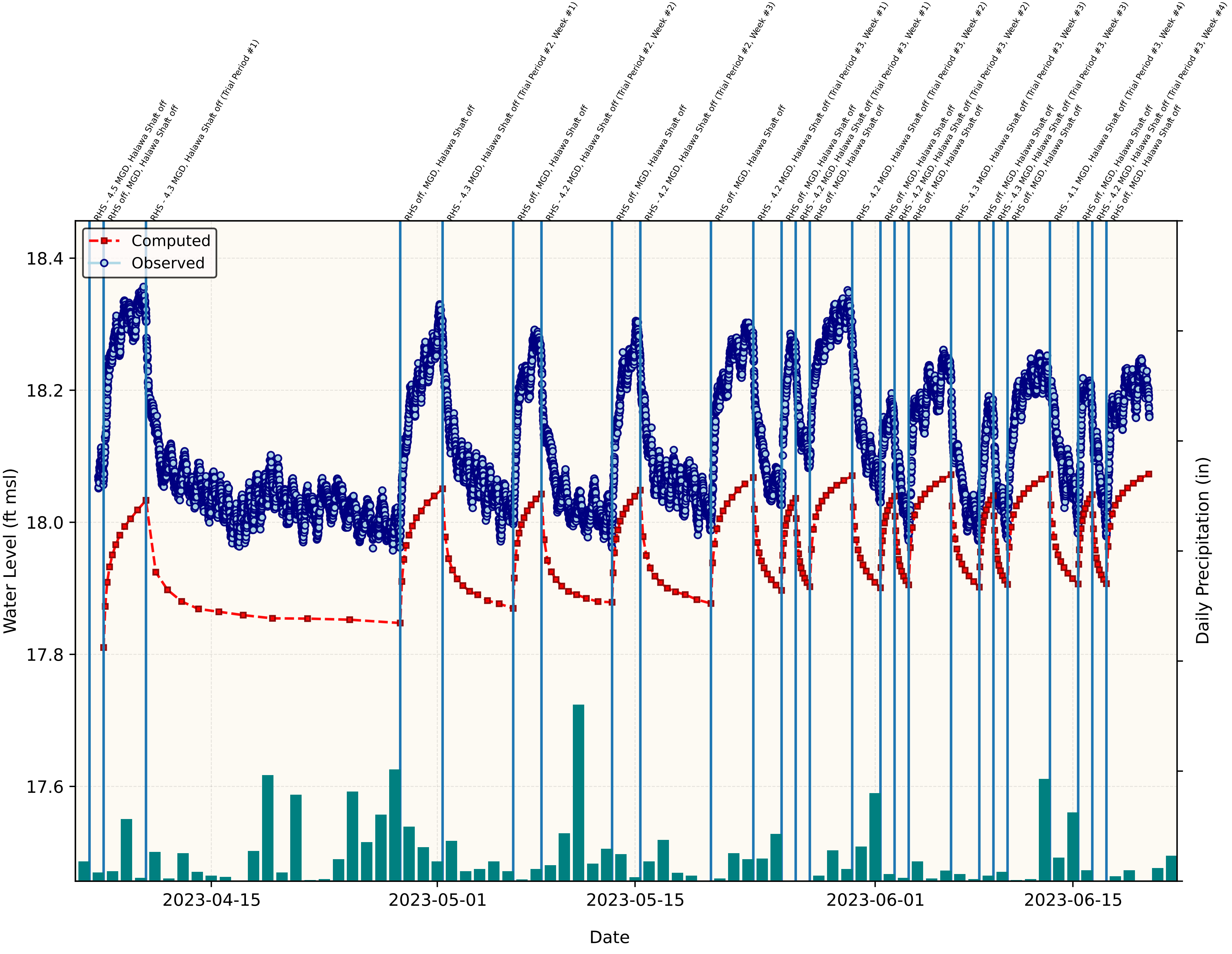
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RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.4
18.2
18.0
17.8
17.6
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2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

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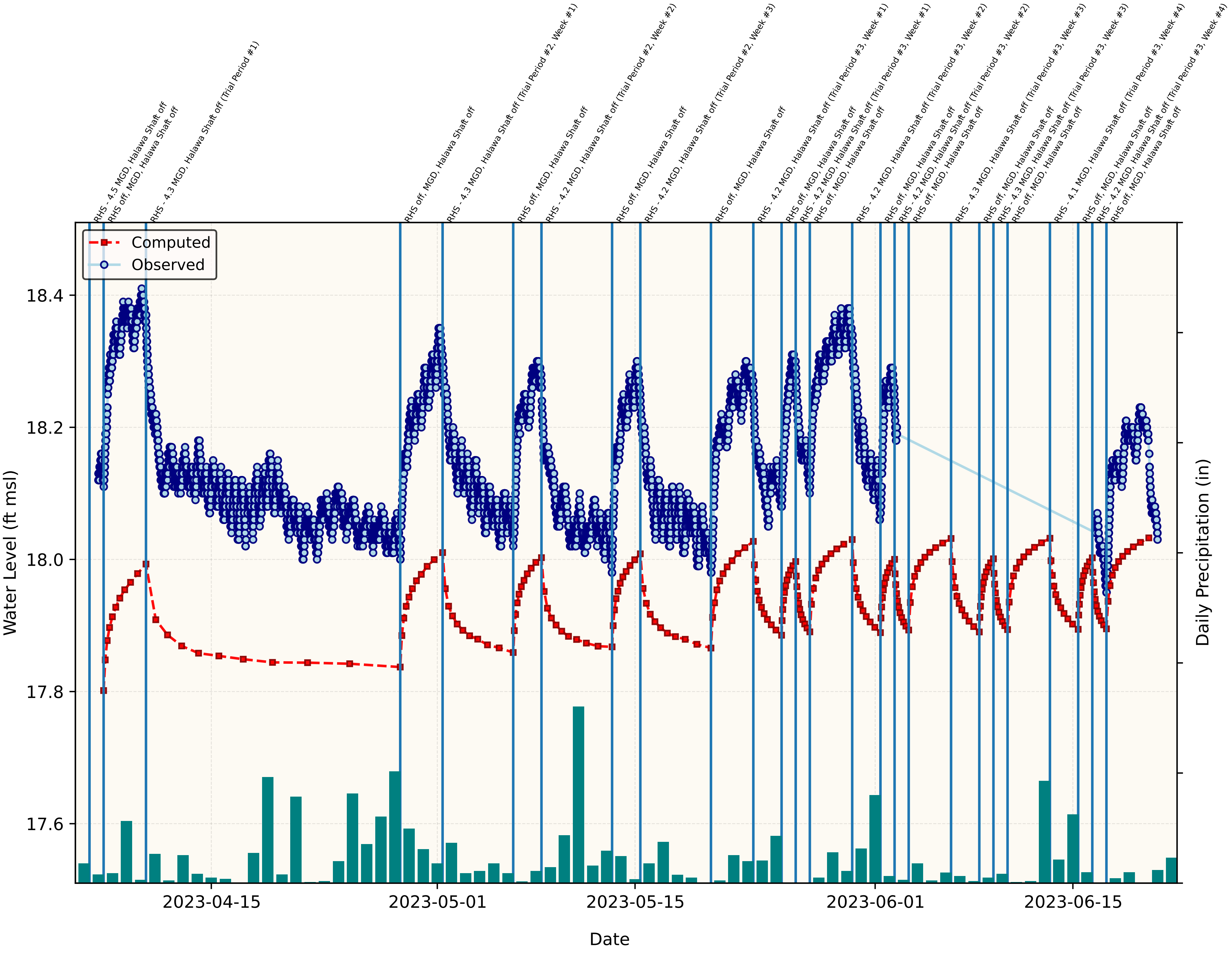
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.4
18.2
18.0
17.8
17.6
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

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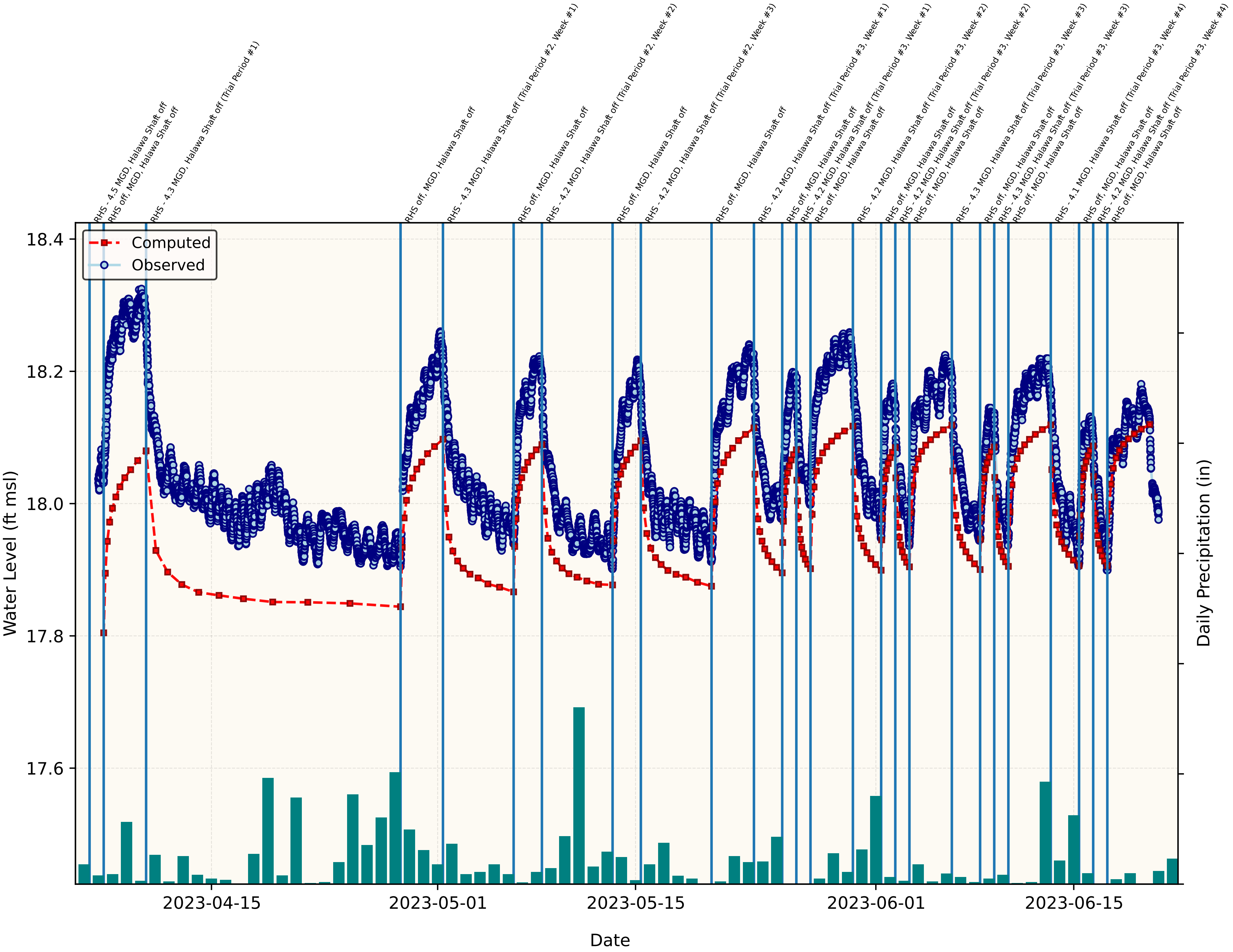

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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.4
18.2
18.0
17.8
17.6
Daily Precipitation (in)
2023-04-15
2023-05-01
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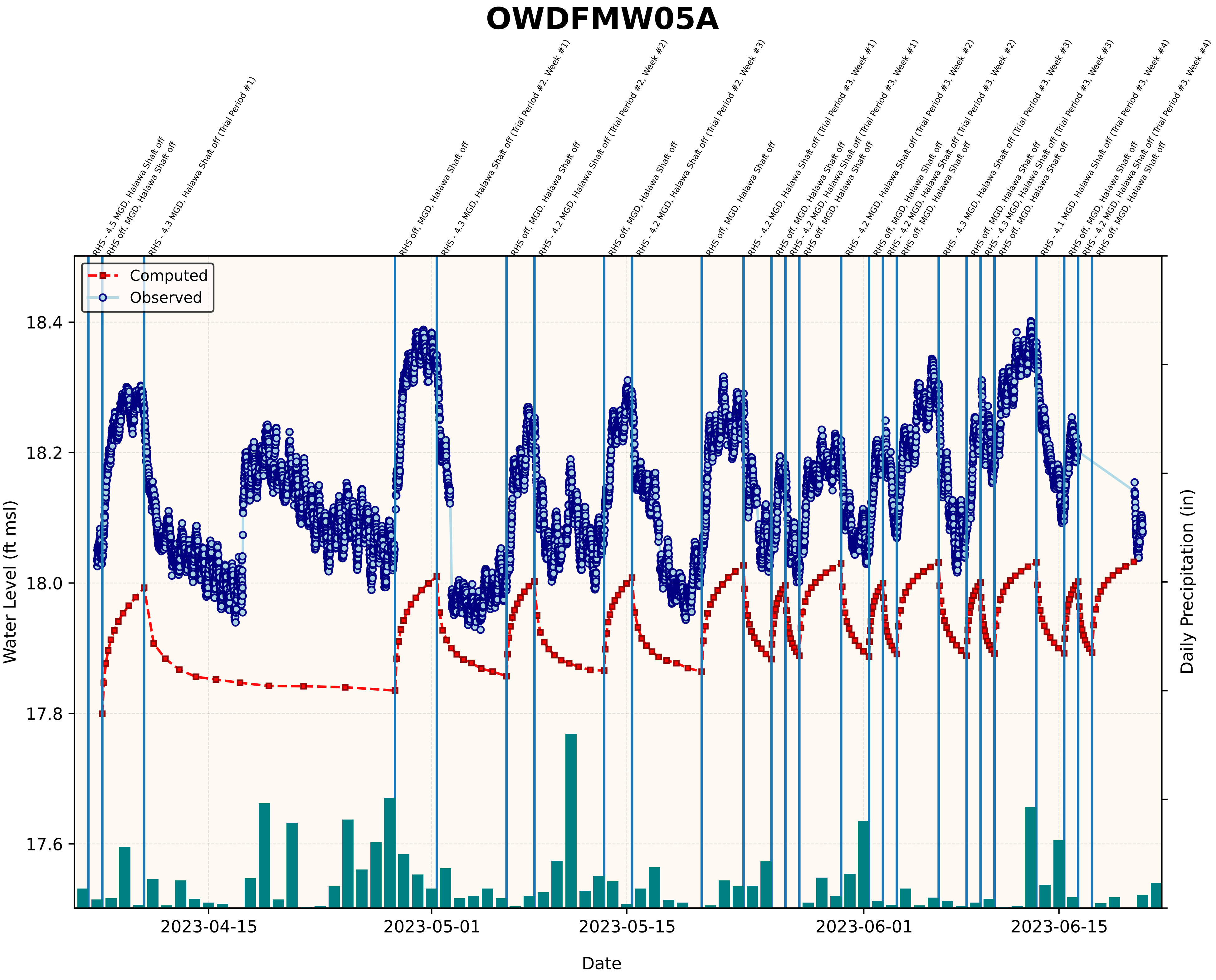
2023-06-15
Date

OWDFMW05A
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
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17.8
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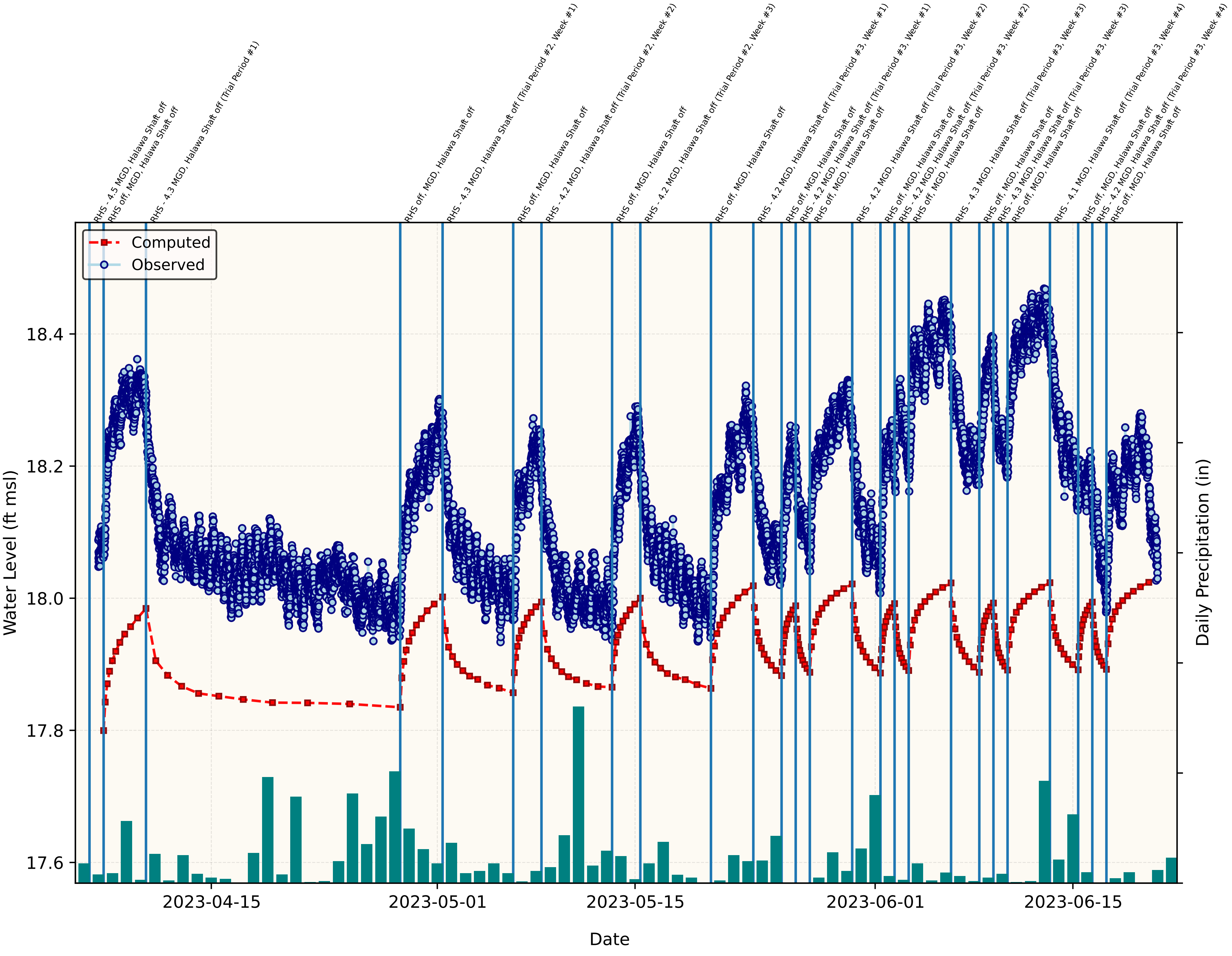
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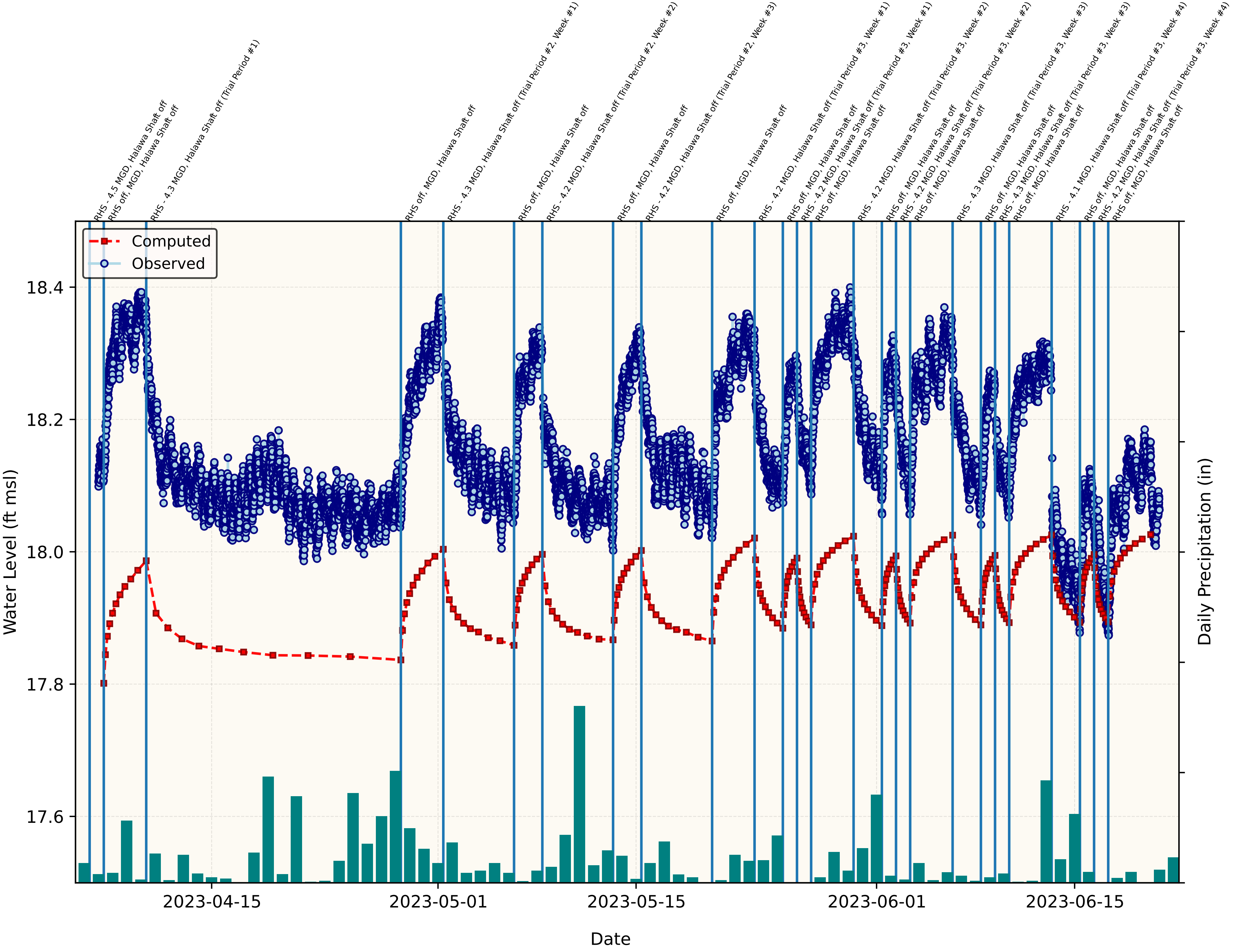
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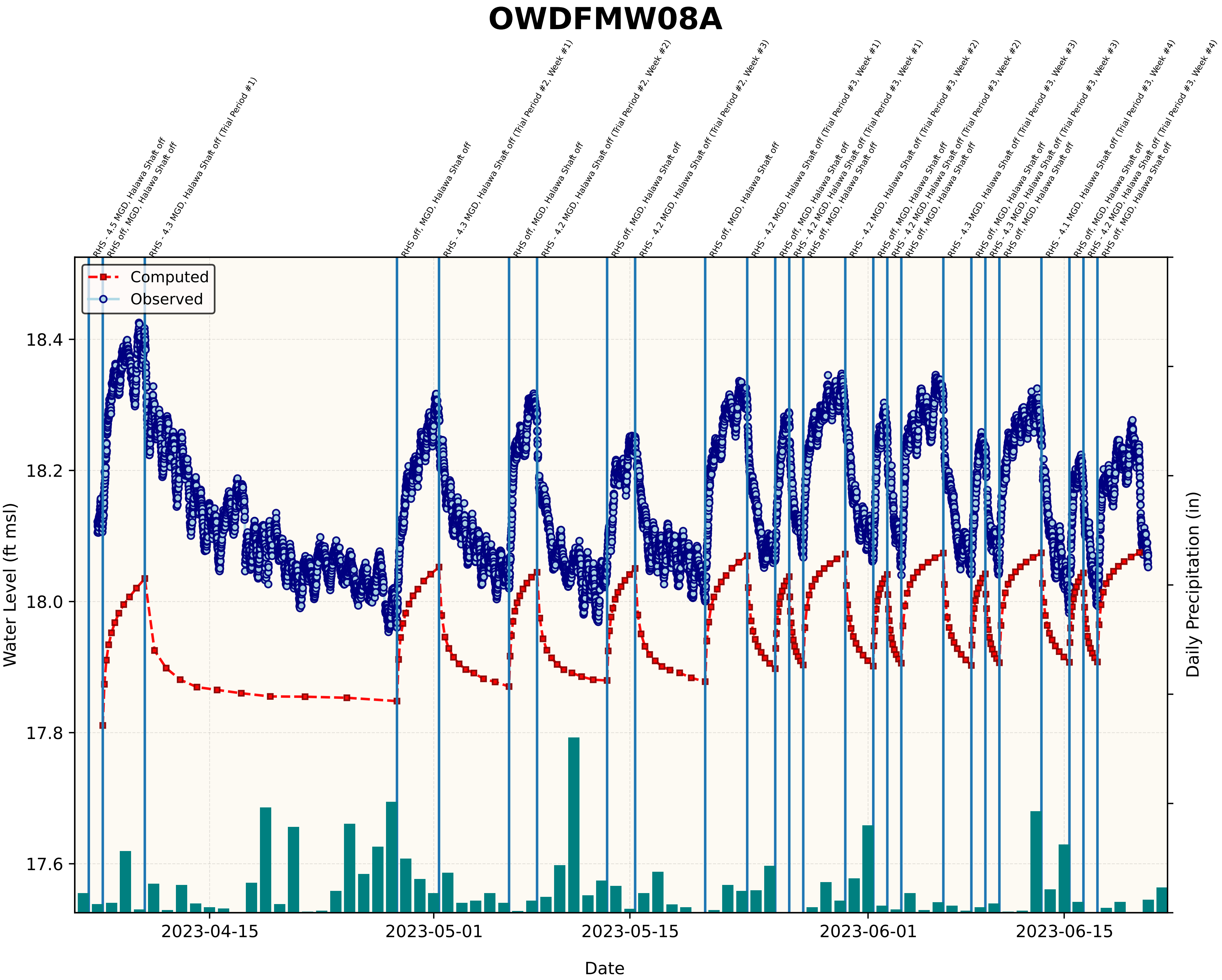
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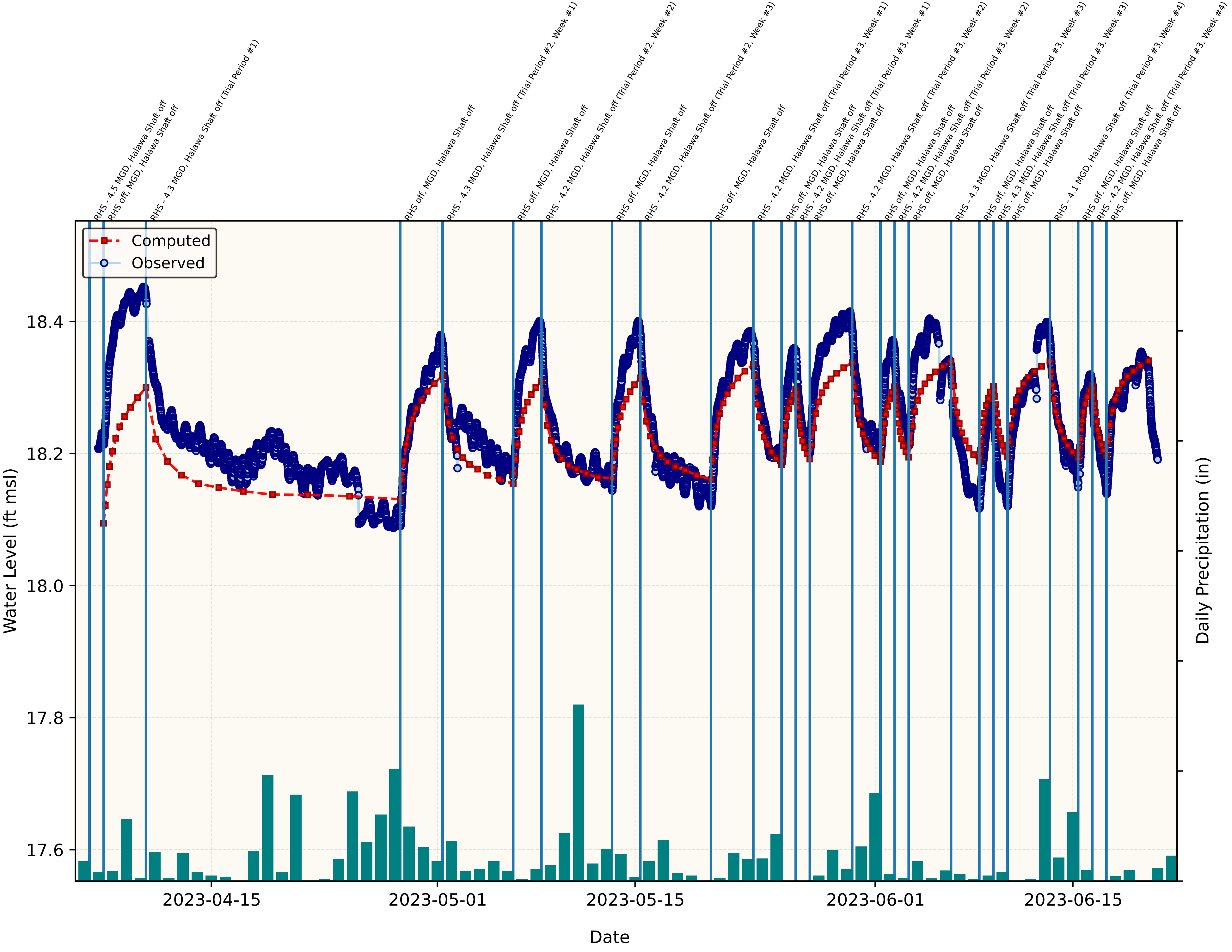
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Observed
Water Level (ft msl)
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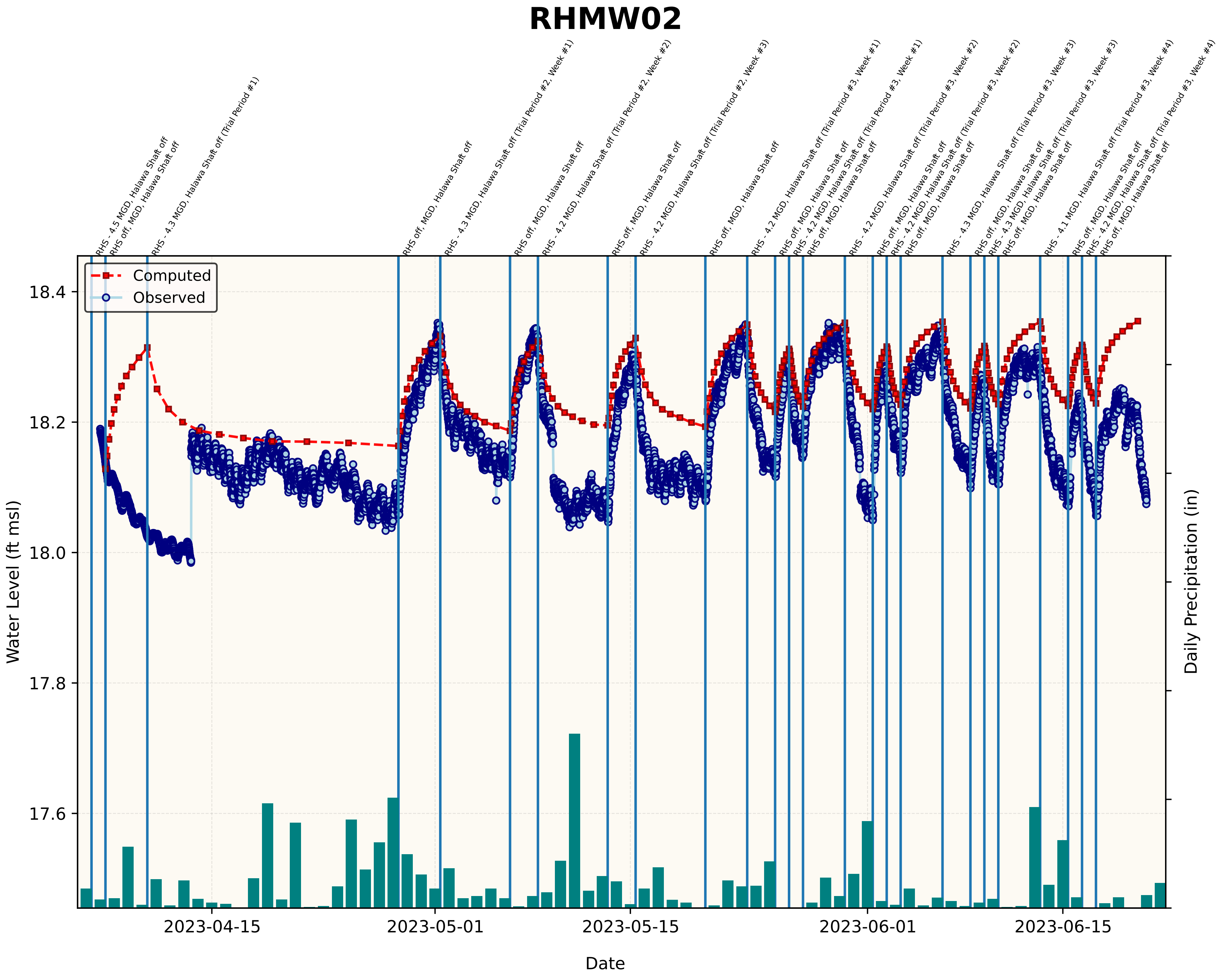
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Observed
Water Level (ft msl)
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Daily Precipitation (in)
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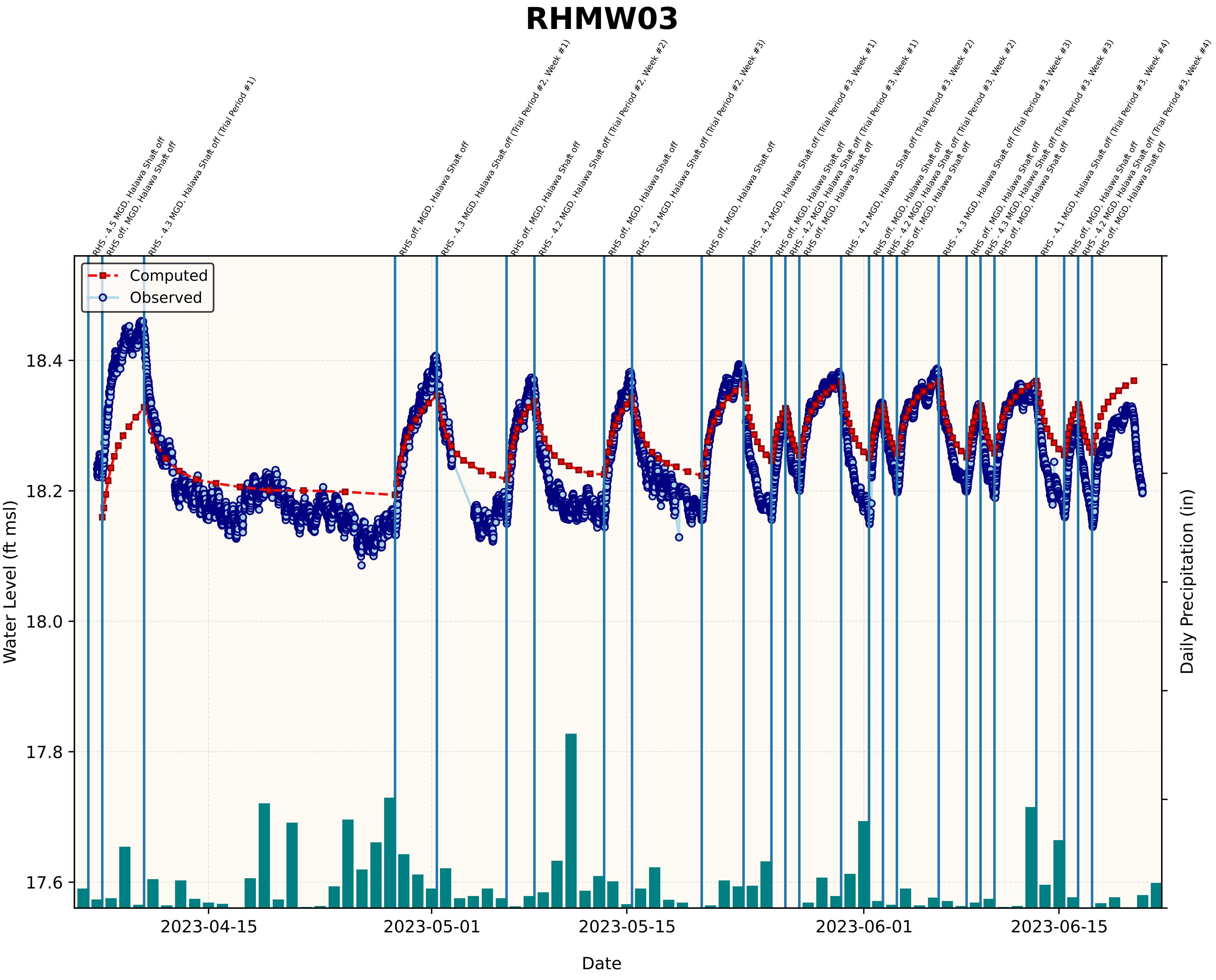RHMW03
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Observed
Water Level (ft msl)
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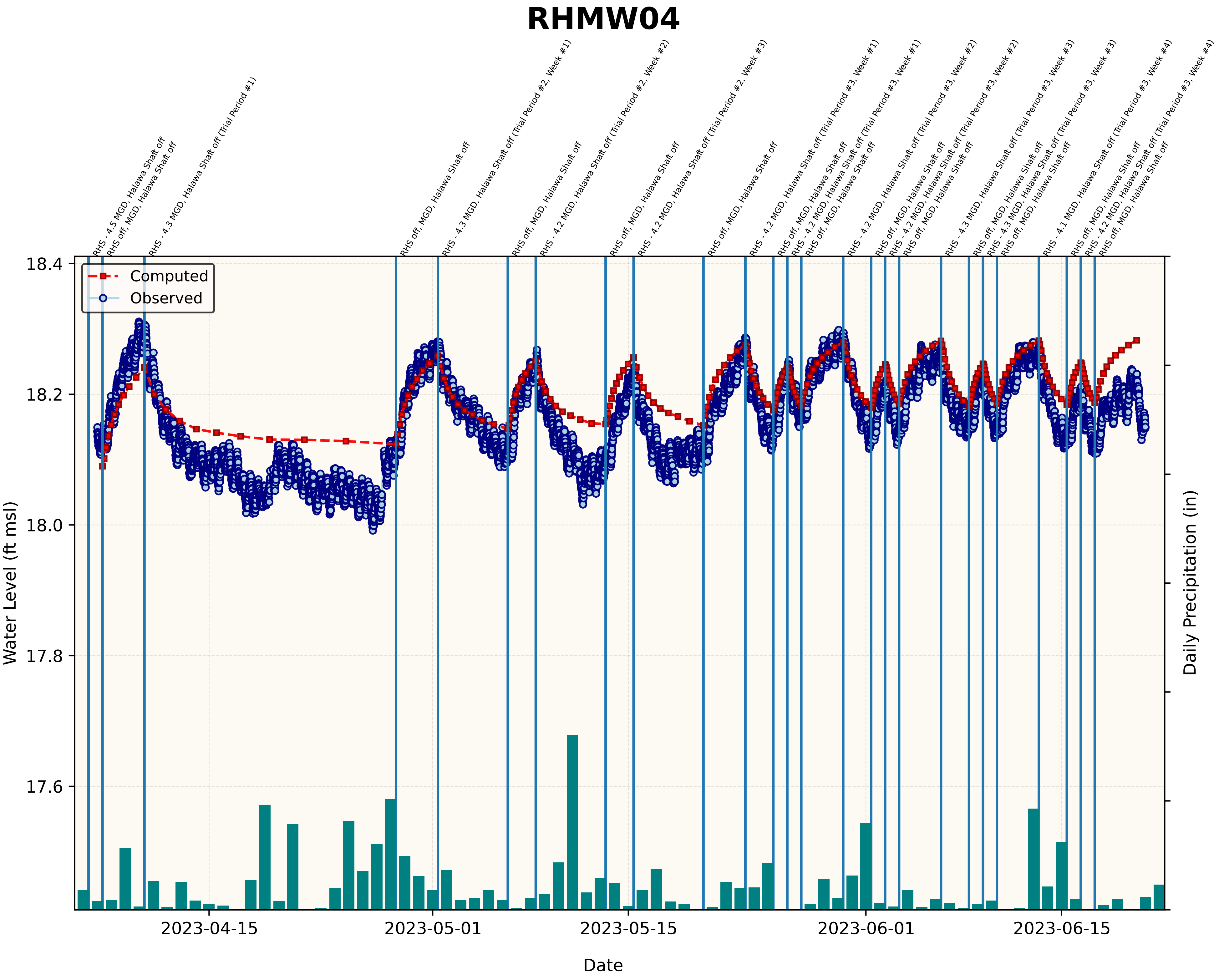RHMW04
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Observed
Water Level (ft msl)
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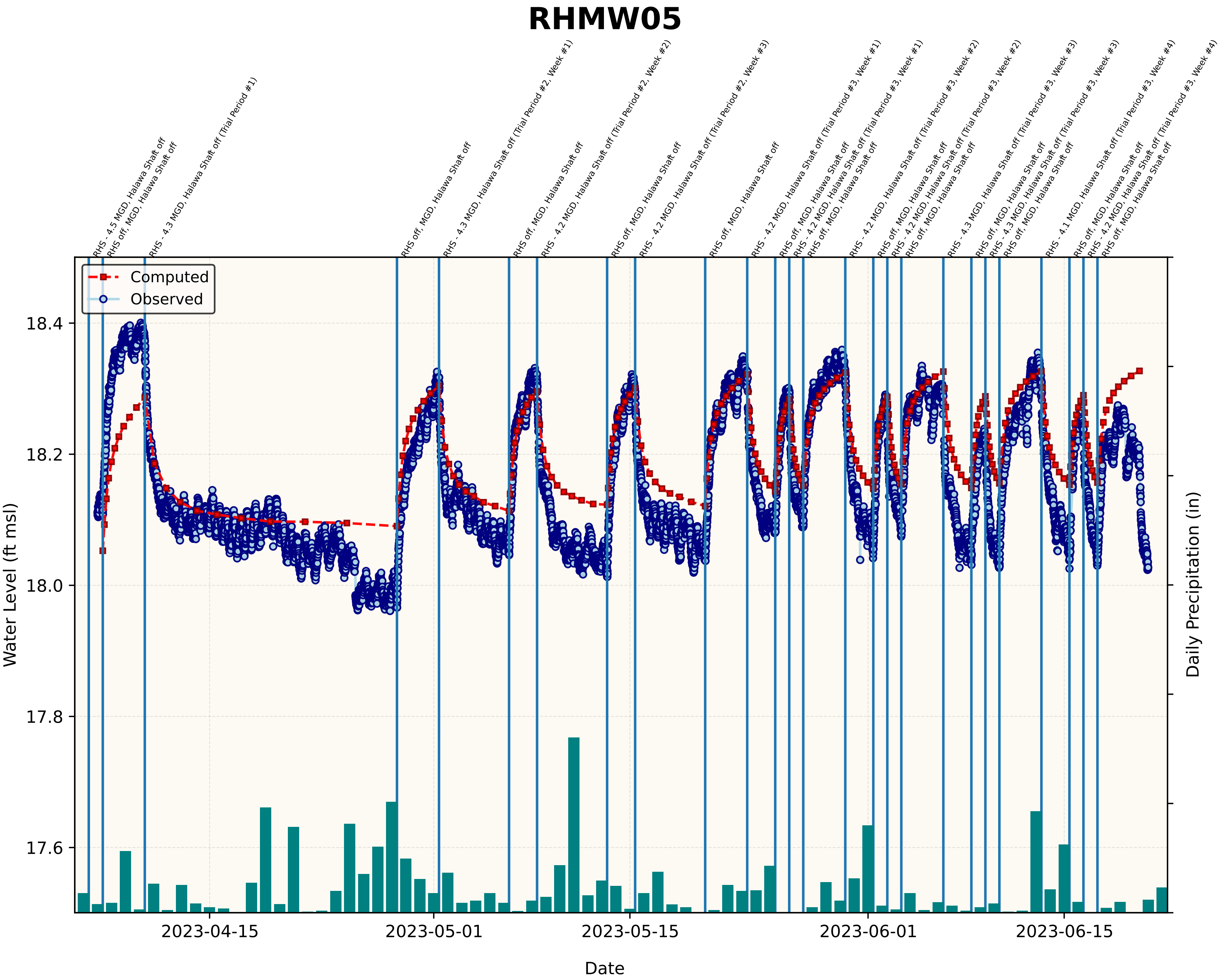
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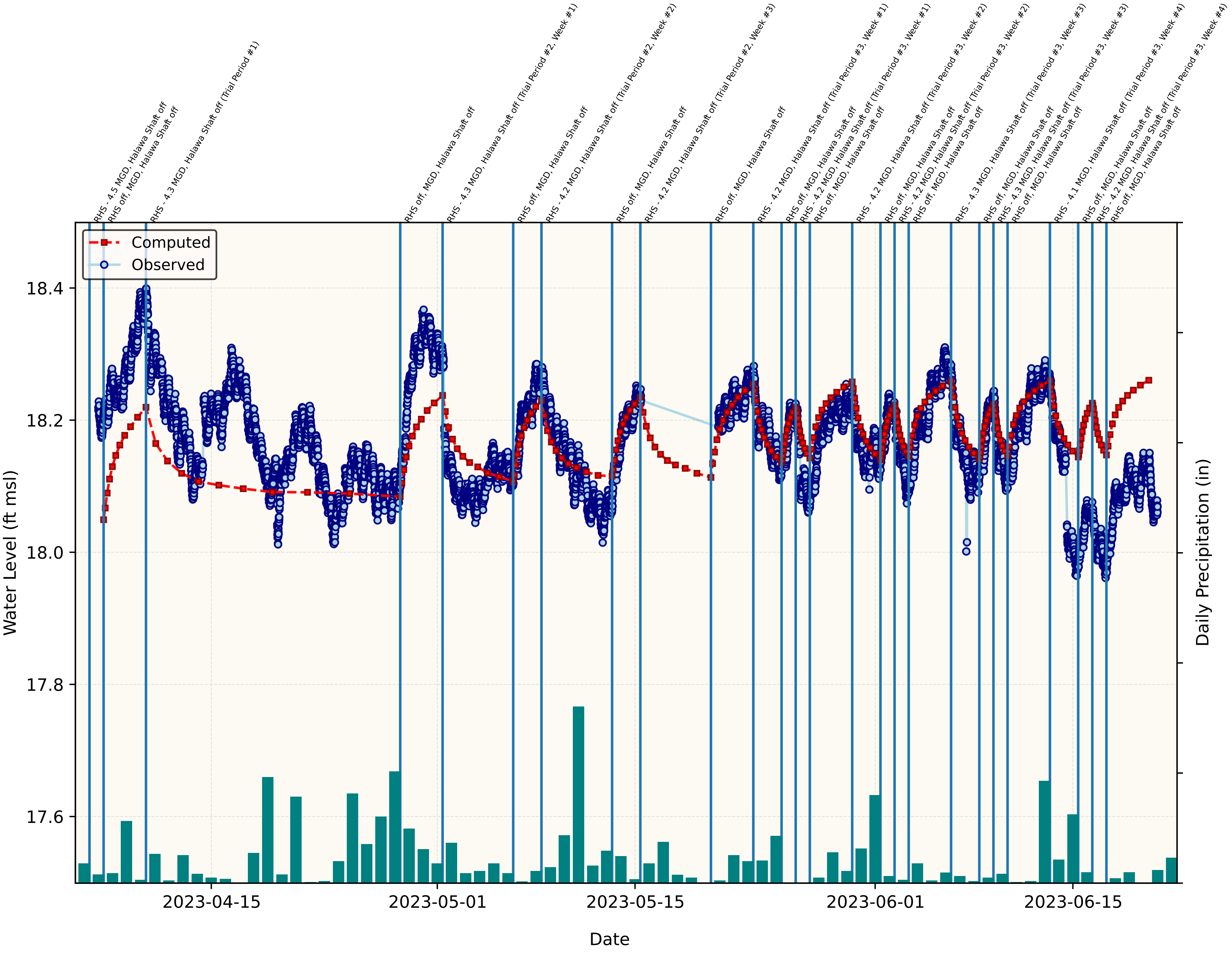

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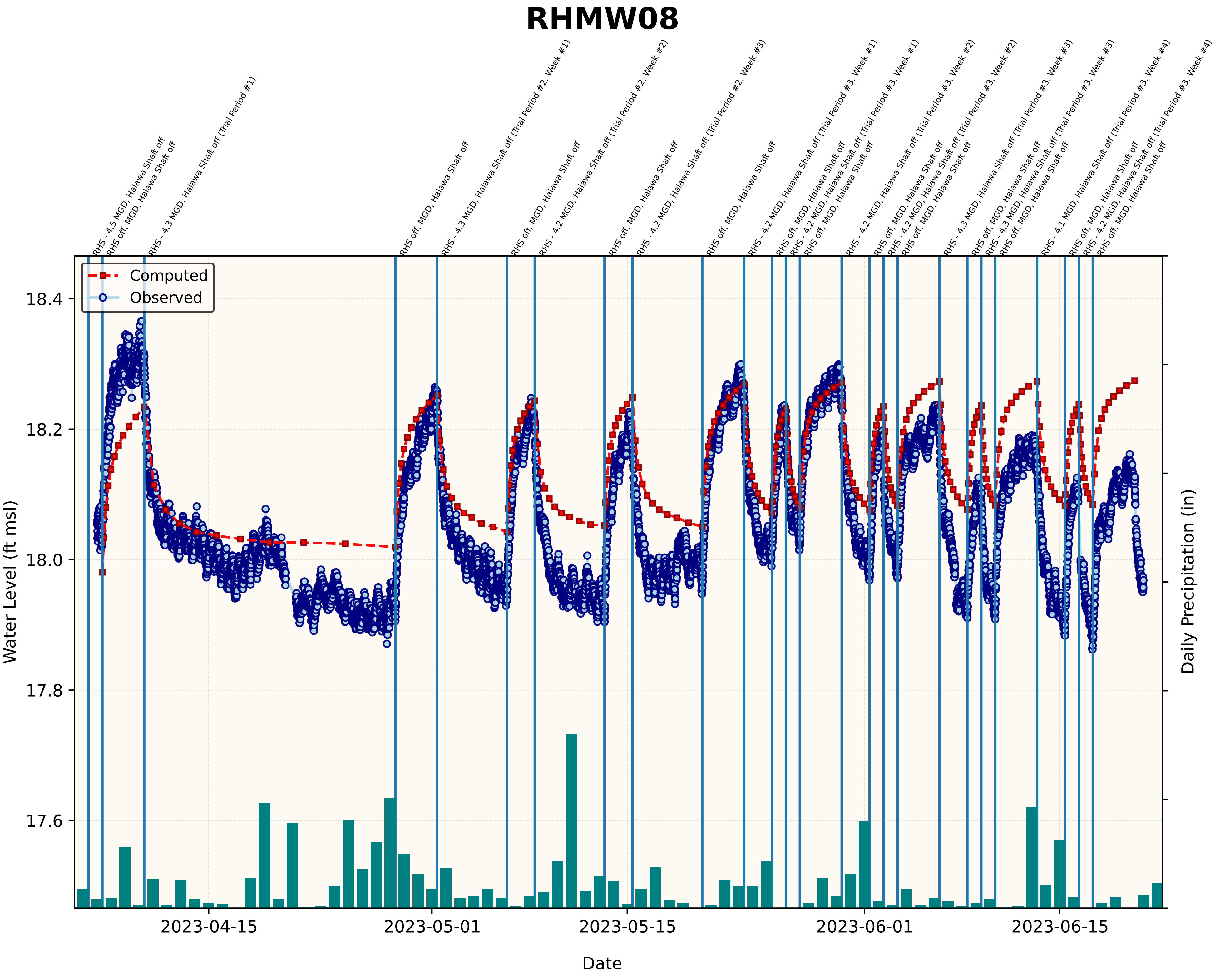
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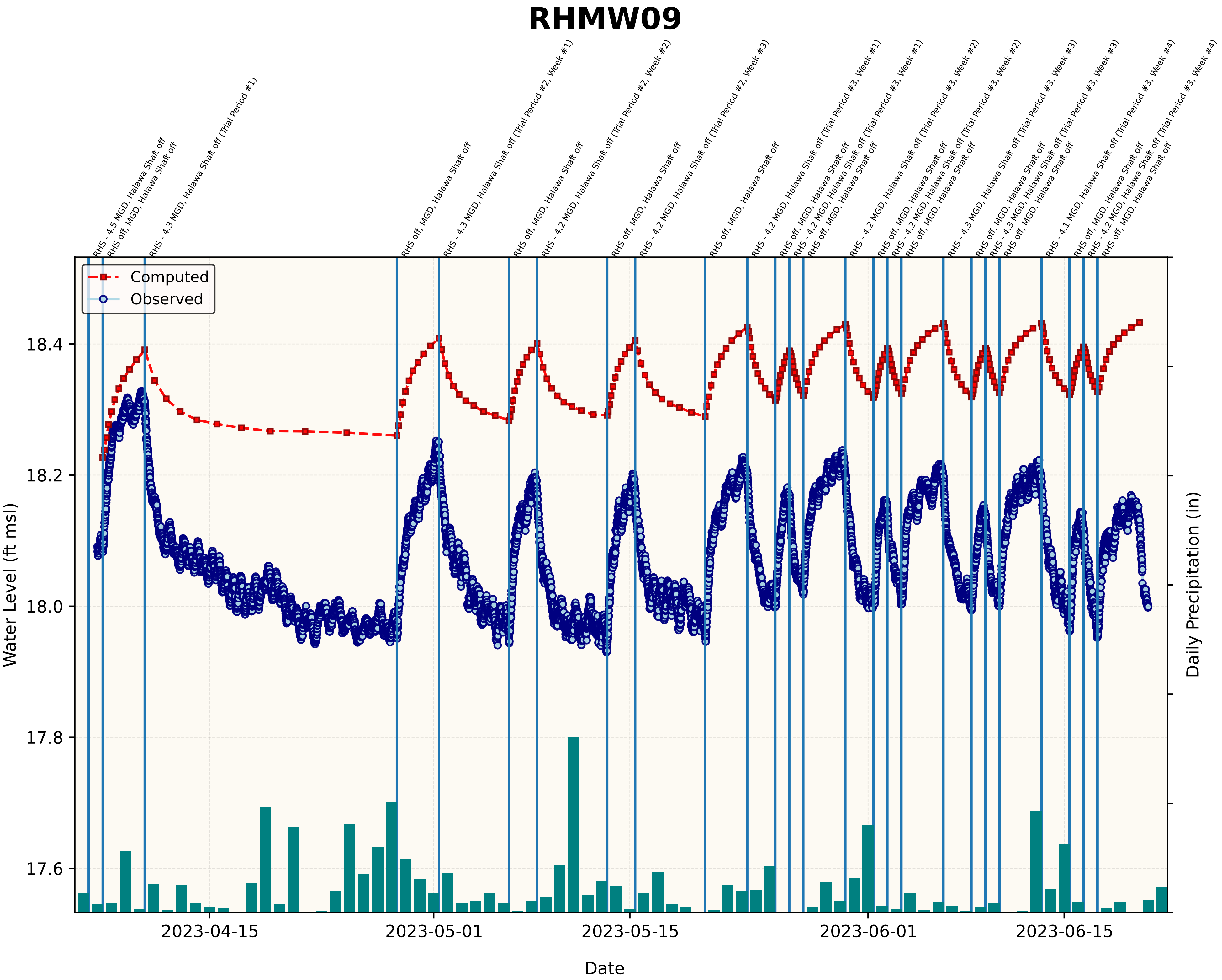
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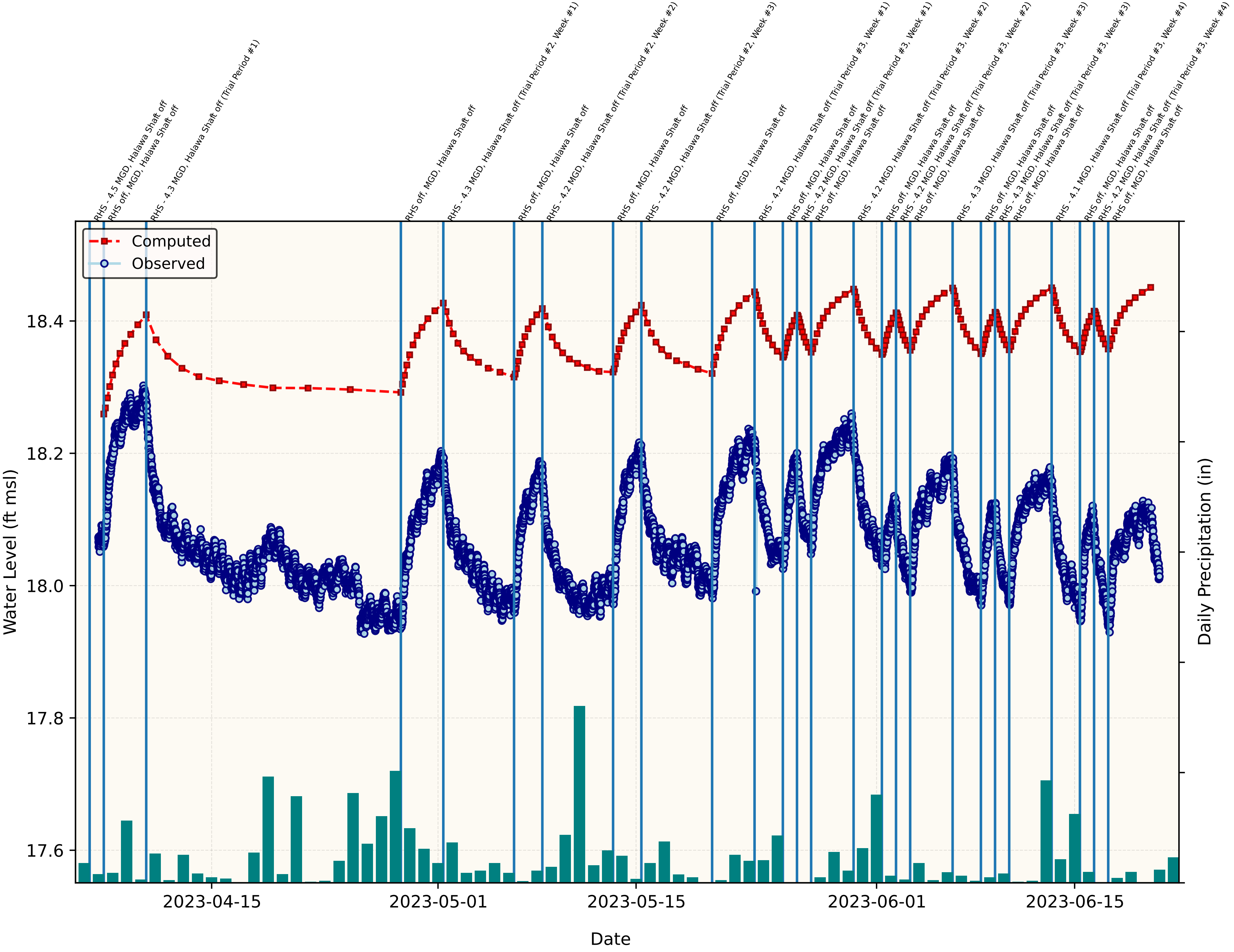
2023-06-15
Date

RHMW10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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
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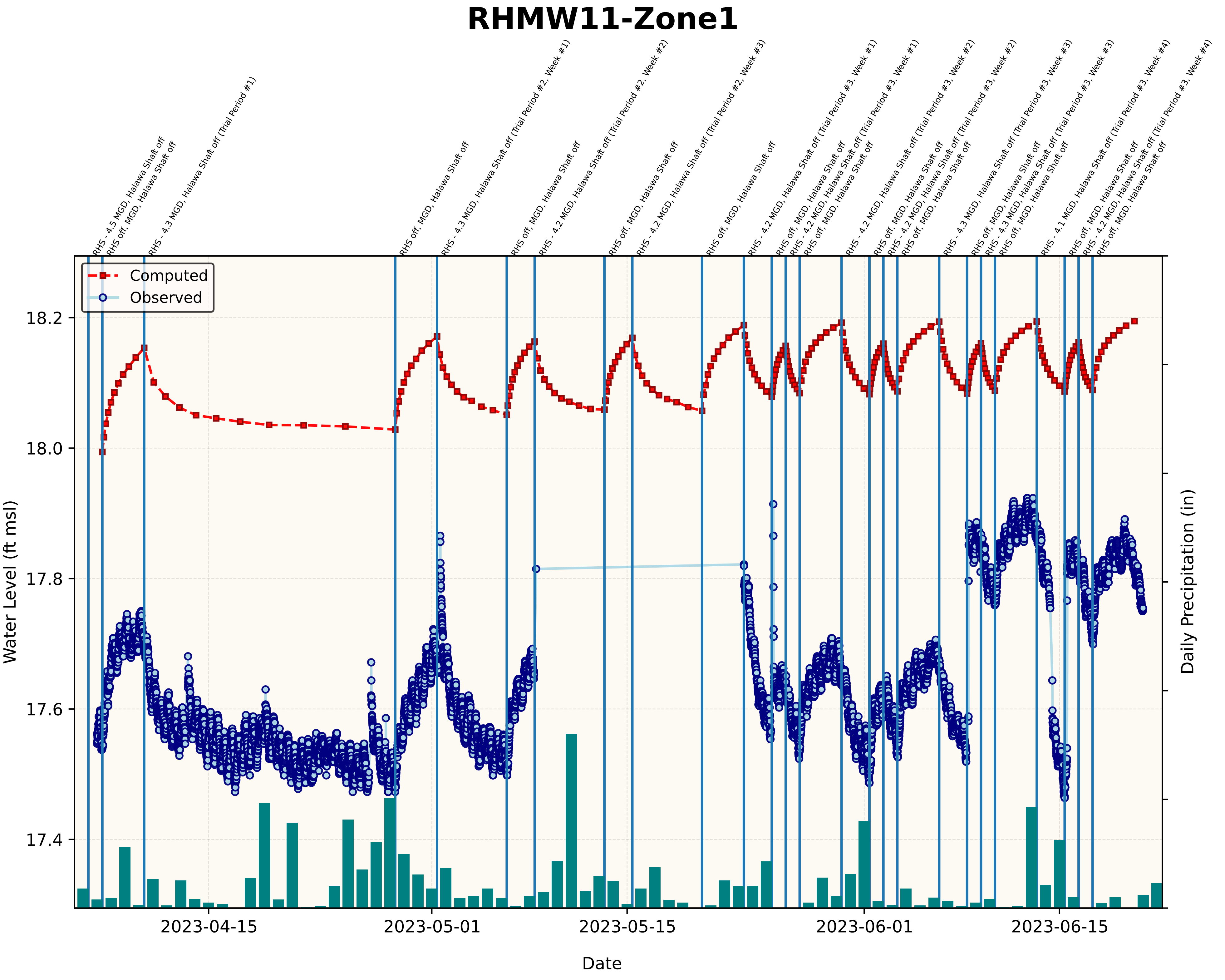
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.4
18.2
18.0
17.8
17.6
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
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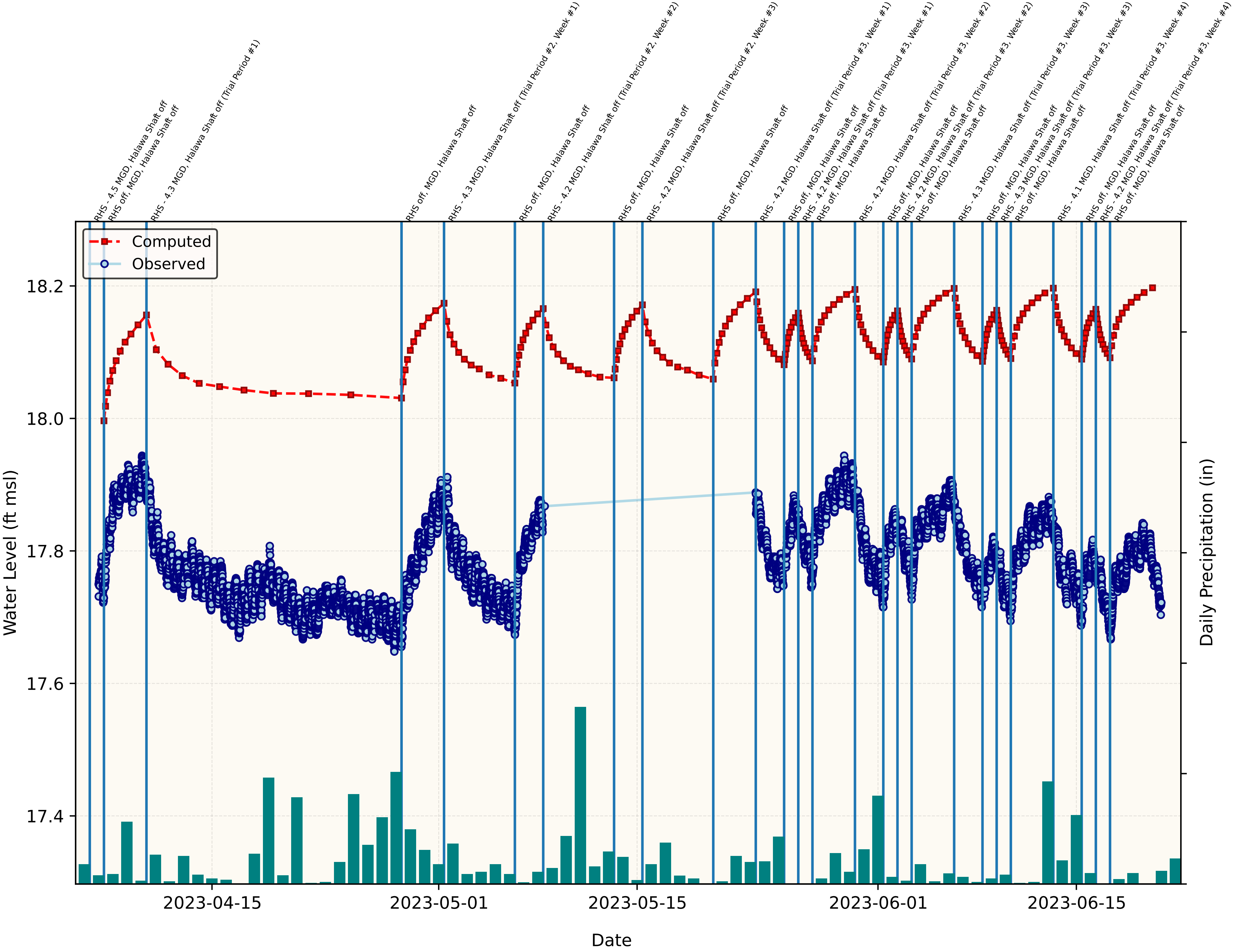
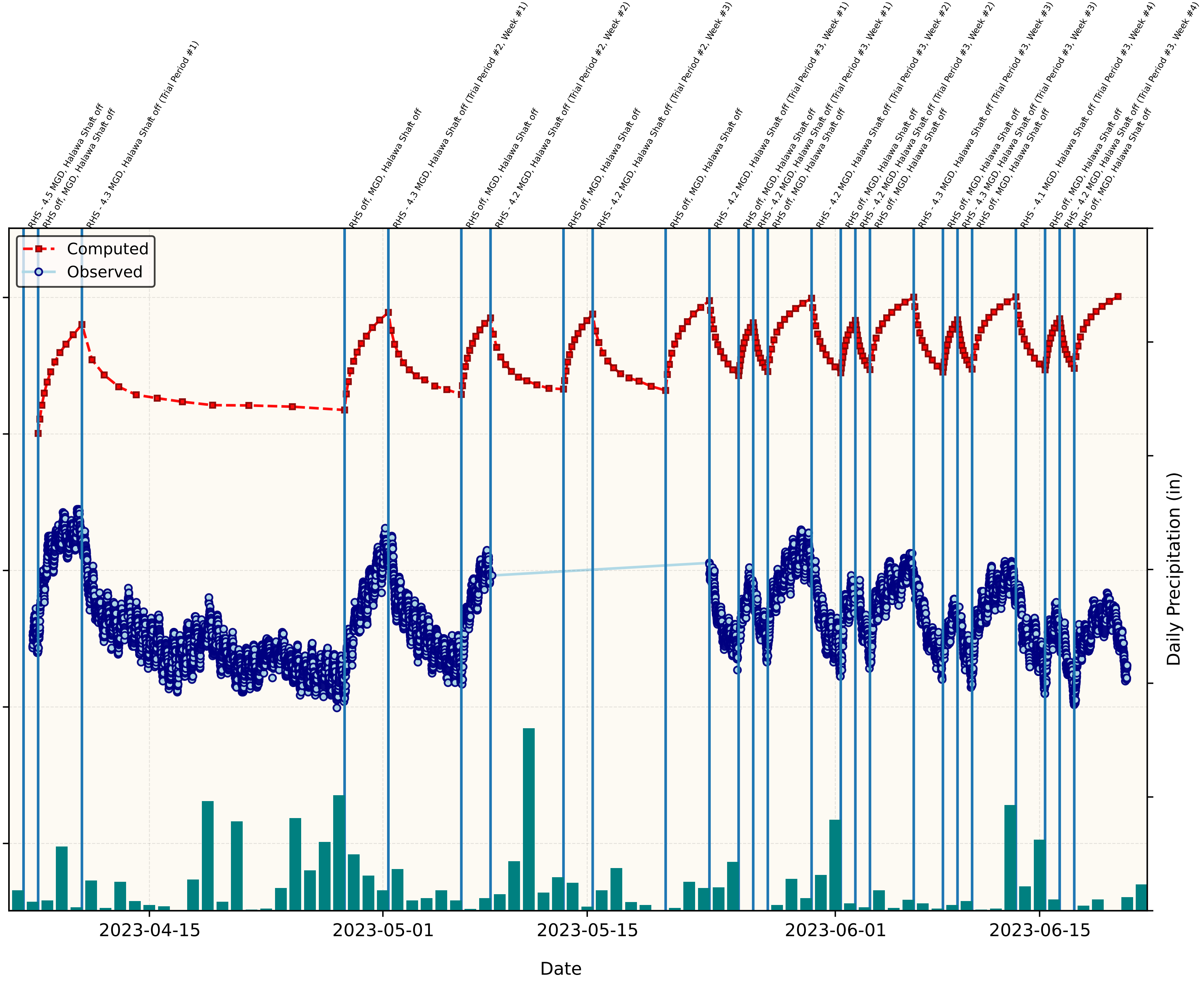
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.2
18.0
17.8
17.6
17.4
Daily Precipitation (in)
Date
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15

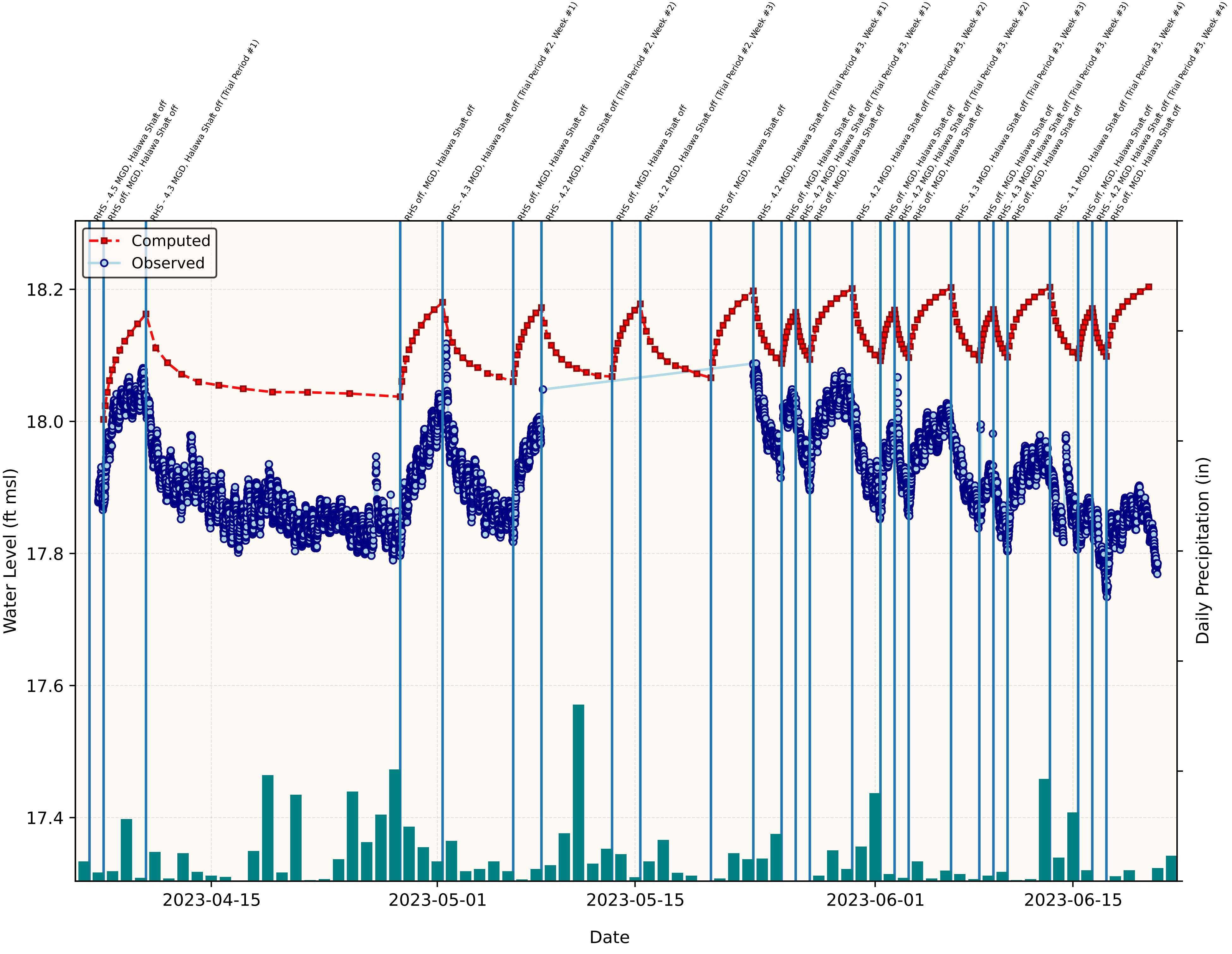
RHMW11-Zone2



RHMW11-Zone3



RHMW11-Zone4



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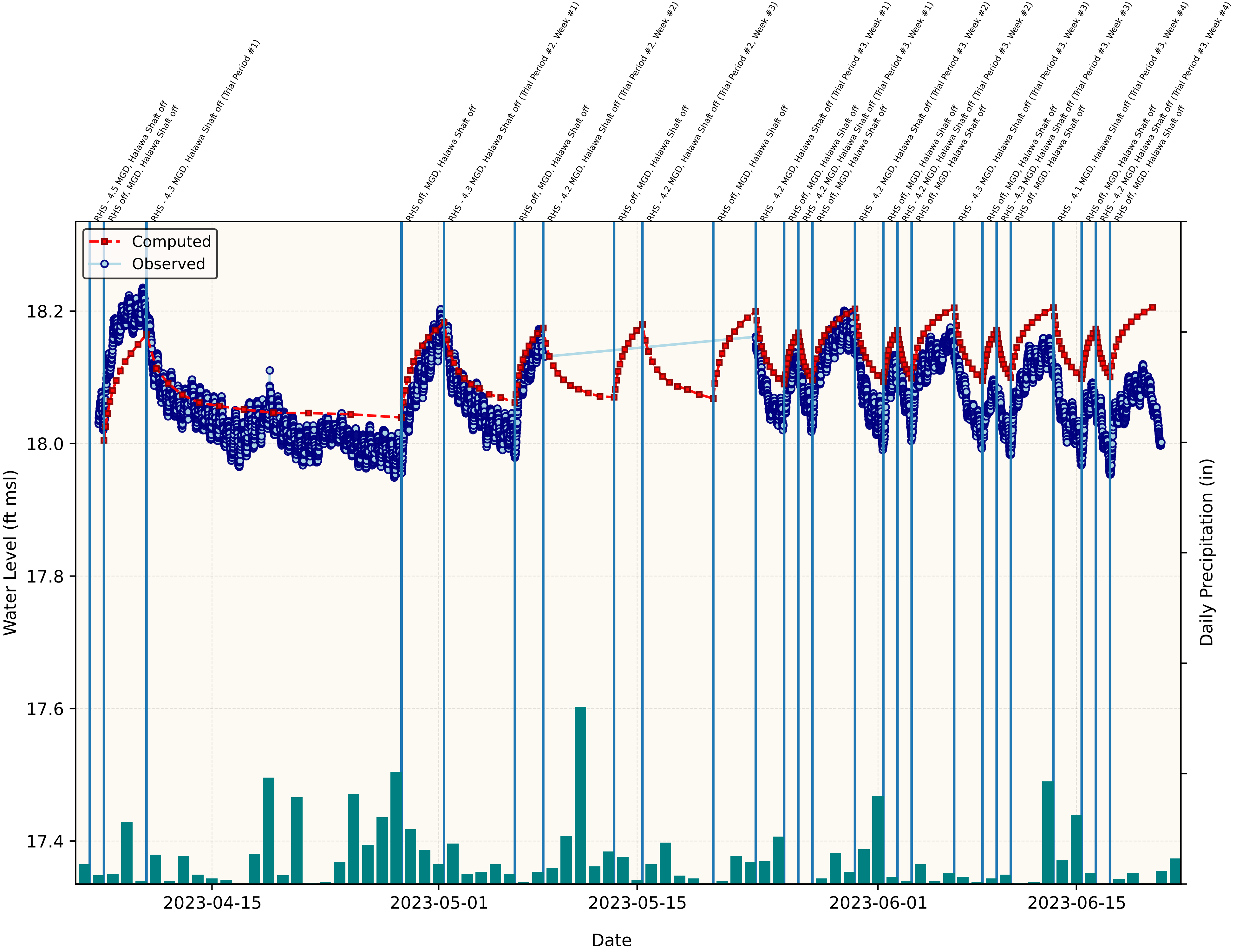

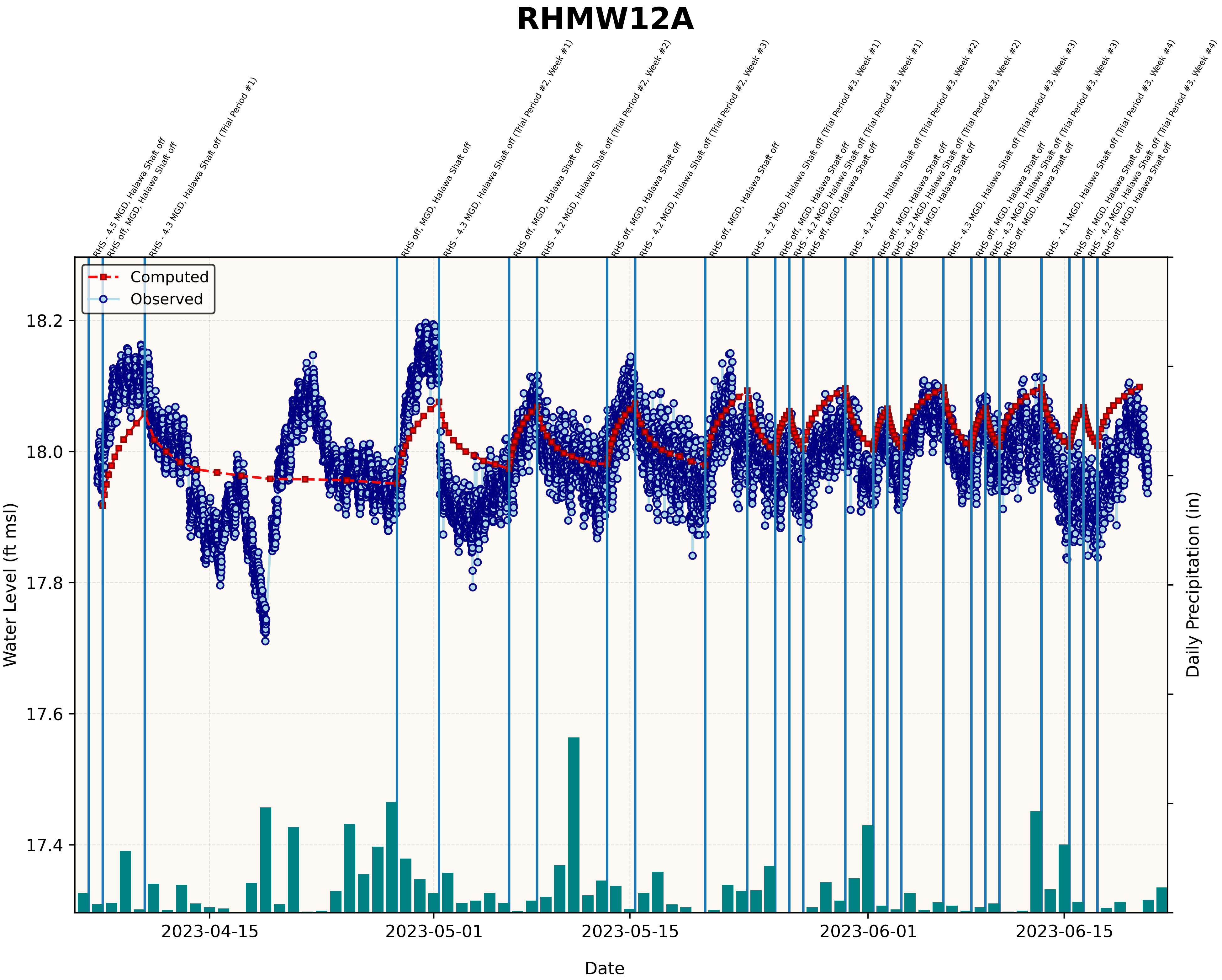
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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
RHS off, MGD, Halawa Shaft off
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RHS off, MGD, Halawa Shaft off
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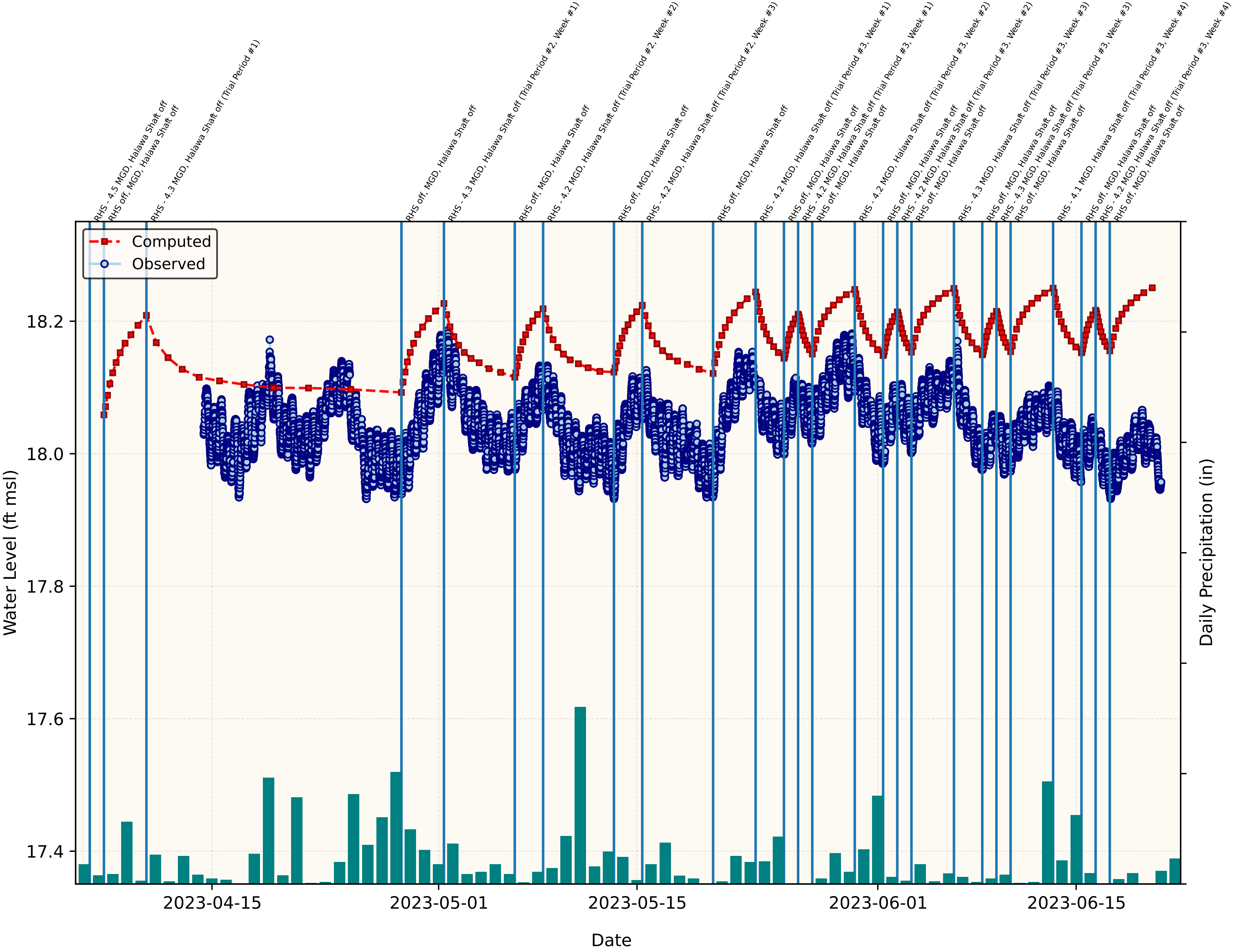
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.2
18.0
17.8
17.6
17.4
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW13-Zone4



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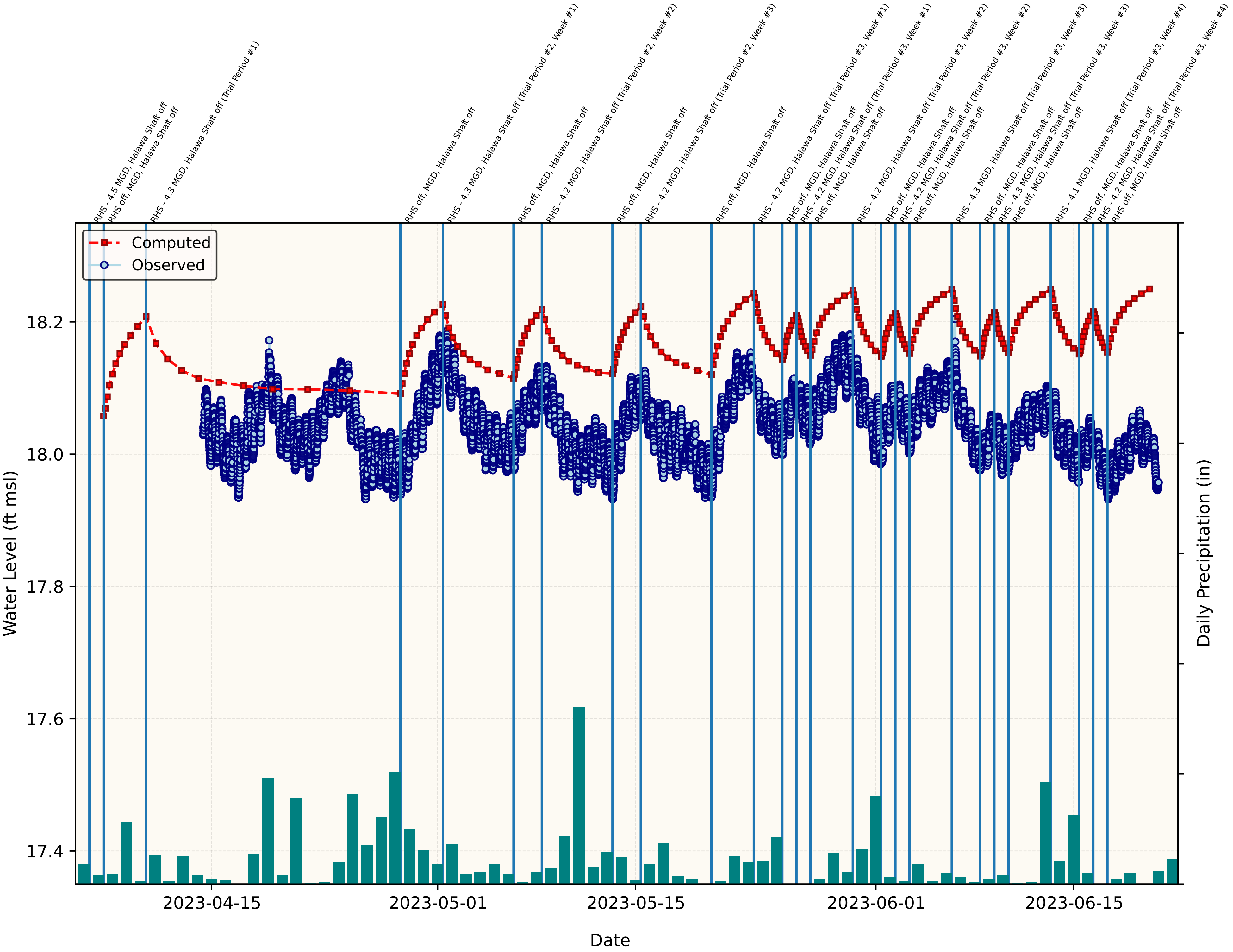
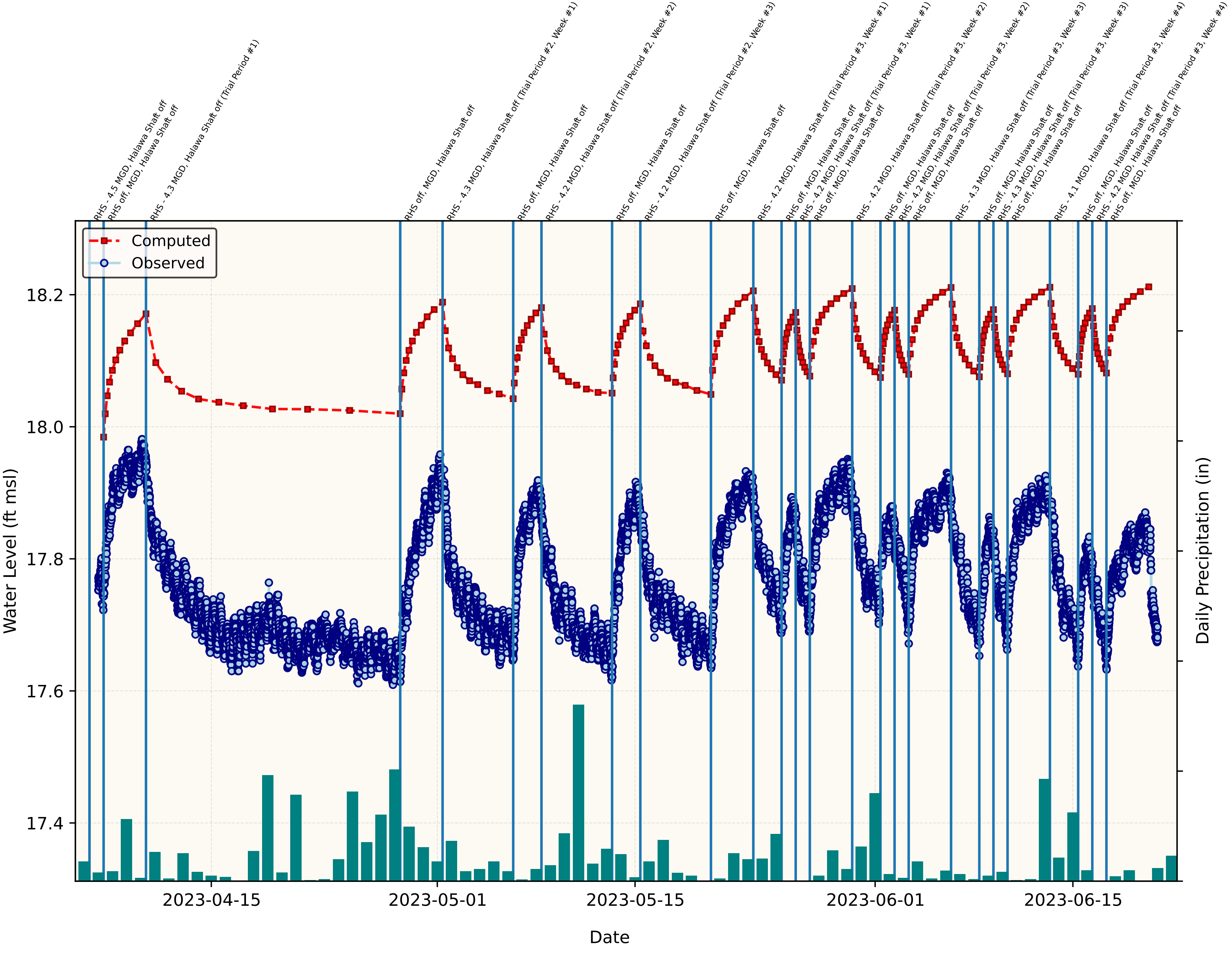
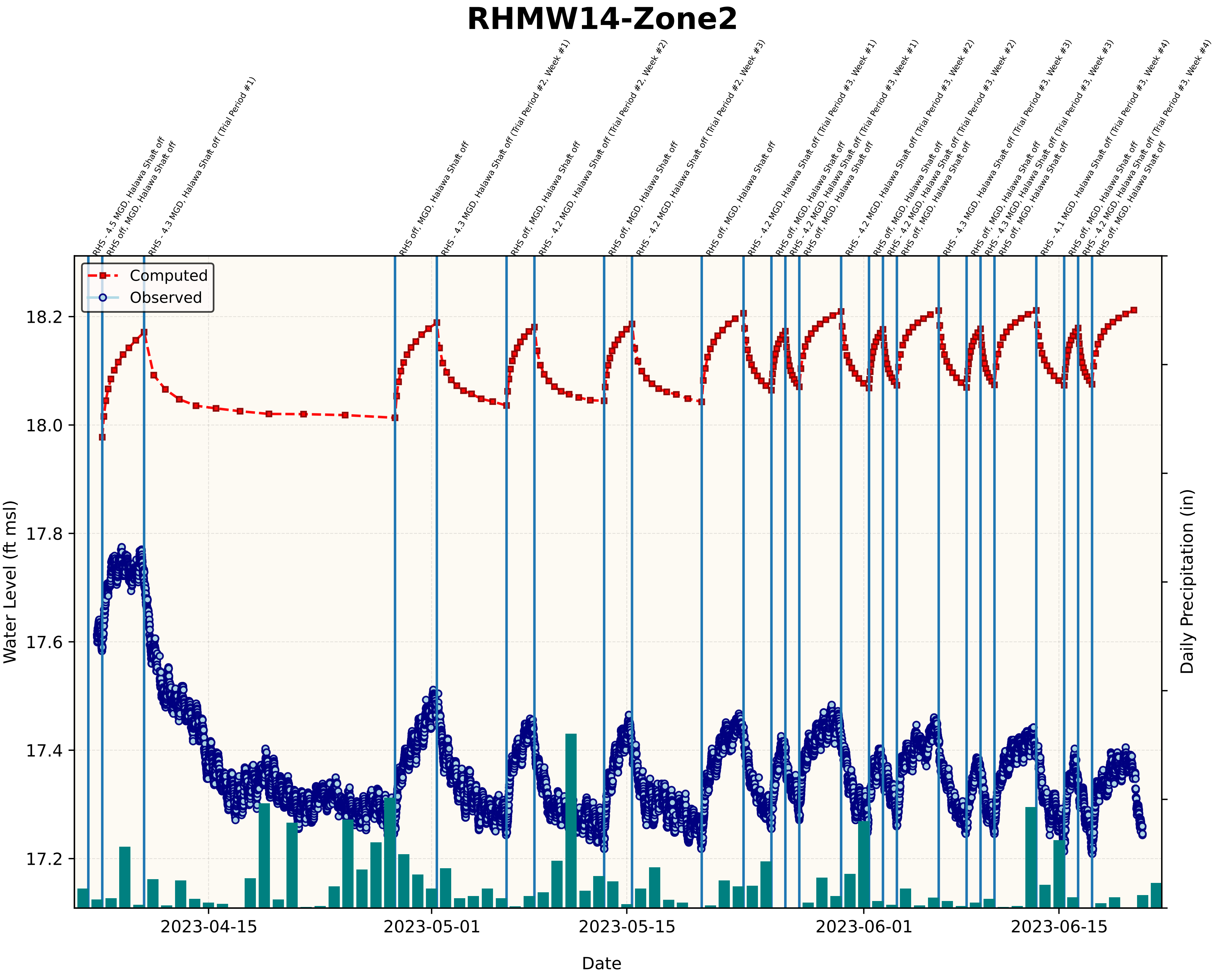


RHMW14-Zone1

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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
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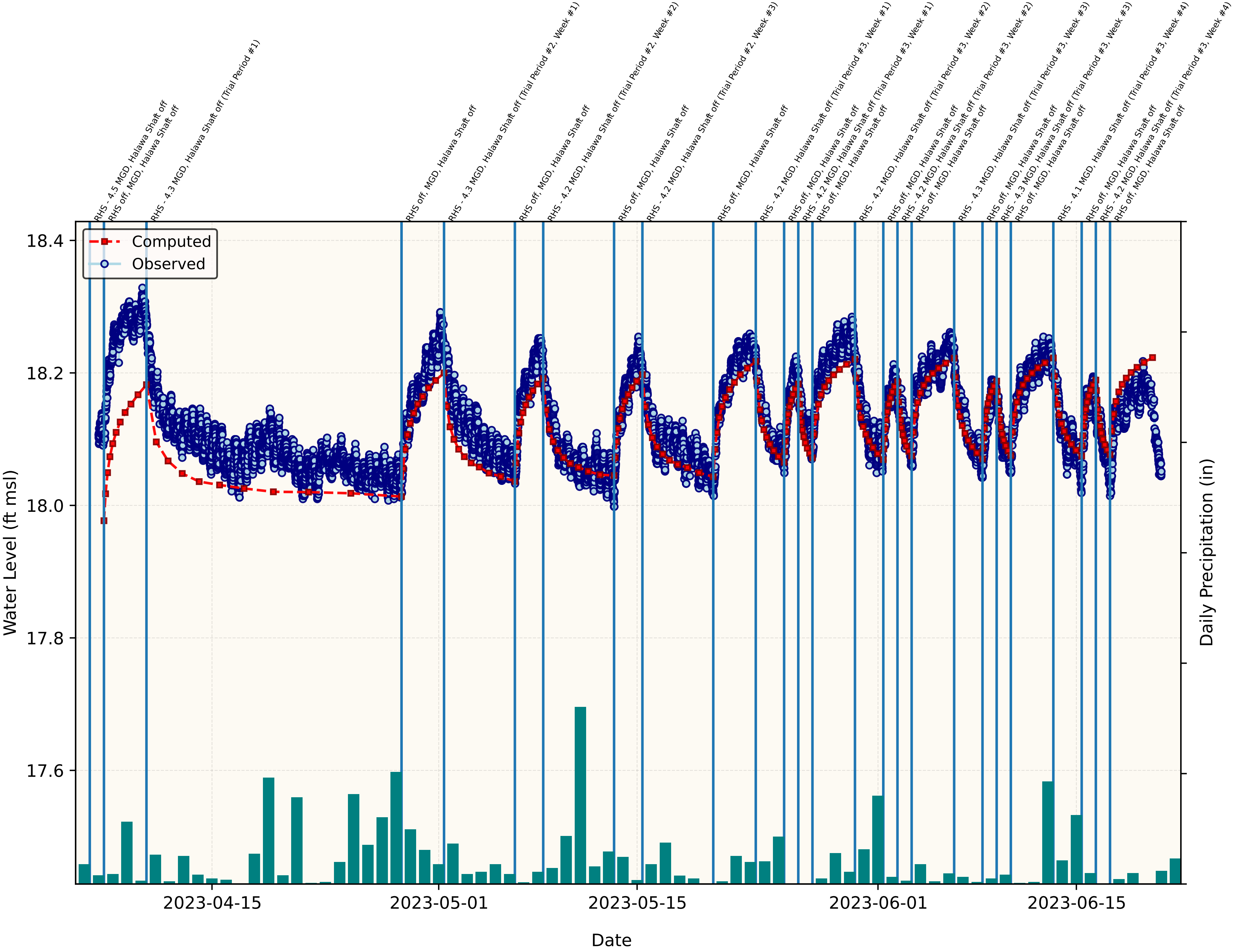
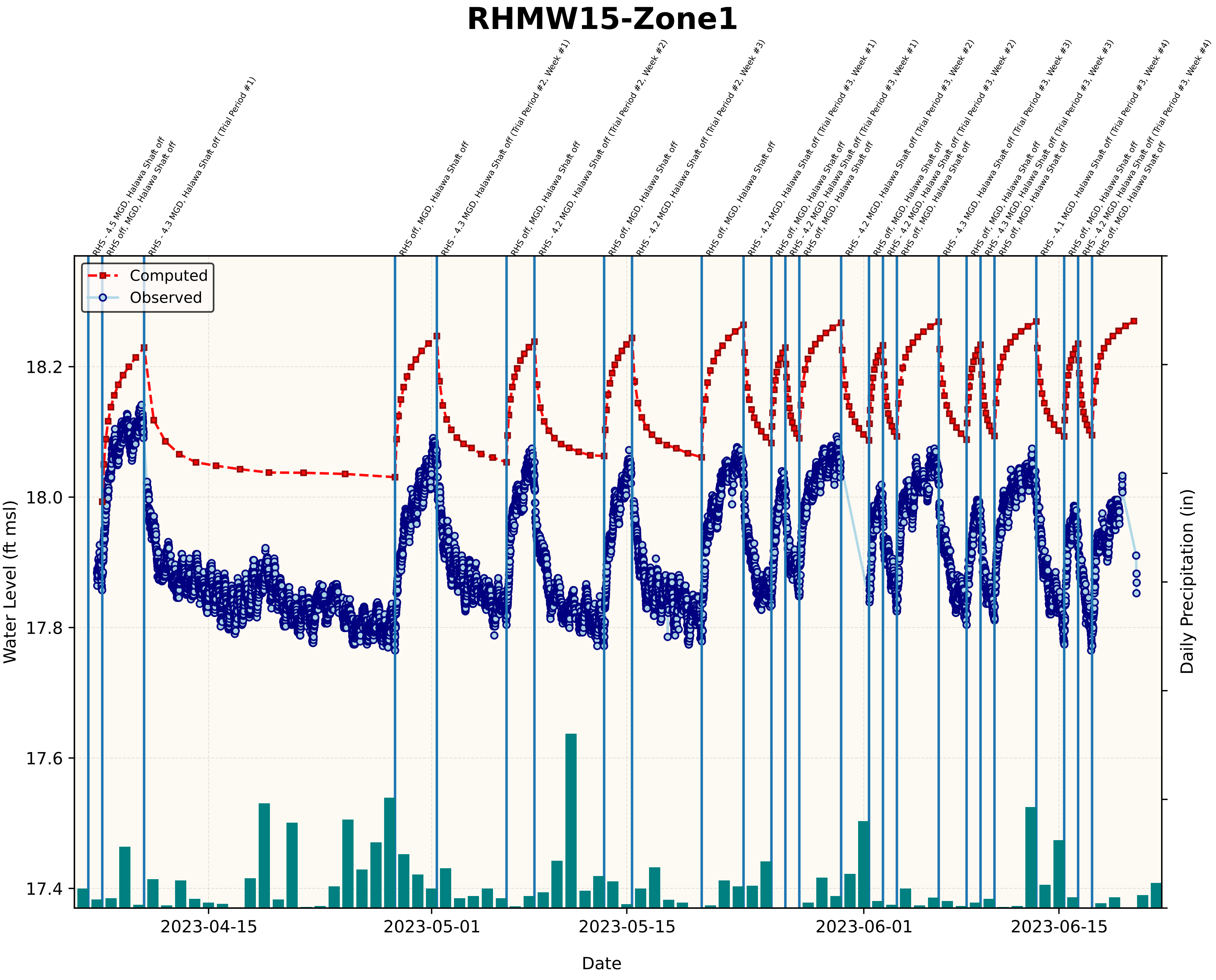
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.2
18.0
17.8
17.6
17.4
17.2
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW14-Zone3

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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
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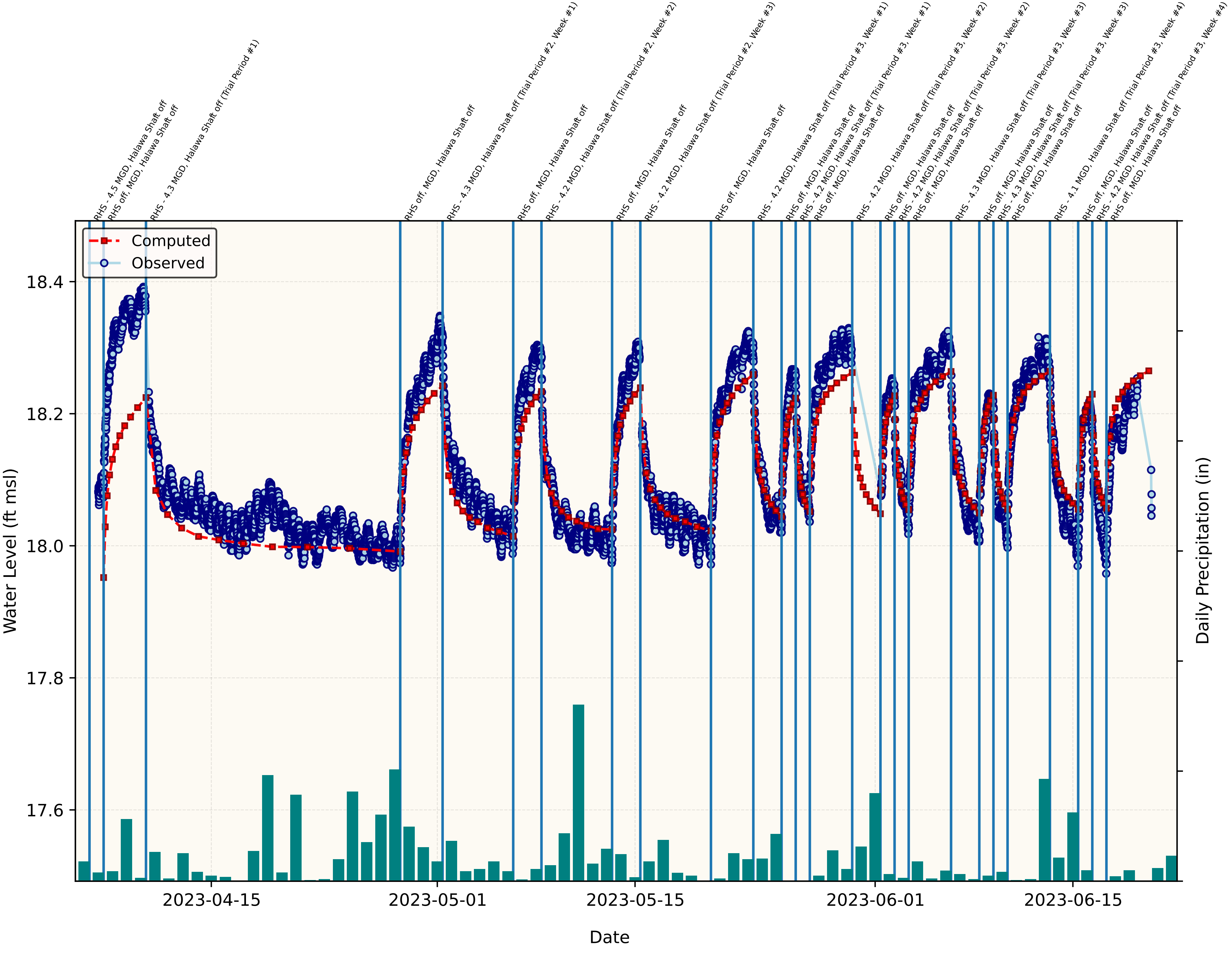
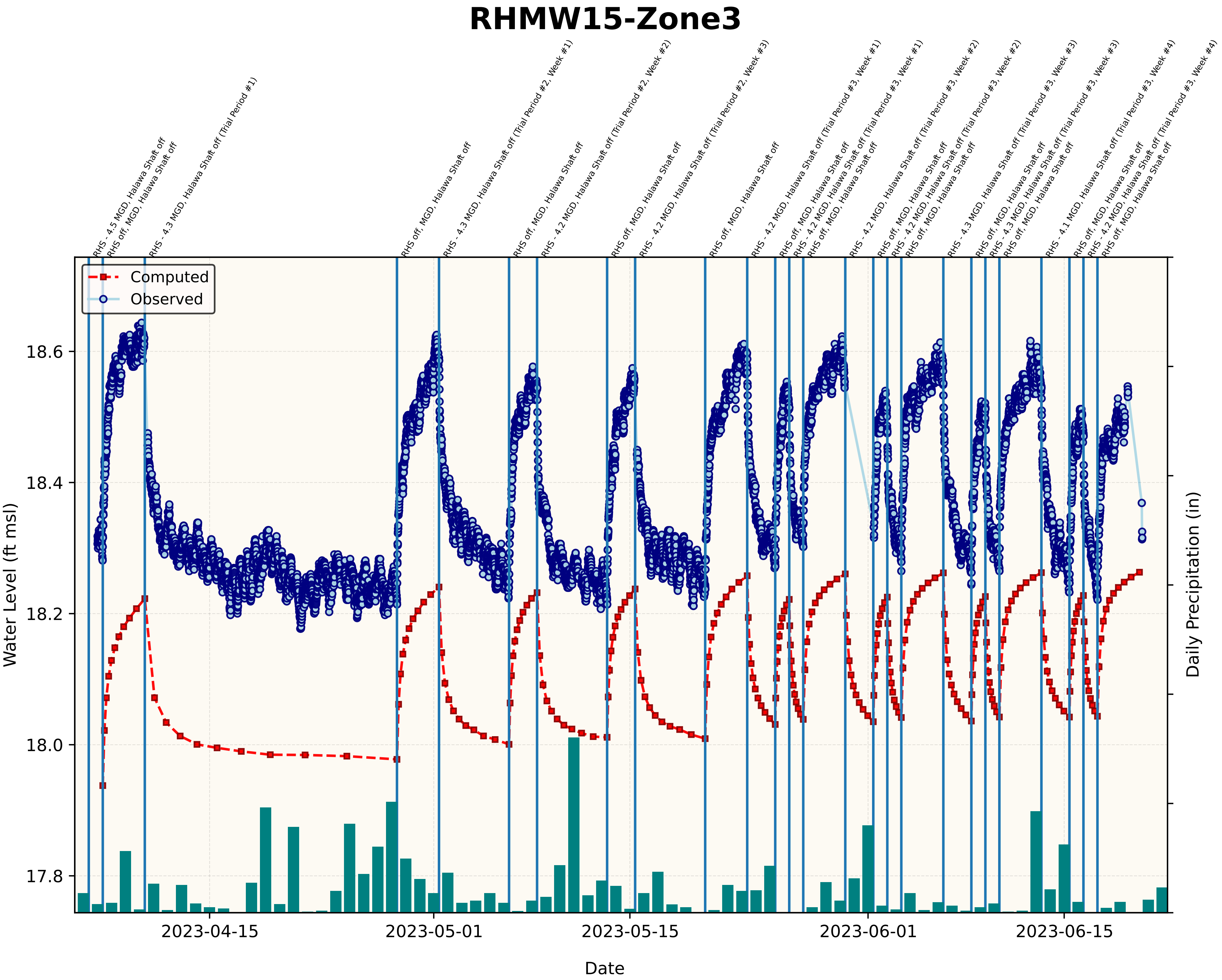
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.2
18.0
17.8
17.6
17.4
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW15-Zone2

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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
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RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
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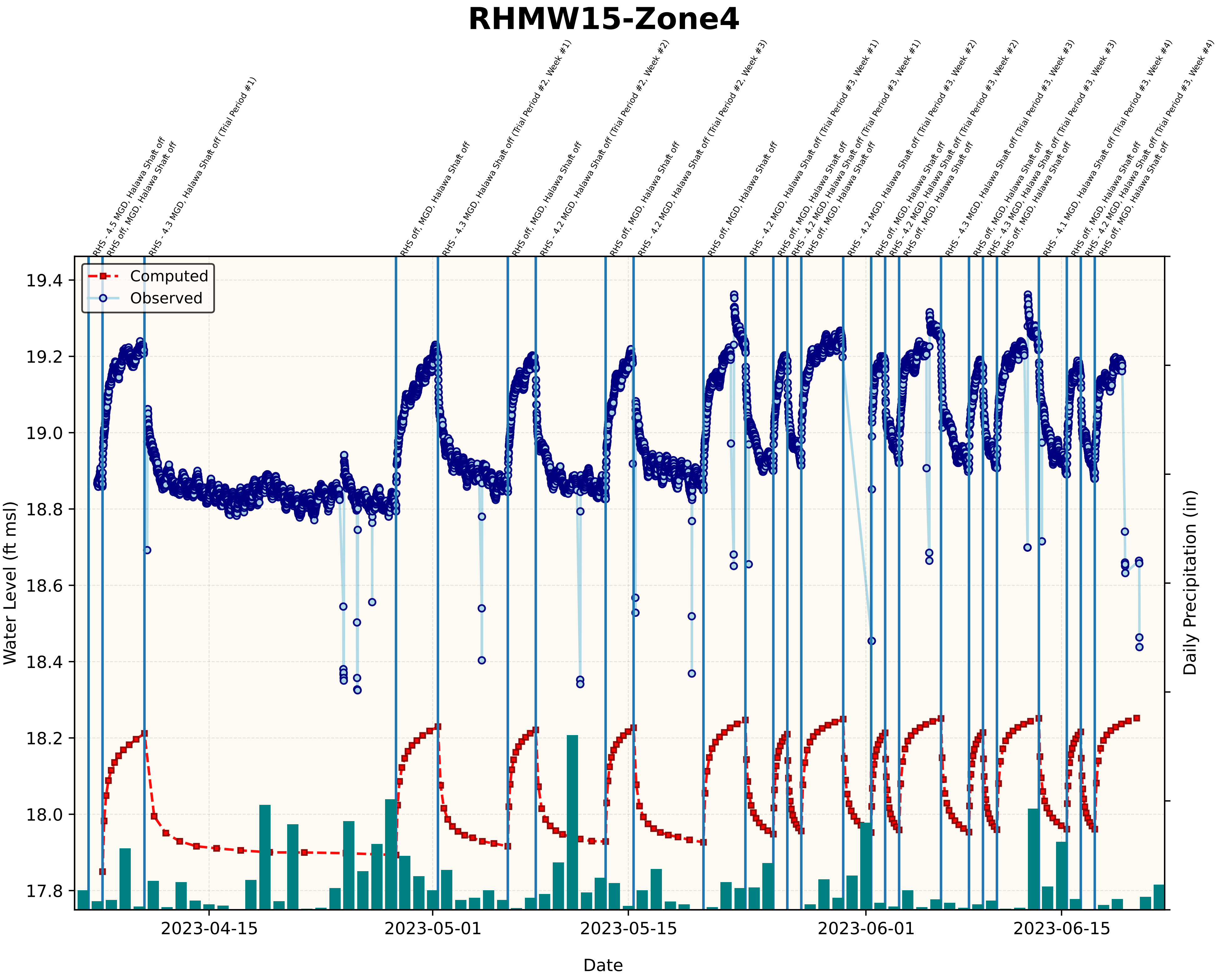
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.6
18.4
18.2
18.0
17.8
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
19.4
19.2
19.0
18.8
18.6
18.4
18.2
18.0
17.8
Daily Precipitation (in)
2023-04-15
2023-05-01
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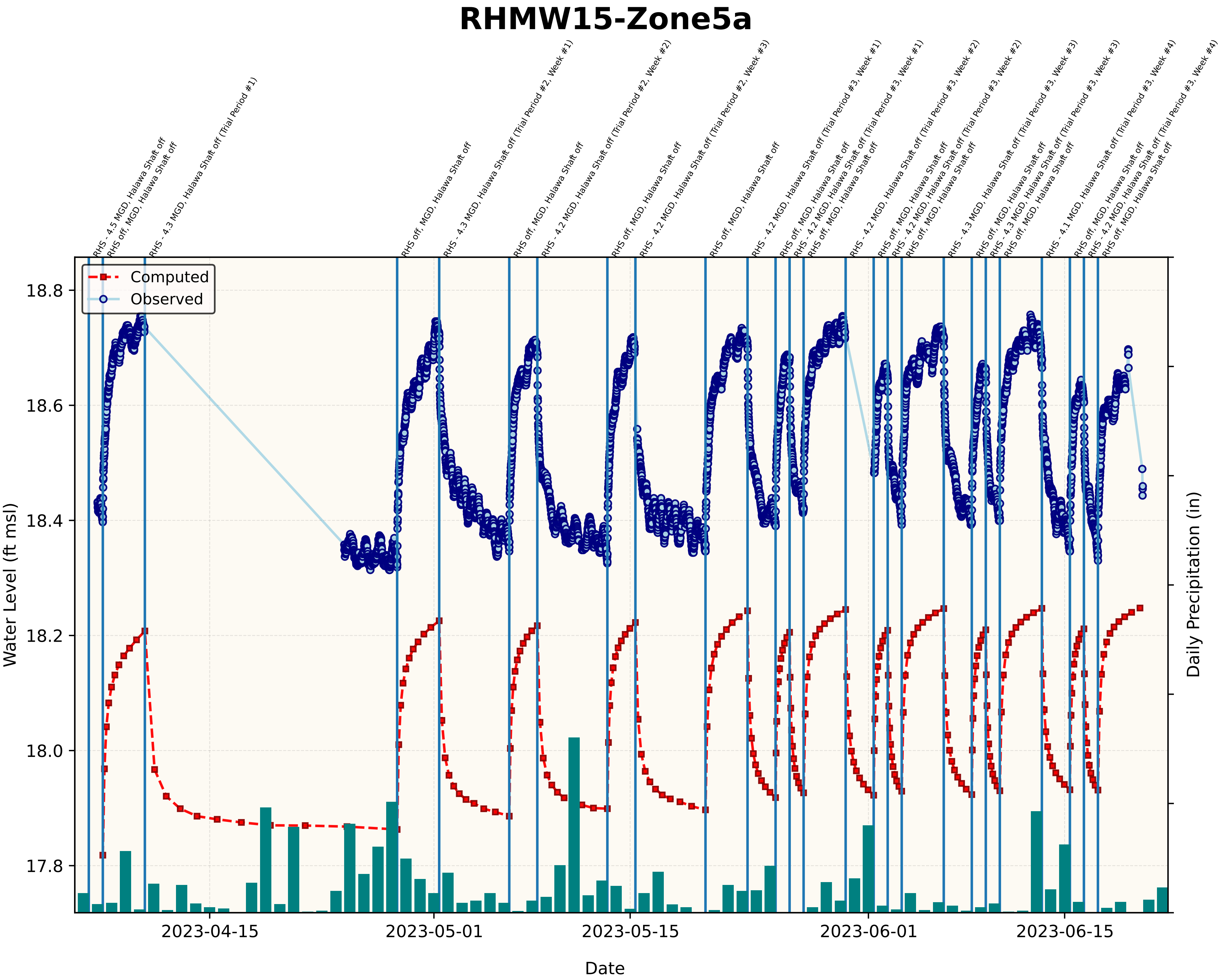
2023-06-01
2023-06-15
Date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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
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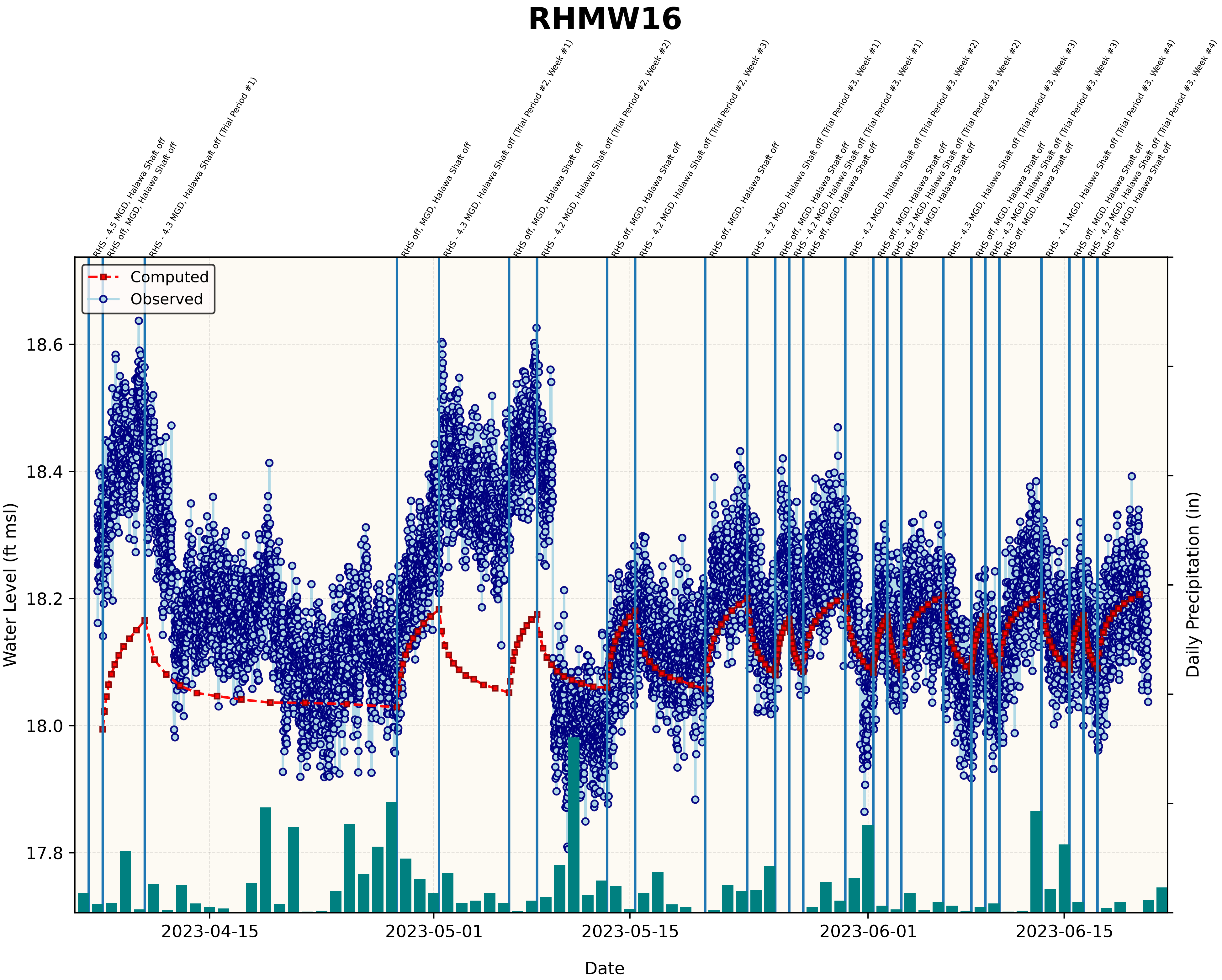
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.8
18.6
18.4
18.2
18.0
17.8
Daily Precipitation (in)
Date
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
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RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
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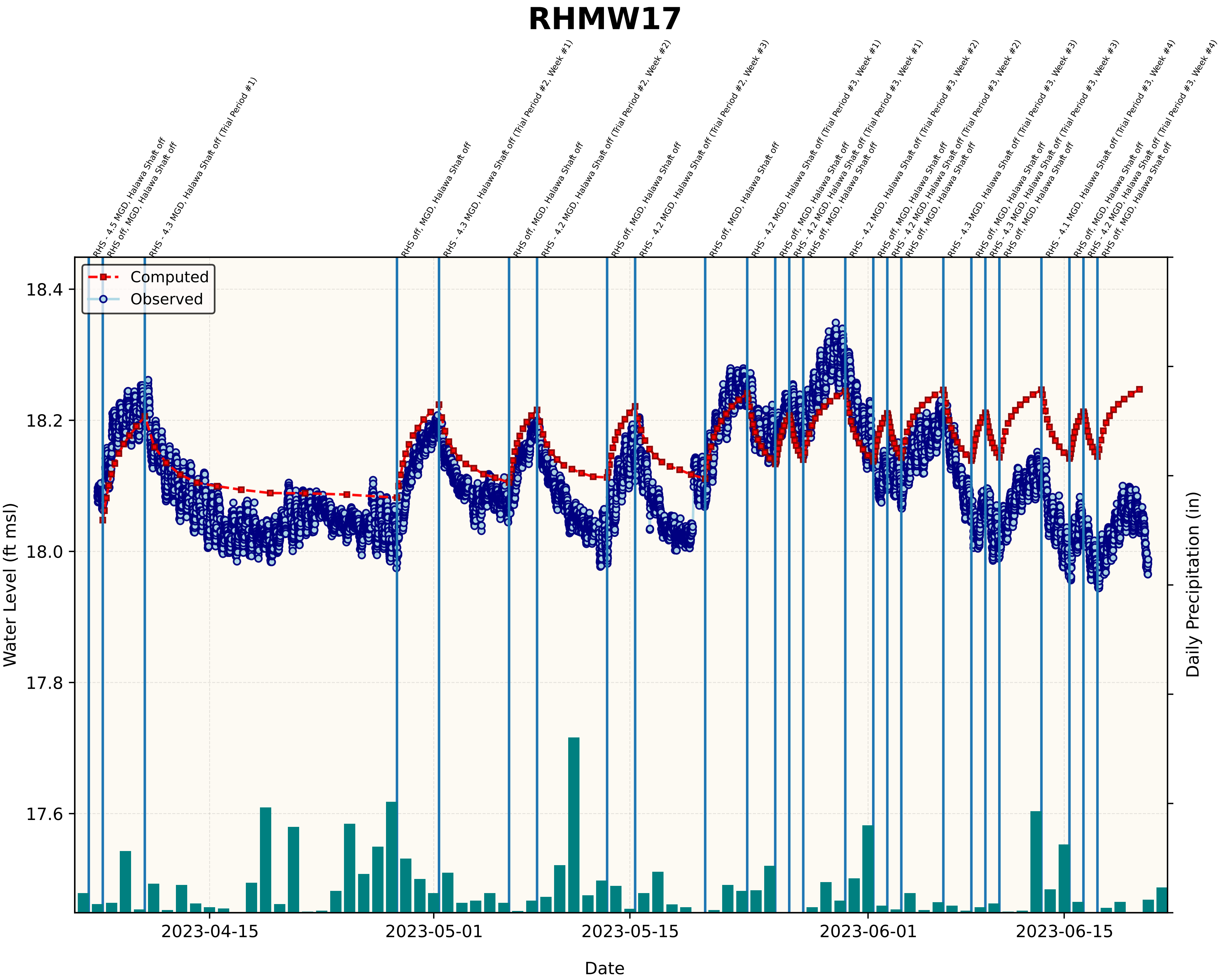
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.6
18.4
18.2
18.0
17.8
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS off, MGD, Halawa Shaft off
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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
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RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.4
18.2
18.0
17.8
17.6
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
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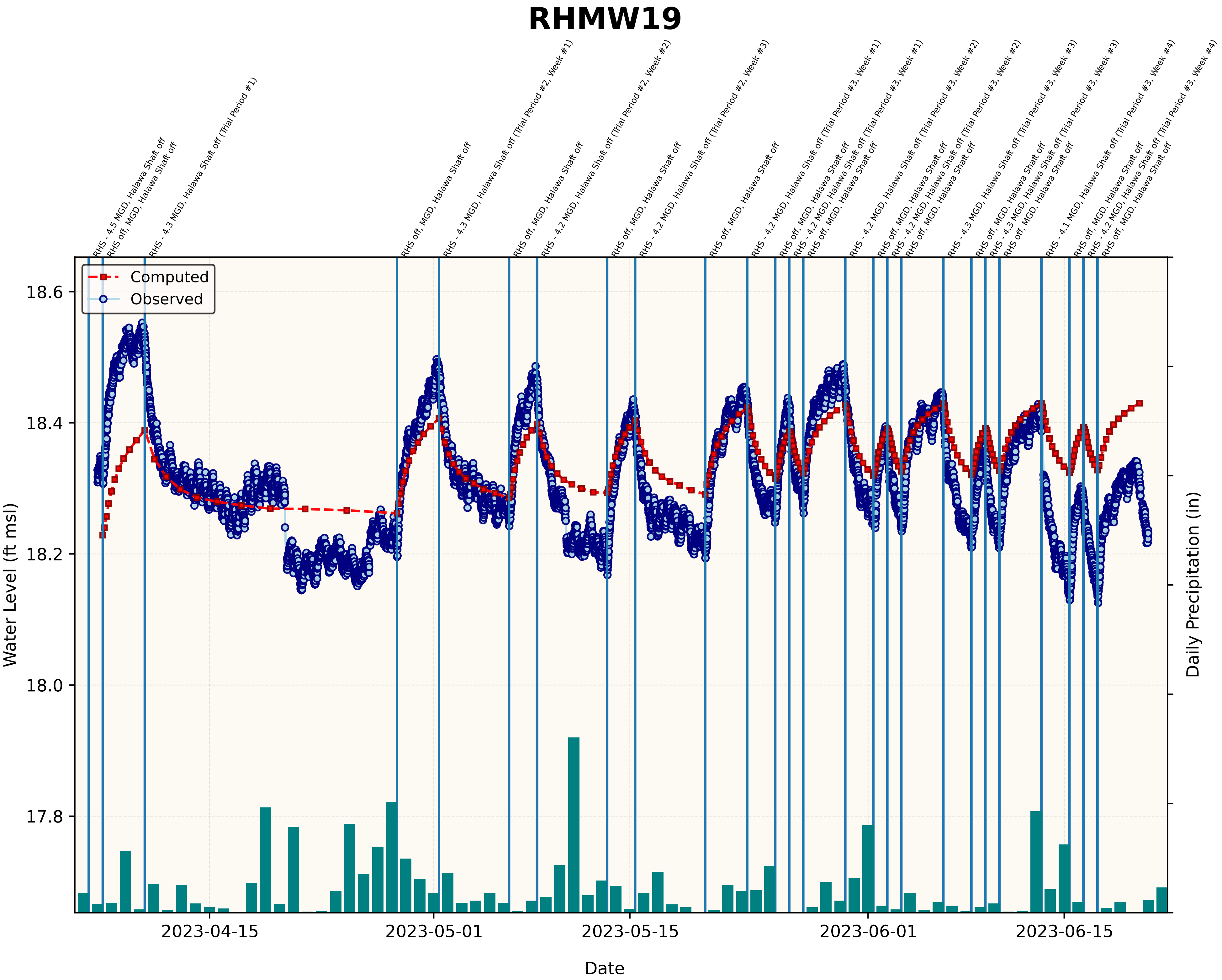
Date

RHMW19
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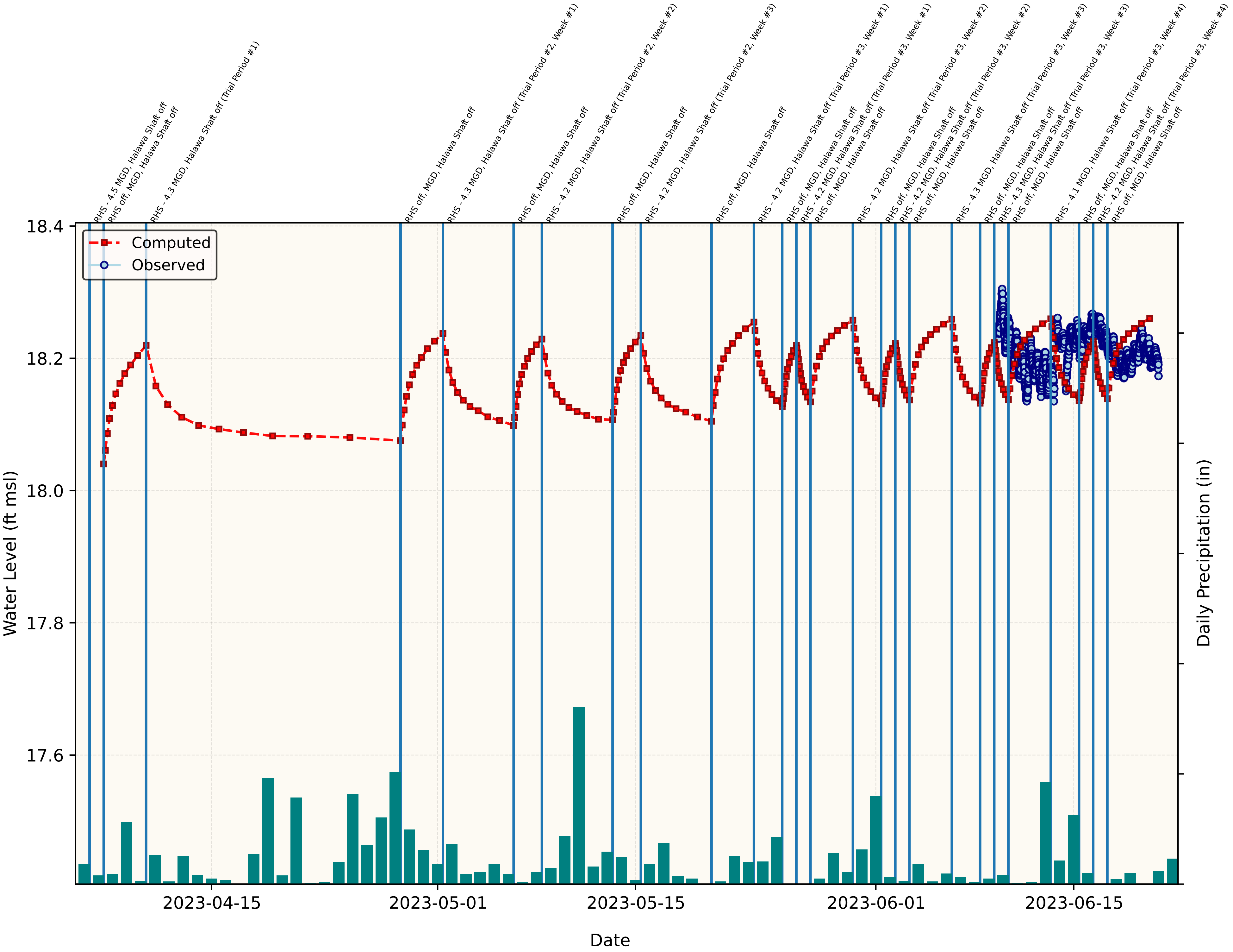
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.6
18.4
18.2
18.0
17.8
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW20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RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.4
18.2
18.0
17.8
17.6
Daily Precipitation (in)
Date
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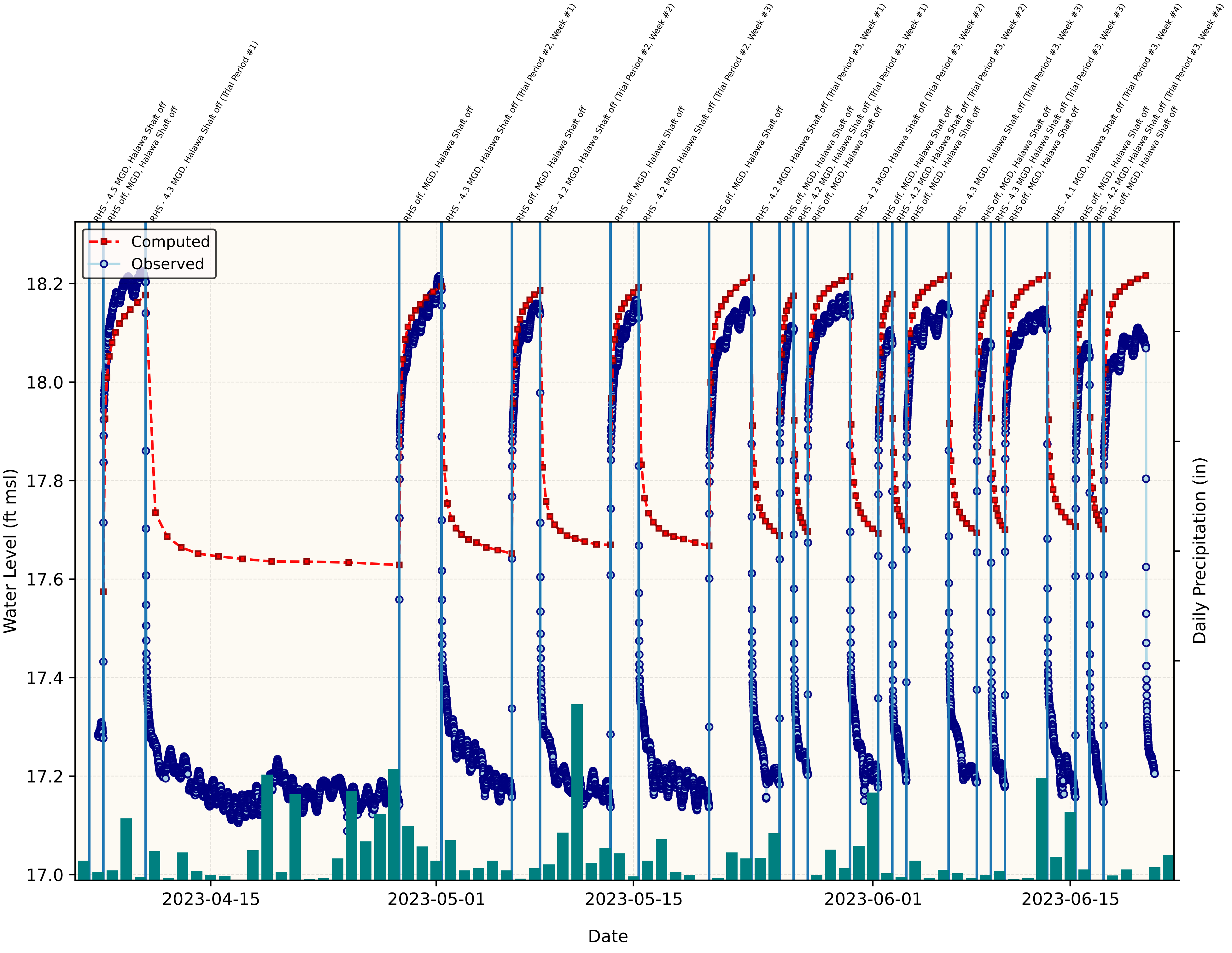
2023-05-01
2023-05-15
2023-06-01
2023-06-15

RHMW2254-01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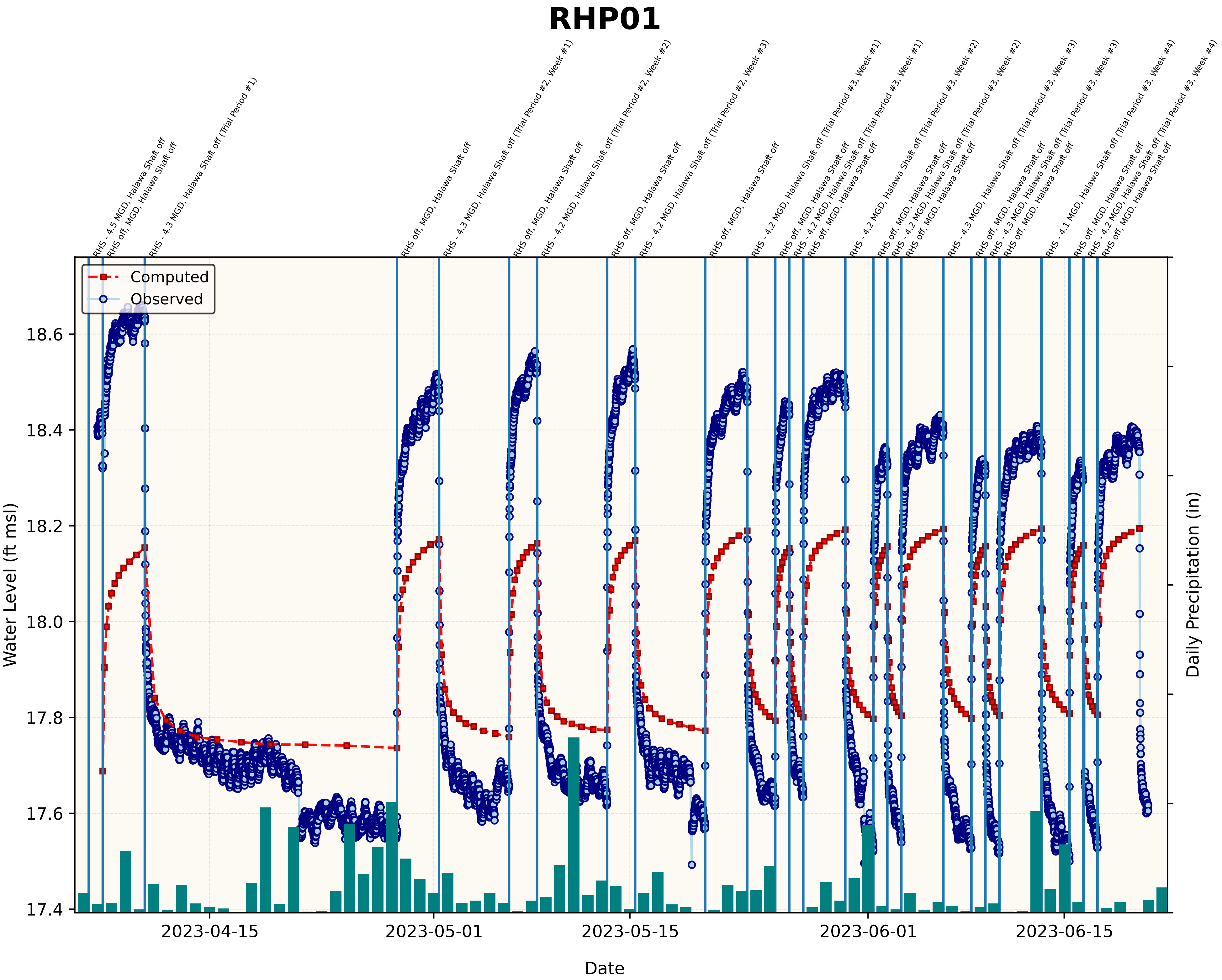
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.2
18.0
17.8
17.6
17.4
17.2
17.0
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS off, MGD, Halawa Shaft off
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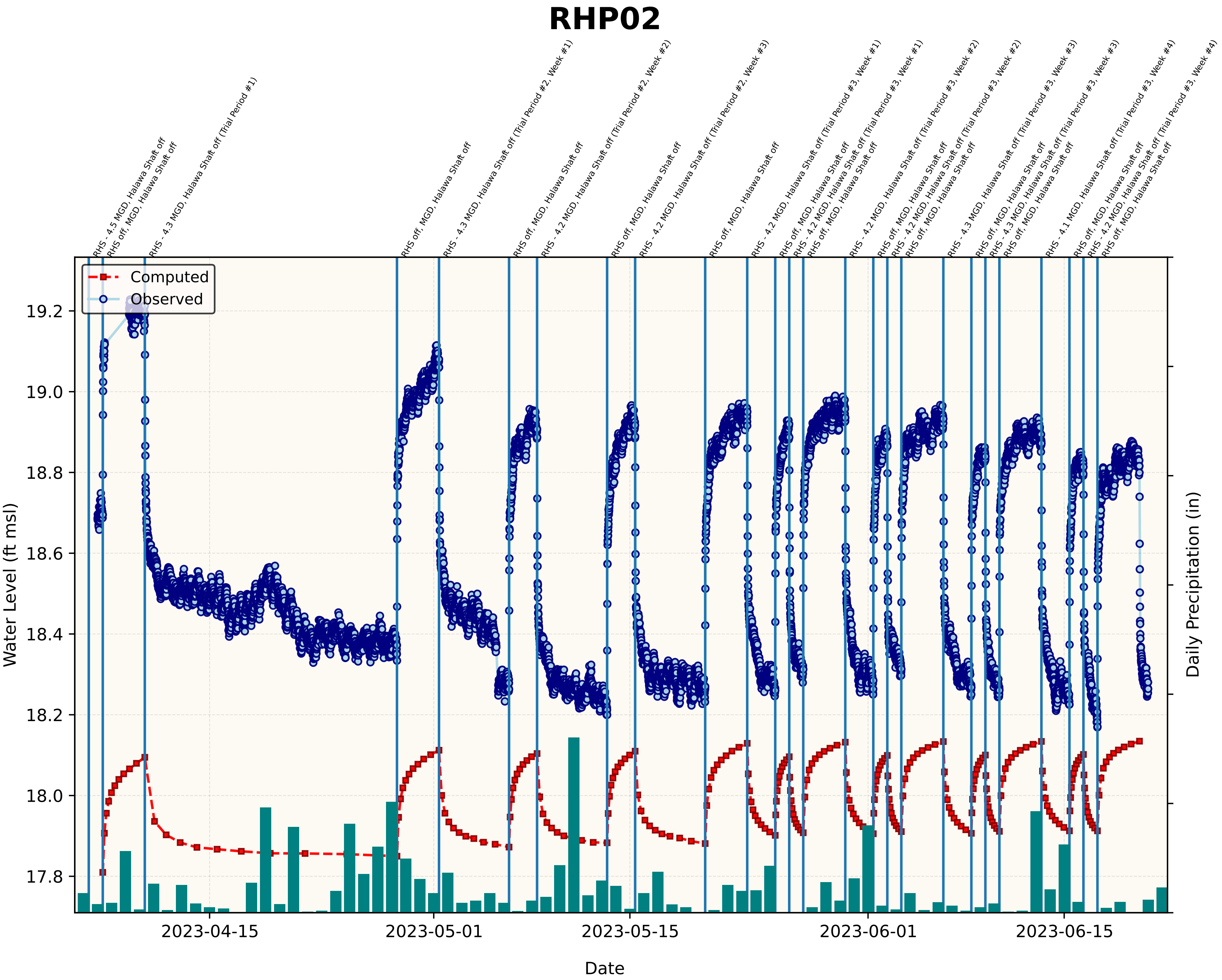
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.6
18.4
18.2
18.0
17.8
17.6
17.4
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS off, MGD, Halawa Shaft off
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RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
19.2
19.0
18.8
18.6
18.4
18.2
18.0
17.8
Daily Precipitation (in)
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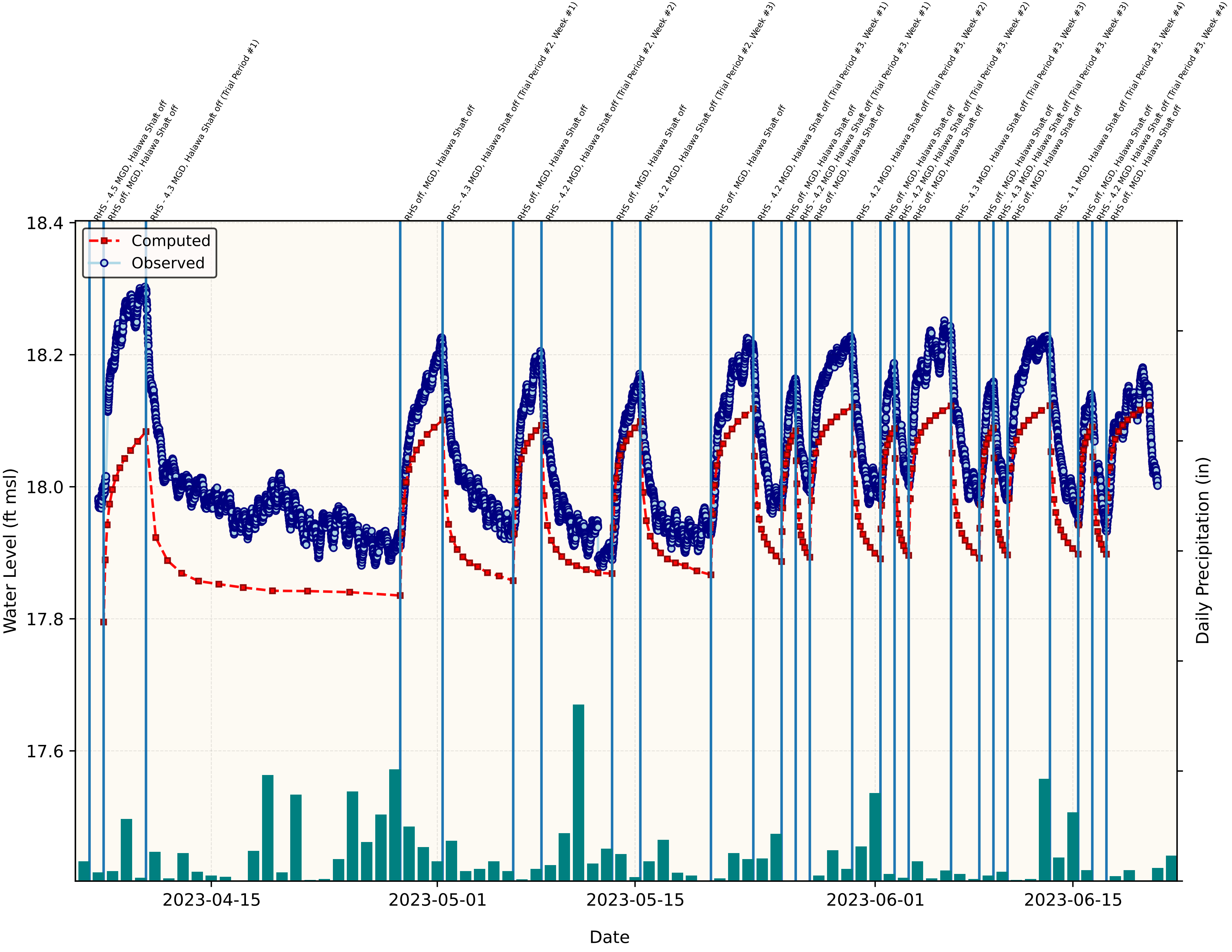
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHP03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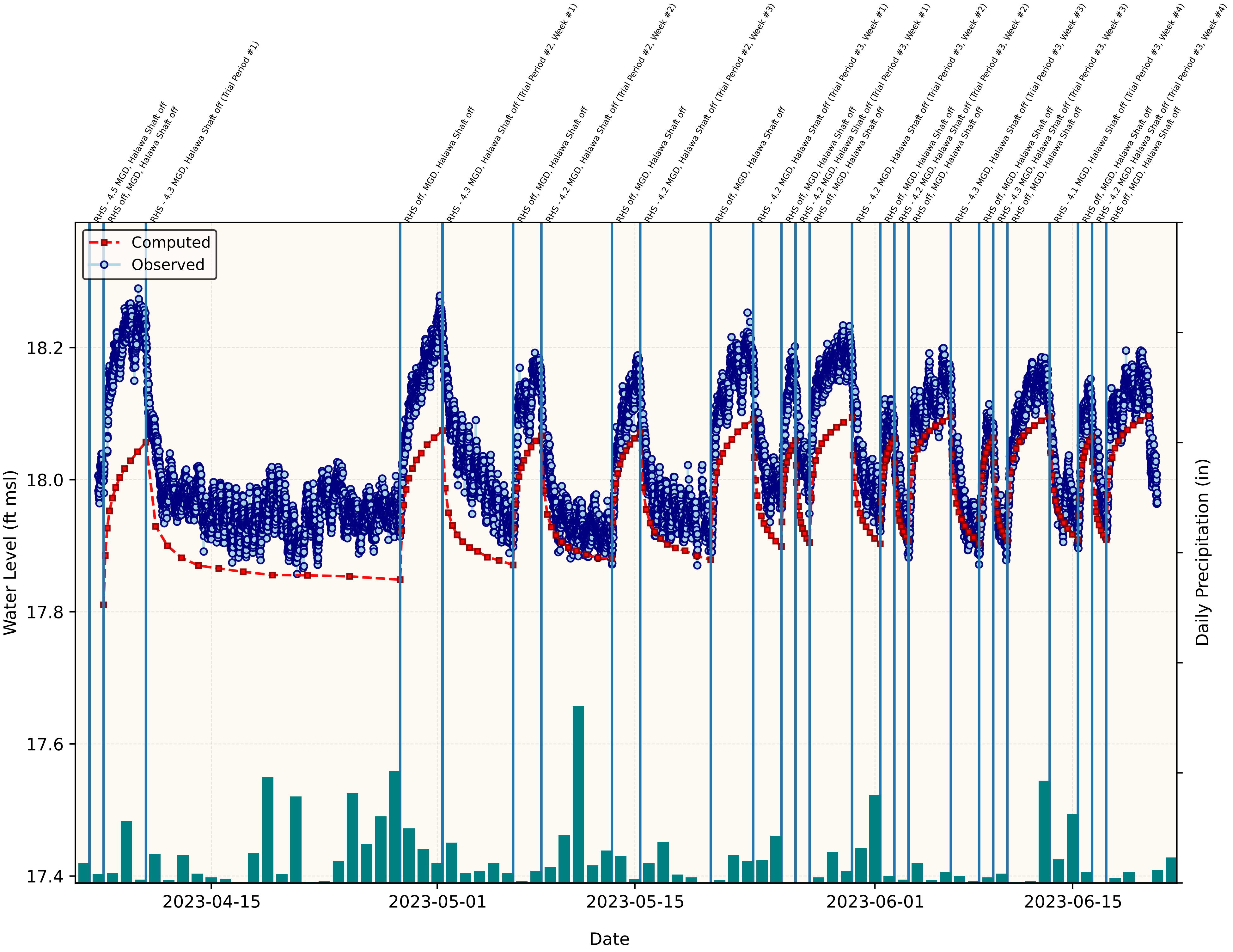
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
18.4
18.2
18.0
17.8
17.6
Water Level (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHP04A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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.2
18.0
17.8
17.6
17.4
Daily Precipitation (in)
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2023-05-01
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2023-06-01
2023-06-15
Date

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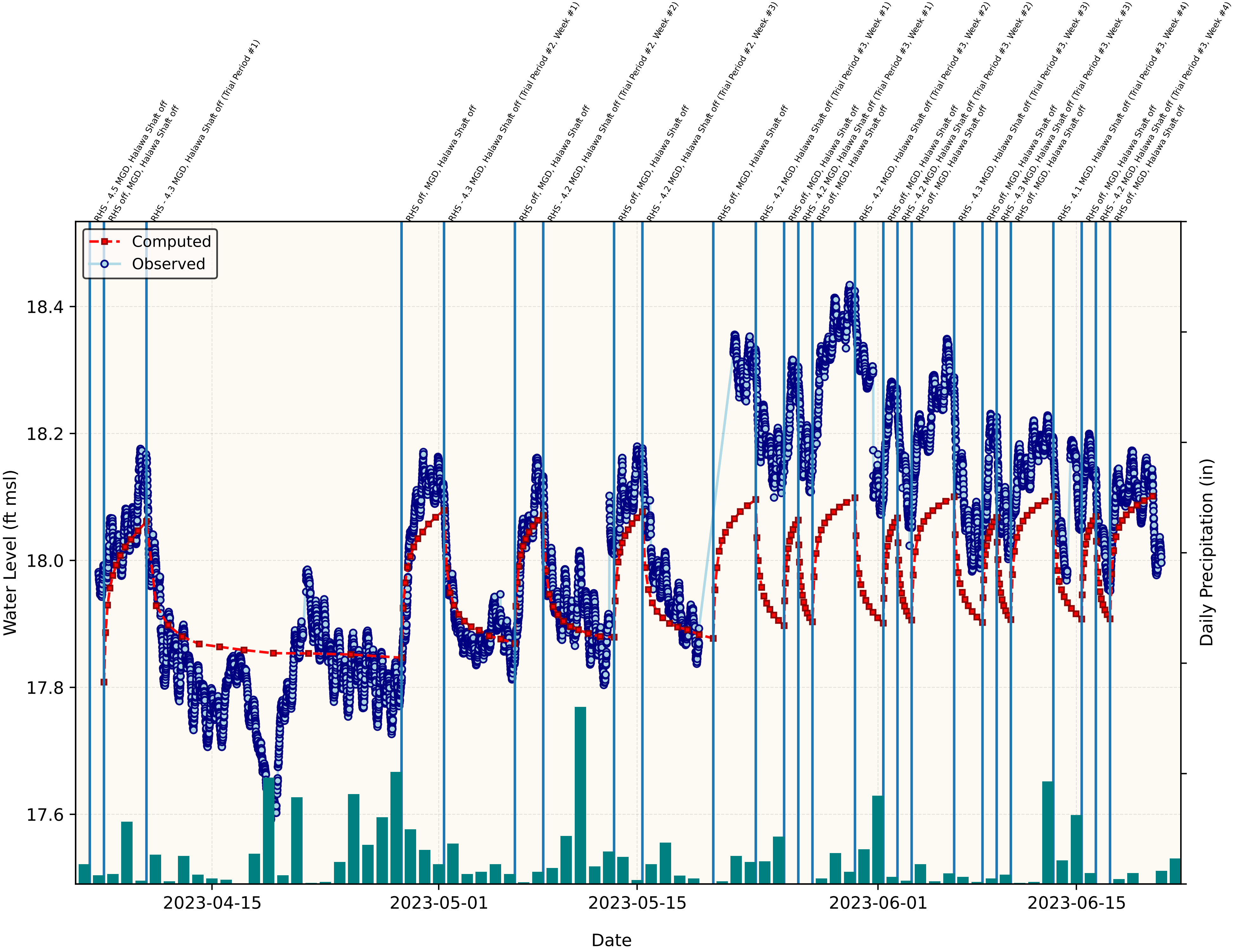

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RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.4
18.2
18.0
17.8
17.6
Daily Precipitation (in)
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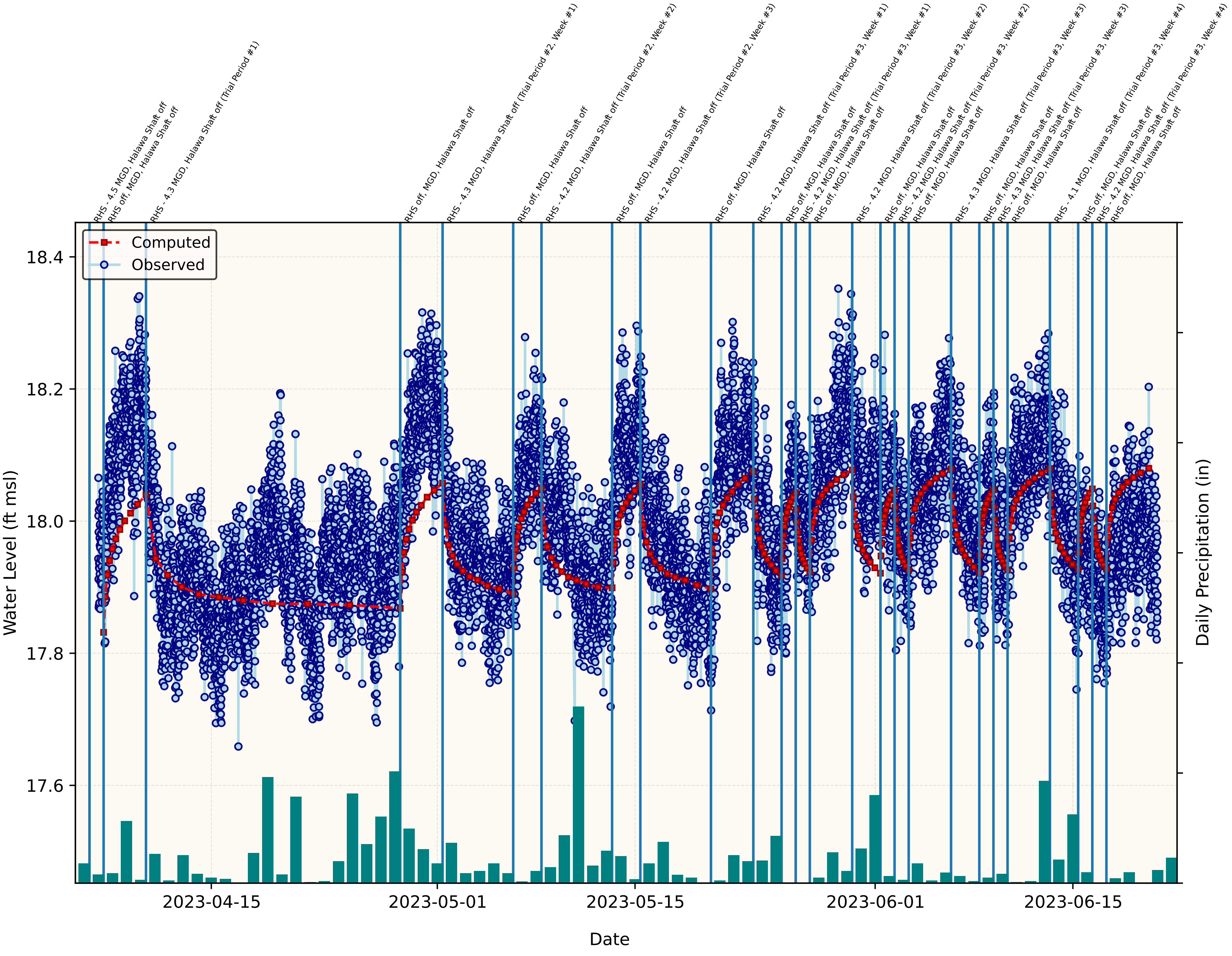
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHP04C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RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.4
18.2
18.0
17.8
17.6
Daily Precipitation (in)
2023-04-15
2023-05-01
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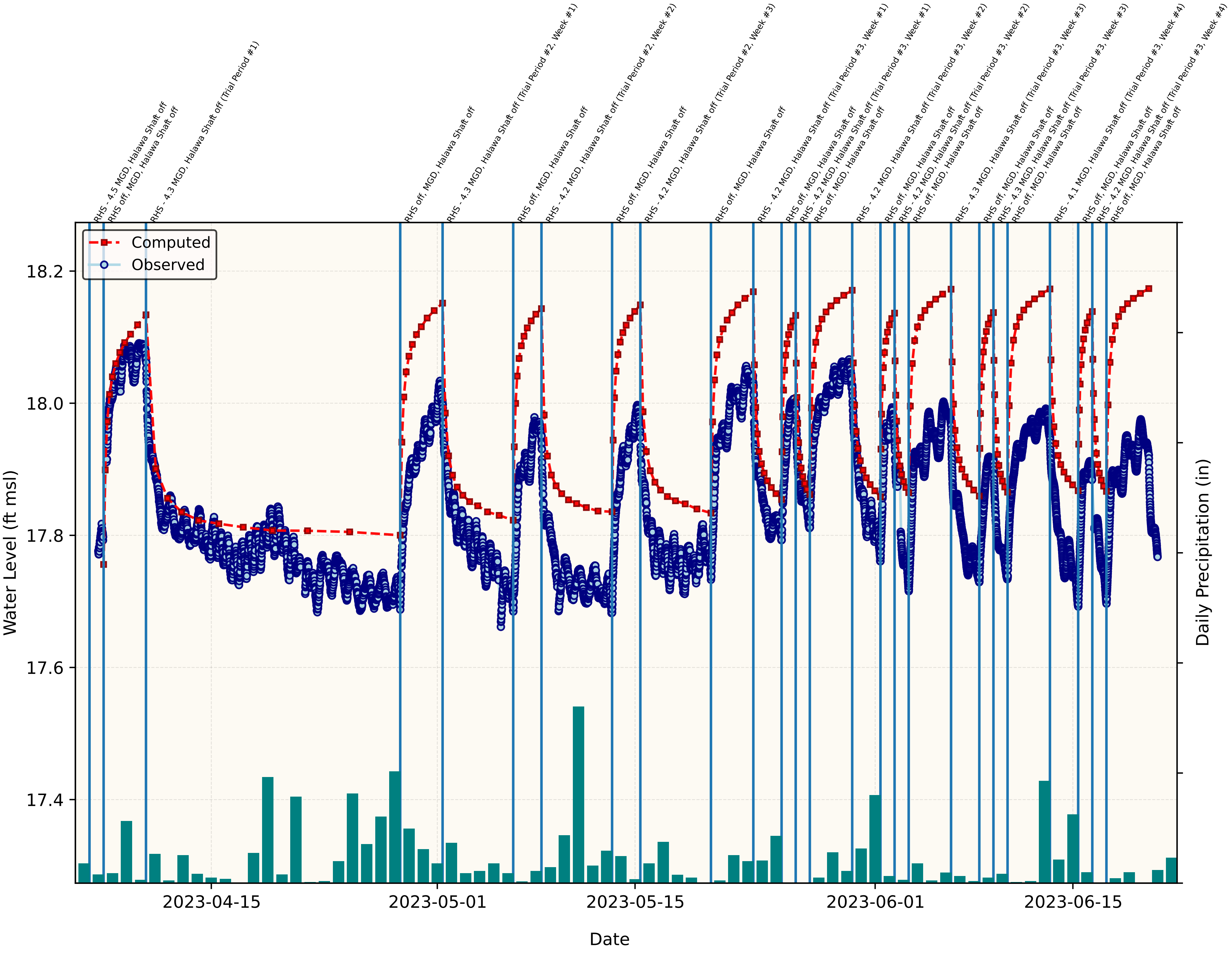
2023-06-01
2023-06-15
Date

RHP05



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RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
18.2
18.0
17.8
17.6
17.4
Daily Precipitation (in)
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2023-05-01
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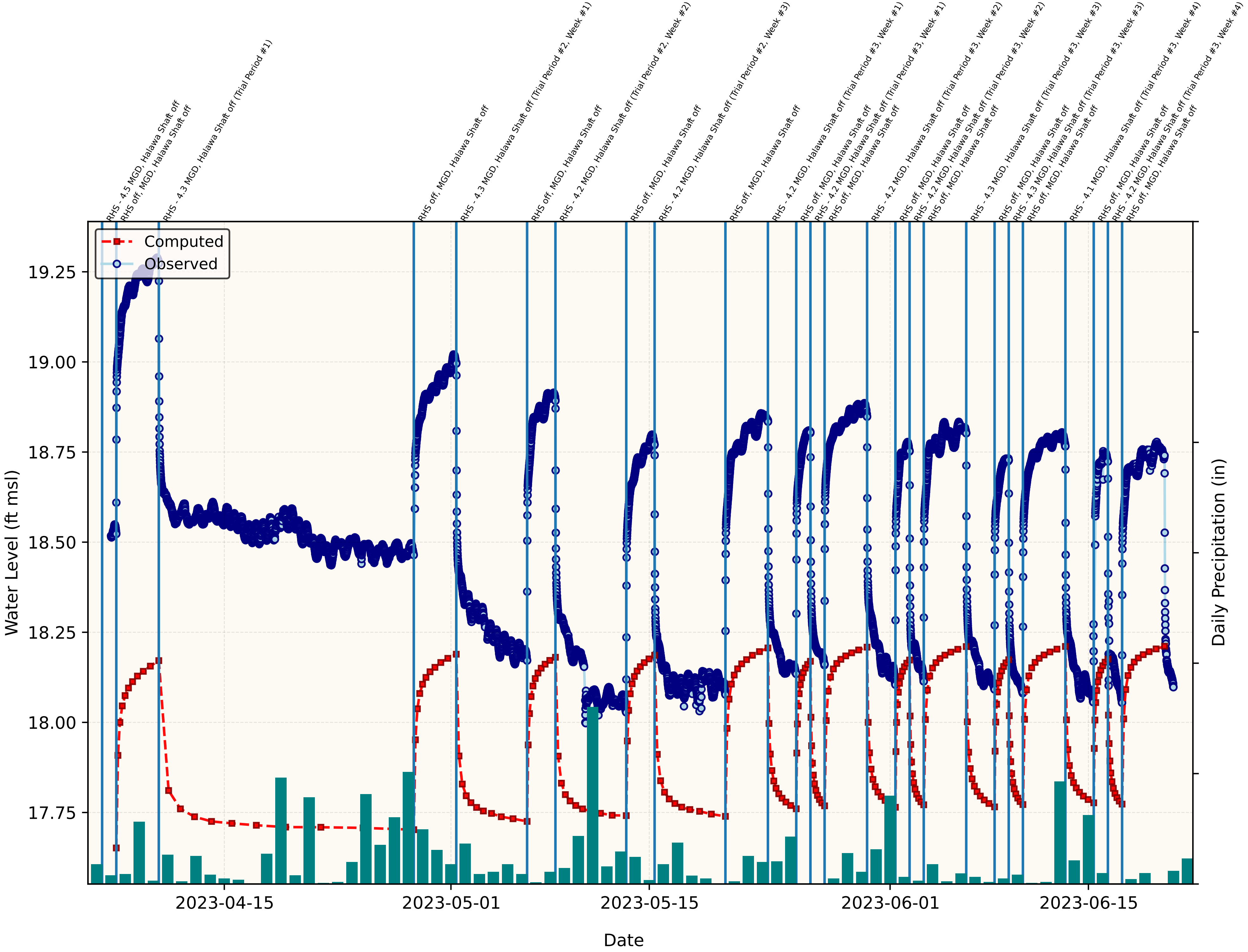
2023-06-01
2023-06-15
Date

RHP07



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RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Water Level (ft msl)
19.25
19.00
18.75
18.50
18.25
18.00
17.75
Daily Precipitation (in)
Date
2023-04-15
2023-05-01
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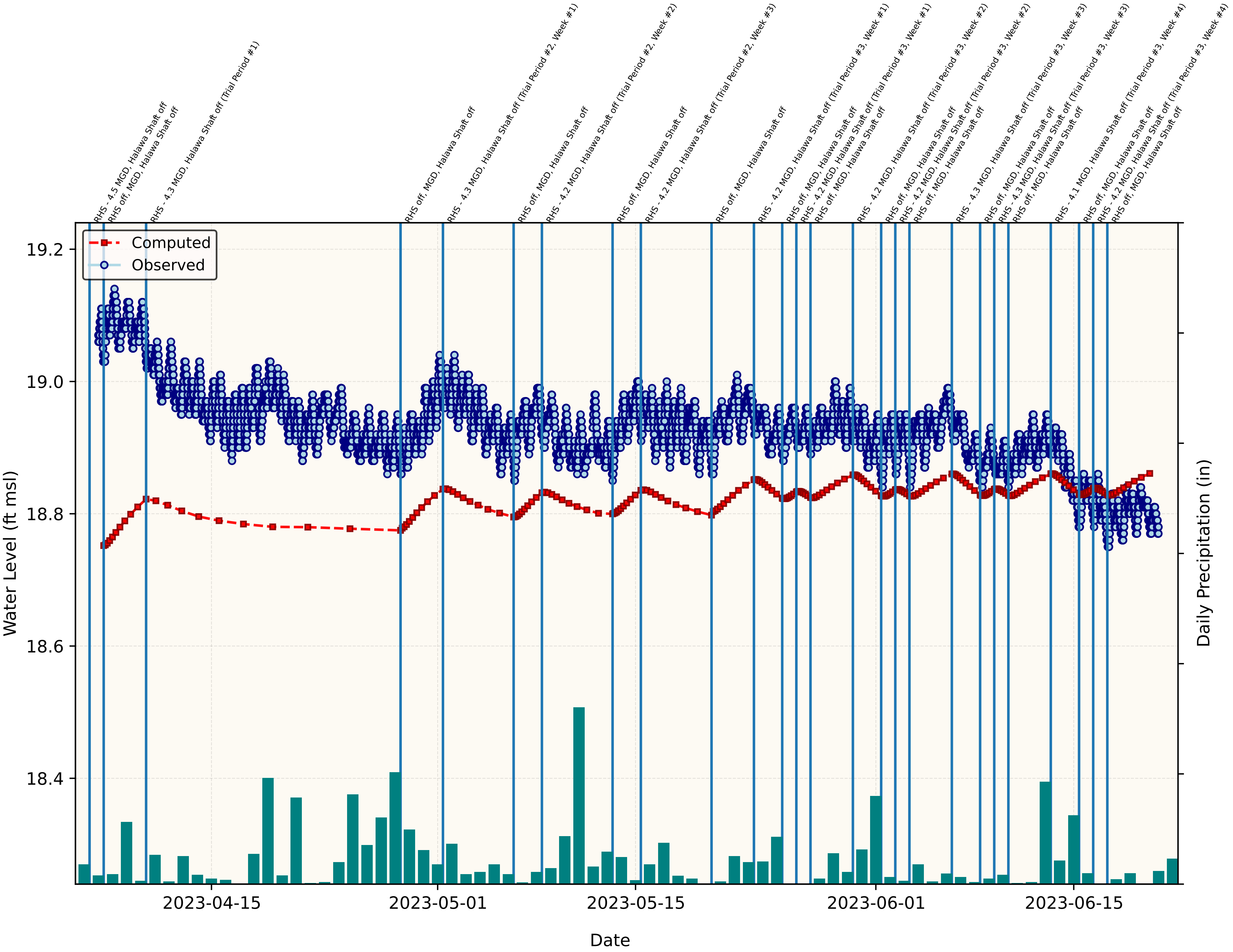
2023-06-01
2023-06-15

TAMC_MW2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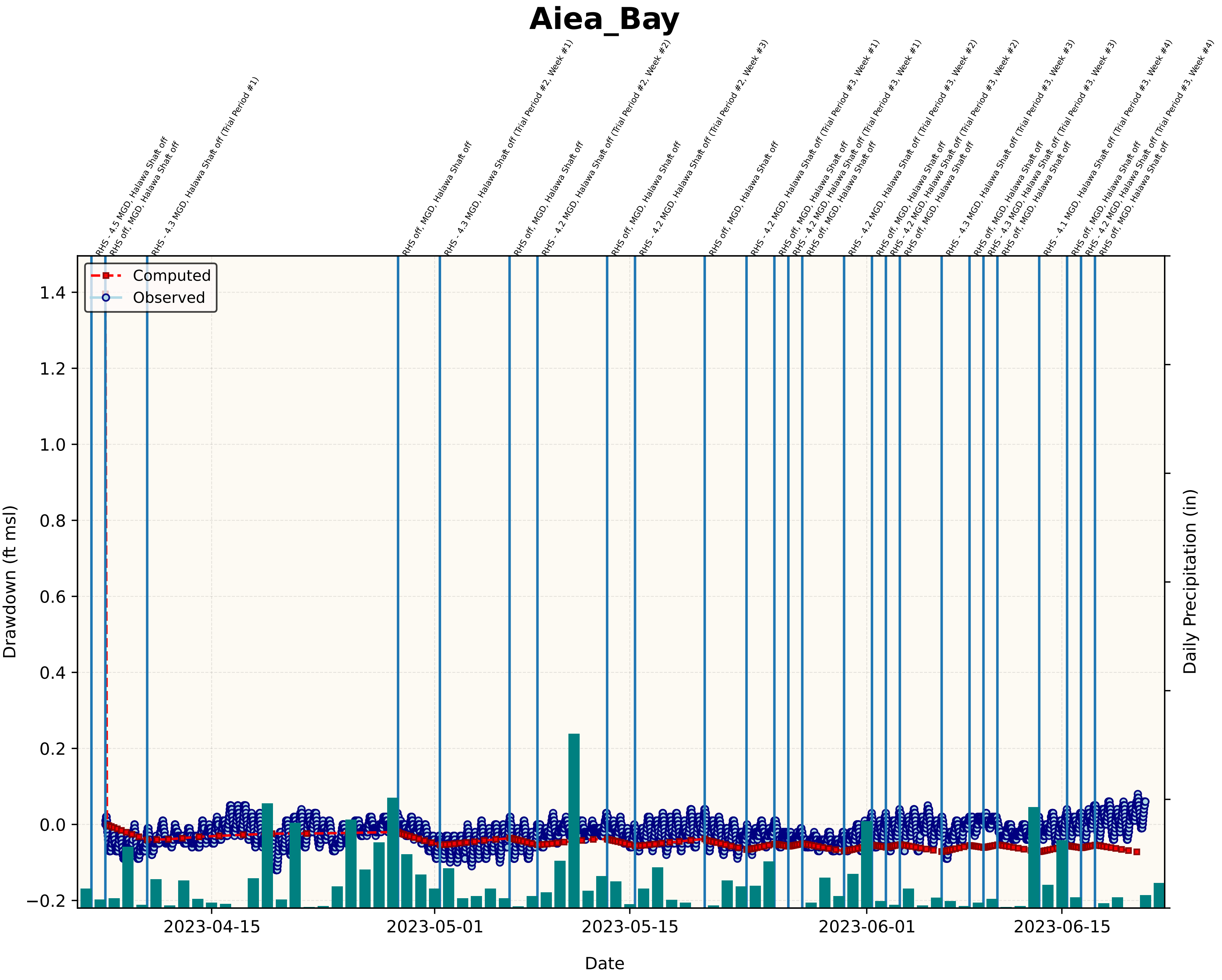
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
19.2
19.0
18.8
18.6
18.4
Water Level (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS off, MGD, Halawa Shaft off
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
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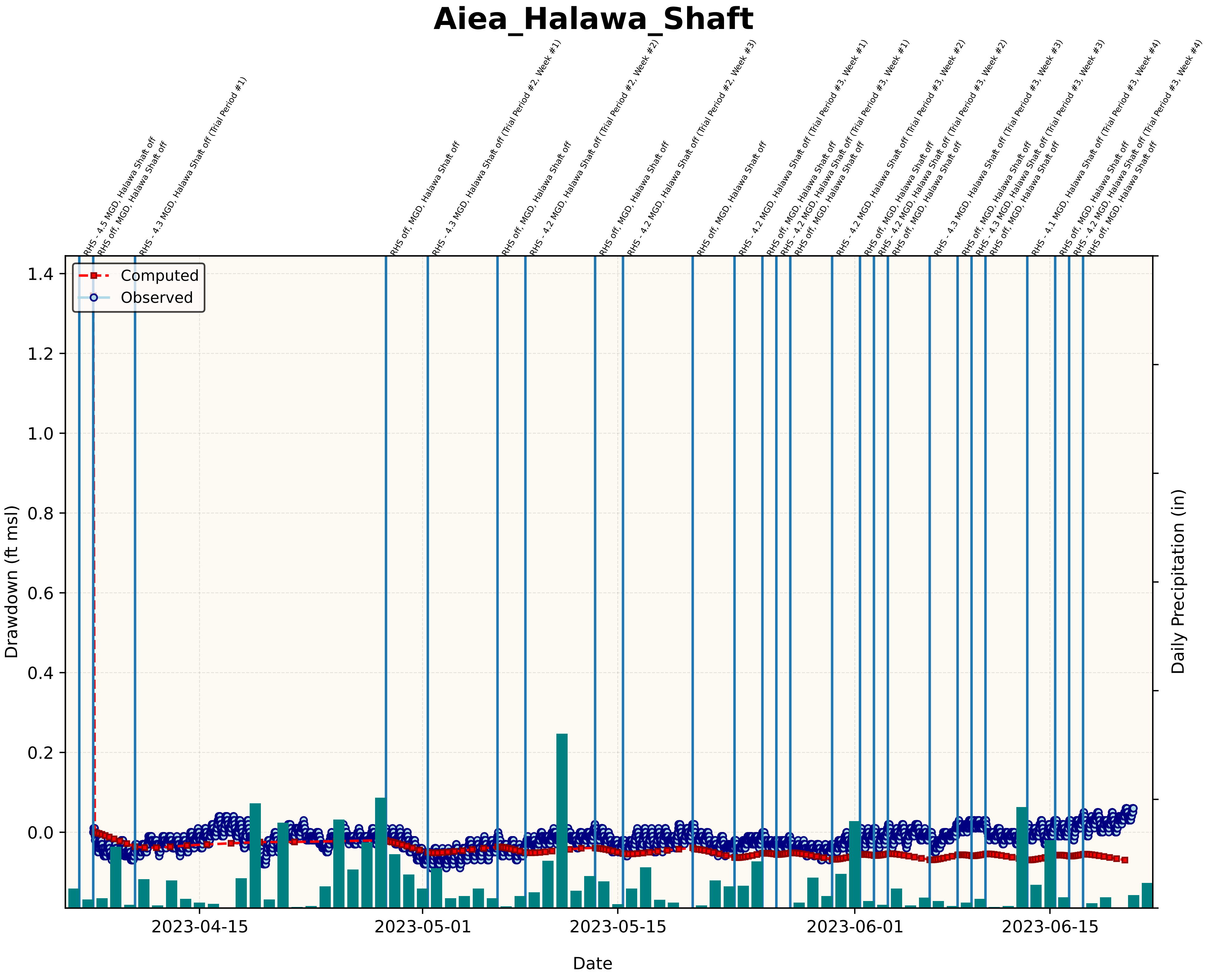
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS off, MGD, Halawa Shaft off
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RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
RHS off, MGD, Halawa Shaft off
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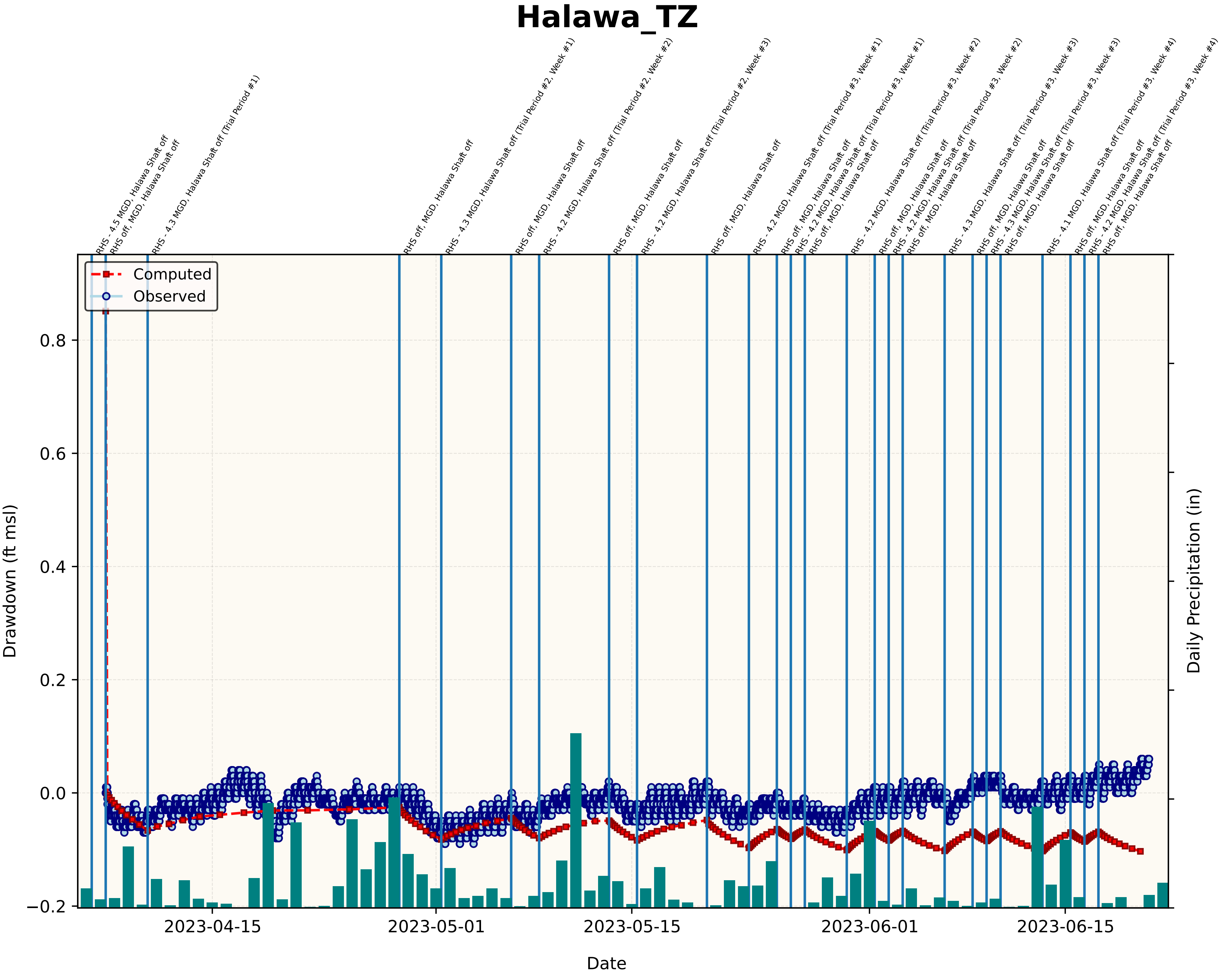
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
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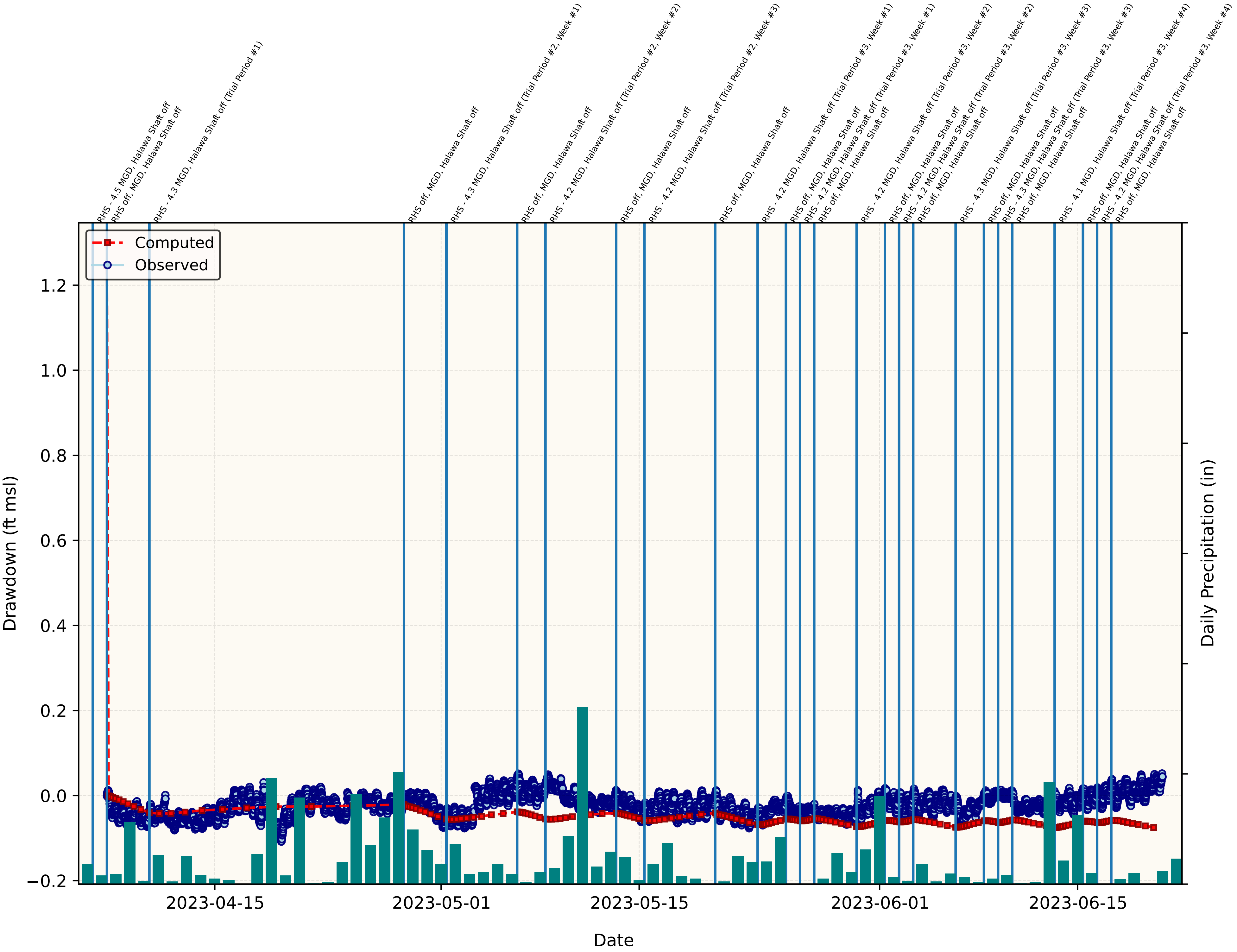
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.8
0.6
0.4
0.2
0.0
−0.2
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

NMW24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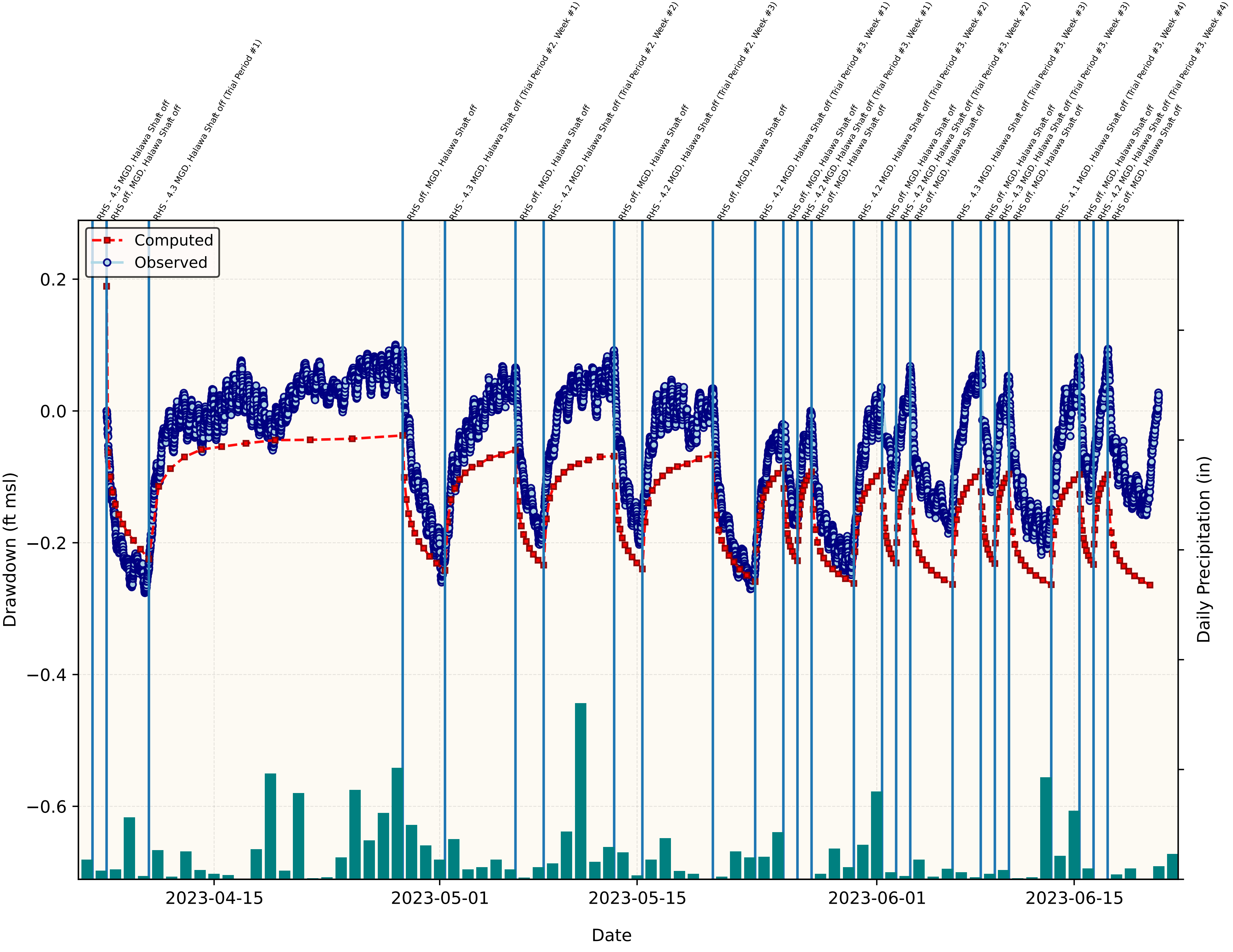
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

OWDFMW01



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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
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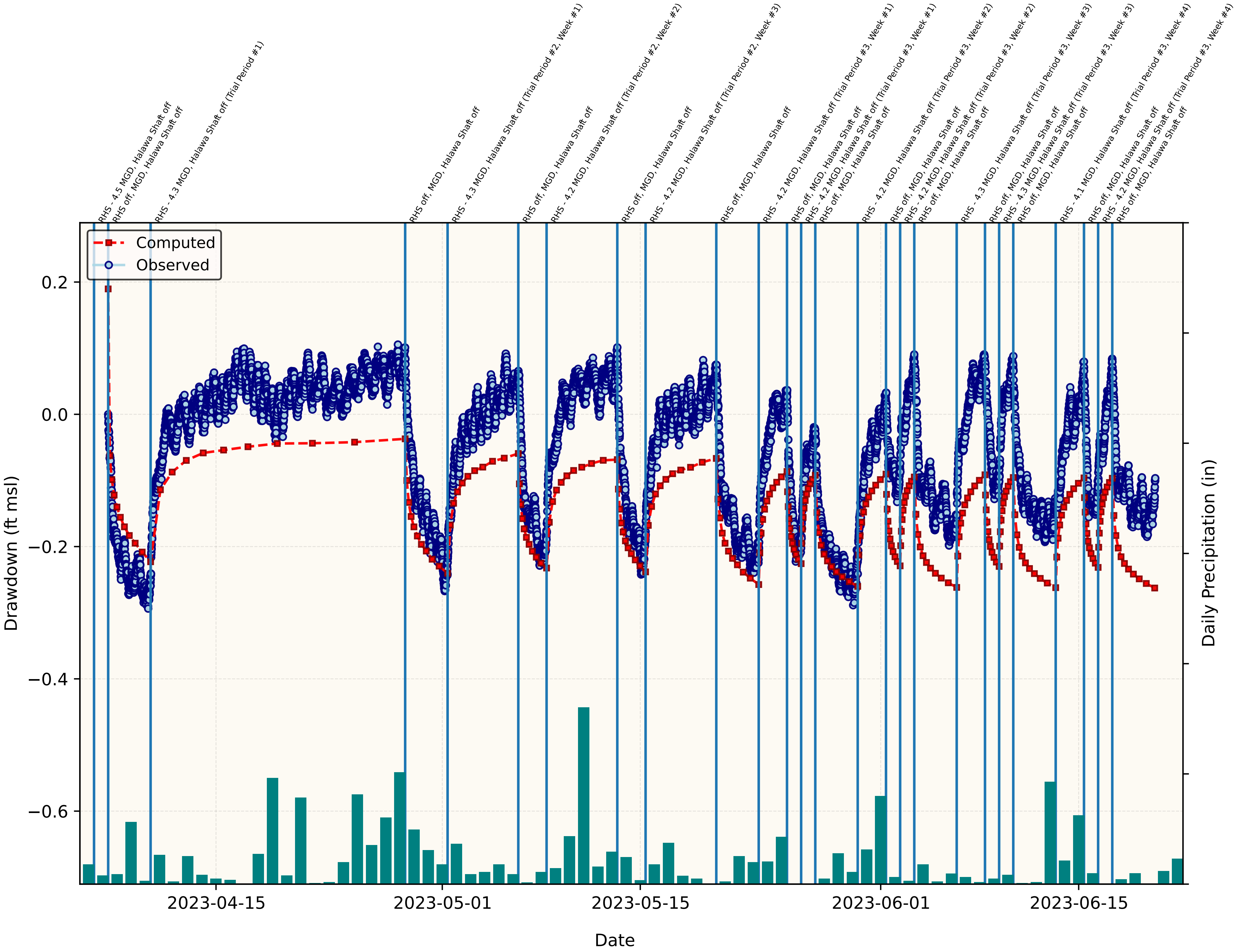
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

OWDFMW02A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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
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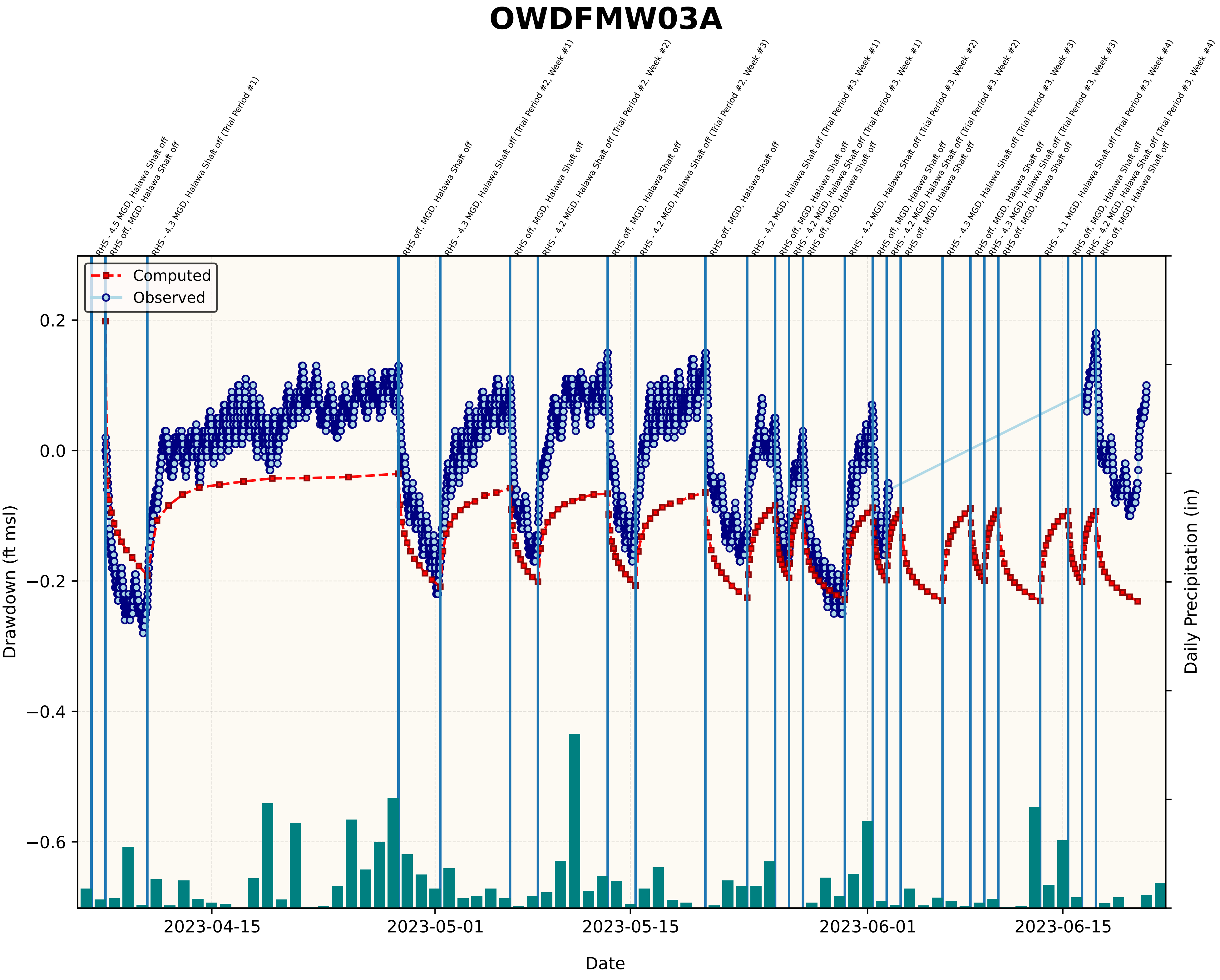
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
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2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

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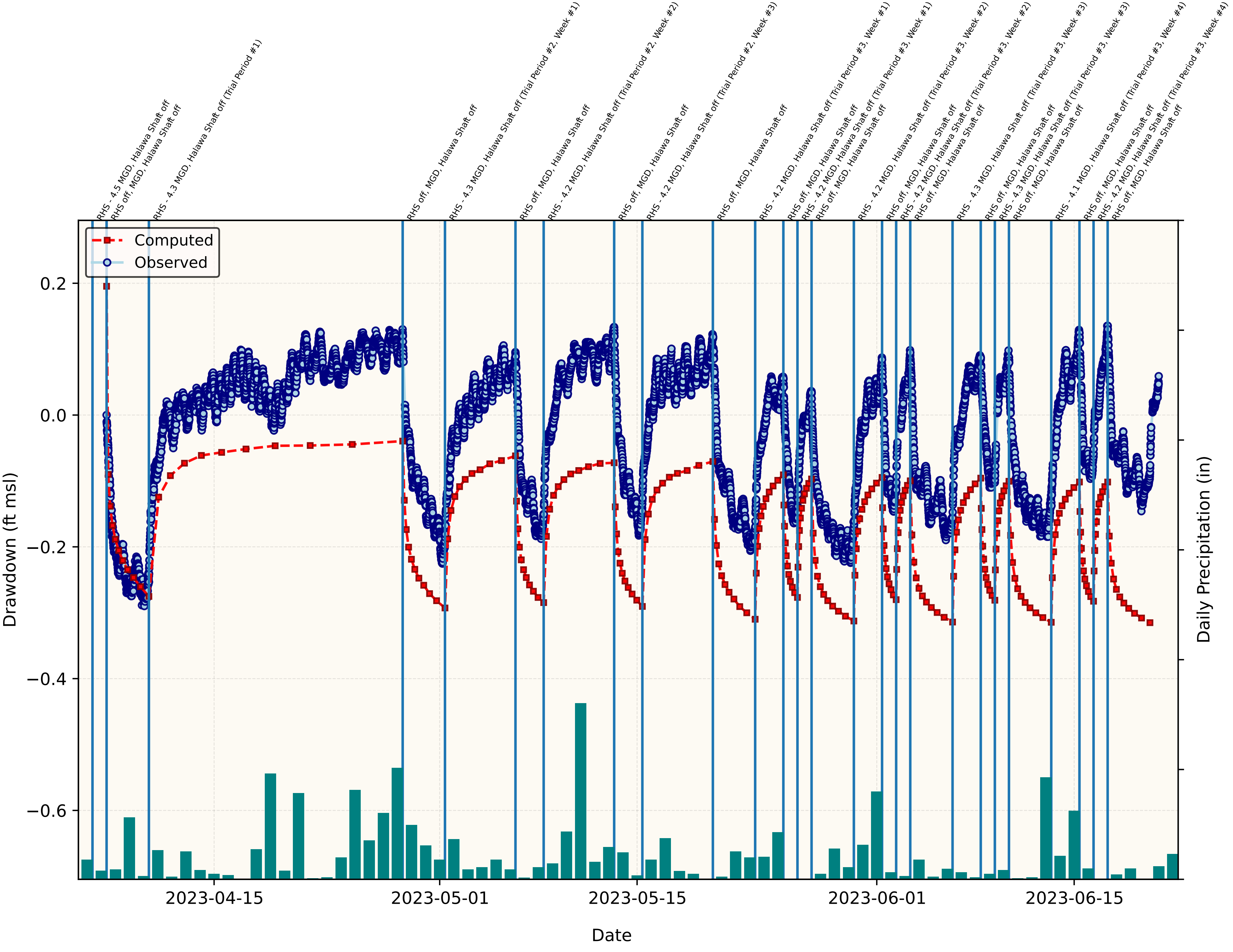

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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
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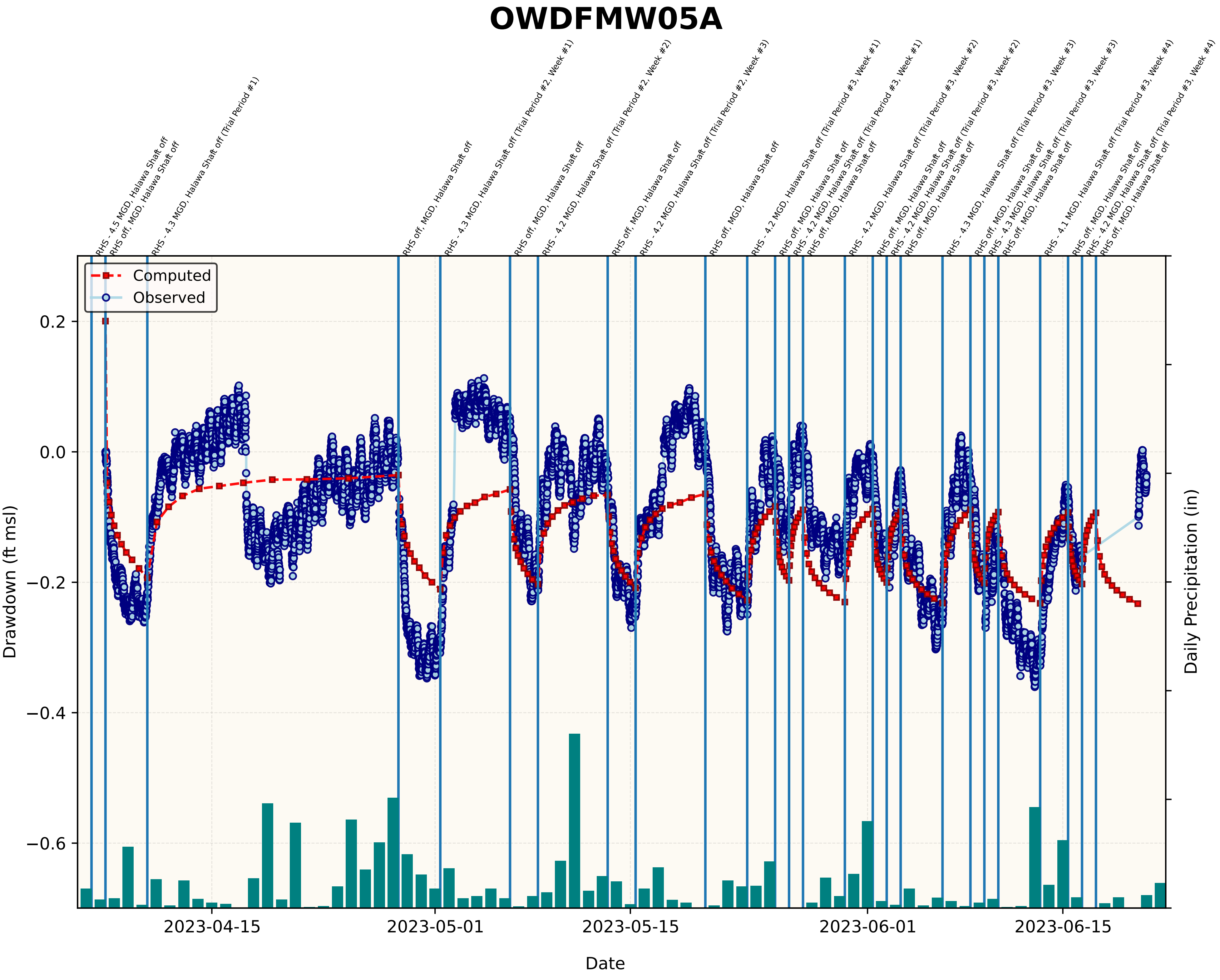
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
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RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
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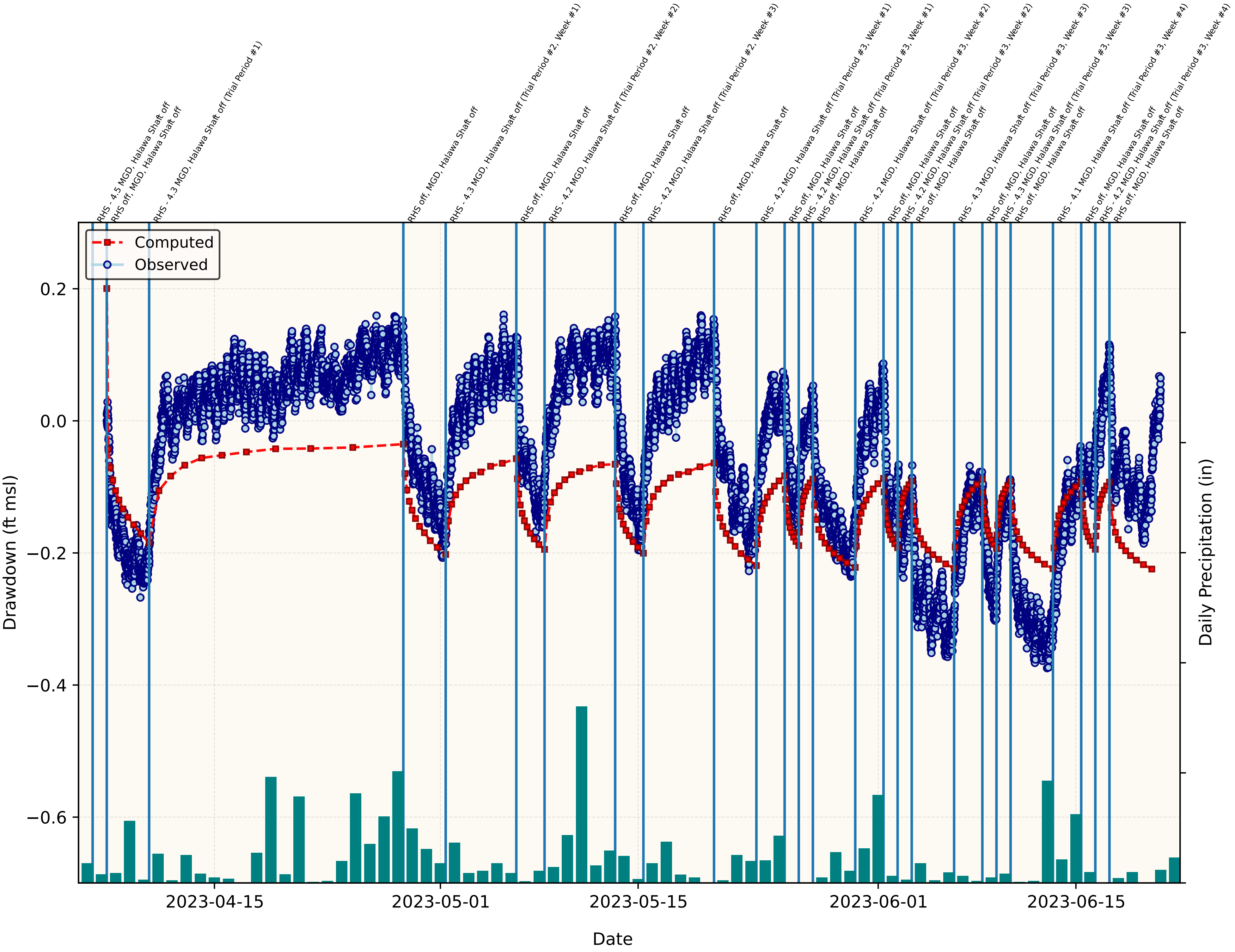
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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
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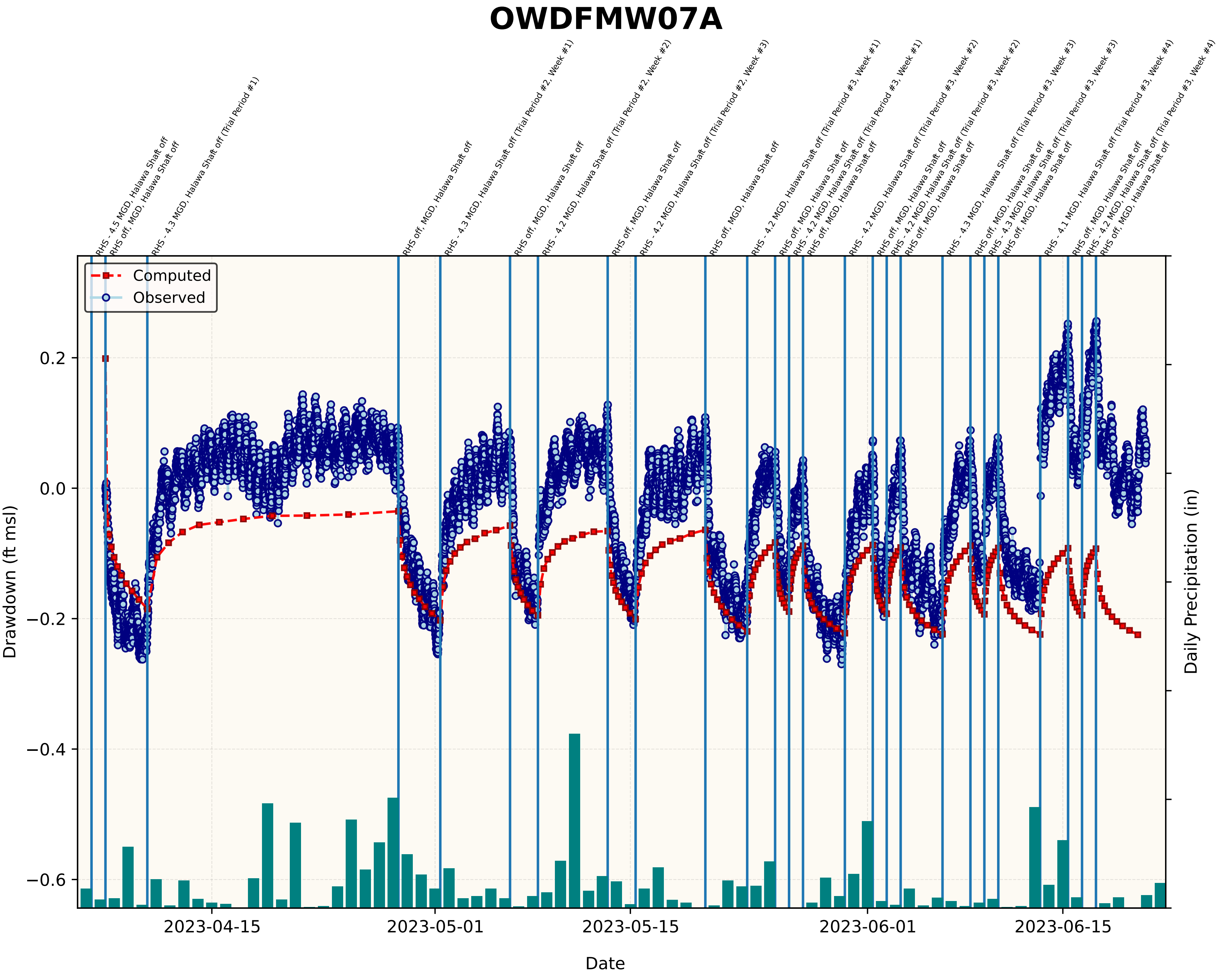
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
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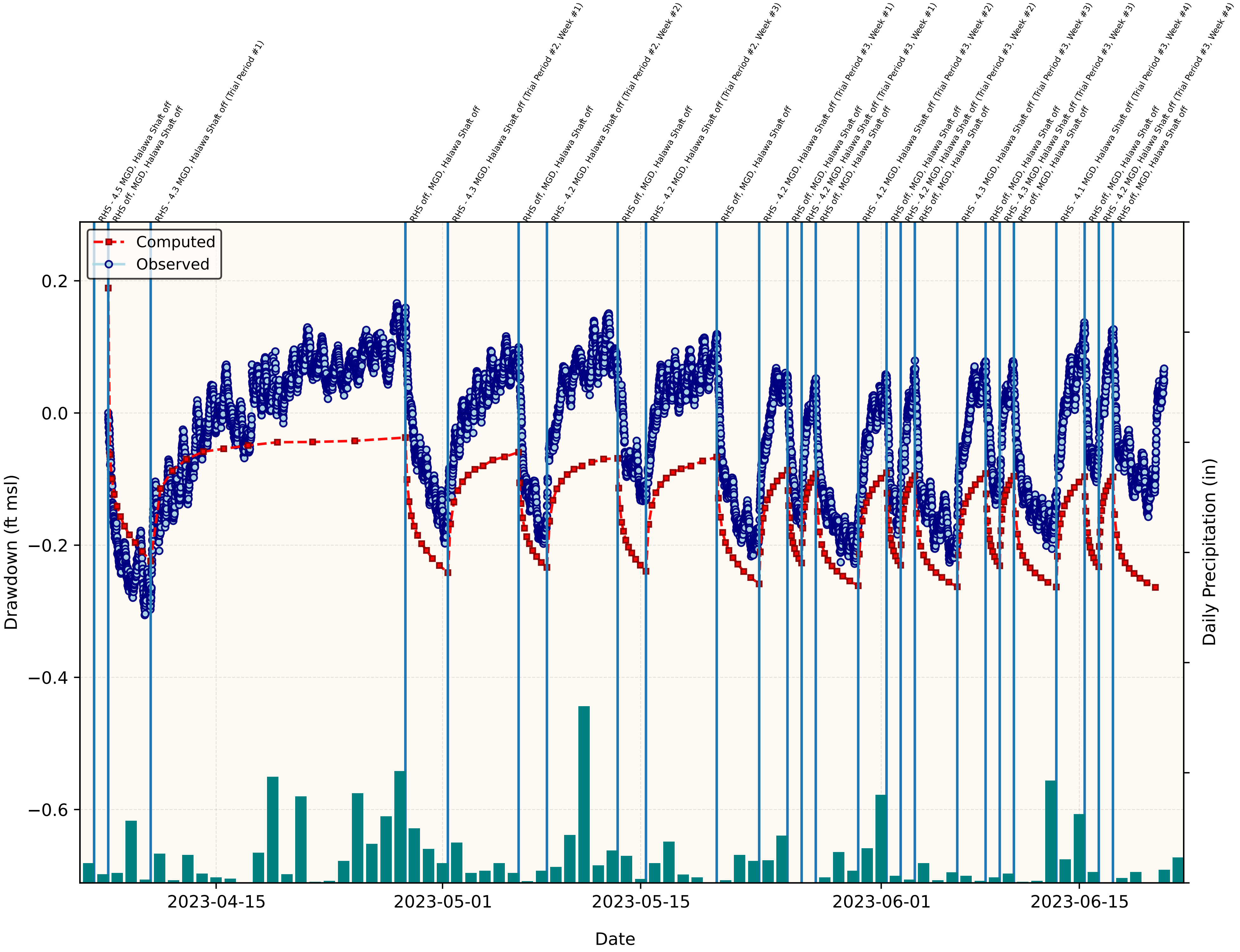
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

OWDFMW08A



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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
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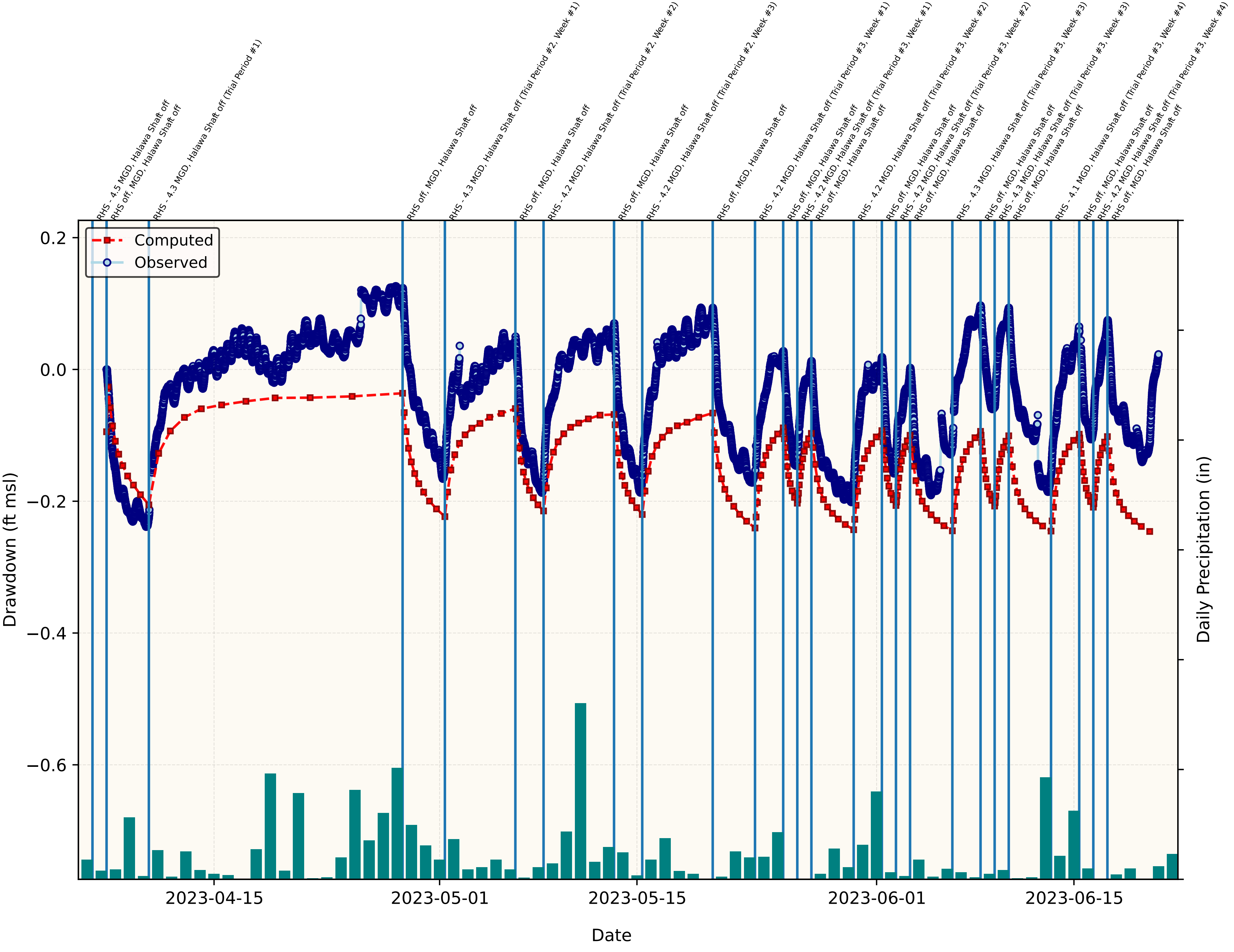
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW01R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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
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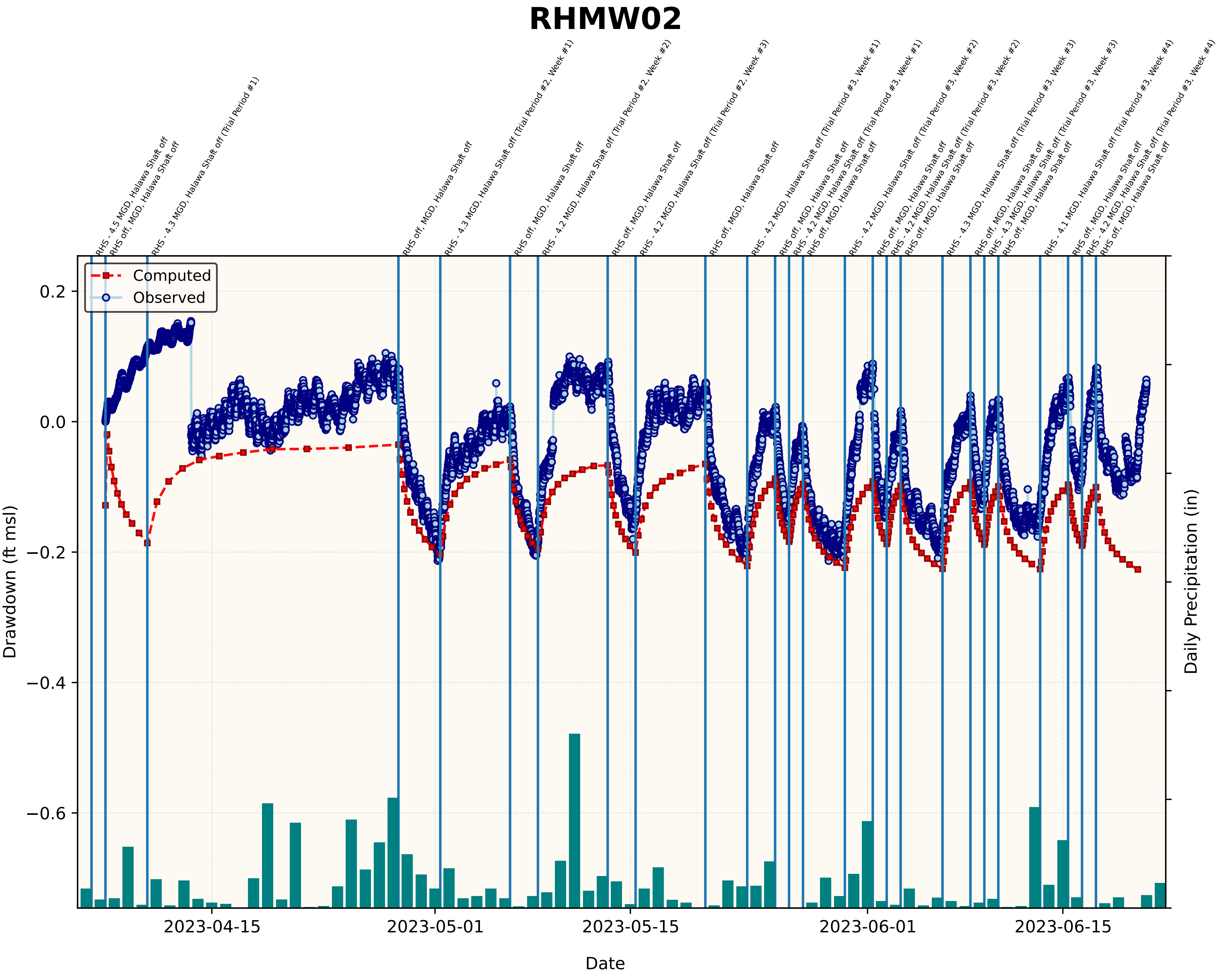
Date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RHS off, MGD, Halawa Shaft off
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
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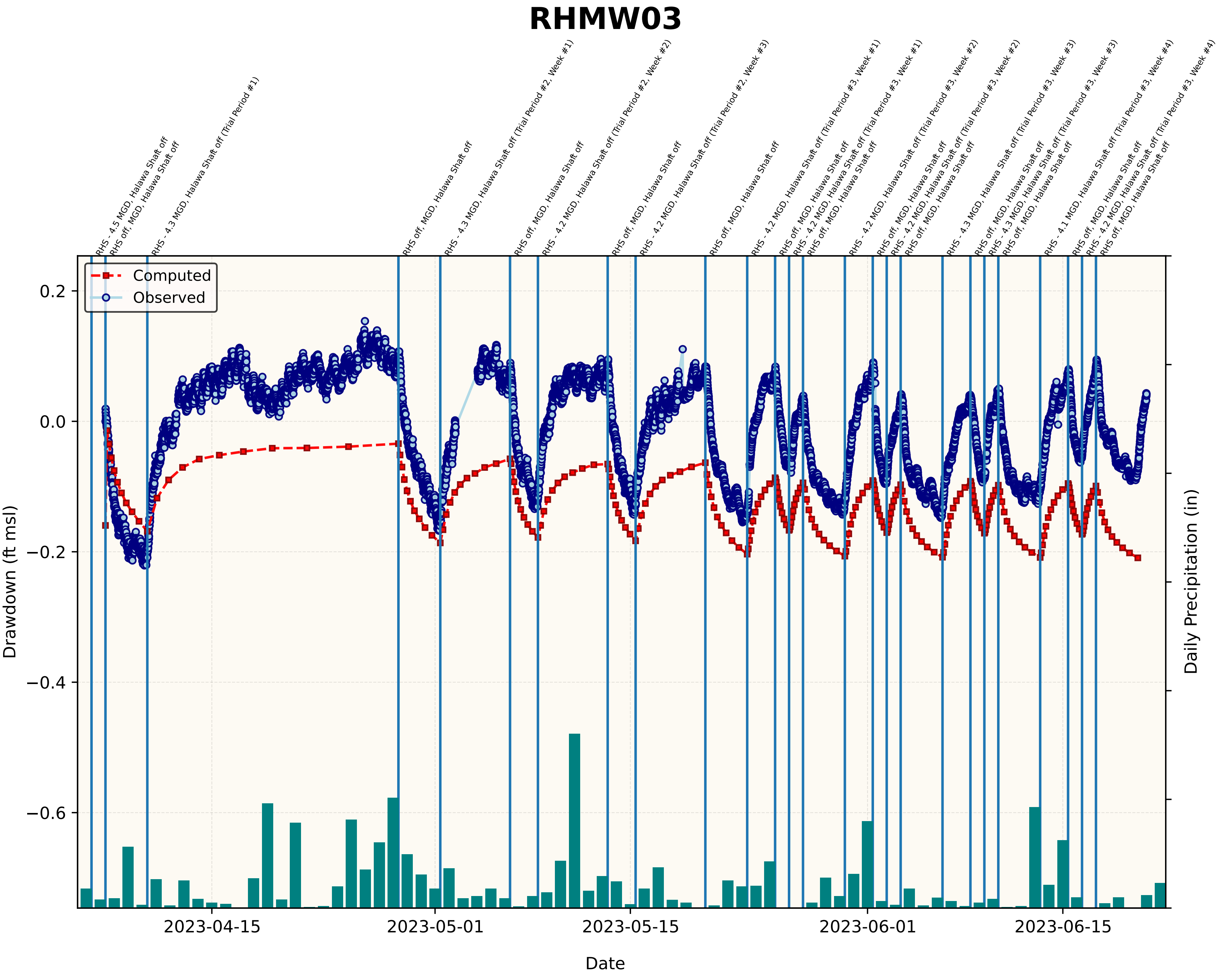
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date



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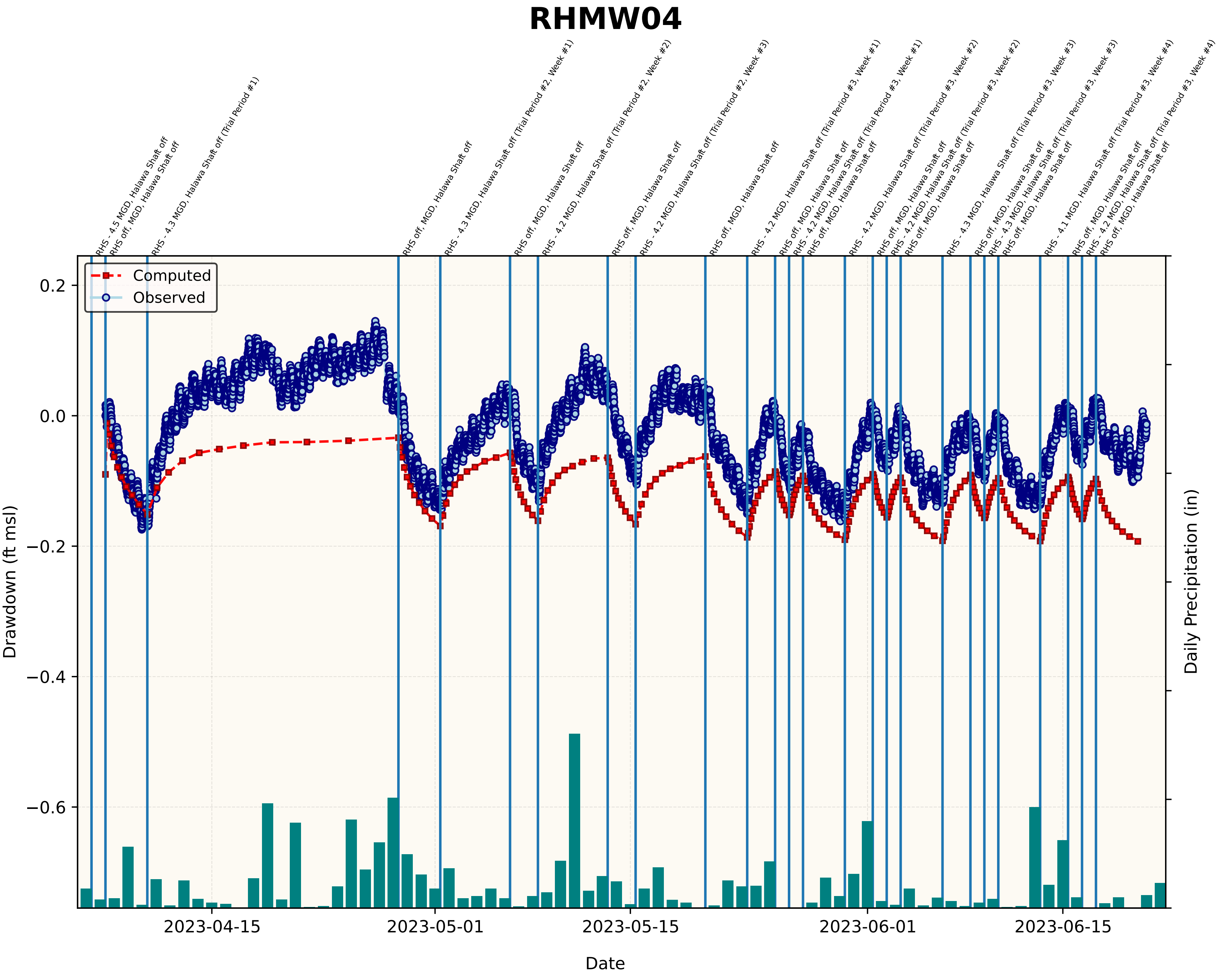
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
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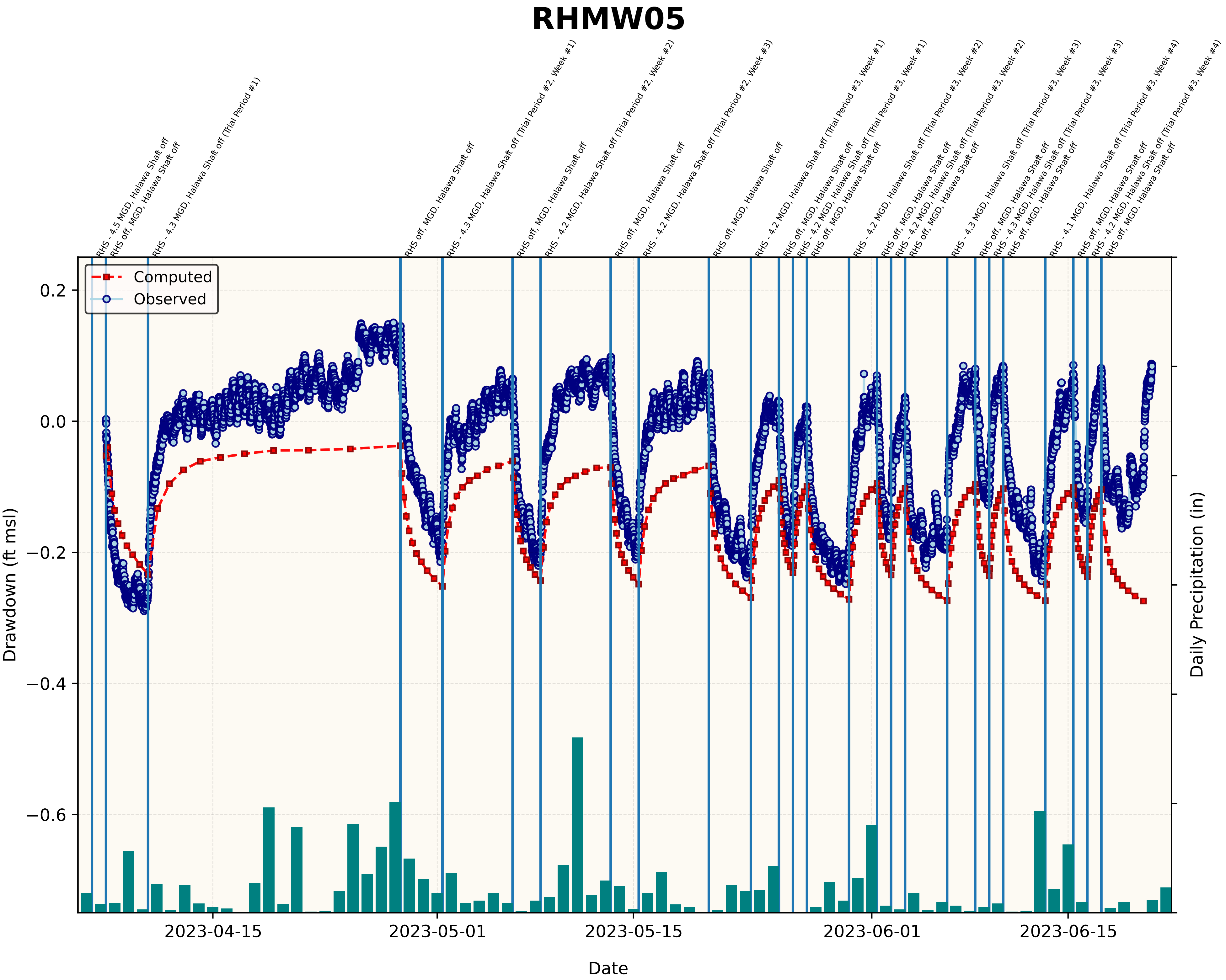
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
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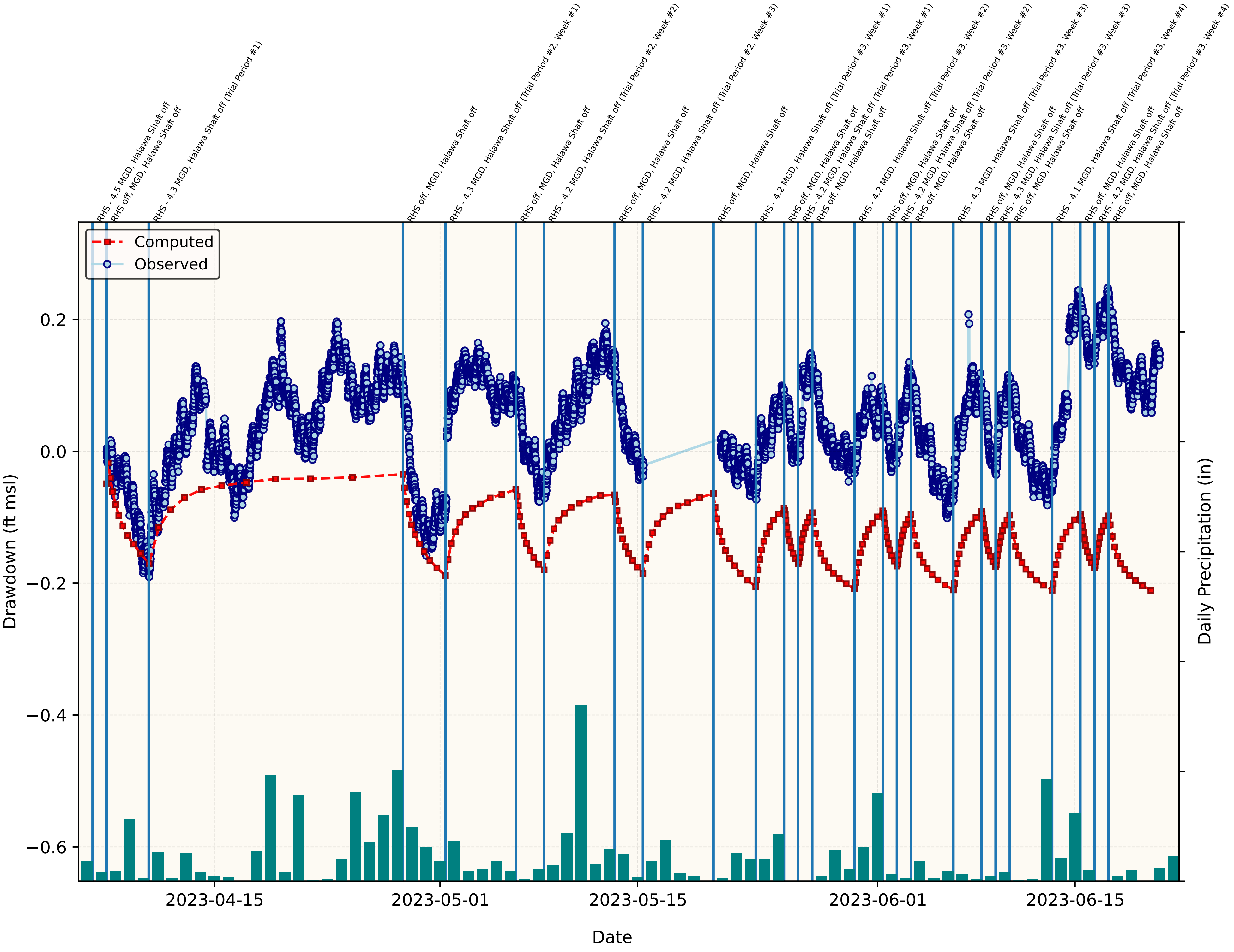
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW06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RHS off, MGD, Halawa Shaft off
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RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
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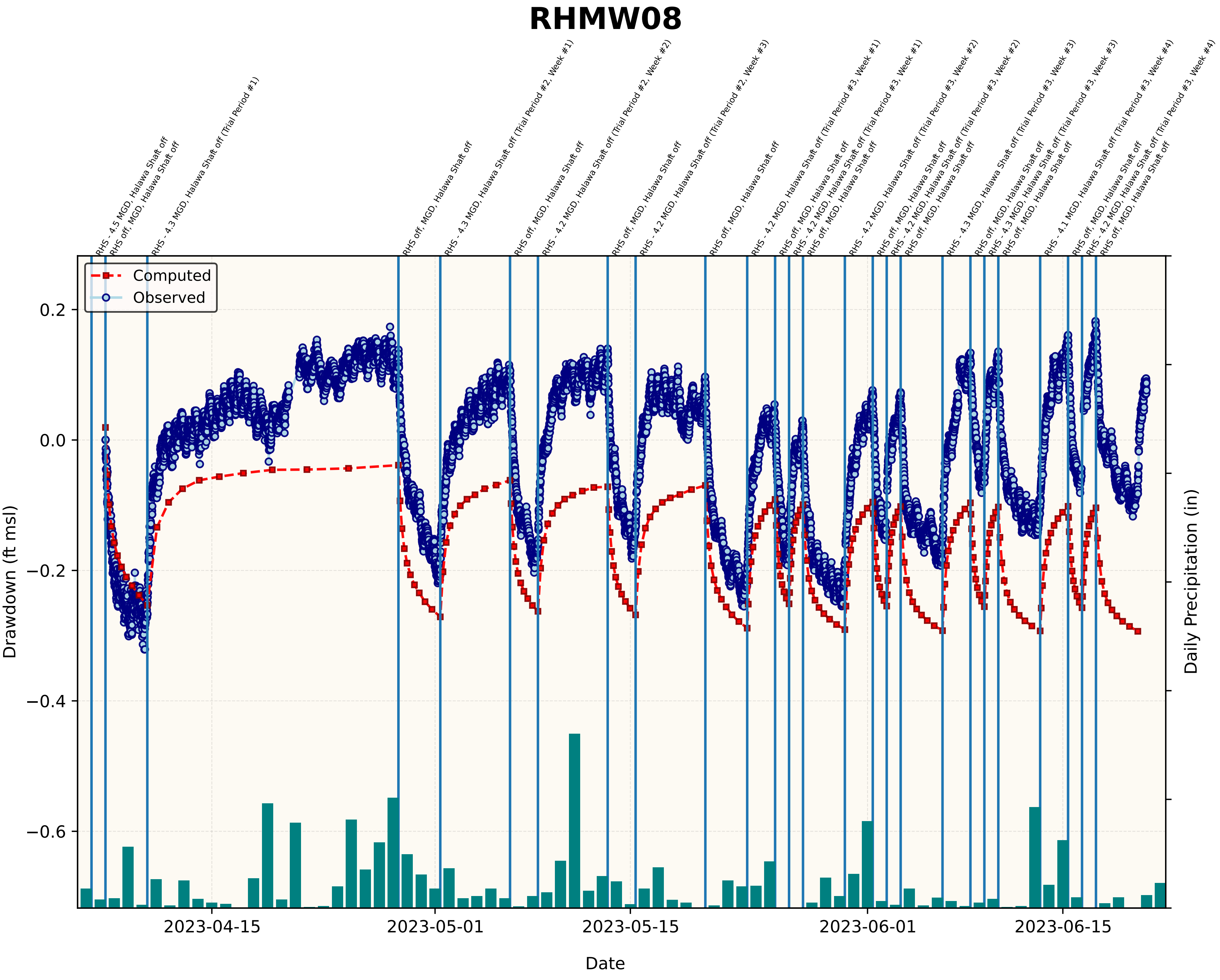
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
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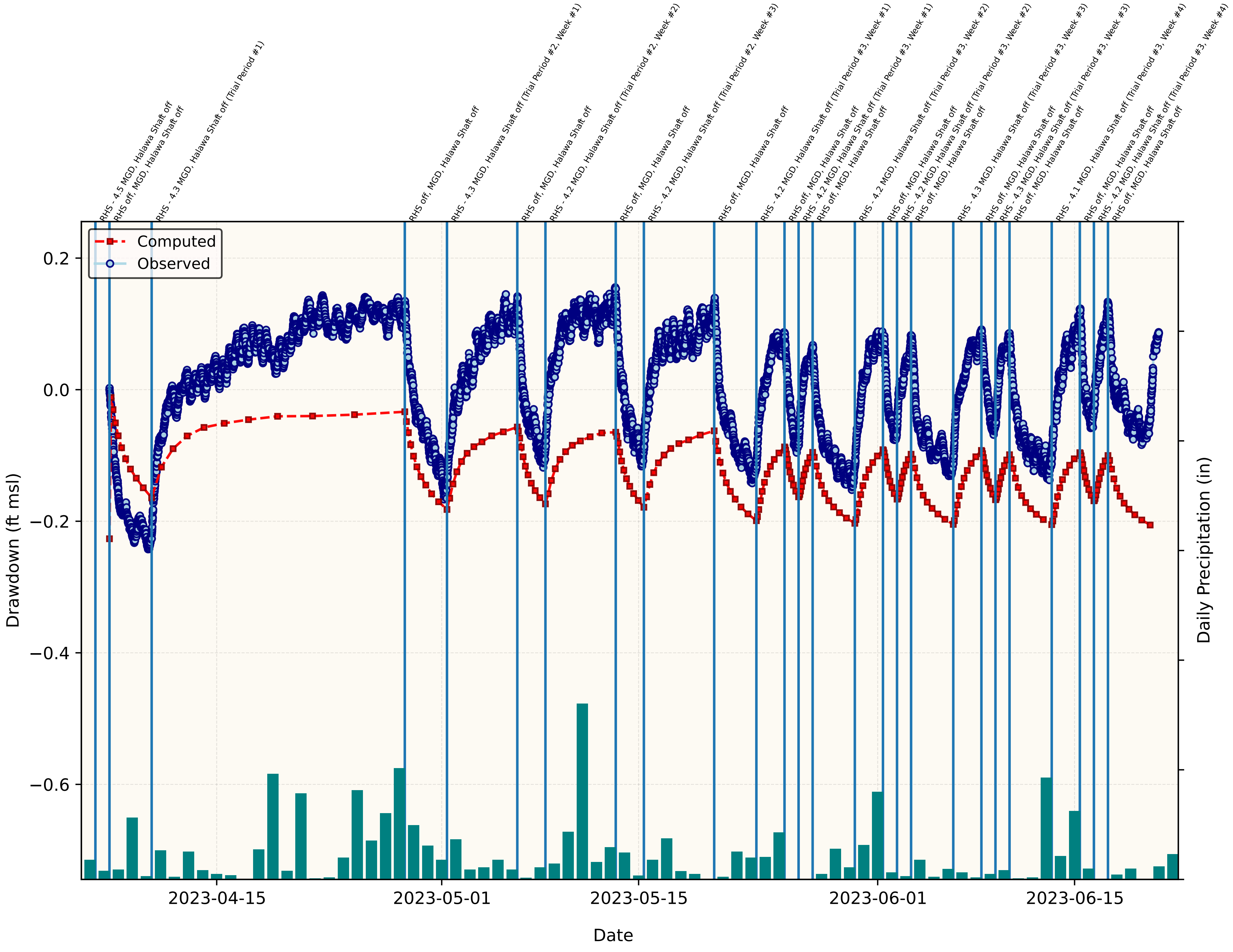
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW09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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
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RHS off, MGD, Halawa Shaft off
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RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
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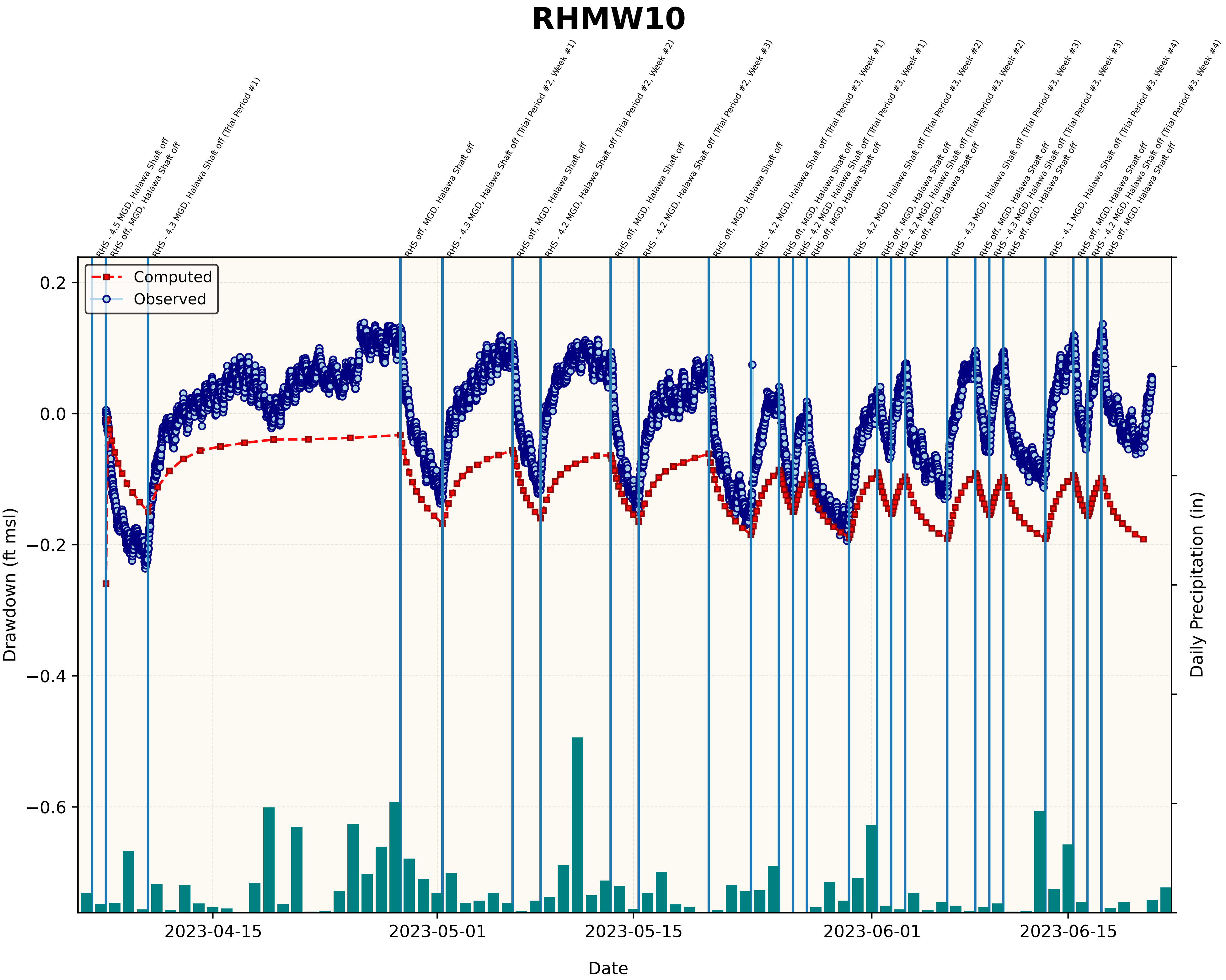
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
Date
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
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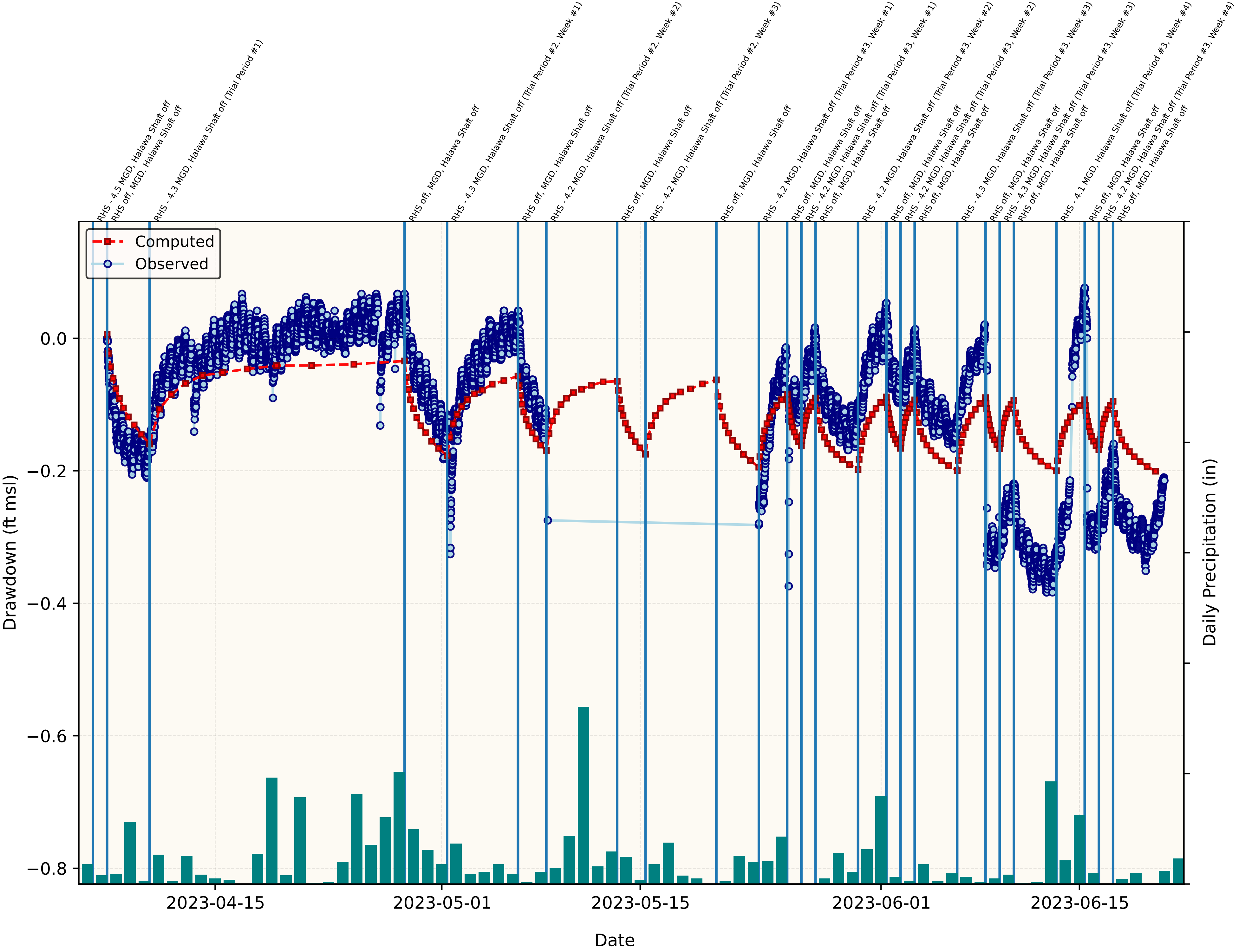
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW11-Zone1



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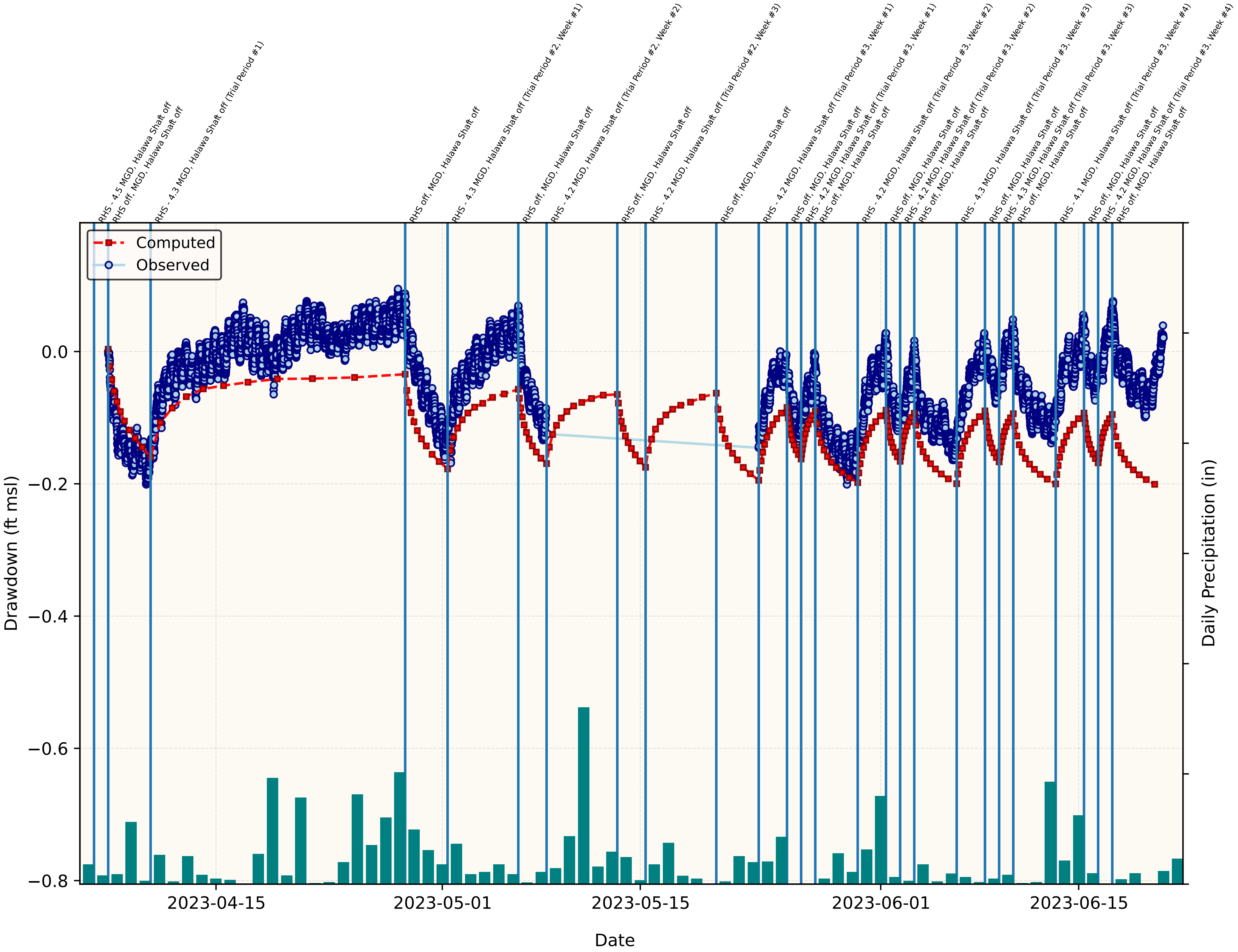

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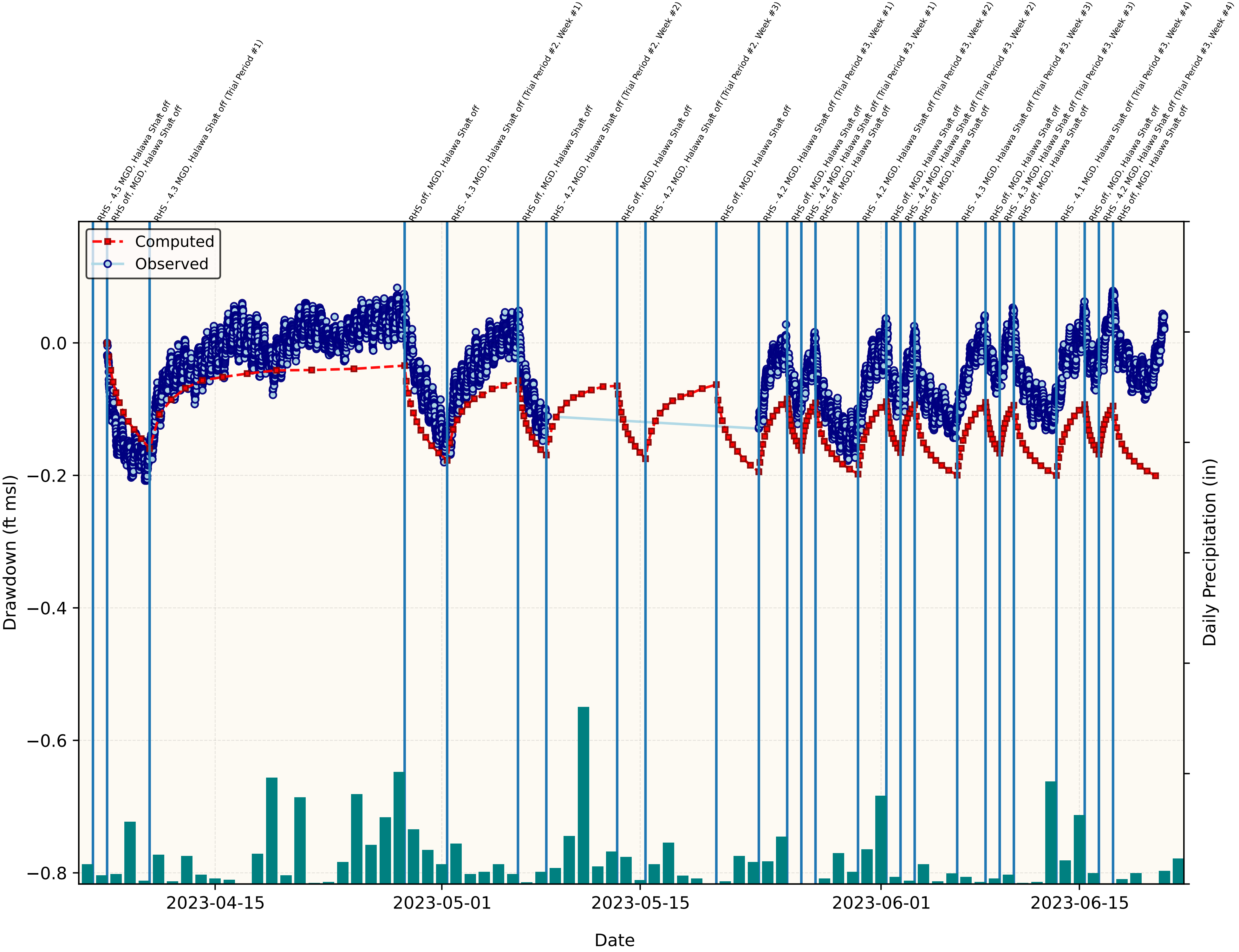

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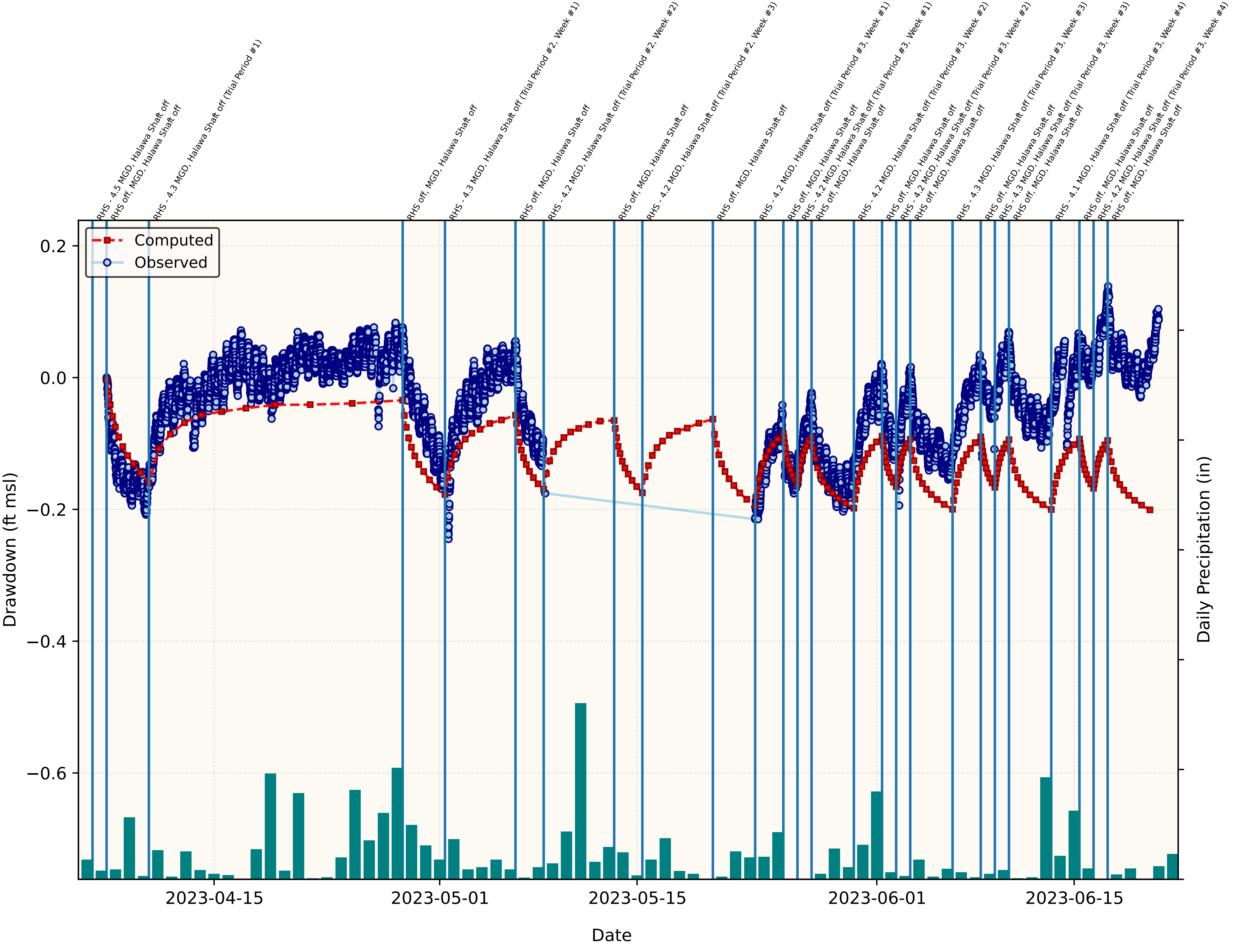

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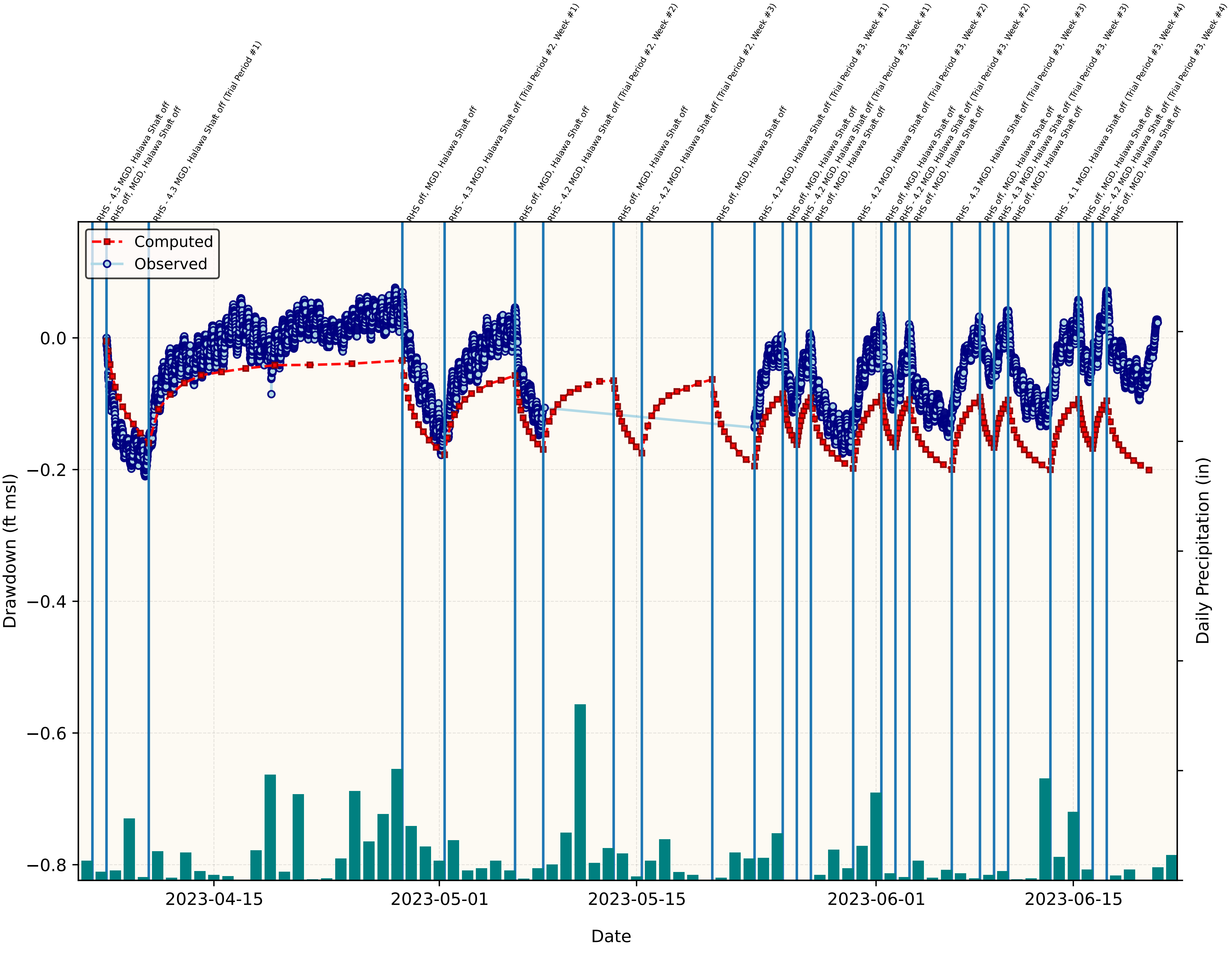

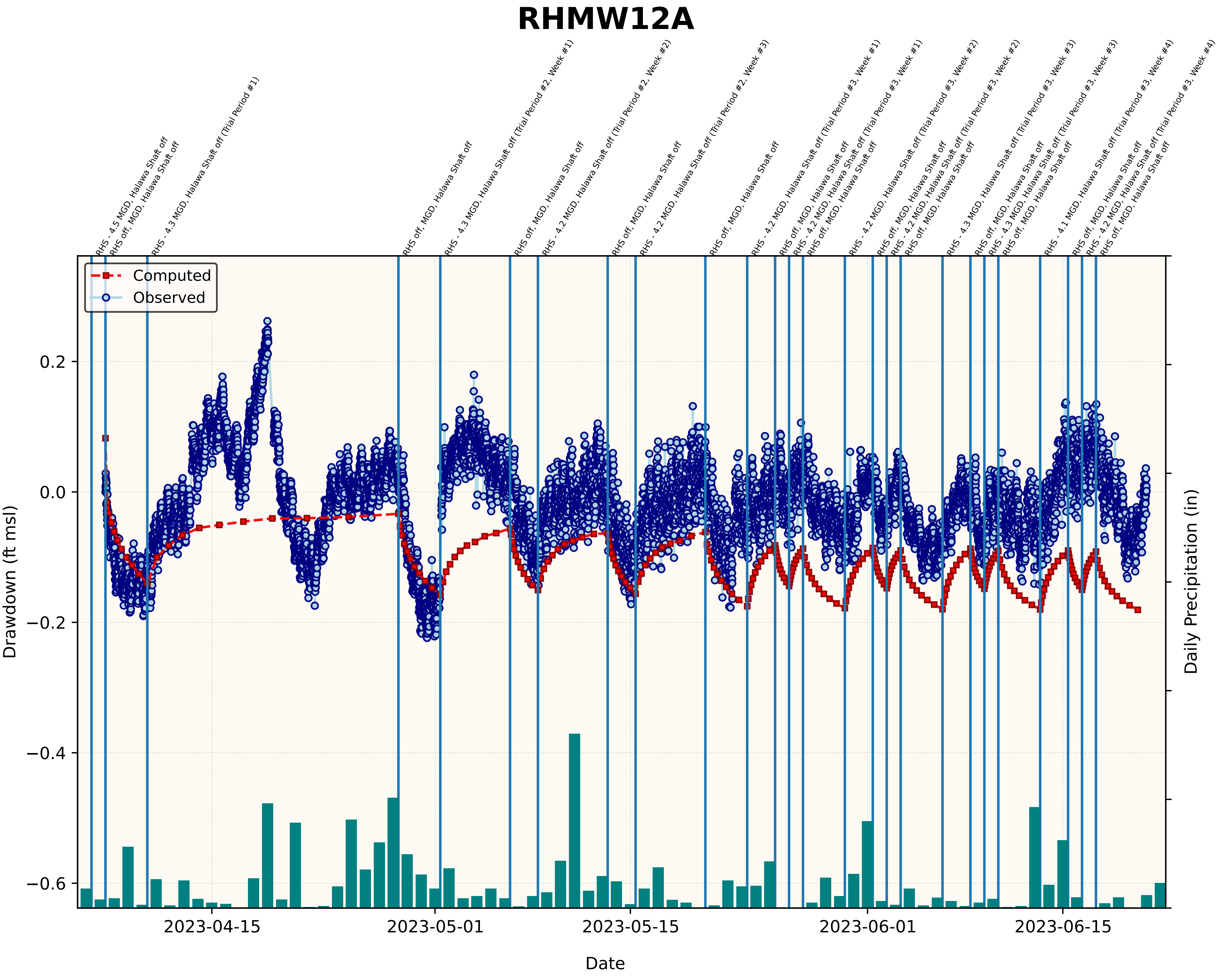

RHMW12A

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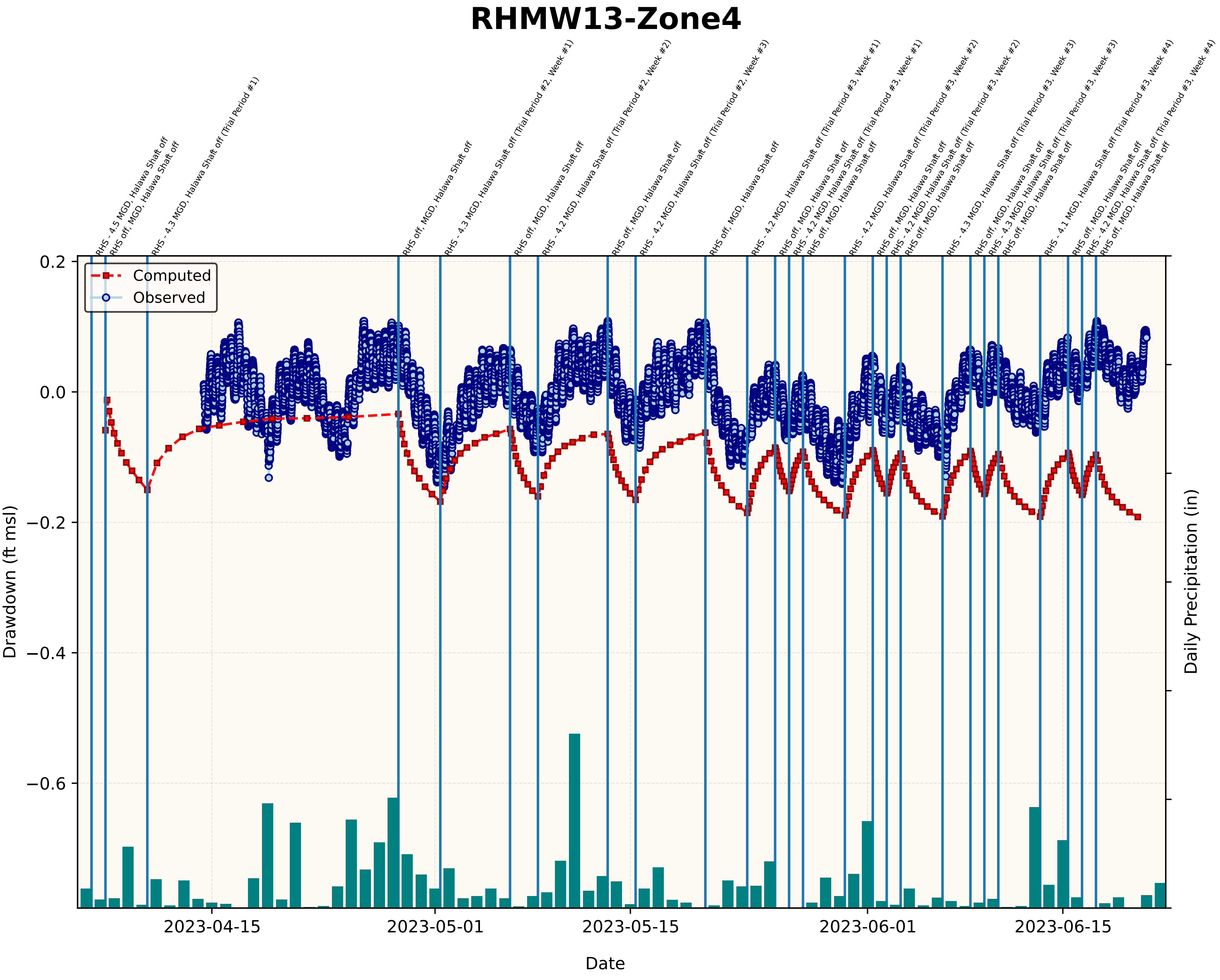
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date


RHMW13-Zone4
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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
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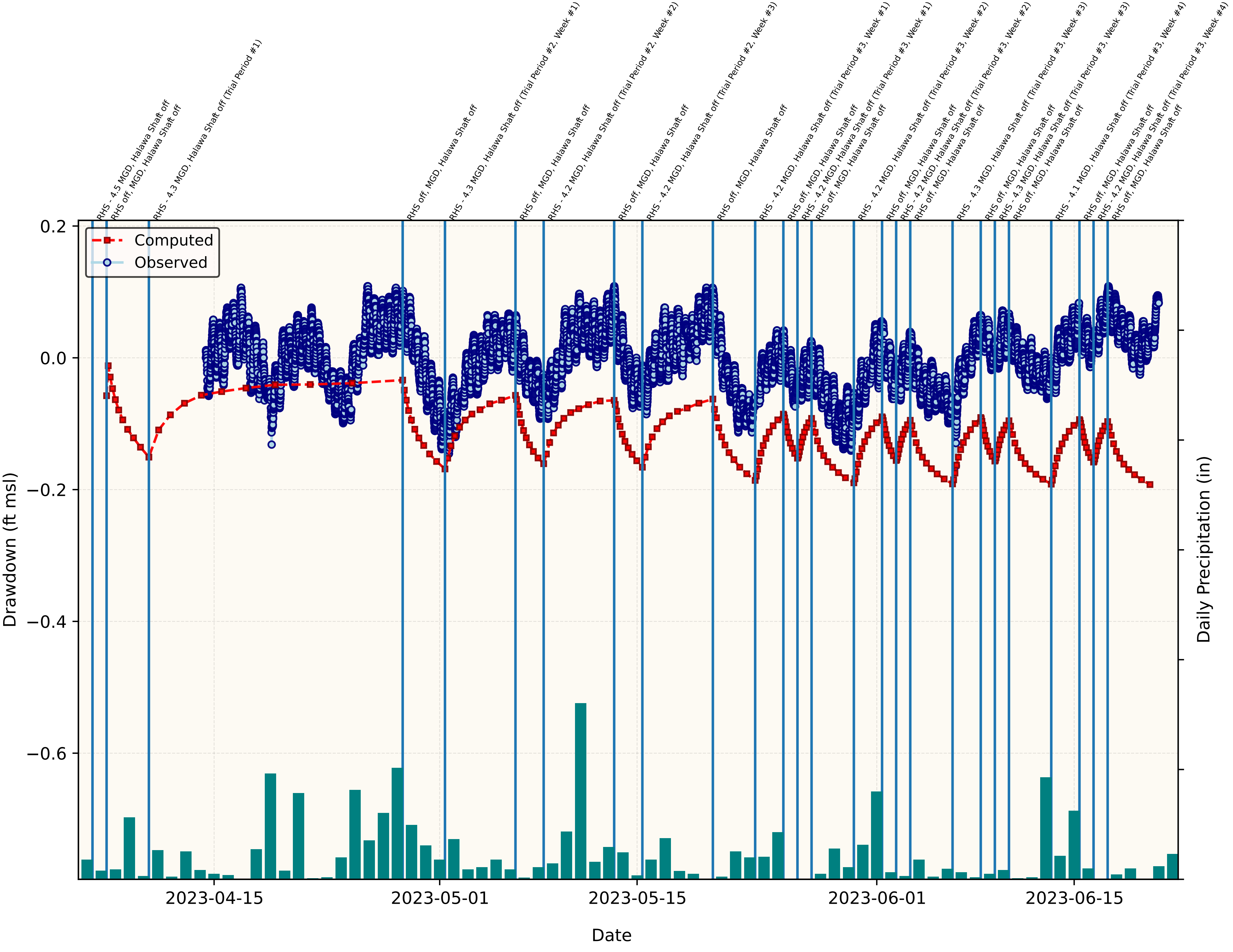
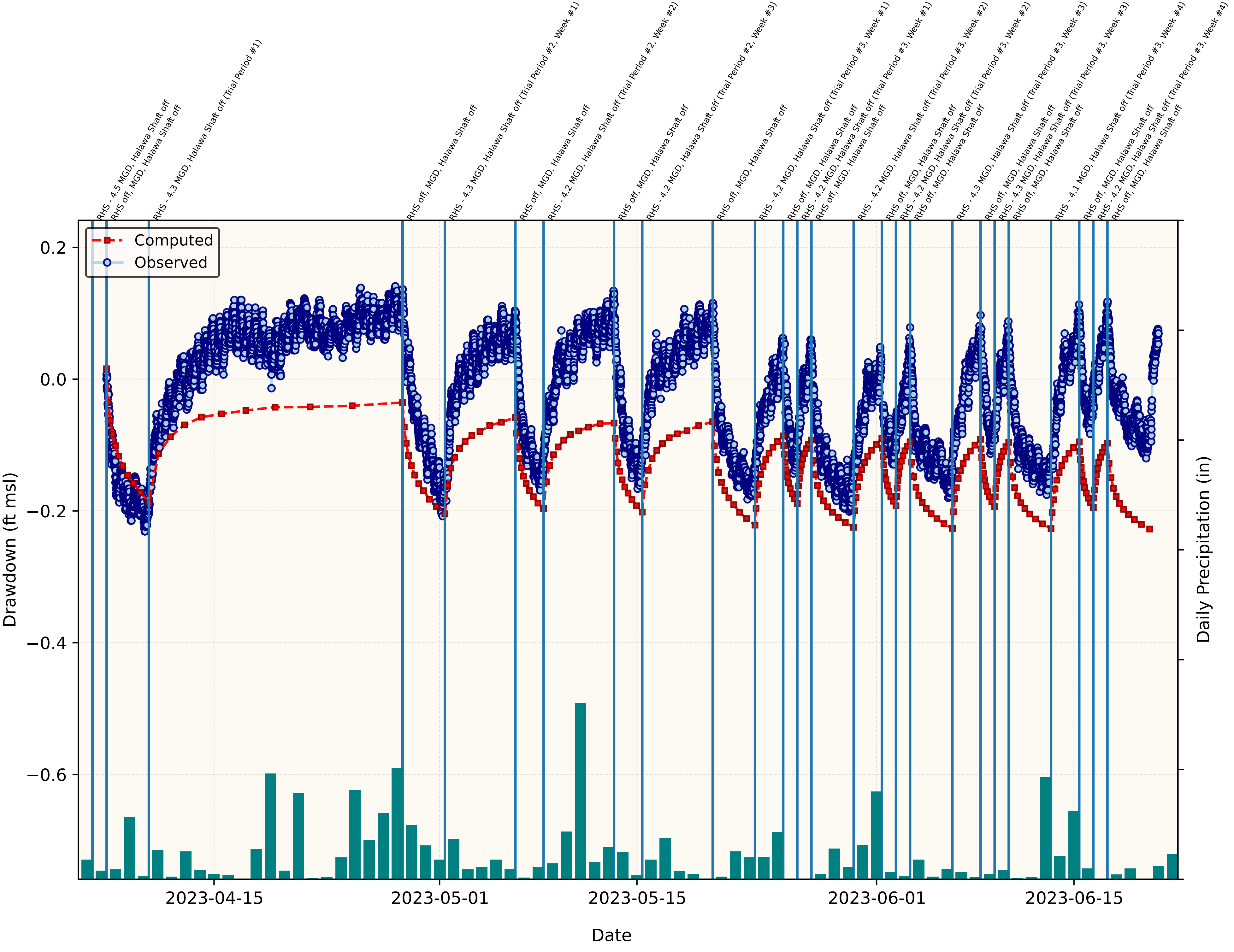
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW13-Zone5a



RHMW14-Zone1



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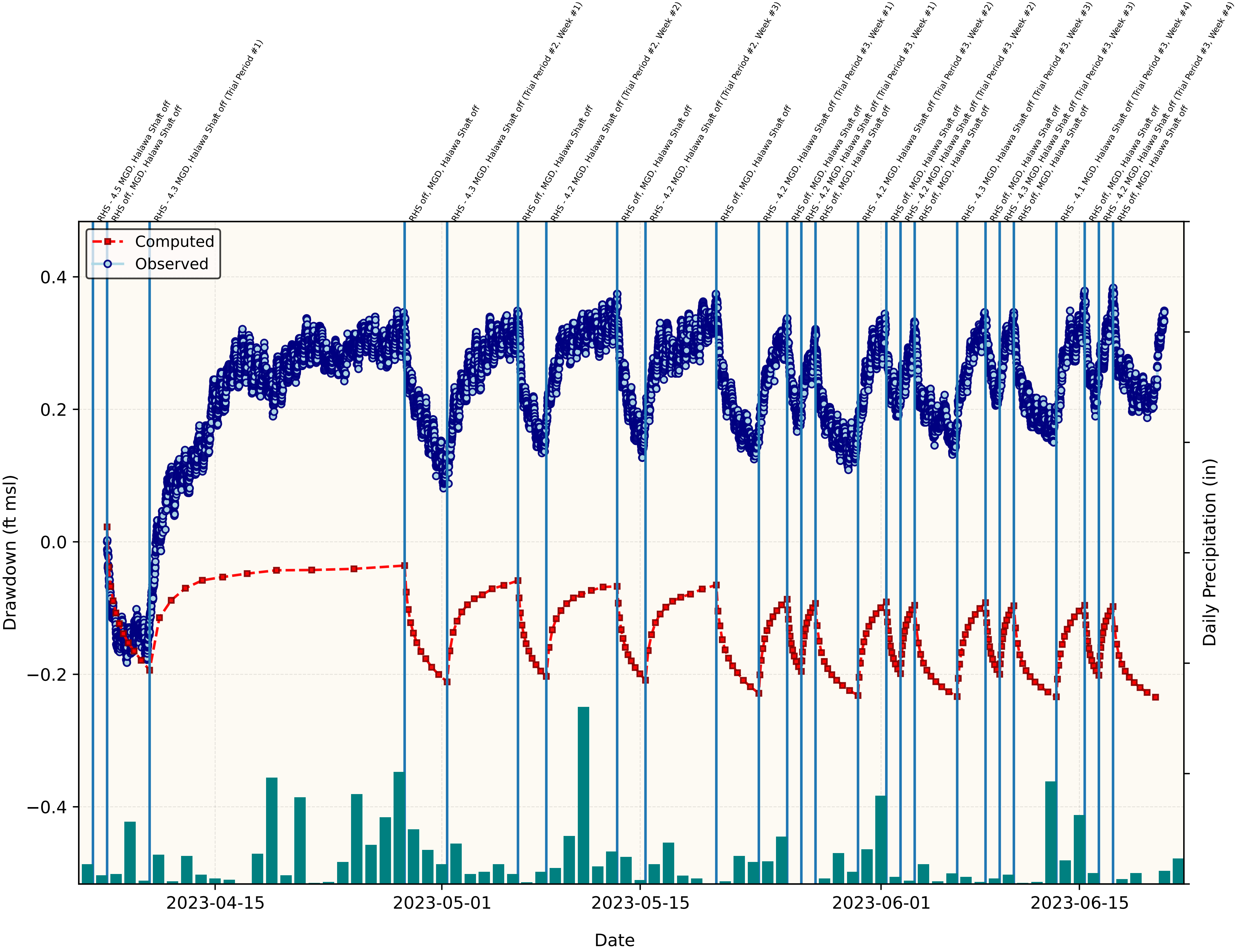

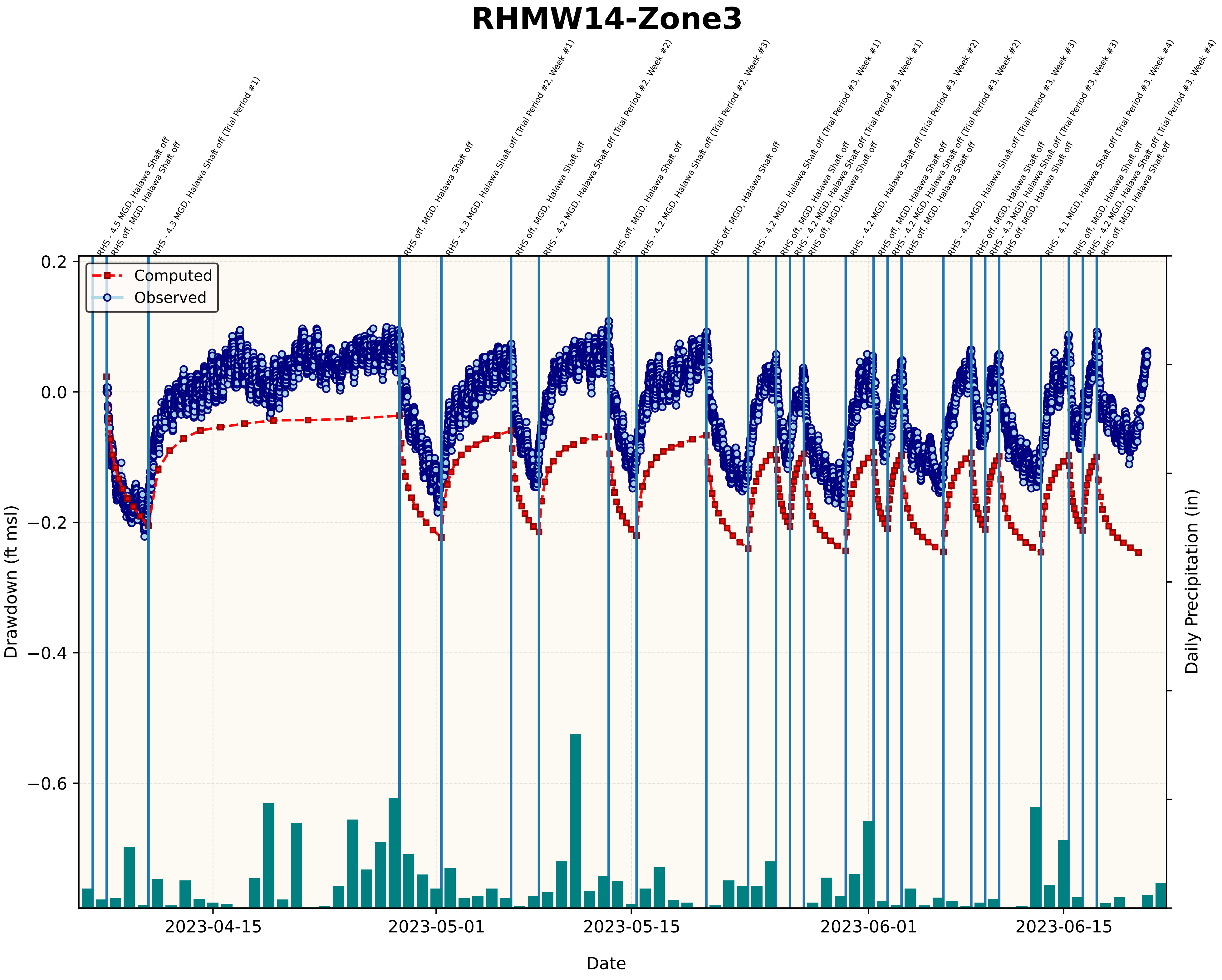
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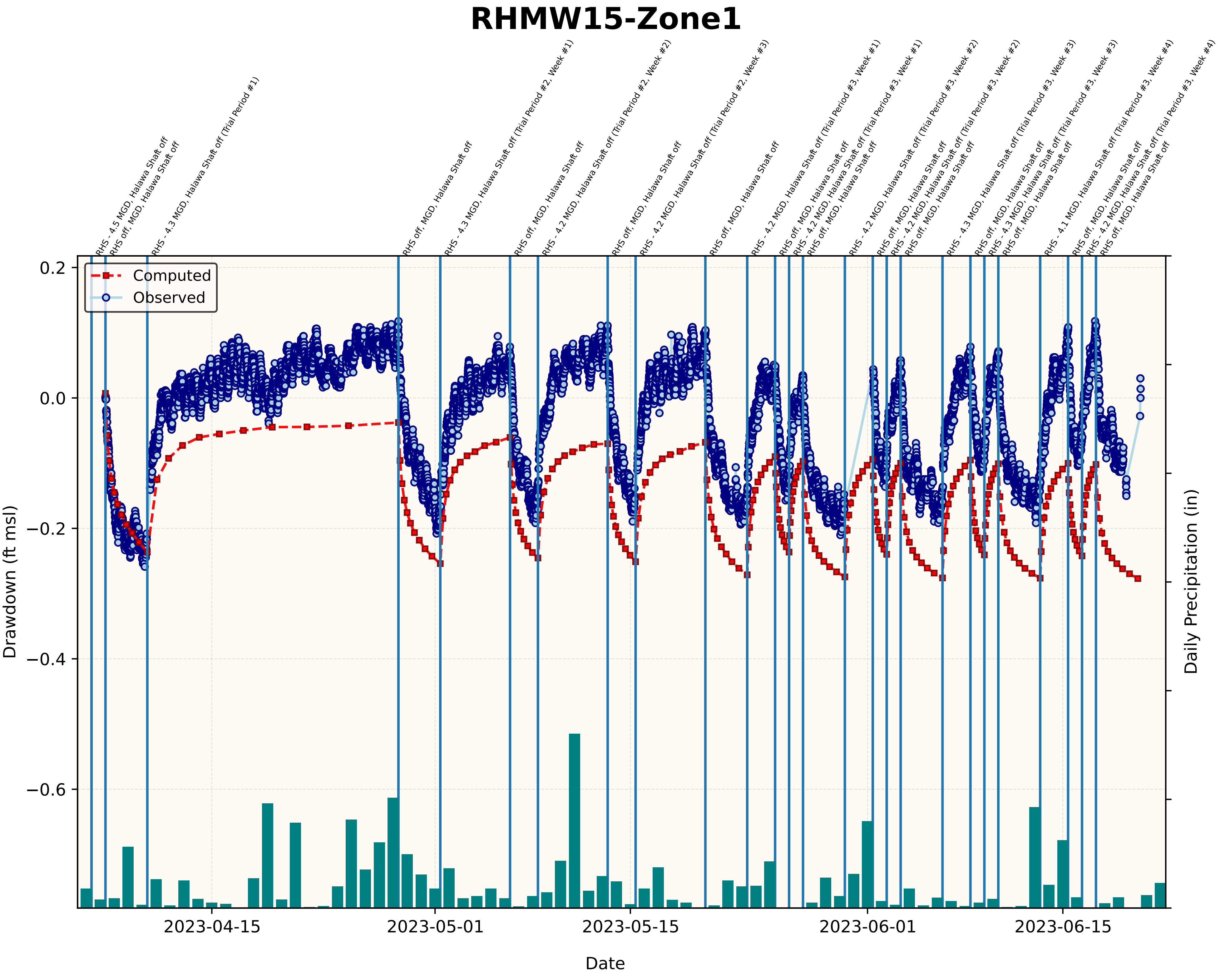
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date


RHMW15-Zone1
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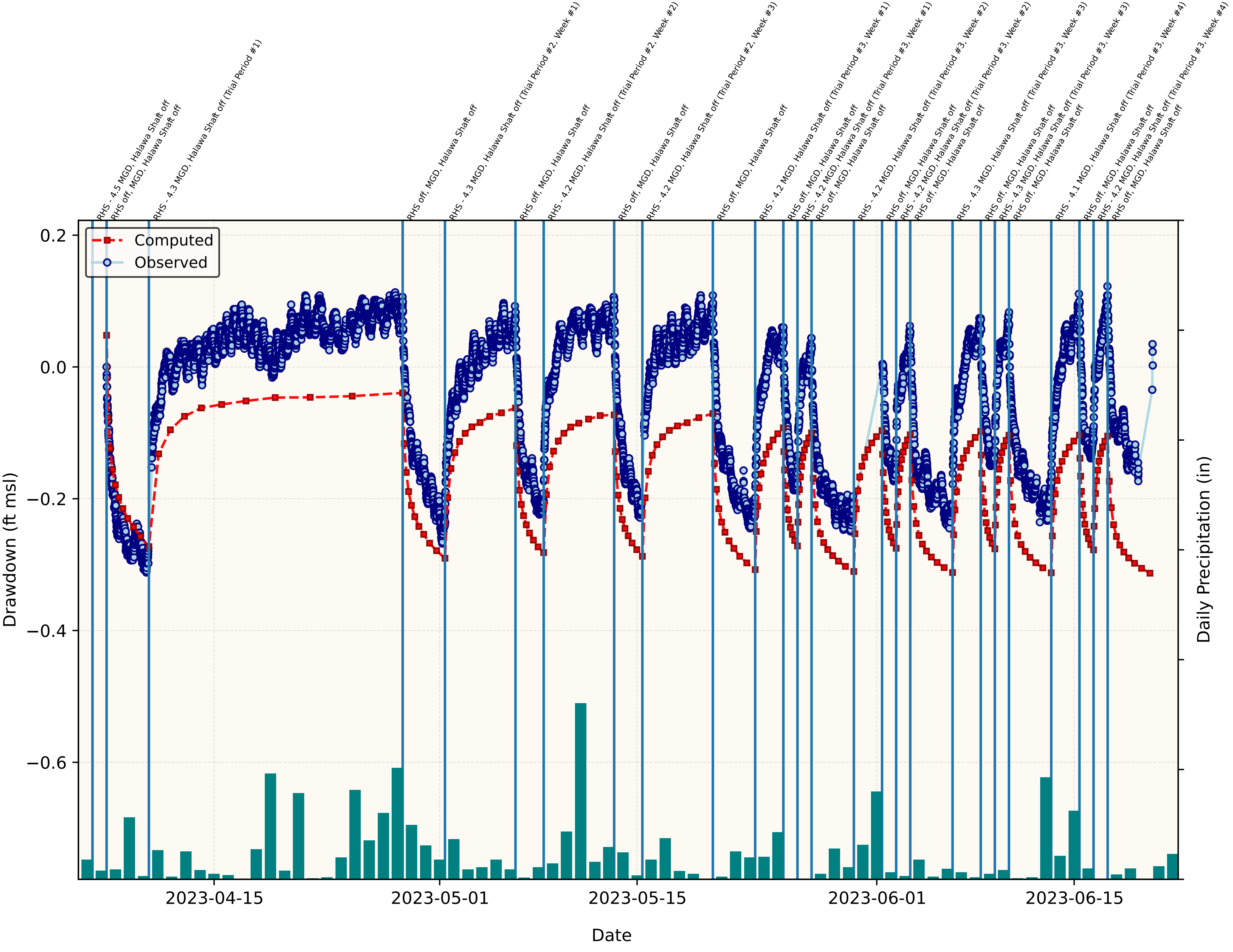
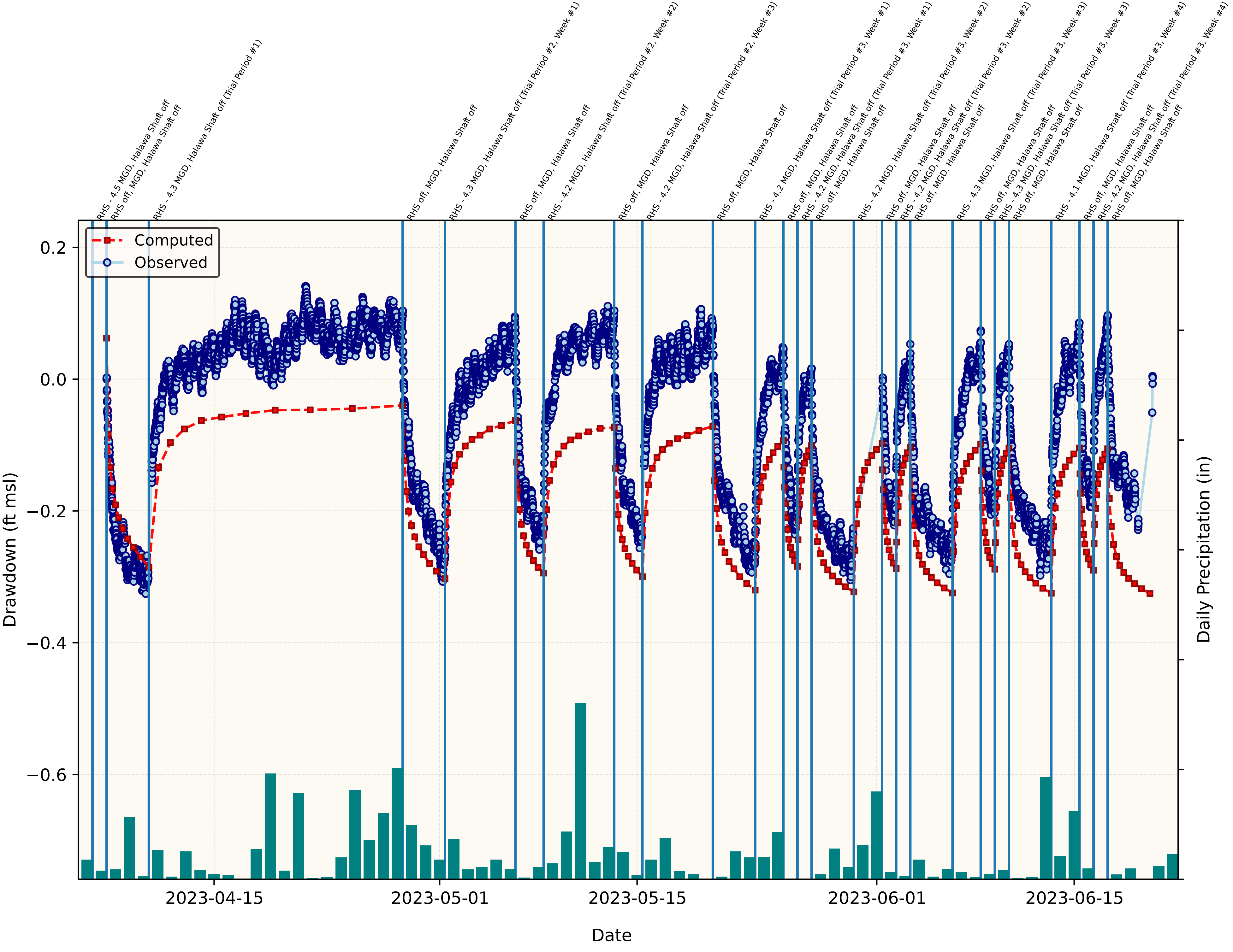
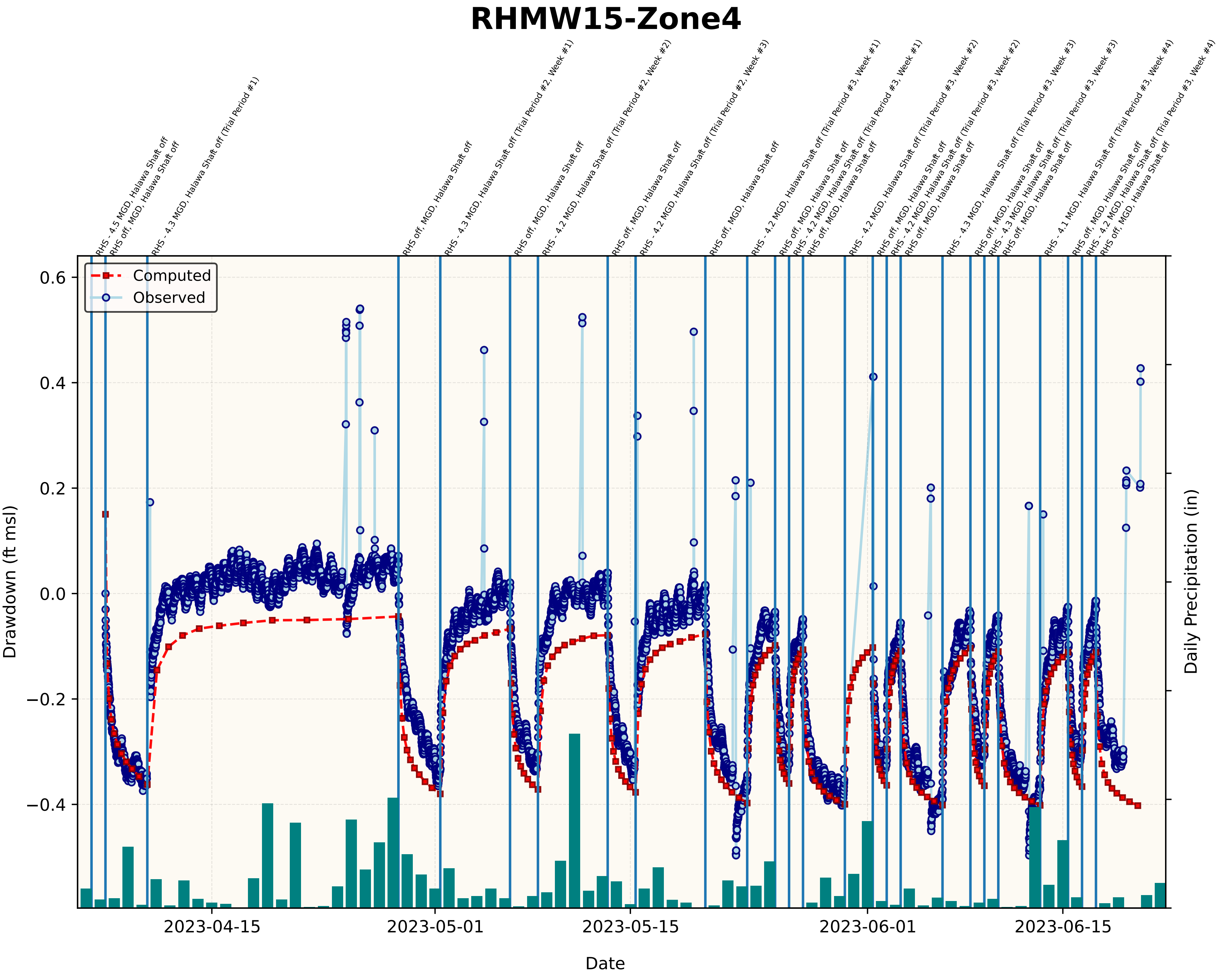
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW15-Zone2



RHMW15-Zone3



RHMW15-Zone4
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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #1)
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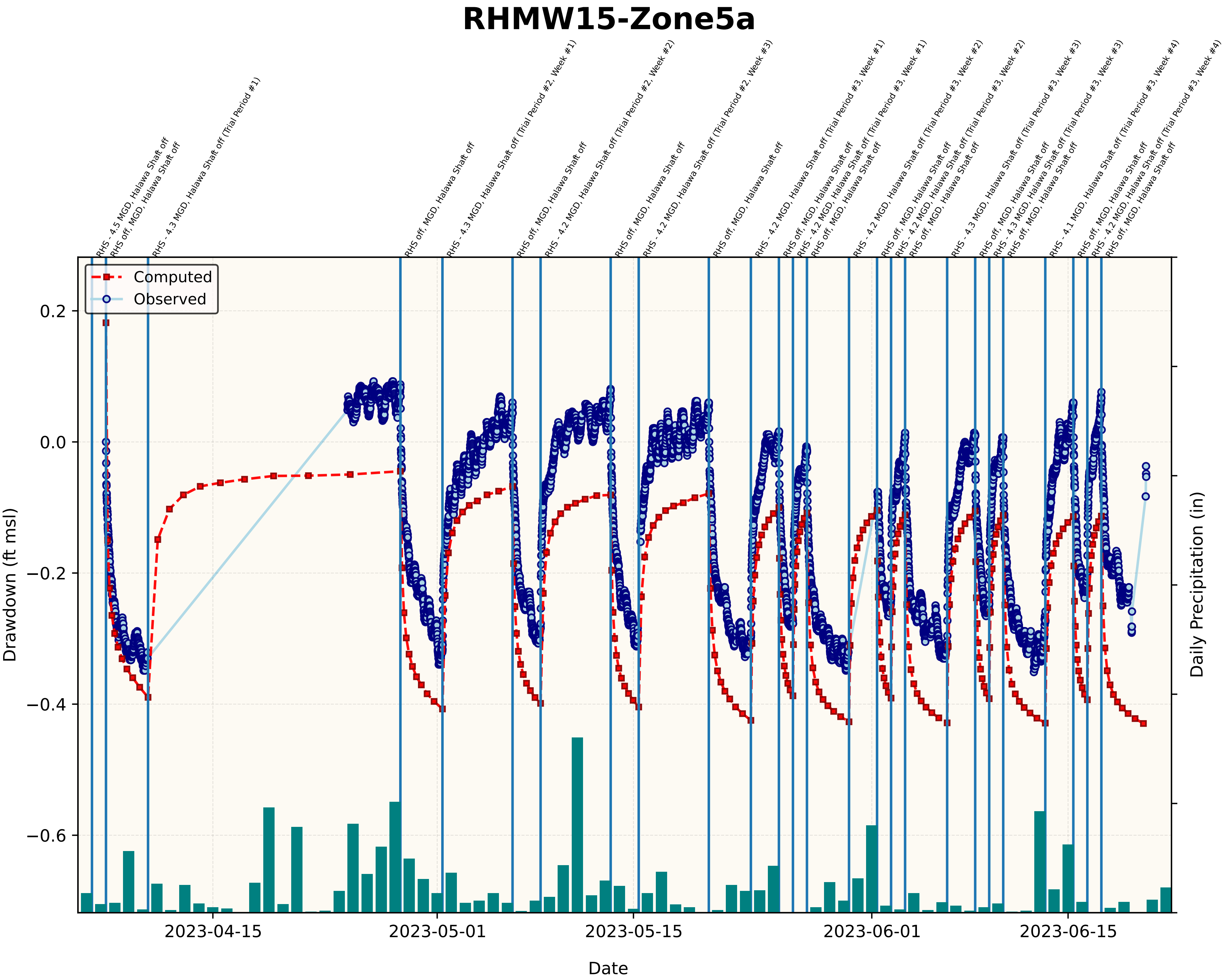
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.6
0.4
0.2
0.0
−0.2
−0.4
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date


RHMW15-Zone5a
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RHS off, MGD, Halawa Shaft off
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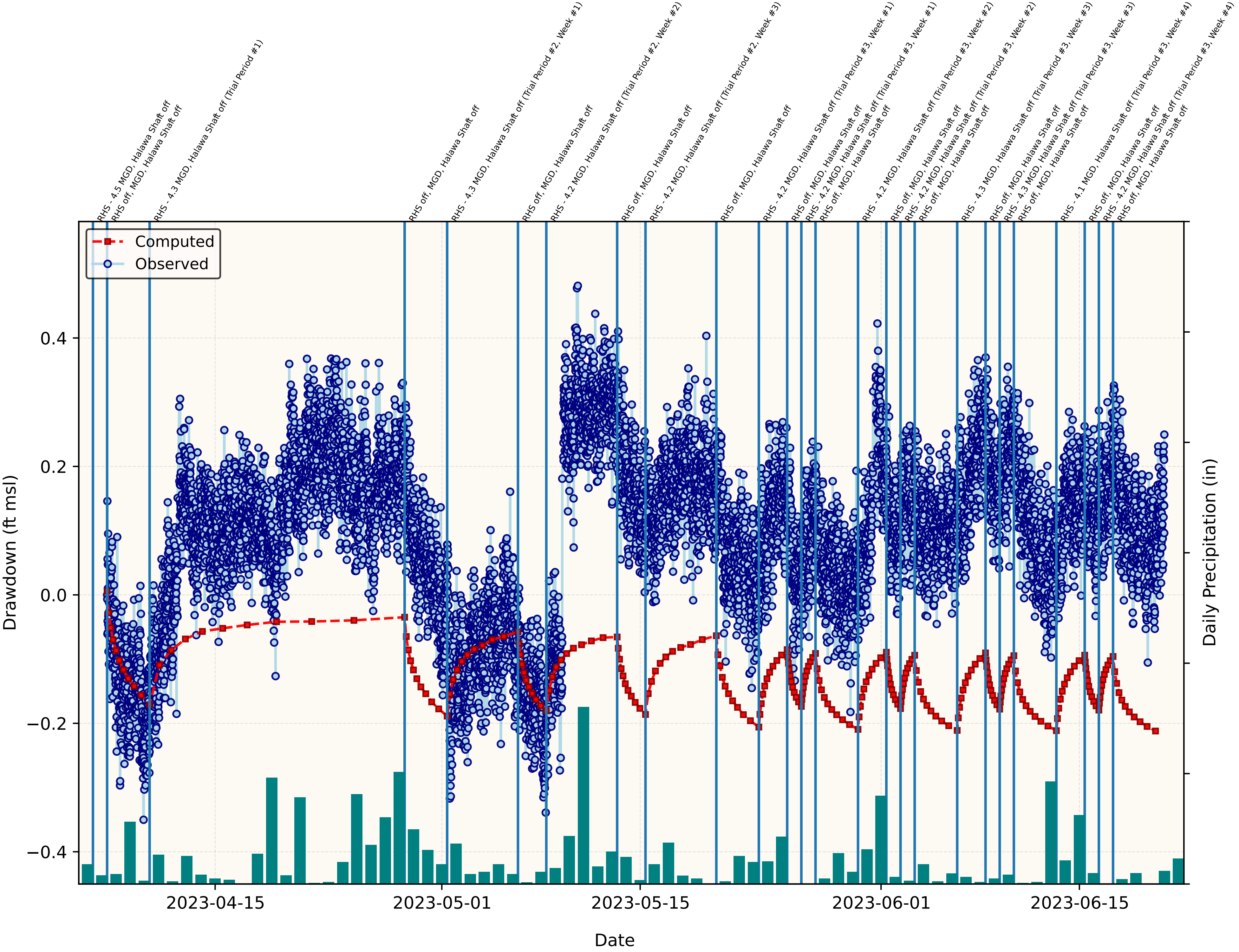
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW16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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
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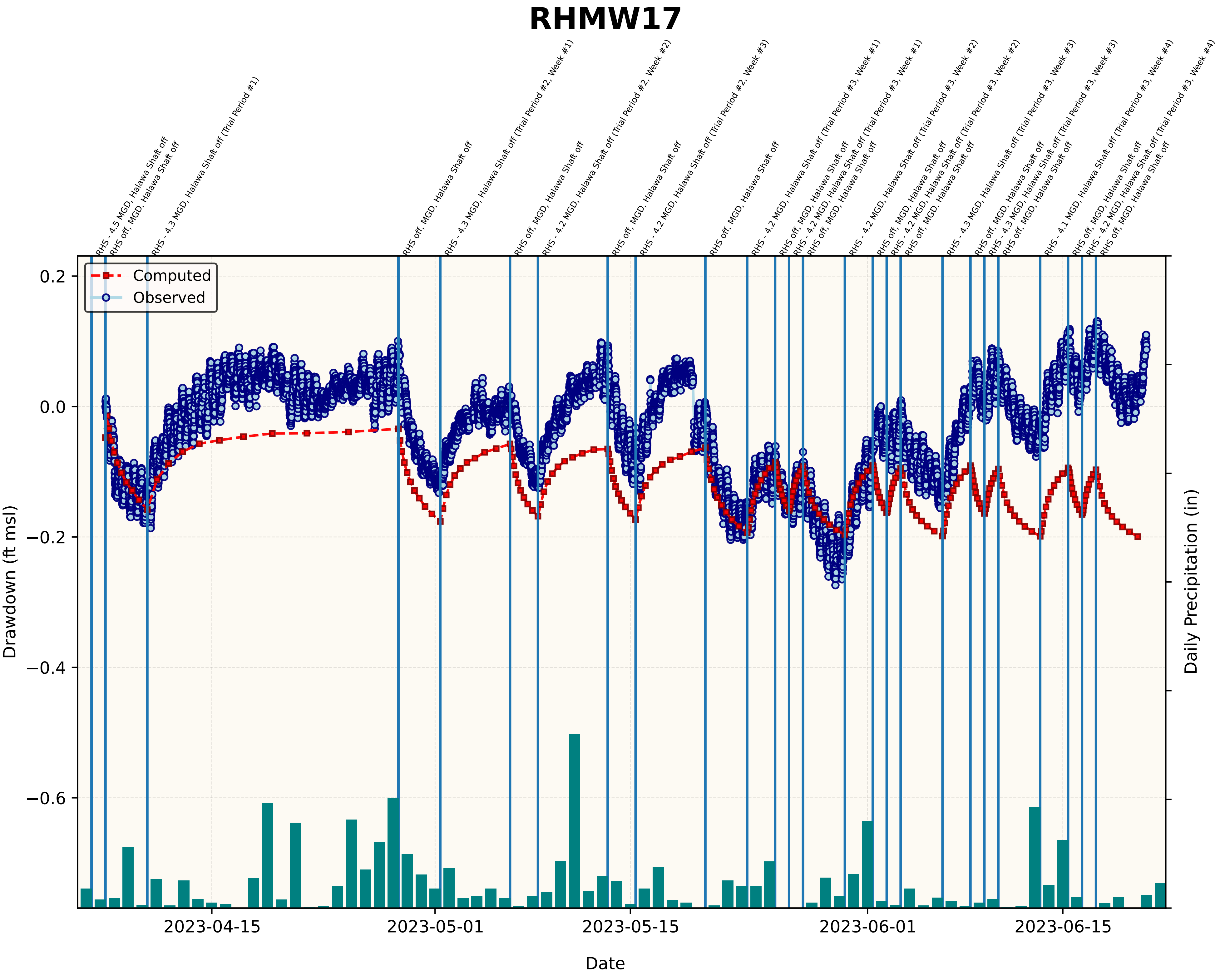
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.4
0.2
0.0
−0.2
−0.4
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
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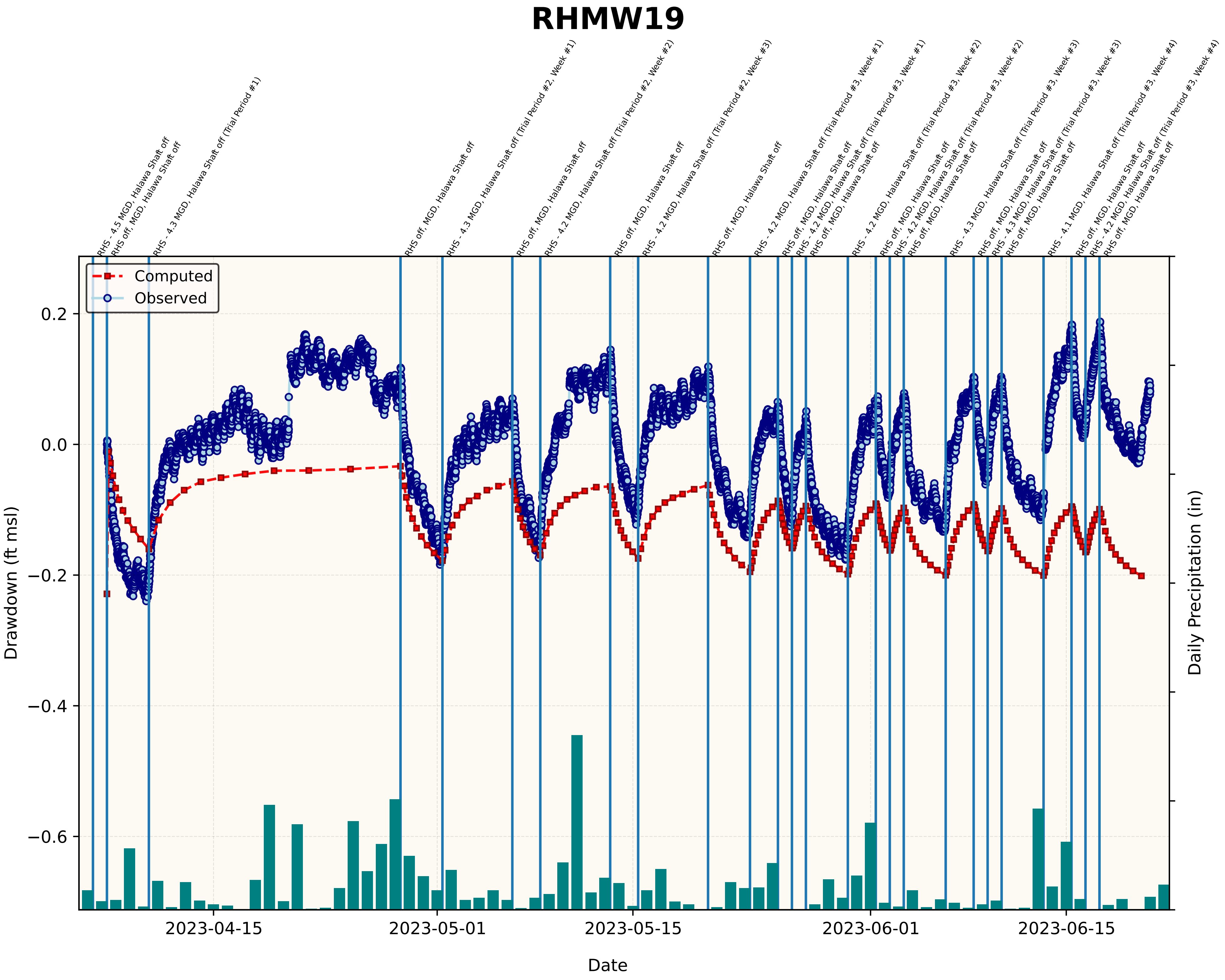
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #3)
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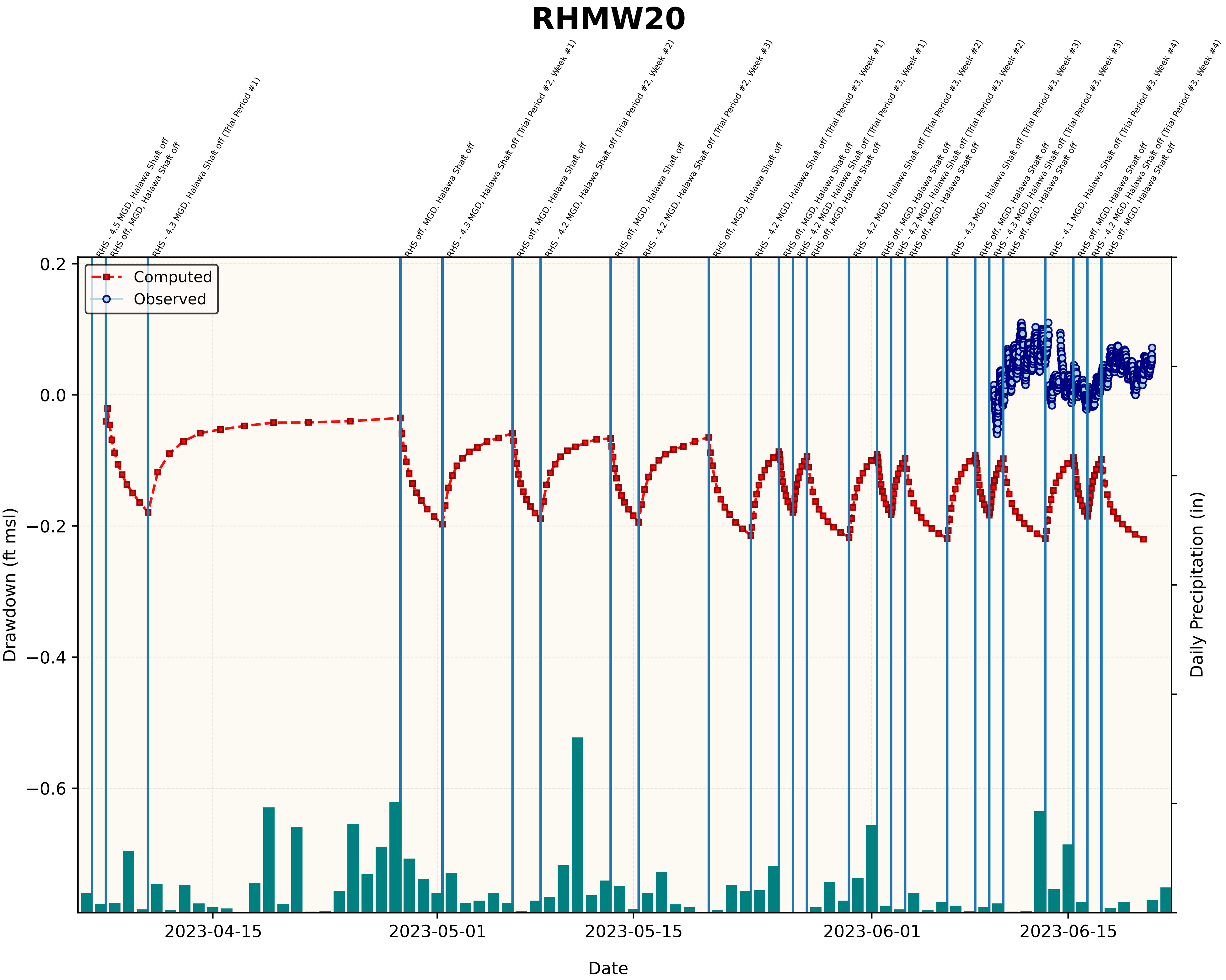
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW20
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RHS off, MGD, Halawa Shaft off
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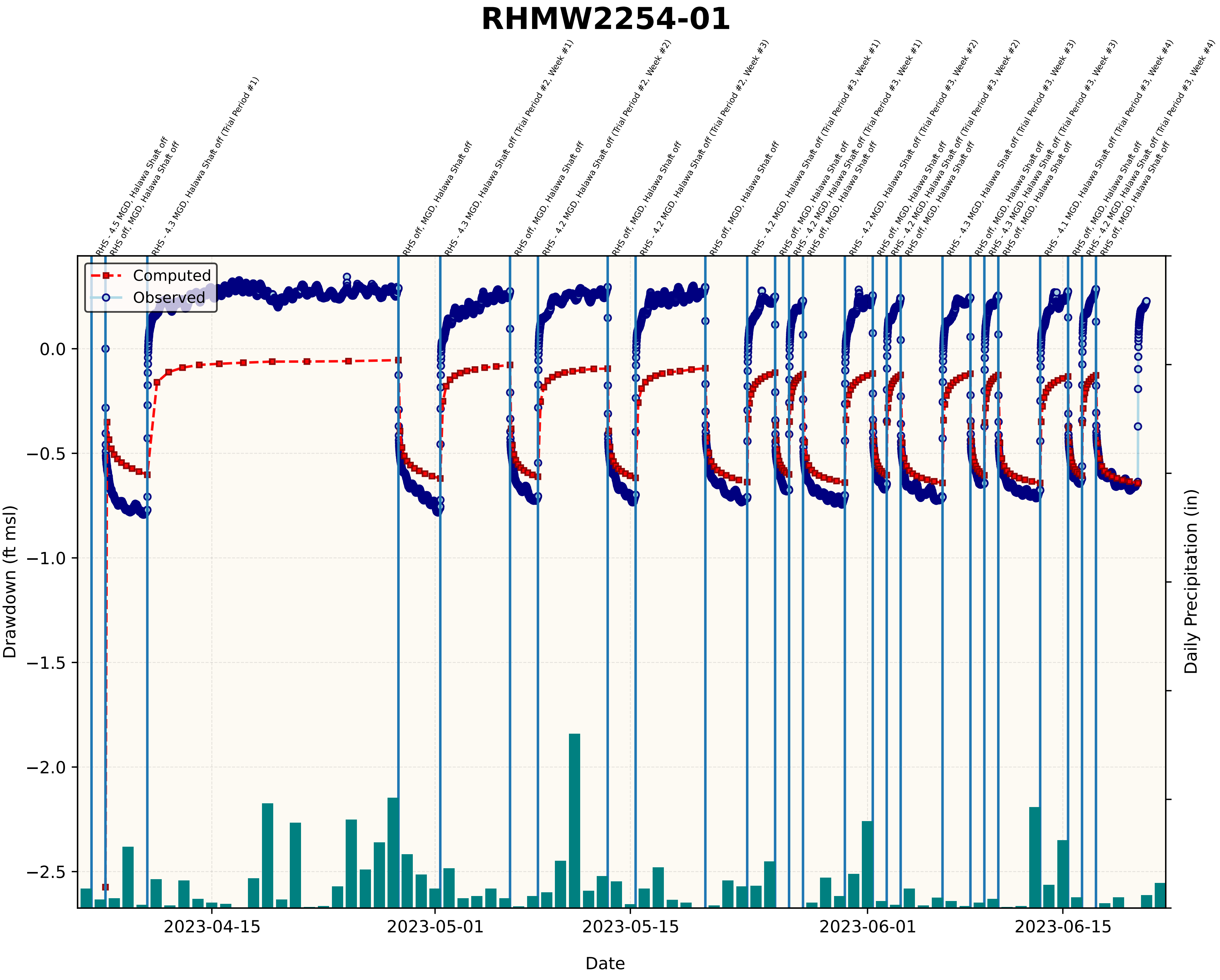
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHMW2254-01
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RHS off, MGD, Halawa Shaft off
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RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #2, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #2, Week #2)
RHS off, MGD, Halawa Shaft off
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #1)
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RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
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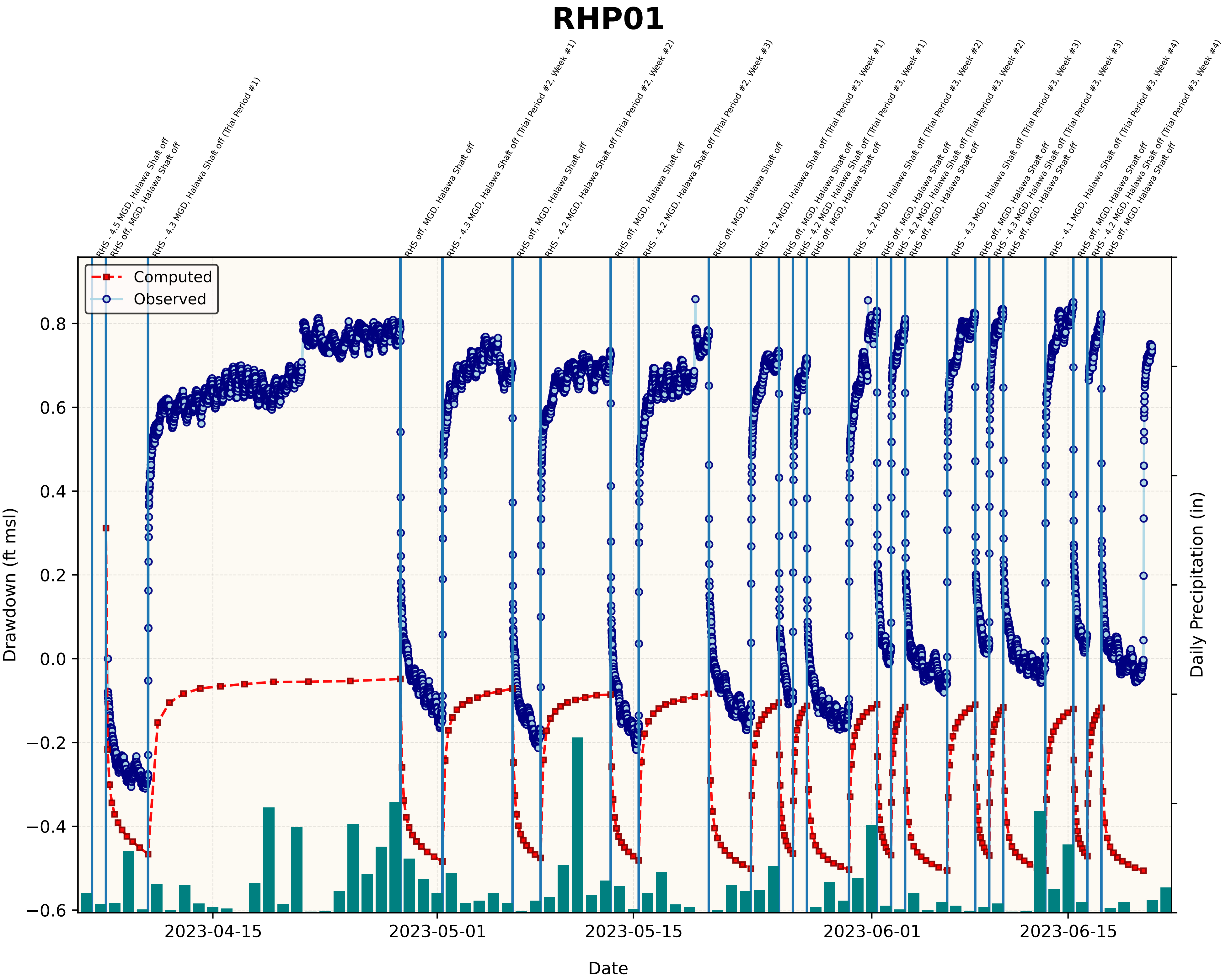
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #2)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.3 MGD, Halawa Shaft off (Trial Period #3, Week #3)
RHS off, MGD, Halawa Shaft off
RHS - 4.1 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
RHS - 4.2 MGD, Halawa Shaft off (Trial Period #3, Week #4)
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS off, MGD, Halawa Shaft off
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RHS off, MGD, Halawa Shaft off
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RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
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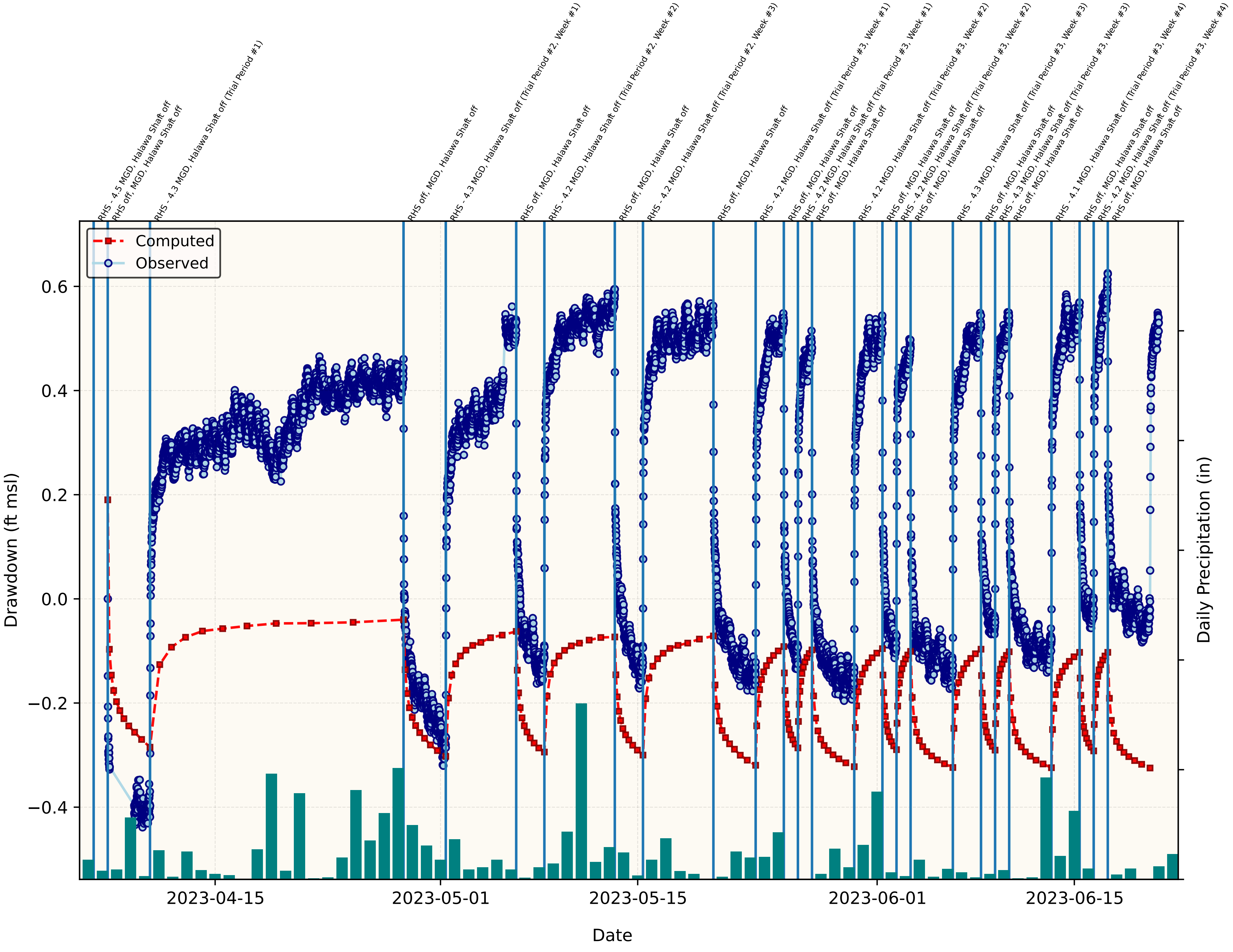
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHP02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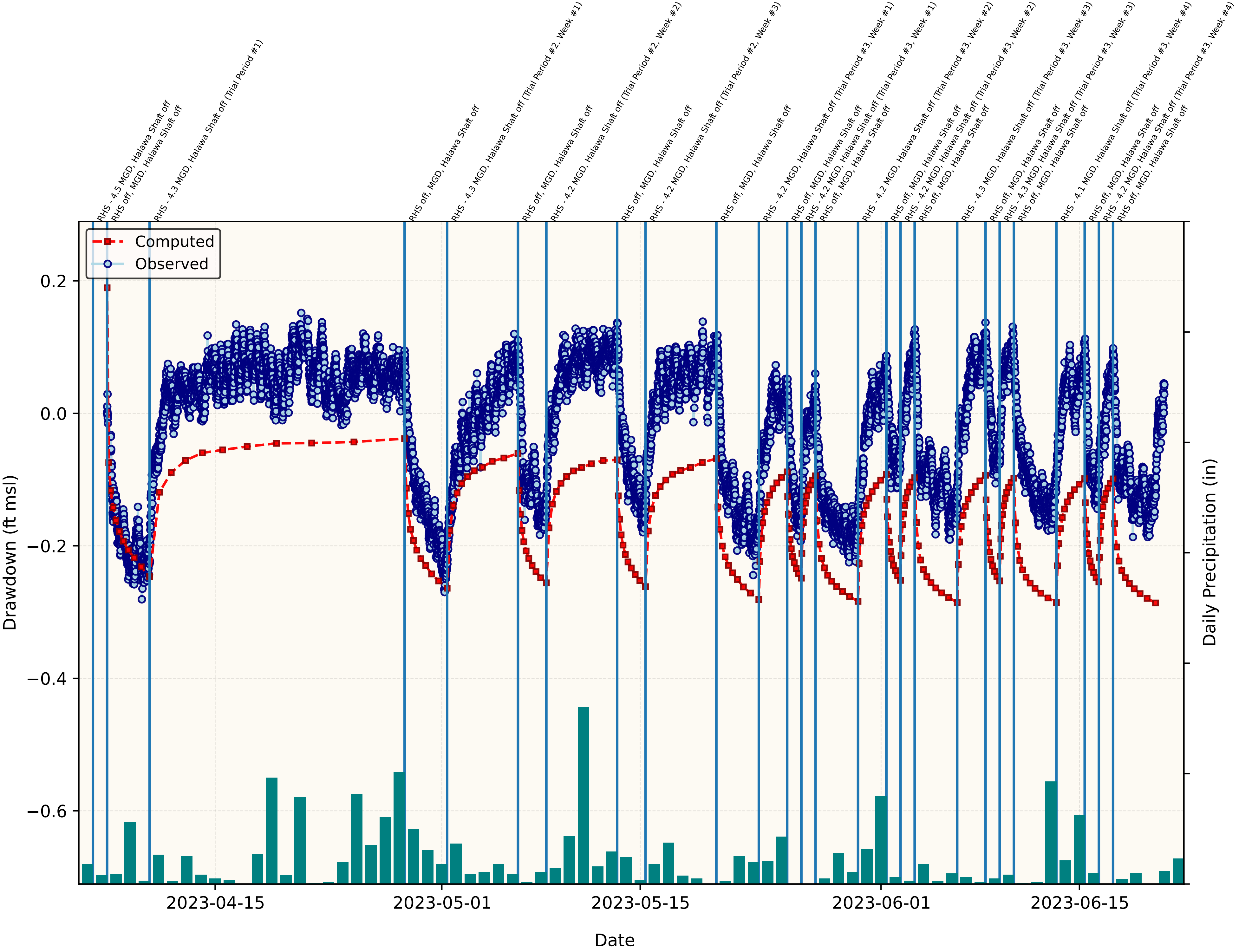
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.6
0.4
0.2
0.0
−0.2
−0.4
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHP04A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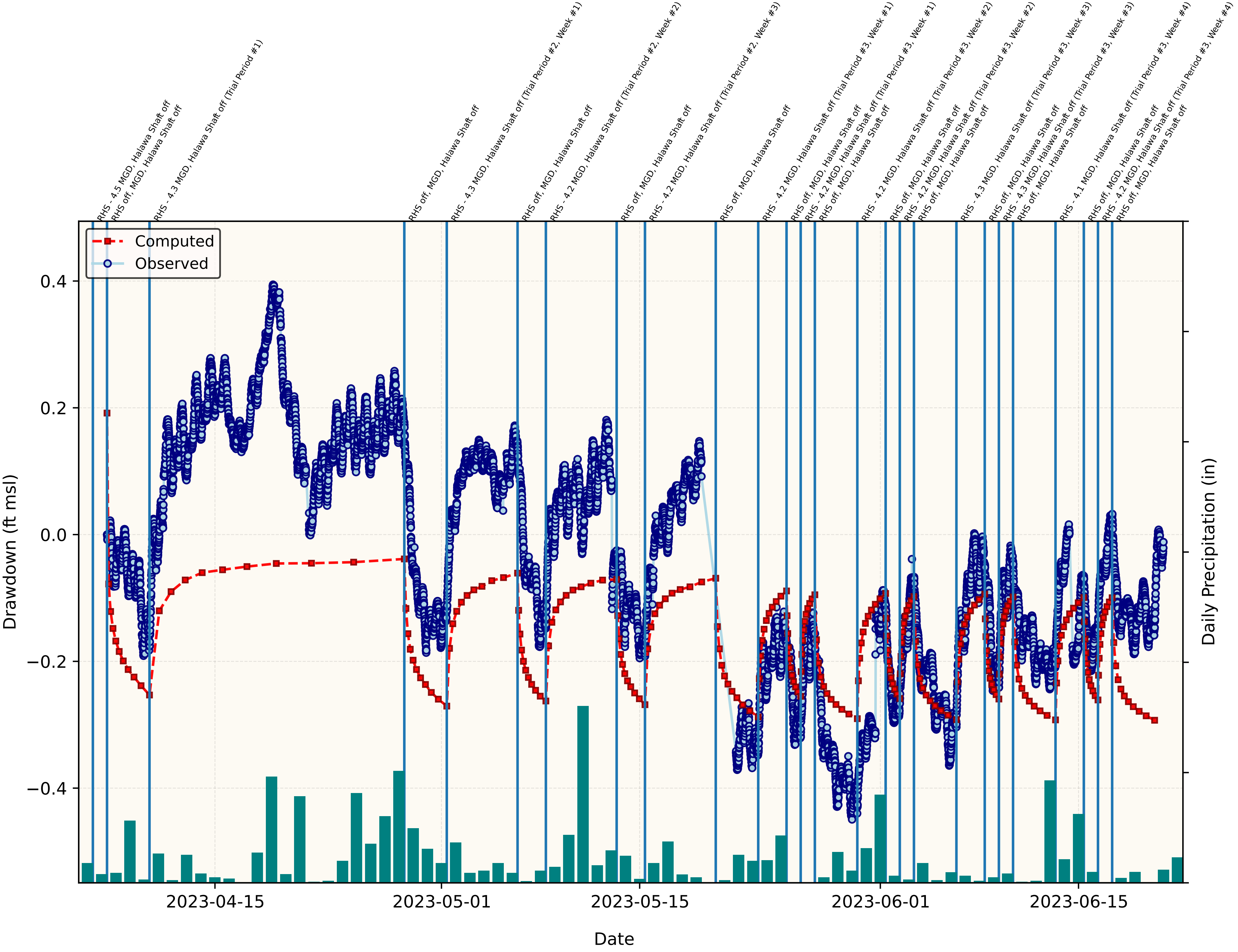
RHS off, MGD, Halawa Shaft off
Computed
Observed
0.2
0.0
−0.2
−0.4
−0.6
Drawdown (ft msl)
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHP04B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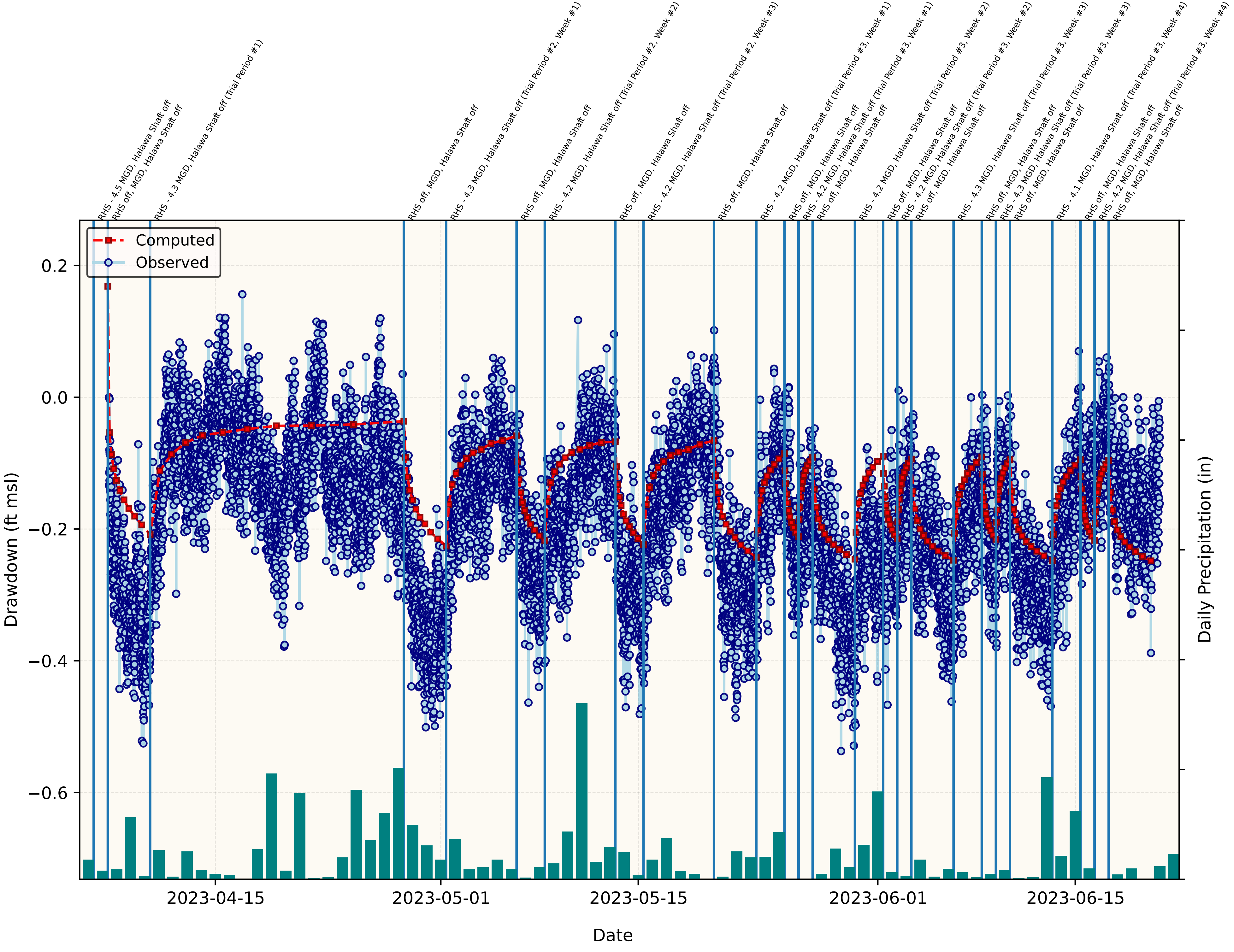
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.4
0.2
0.0
−0.2
−0.4
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

RHP04C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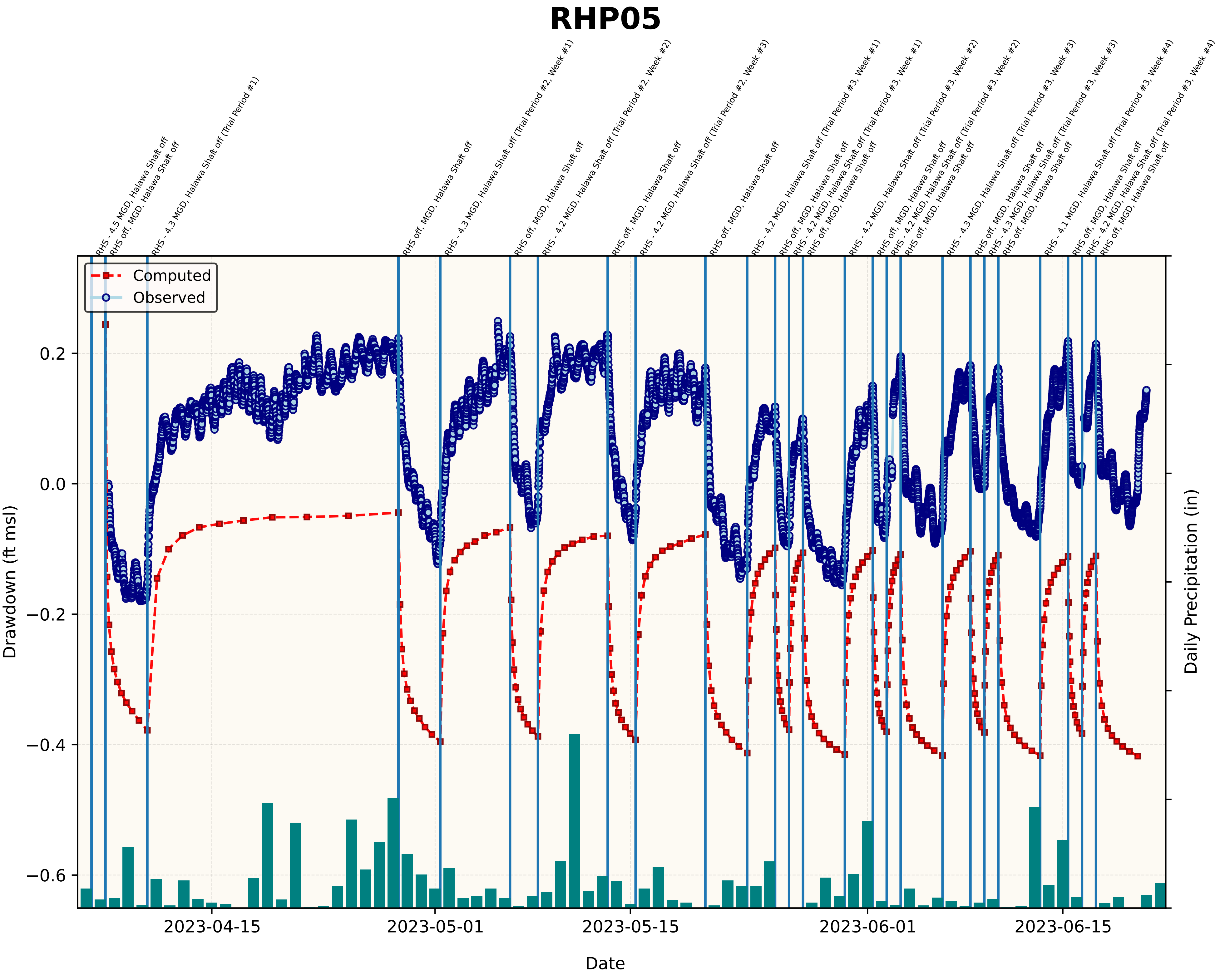
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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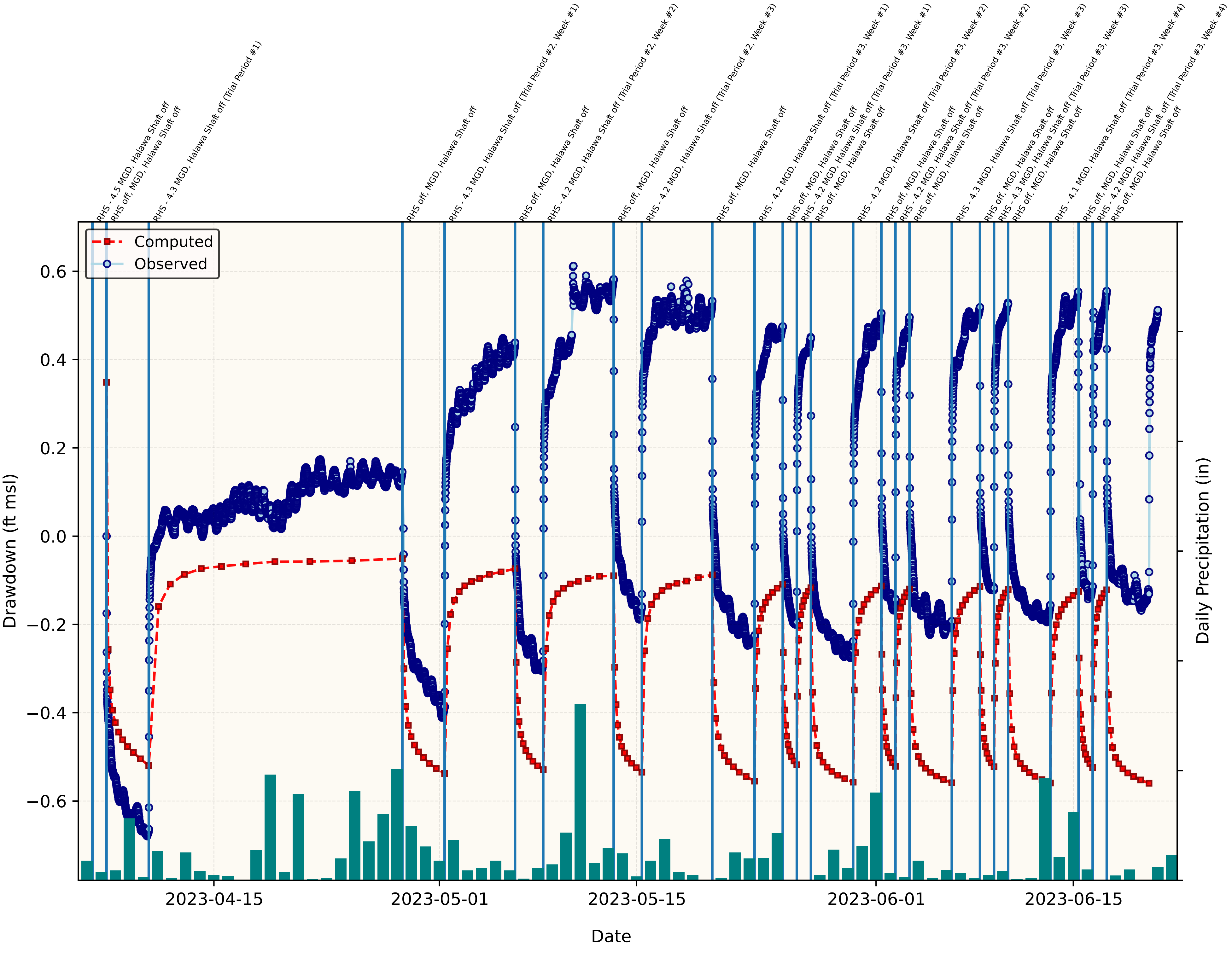
RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
Date
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15

RHP07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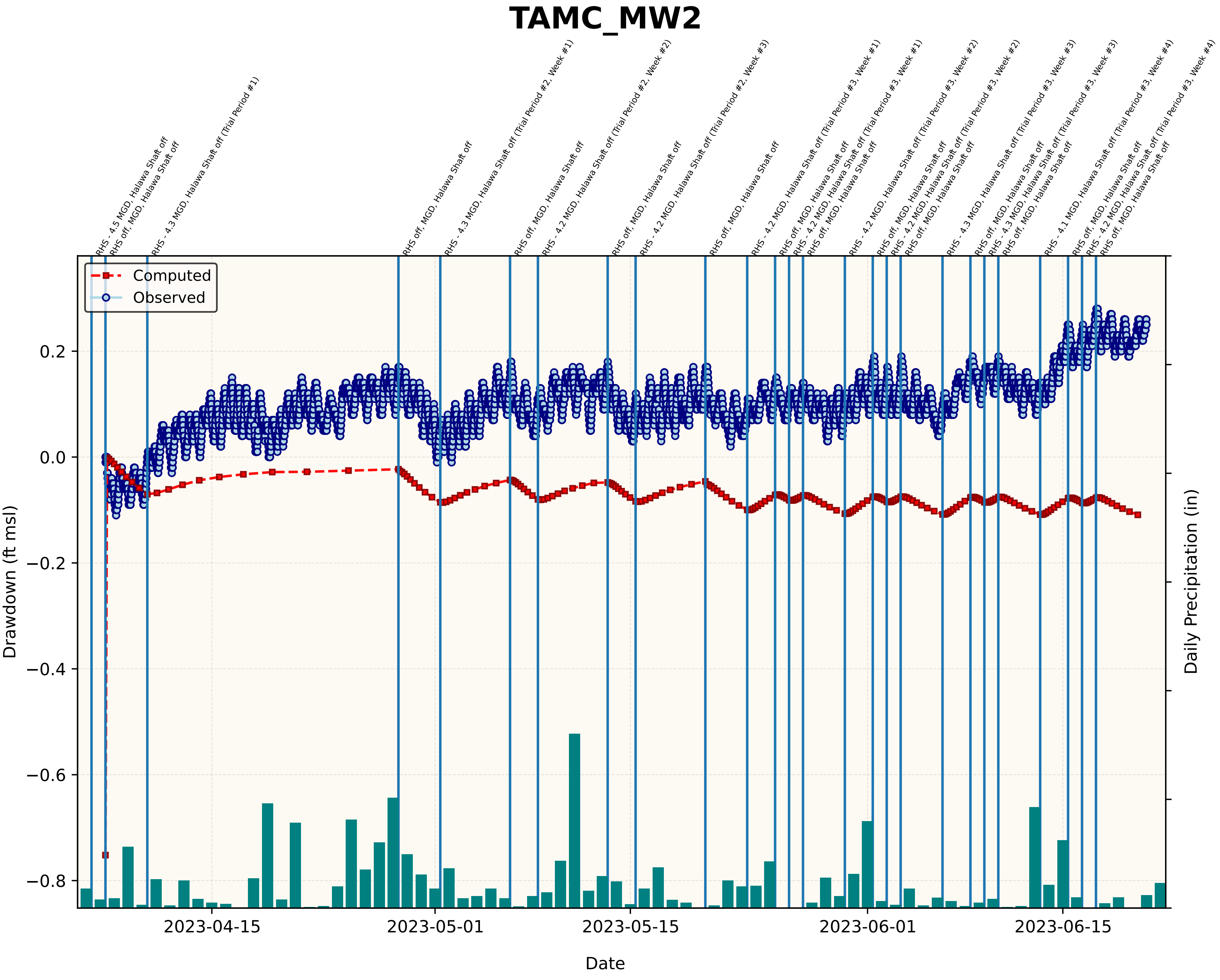
Computed
Observed
Drawdown (ft msl)
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date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RHS off, MGD, Halawa Shaft off
Computed
Observed
Drawdown (ft msl)
0.2
0.0
−0.2
−0.4
−0.6
−0.8
Daily Precipitation (in)
2023-04-15
2023-05-01
2023-05-15
2023-06-01
2023-06-15
Date

Appendix C: Responses to Regulatory Agency Comments

Project Title: Draft Report of Findings, RHS Flow Optimization Study (2023-08-17)
JBPHH, O‘ahu, Hawai‘i
Reviewer: (b) (6), SSPA
Date: September 2023

<table>
<tr><th>Item</th><th>Section No.</th><th>Comment</th></tr>
<tr><td>1</td><td>General</td><td>The use of multiple methods to evaluate the data is laudable. However, more explanation is needed of some of the analyses presented in the report,
○ e.g., AnAqSim I believe is a quasi-3D homogeneous-isotropic simulator, and as such heterogeneity is not represented and vertical flow components are simplified.
○ Assumptions underlying each method could be tabulated together for simplicity and comparability, and to support discussion of how these factors were considered in the weighting of the different methods.</td></tr>
<tr><td colspan="3">Response: Concur. Table 4-11 was revised to summarize the various methods and their assumptions.</td></tr>
<tr><td>2</td><td>General</td><td>In review of some of the time-series water levels obtained with the installed transducers, several occasions were noted when transducers did not appear to be re-installed to the same depth below the water table as they were prior to withdrawal (presumably, for sampling). This can have several repercussions including potential miscalculation of drawdowns and elevations, and abrupt changes in (apparent) water quality resulting from the transducer sitting at a different depth below the water table. Initial review of the received data identified some such potential anomalies.
○ Please detail the processing of groundwater level data for elevation accuracy – these data underpin all calculations either directly or indirectly.
○ Please ensure that thorough review is conducted of the water level data (depths and elevations) and water quality data recorded by the transducers for consistency and for anomalies including but not limited to those noted above.</td></tr>
<tr><td colspan="3">Response: Added the following statement to Section 3.3: “Each time transducers were removed to facilitate sampling, field teams attempted to redeploy them to on average within 1 ft of the previous depth. Differences in depth were accounted for by hand readings collected from the same surveyed measurement point at the same time as transducer placement.”

In addition, the following was added to Section 3.3 of the report to clarify the water level data:
○ Calibrated tapes were used to collect depth-to-water readings.
○ Measurement point elevations were surveyed with Second Order, Class 1 Leveling Surveys.
○ Gyroscopic surveys were also conducted to correct for hole deviations.
The datasets will be provided.</td></tr>
<tr><td>3</td><td>General</td><td>The interpretation of hydraulic capture (containment) by RHS is complicated by many factors, several of which are noted in the report:
○ RHS is a tunnel, not a vertical well, but similar hydraulic principles apply – i.e., water enters from and leaves via the most transmissive intervals, wherever they are located.
○ RHS “flows” even when not pumped: it does not make a net withdrawal, but rather water flows from east to west within the tunnel. This was identified from first principles, and verified by divers within the tunnel in 2022. Was a simulation attempted at zero (net) pumping rate to help understand the role of RHS on flow and migration patterns when it is not being pumped?</td></tr>
<tr><td colspan="3">Response: Concur. As to the question in the last bullet, we have not attempted zero-net pumping simulations at this point, and do not anticipate updating this report to investigate this (because the no-pumping conditioned was not maintained for more than 3 days during this study and evaluation of this condition is not critical to inform the decision of which flow rate the pump should be operated). The reported flow in the tunnel during non-pumping conditions would be more appropriately evaluated during the modeling that will be conducted over the next year.</td></tr>
<tr><td>4</td><td>General</td><td>The report identifies two target zones for capture: (a) at RHS tunnel in response to the November 2021 release and impacts, and (b) at the Tank Farm in response to past releases. However, I understood the original intent of the Study was to obtain data to evaluate the rates needed to flush the area around RHS, not at the Tank Farm. This appears to have been confirmed in the August 30, 2023, SPM.</td></tr>
<tr><td colspan="3">Response: Concur. The primary purpose of the Flow Optimization Study was to evaluate capture in the immediate vicinity of RHS at different pumping conditions, which is why the GAC system was installed. We also preliminarily evaluated at the effects of the RHS on the groundwater around the tank farm, which will be further developed over the next year of modeling and sampling. The report text (throughout Section 4.0) and Figure 4-2 have been revised to better distinguish between the Target Capture Zone (around RHS) and the Tank Farm Evaluation Zone.</td></tr>
</table>

Project Title: Draft Report of Findings, RHS Flow Optimization Study (2023-08-17)
JBPHH, Oʻahu, Hawaiʻi
Reviewer: (b) (6), SSPA
Date: September 2023

<table>
<tr><th>Item</th><th>Section No.</th><th>Comment</th></tr>
<tr><td>5</td><td>General</td><td>Differences in inference between the various lines of evidence (e.g., the three-point gradients [TPG]), as well as comparisons of the modeled versus interpolated (mapped) water levels (as calculated using the three “potentiometric” methods - interpolation, AnAqSIM, and the best available groundwater flow model [GWFM]) should be discussed further to help evaluate their appropriateness and reliability. For example, water levels calculated with AnAqSim appear visually very different to those obtained with the GWFM and water level mapping. Comparison of contours from the different methods could be made using figures of identical scale/layout, with contours illustrated at the same elevations or intervals.</td></tr>
<tr><td colspan="3">Response: Concur. We added some discussion throughout Section 4.4 and to Section 4.6 to explain among other things, the progressive complexity and capabilities of the various methodologies to better reflect the complicated site conditions. We also added Figures 4-19a, 4-19b, 4-19c (with according adjust to subsequent figure numbering) to show the results of all three methods on the same page for easy comparison of water level contours and particle tracks by method.</td></tr>
<tr><td>6</td><td>General</td><td>One method stands out as different from the others – that is the water level mapping. This method shows a hydraulic capture (containment) that appears visually to scale broadly and consistently with pumping rate changes. All other methods show no or very little difference despite the different pumping rates. This difference between the methods seems somewhat questionable, and further comment or discussion of this is recommended.</td></tr>
<tr><td colspan="3">Response: We agree the differences are not necessarily what one would have expected. This may result from the use of forward particle tracking to assess capture from the target areas. The water level mapping under various conditions straddles the threshold of full capture based on the input assumptions. The AnAqSim and MODFLOW models indicate full capture (of particles released from both the RHS Target Capture Zone and the Tank Farm Evaluation Area) under all scenarios because they account for additional factors such as the presence of valley fill. If we were to run reverse particles from RHS, there might be differences in the capture zone as the pumping rate changes. In addition, the models have varying capabilities to adequately represent three-dimensional flow, heterogeneity, and anisotropic behavior, all of which likely factor into the actual field conditions. A discussion was added to Section 4.6 of the report.</td></tr>
<tr><td>7</td><td>General</td><td>Finally, given the wealth of data obtained during the Study, can the various analysis and the data obtained in this Study and presented in the Flow Report aid in the design of previously discussed tracer studies to help verify capture?</td></tr>
<tr><td colspan="3">Response: Yes; AECOM and the Navy can coordinate with UH, should they desire.</td></tr>
<tr><td>8</td><td>General</td><td>The Flow Report states, “*An additional line of evidence that suggests a flow direction down Red Hill ridge is total petroleum hydrocarbons – residual oil range organics (TPH-o) data collected in the weeks* and *months following the release at Tanks 18 and 20 in May of 2021, which showed travel of TPH-o from the release location to RHMW03 to RHMW02 and potentially farther down-ridge.*” (page ii) The apparent 2021 breakthrough of oil and diesel range TPH at RHMW02 during the summer of 2021 may arise from several causes including the following (listed below), which need to be better distinguished before deriving velocities or migration directions from these data:
o Local remobilization of residual fuels already present at or close to the water table, via water level fluctuations in response to recharge and pumping changes, among other effects.
o Local remobilization of residual fuels already present within the vadose zone, via vertical infiltration of water from above following aerial precipitation and other surface infiltration events.
o Actual breakthrough via migration related to the spring 2021 fuel release[1]. This breakthrough itself may comprise one or more modes of migration – e.g., dissolved phase, free-phase (light non-aqueous phase liquid [LNAPL]), and enhanced transport via emulsification.
[1] This is also relevant to the flow-and-transport modeling report and analyses</td></tr>
<tr><td colspan="3">Response: We agree that these are three possible explanations. The Executive Summary and Section 4.5.5 of the report have been revised accordingly.</td></tr>
<tr><td>9</td><td>General</td><td>The Flow Report states, “*Capture cannot be guaranteed without direct field verification through a well*-designed tracer *study.”* (page iii) I understand part of the support for this statement – however, I would tend to say that estimates of capture are best verified through the successful completion of a well-designed tracer study, because there are other methods that in some settings come very close to the verifiability that a tracer study offers.</td></tr>
<tr><td colspan="3">Response: Concur. The Executive Summary and Sections 4.6, 4.7, and 5.0 of the report have been revised accordingly.</td></tr>
</table>

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JBPHH, Oʻahu, Hawaiʻi
Reviewer: (b) (6), SSPA
Date: September 2023

<table>
<tr><th>Item</th><th>Section No.</th><th>Comment</th></tr>
<tr><td>10</td><td>3.2</td><td>The Flow Report presents a huge volume of data and information: what is the availability of these monitoring data, and can these be easily obtained in usable formats (i.e., with some level of processing suitable for spatial and temporal analysis)?</td></tr>
<tr><td colspan="3">Response: Currently EDMS includes “raw” .csv data. Table 3-2 includes the coordinates of the monitoring locations. Spreadsheets with calculations to adjust for sampling and corrections listed above can be provided upon request.</td></tr>
<tr><td>11</td><td>3.3</td><td>Has verticality analysis via gyroscopic surveys been completed at all wells?</td></tr>
<tr><td colspan="3">Response: Water levels were corrected for horizontal displacement based on gyroscopic surveys conducted at each well, except for RHP04B, RHP05, and RHMW20, for which the final data is not yet available. Section 3.3. of the text has been revised accordingly.</td></tr>
<tr><td>12</td><td>3.5</td><td>Are cumulative flow totals available to corroborate the instantaneous values?</td></tr>
<tr><td colspan="3">Response: The Navy is looking into this and will try to obtain and share the data.</td></tr>
<tr><td>13</td><td>4.1.2</td><td>Which EALs should be referred to here?</td></tr>
<tr><td colspan="3">Response: Section 4.1.2 refers to the DOH’s promulgated EALs for TPH-d and TPH-o, which apply to all sites in Hawaii. This has been noted this in the text.</td></tr>
<tr><td>14</td><td>4.3.4</td><td>Hydraulic gradients using the TPG method: the estimate of irreducible error described in this section is of similar magnitude to that interpreted from previous work based on analyses of innate heterogeneity (in which case it is not “error” but unresolvable spatial variability). Both factors challenge the use of the TPG method at this site, and this is further complicated by the extreme eccentricity of many of the triangular elements. Thus, the TPG method is likely a weak line of evidence except where the eccentricity is limited and the element size is sufficiently large.</td></tr>
<tr><td colspan="3">Response: We used the TPG method because it was recommended to us in the past. We agree there are shortcomings with the method, especially on such a complex site as this.</td></tr>
<tr><td>15</td><td>4.3.4</td><td>Hydraulic gradients using the TPG method: Were the high eccentricity elements near RHS selected to provide more apparent resolution parallel to valley fill? Less eccentric elements could also be used here which may provide more reliable information.</td></tr>
<tr><td colspan="3">Response: The draft report used all data that were available, which (as noted) resulted in some very acute triangles. We agree there are shortcomings with the method (and this particular application of the method), especially on such a complex site as this, but it has been recommended to us in the past. In response to this comment, we also analyzed a select subset of the data in order that results in fewer, less eccentric triangles. Figure 4-10 and Section 4.3.4 of the text have been updated.</td></tr>
<tr><td>16</td><td>4.3.4</td><td>Hydraulic gradients using the TPG method: It would be helpful to include a figure that shows the gradient direction and magnitude for each of the three pumping rates on a single plot to visualize effects of the different pumping rates on (apparent) flow directions near RHS and determine whether they appear to be consistent. This may help answer questions such as:
○ Are apparent gradient changes consistent with changes in pumping, or do they appear dominated by noise and therefore of limited interpretive value?
○ Does selection of alternative elements of lower eccentricity and larger size provide more consistent findings and greater interpretive value?</td></tr>
<tr><td colspan="3">Response: Concur; Figure 4-10 and Section 4.3.4 of the text have been revised accordingly.</td></tr>
<tr><td>17</td><td>4.6,
Table 4-10</td><td>Summary of Particle Tracking Results: One method stands out as different from the others – that is the water level mapping. This method shows hydraulic capture (containment) that appears to scale broadly and consistently with pumping rate changes. All other methods show no or very little difference despite different pumping rates. Further comment or discussion of this result is recommended. This is also demonstrated by Figures 4-11 thru 4-13, 4-18.</td></tr>
<tr><td colspan="3">Response: Concur; please see response to comment 6, above. A discussion was added to Section 4.6 of the report.</td></tr>
</table>

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Item	Section No.	Comment
8	5, Specifically, Conclusion #2	The conclusions appear to downweight methods of analysis that suggest capture of the Tank Farm area is questionable (water level mapping, TPGs, and chemistry, for example), and rely more on the modeling analyses. Although it was stated at the recent August 30, 2023 SPM meeting that the inferences presented in the Flow Report with regard hydraulic capture (containment) of the Tank Farm area are of less import than those of the RHS area, the considerations used to weigh the different methods should nonetheless be described further.

Response: The purpose of this study was to evaluate flow around RHS to determine whether the RHS pumping rate can be optimized to continue protecting groundwater quality while conserving groundwater and other resources. Any conclusions related to the tank farm are preliminary and will be further evaluated over the coming year.

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Reviewer: (b) (6), Hawaii State Department of Health
Date: August 2023

<table>
<tr><th>Item</th><th>Section No.</th><th>Comment</th></tr>
<tr><td>1</td><td>General</td><td>At this time, the DOH Is unable to conduct a detailed review of the Draft Report, as the post-processed supporting datasets associated with the flow optimization study were not included as part of the document.</td></tr>
<tr><td colspan="3">Response: The datasets will be provided.</td></tr>
<tr><td>2</td><td>General</td><td>The Draft Report does not include the analytical results of groundwater sampling conducted during the flow optimization study to evaluate any potential changes in contaminant concentrations associated with reducing the average pumping rate of the RHS GAC system.</td></tr>
<tr><td colspan="3">Response: At the time the Draft Report was submitted, validated results of analytical groundwater sampling were not yet available from the third-party validators. At the time of the submission of the Final Report, the follow analytical results have been validated:
• NOI Week of April 3, 2023 & delineation (P-)wells
• Q2 2023 LTM (April 11 to April 21, 2023) & delineation (P-)wells
• NOI Week of April 24, 2023
• NOI Week of May 1, 2023 & delineation (P-)wells
These results are discussed in Section 4.5.3 and presented on Figures 4-18a through 4-18f. The validated results can also be found in EDMS. Additional validated data will be added to EDMS as they become available.</td></tr>
<tr><td>3</td><td>General</td><td>Neither does the report contain the modeling files used in the Navy’s reported evaluations.</td></tr>
<tr><td colspan="3">Response: The modeling files will be provided.</td></tr>
<tr><td>4</td><td>Table 3-2</td><td>The northing and easting coordinates are swapped or duplicated for a significant percentage of the well locations.</td></tr>
<tr><td colspan="3">Response: Table 3-2 has been revised (all figures used the correct coordinates and therefore did not require changes in response to this comment).</td></tr>
<tr><td>5</td><td>Section 4.3.2</td><td>The vertical gradients for RHMW13 appears to be backwards.</td></tr>
<tr><td colspan="3">Response: The data entered in Table 4-1 and Table 4-2 related to RHMW13 have been revised. Figure 4-4b has also been revised.</td></tr>
<tr><td>6</td><td>General</td><td>The range of uncertainty for water levels is listed at 0.1 to 0.2 feet without justification, but it is utilized to marginalize data.</td></tr>
<tr><td colspan="3">Response: The text in Section 4.3.4 has been revised; additional analysis of data variability was added to Section 4.3.1.1.</td></tr>
<tr><td>7</td><td>Section 4.5.5</td><td>The discussion of TPH-o at RHS in summer 2021 is used to support the conclusion that there is groundwater and dissolved constituent movement from the tanks to RHS, yet the Navy also states that TPH-o at RHMW03 and the RHS was not related to fuel stored in the tanks, strongly inferring the contamination was not related to the May 2021 release.</td></tr>
<tr><td colspan="3">Response: The text was not intended to make the inference stated in this comment. In addition, the text has been revised to identify other potential explanations for the summer 2021 TPH-o “spike” at RHMW03.</td></tr>
<tr><td>8</td><td>Section 4.5</td><td>There is insufficient analysis of the isotope and water quality data.</td></tr>
<tr><td colspan="3">Response: As indicated in the report, the samples were collected as requested by DOH. The stable isotopes of water data were available and in EDMS at the time of the draft report. Stable isotopes of nitrate data being performed by the University of Hawaii are still not complete. The water isotope data were inconclusive with respect to the primary purpose of this report but may be used in the future.
The Navy collected the transducer sensor data and posted them to EDMS for use by University of Hawaii in designing their in-well and tracer testing programs. Section 4.5.1 summarizes these data, which are not conclusive with regard to the primary purpose of this report.</td></tr>
</table>

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JBPHH, O‘ahu, Hawai‘i
Reviewer: [redacted], Hawaii State Department of Health
Date: August 2023

Item	Section No.	Comment
9	General	For the DOH to conduct a detailed review of the flow optimization study, the post-processed data are to be formally provided to the DOH in working digital formats to confirm the datasets are complete, accurate, and are in fact the precise sets used in the Draft Report, as well as to allow independent data evaluations. This includes all post-processed data (converting raw field data into useable response datasets) used to generate the following charts, graphs, and evaluations: • Water level elevations throughout the period of study as presented on PDF Pages 51 through 55 of the Draft Report. • Vertical gradients and compiled drawdown over time as presented on PDF Pages 61 through 73 of the Draft Report. • The dataset(s) used to create the scatter plots presented on PDF Page 75 of the Draft Report. • Water level over time with compiled water quality parameter measurements as presented on PDF Pages 88 through 106 of the Draft Report. • A copy of the excel spreadsheet presented on PDF Page 118 of the Draft Report. • The underlying dataset(s) used to prepare figures and graphs presented on PDF Pages 125 through 227 of the Draft Report. • Working copies of the groundwater models used in the optimization study. Post-process data that was collected but not used in the flow optimization analysis should be explicitly described, including justification for why it was not used.
Response: Corresponding files will be provided.		
10	General	The DOH is concerned that the flow optimization study conclusions are primarily based on models, one of which (or variants thereof) the DOH has previously disapproved. As with past reviews of Navy submissions, the DOH does not rely on modeling results that are inconsistent with actual site data and basic hydrogeologic principles, and none of the models used in the flow optimization study appear to adequately reflect the measured gradient data at the site. The DOH and U.S. Environmental Protection Agency (EPA) are currently reviewing the Navy’s latest submission of an interim groundwater flow model. Until this review is complete, and the interim model has been accepted, results from the interim model should not be used as a primary line of evidence when developing conclusions for the flow optimization study.
Response: The report appropriately considers multiple lines of evidence. Please note that the “Best Available” model is not a variant of prior models.		
11	General	As the purpose of the flow optimization study is to support the Navy’s request to reduce the average pumping rate of the RHS GAC system, not necessarily to illustrate robust capture, the DOH suggests that the Navy further evaluate whether some of the other lines of evidence presented in the Draft Report (e.g., vertical gradients, water quality data, isotopes, and analytical data) support this request.
Response: All relevant lines of evidence converge around the conclusion that the RHS pumping rate can be safely reduced.		