

Chapter 2: South Florida Hydrology and Water Management

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SUMMARY

Given hydrology's significance to the entire South Florida ecosystem and all aspects of regional water management, this chapter presents hydrologic data and analysis for Water Year 2017 (WY2017; May 1, 2016–April 30, 2017). Similar information from previous water years is available in Chapter 2 of past South Florida Environmental Reports (SFERs) – Volume I. This year's chapter includes a brief overview of the regional water management system, hydrologic impact of WY2017 tropical systems, extreme high rainfall events and drought conditions, the 2016–2017 El Niño Southern Oscillation (ENSO) development, and WY2017 hydrology of several subregions and major hydrologic units within South Florida Water Management District (SFWMD or District) boundaries. The dry season in South Florida is from November through May and the wet season is from June through October. The ENSO climatic phenomenon is linked to South Florida hydrology. El Niño events result in increased rainfall in the dry season and La Niña events are associated with drought. Cooling sea surface temperature (SST) of the tropical Pacific west of Peru that was observed in 2016 continued through February 2017 but warming started in March 2017 giving indication for a potential El Niño or neutral condition development. Appendices 2-1 through 2-6 of this volume provide supplementary information for this chapter. The broad influences of water year hydrology on various aspects of the regionwide system are covered in most other Volume I chapters.

WY2017 District areal average rainfall was 46.89 inches, which is 5.86 inches below the historical average making it meteorologically a drier than average year. The dry season was drier than average in all basins except Lower Kissimmee. Rainfall deviations from historical average were Palm Beach (-14.54 inches), East Everglades Agricultural Area (EAA; -10.51 inches), Broward (-9.3 inches), Martin St/Lucie (-8.47 inches), West EAA (-8.44 inches), Everglades National Park (ENP; -7.40 inches), Lake Okeechobee (-6.13 inches), Upper Kissimmee (-4.55 inches), Big Cypress Basin (-4.09 inches), Miami-Dade (-3.83 inches), Southwest Coast (-3 inches), Water Conservation Area (WCA) 1 and WCA-2 (-2.97 inches), East Caloosahatchee (-2.61 inches), WCA-3 (-2.23 inches), and Lower Kissimmee (+0.48 inches).

In the previous water year (WY2016), the dry season was wet and the water level in WCA-3A was higher than normal. On February 11, 2016, the Florida Department of Environmental Protection (FDEP) issued an emergency final order to SFWMD and the United States Army Corps of Engineers (USACE) to lower water levels by deviating from existing water management practices. The order's objective was accomplished in 90 days resulting in lowered water levels in WCA-3A to below regulation. An after-action report was published in the 2017 SFER (Appendix 2-1; SFWMD 2017). The order extended into WY2017 for eleven days (May 1–11, 2016) during which 21,223 acre-feet (ac-ft) water was discharged from WCA-3A and the water level declined below the Zone A regulation level on May 9, 2016.

¹ **Acknowledgments:** The authors acknowledge Andrew Neidrauer's contribution in providing Lake Okeechobee water levels, regulation schedule, and the water management decisions figure.

Lake Okeechobee—the main storage of the regional water management system—was at a stage of 14.15 feet (ft) National Geodetic Vertical Datum of 1929 (NGVD29) on May 1, 2016. The lake stage reached the maximum of 16.16 ft NGVD29 on October 7, 2016, and started declining to 11.61 ft NGVD29 by April 30, 2016, due to the drier than average dry season. WY2017 was a meteorologically dry year, but available storage in Lake Okeechobee mitigated water supply needs. Concern of a water shortage was high in April 2016 and prompted the SFWMD Governing Board to issue a drought warning.

Table 2-1 compares WY2017 flows to the last water year’s flows and historical average flows. **Figure 2-1** presents WY2017 surface water flows for major hydrologic components in the regional system, along with historical average flows shown for comparison. Inflows and outflows in WY2017 were mostly below that of WY2016 but above historical average. WCAs and ENP inflows and outflows were lower.

Table 2-1. Summary of flows in ac-ft for WY2017, the percent of historical average they represent, and their comparison to WY2016 flows. (Note: Structures used to calculate inflows and outflows into the major hydrological units are presented in Appendix 2-5 of this volume.)

Location	WY2017 Flow (ac-ft)	Percent of Historical Average	WY2016 Flow (ac-ft)
Northern Everglades			
Lake Kissimmee Outflows	856,145	118	941,604
Lake Istokpoga Outflows	429,180	184	233,356
Lake Okeechobee Inflows	2,460,826	115	2,984,077
Lake Okeechobee Outflows	2,672,499	180	2,323,597
Flows into St. Lucie Canal from Lake Okeechobee	394,728	152	383,303
Flows into St. Lucie Estuary through St. Lucie Canal	417,032	133	558,412
Lake Okeechobee Releases to St. Lucie Estuary ^a	338,207		369,844
C-44 Basin Runoff into St. Lucie Estuary ^a	78,825		188,568
Flows into Caloosahatchee Canal from Lake Okeechobee ^a	1,231,755	223	972,904
Flows into Caloosahatchee Estuary through Caloosahatchee Canal	1,940,819	153	1,929,150
Lake Okeechobee Releases to Caloosahatchee Estuary ^a	1,010,066		849,042
Basin Runoff into Caloosahatchee Estuary ^a	930,753		1,080,108
Southern Everglades			
WCA-1 Inflows	236,245	51	351,943
WCA-1 Outflows	164,088	38	350,425
WCA-2 Inflows	545,850	84	864,470
WCA-2 Outflows	499,918	77	872,912
WCA-3 Inflows	990,095	84	1,575,428
WCA-3 Outflows	1,169,431	115	1,368,423
Everglades National Park Inflows	1,340,883	133	1,566,604

a. calculated

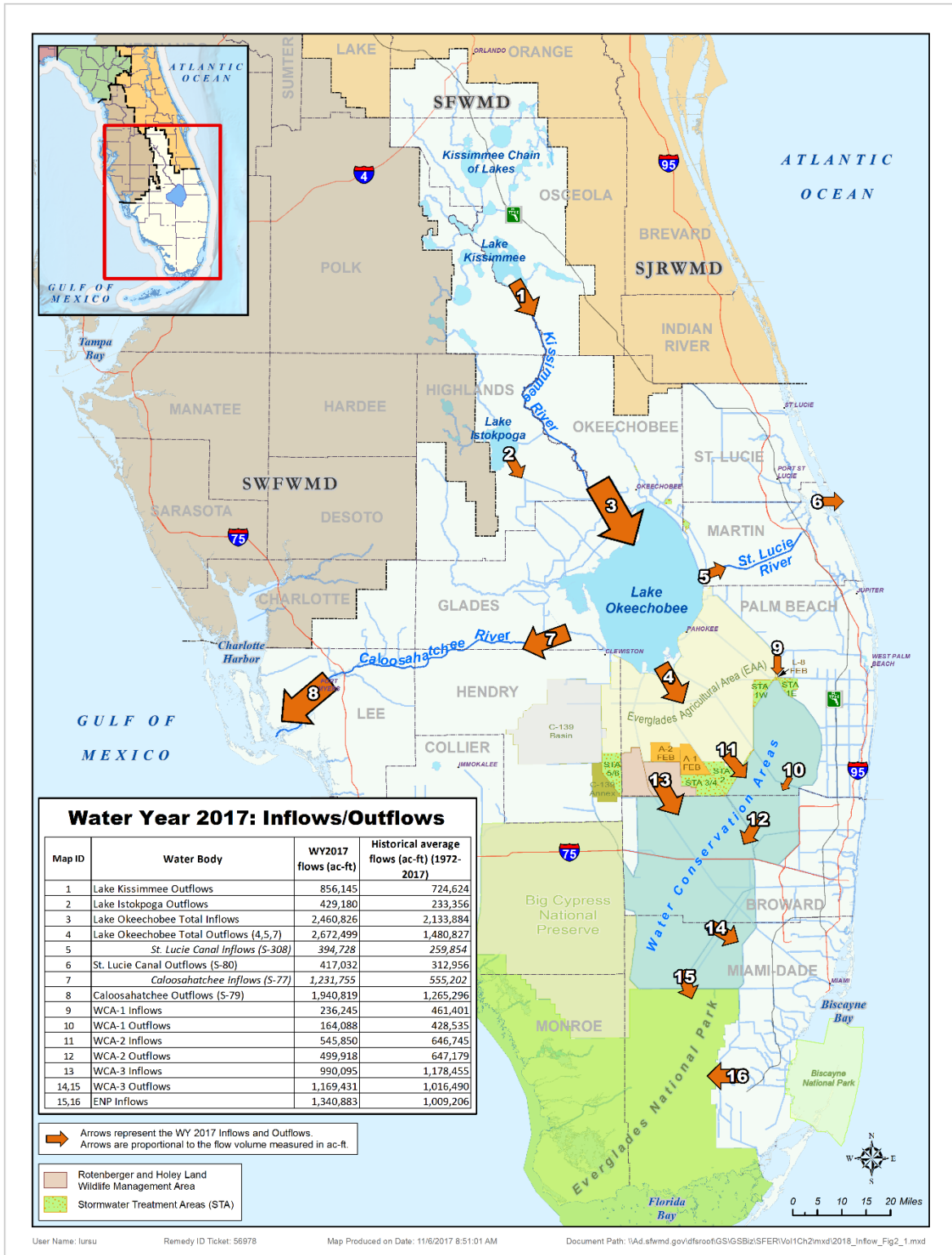


Figure 2-1. WY2017 and historical average inflow and outflow into major hydrologic units of the regional water management system. (Note: The three arrows depicted from Lake Okeechobee represent lake outflows in the inset.)

INTRODUCTION

THE SOUTH FLORIDA WATER MANAGEMENT SYSTEM: A REGIONAL OVERVIEW

The ecological and physical characteristics of South Florida have been shaped by years of hydrologic variation—ranging from extreme drought to flood—sometimes within a relatively short time period. The regional hydrology is driven by rainfall, rainfall-generated runoff, groundwater recharge and discharge, and evapotranspiration. Surface water runoff is the source for direct and indirect recharge of groundwater, lake and impoundment storage, and replenishments of wetlands. Excess surface water is discharged to the peninsula's coasts. Most of the municipal water supply is from groundwater that is sensitive to surface recharge through direct rainfall, runoff, and canal recharge. The general hydraulic gradient is north-to-south, where excess surface water flows from the Upper Kissimmee Basin in the north to the Everglades in the south, with water supply and coastal discharges to the east and west. The current hydraulic and hydrologic system includes lakes, impoundments, wetlands, canals, and water control structures managed under water management schedules and operational rules. Constructed wetlands known as stormwater treatment areas (STAs; 68,000 acres) retain phosphorus from drainage waters and are part of the hydraulic and water management system of South Florida (Chimney 2017).

The development of South Florida requires a complex water management system to manage floods, droughts, and hurricane impacts. Excess water is stored in lakes, detention ponds, wetlands, impoundments, and aquifers, or is discharged to the coast to estuaries and the ocean. Information regarding the operation of the South Florida water management system is summarized in Abteu et al. (2011). As a major component of this system, Lake Okeechobee's storage capacity is over 3.54 million ac-ft at an average lake level of 14.02 ft NGVD29—the largest of any hydrologic feature in South Florida. The lake is critical for flood control during wet seasons and water supply during dry seasons. Lake outflows are received by the EAA, St. Lucie River and Estuary, Caloosahatchee River and Estuary, Lake Worth Lagoon, and Everglades STAs. The STAs discharge into the Everglades Protection Area (EPA). In drought conditions, some water from the lake is directly sent south for water supply to reduce transmission losses. Further details of these subregional flows are presented in the *Water Levels and Flows* subsection, within the *Water Management in Water Year 2017* section of this chapter.

Over an 18,000-square mile area, the District manages the region's water resources for flood control, water supply, water quality, and natural systems' needs under water management schedules based on specific criteria. The major hydrologic components are the Upper Kissimmee Chain of Lakes, Lake Istokpoga, Lake Okeechobee, EAA, Caloosahatchee and St. Lucie River basins, Upper East Coast (UEC), Lower East Coast (LEC), WCAs, Lower West Coast (LWC), and ENP. The Kissimmee Chain of Lakes (Lake Myrtle, Alligator Lake, Lake Mary Jane, Lake Gentry, Lake East Tohopekaliga, Lake Tohopekaliga, and Lake Kissimmee) is a principal source of inflow to Lake Okeechobee. Various groundwater aquifers are part of the water resources, with most of their water levels responding relatively quickly to changes in rainfall and surface water conditions. The STAs are also components of the system.

Generally, the region is wet with an average annual rainfall of 53 inches. For water management purposes, the District has divided the region into 14 rainfall areas plus ENP (**Figure 2-2**). Rainfall for each area is reported daily, and multiple and overlapping gauges are used to compute average rainfall over each area. Real-time rainfall observations over the rainfall areas aid real-time water management decisions. Due to the relatively low gradient of regional topography, pumping is necessary to move water in the system. Across the region, the average pumping volume for Fiscal Years (October 1–September 30) 1995-1996 through 2014-2016 was 3,036,476 ac-ft (**Table 2-2**). Fiscal Year 2015-2016 pumping was 5,825,827 ac-ft, which is the highest volume of pumping since FY1996. In many cases, the same water is pumped in and out, as is the case with most of the Everglades STAs. The number of pump stations has increased from 20

to over 70 since 1996, with additional temporary pumps that vary in number from time to time. Some pumps are installed but not yet certified or registered and fully operational.

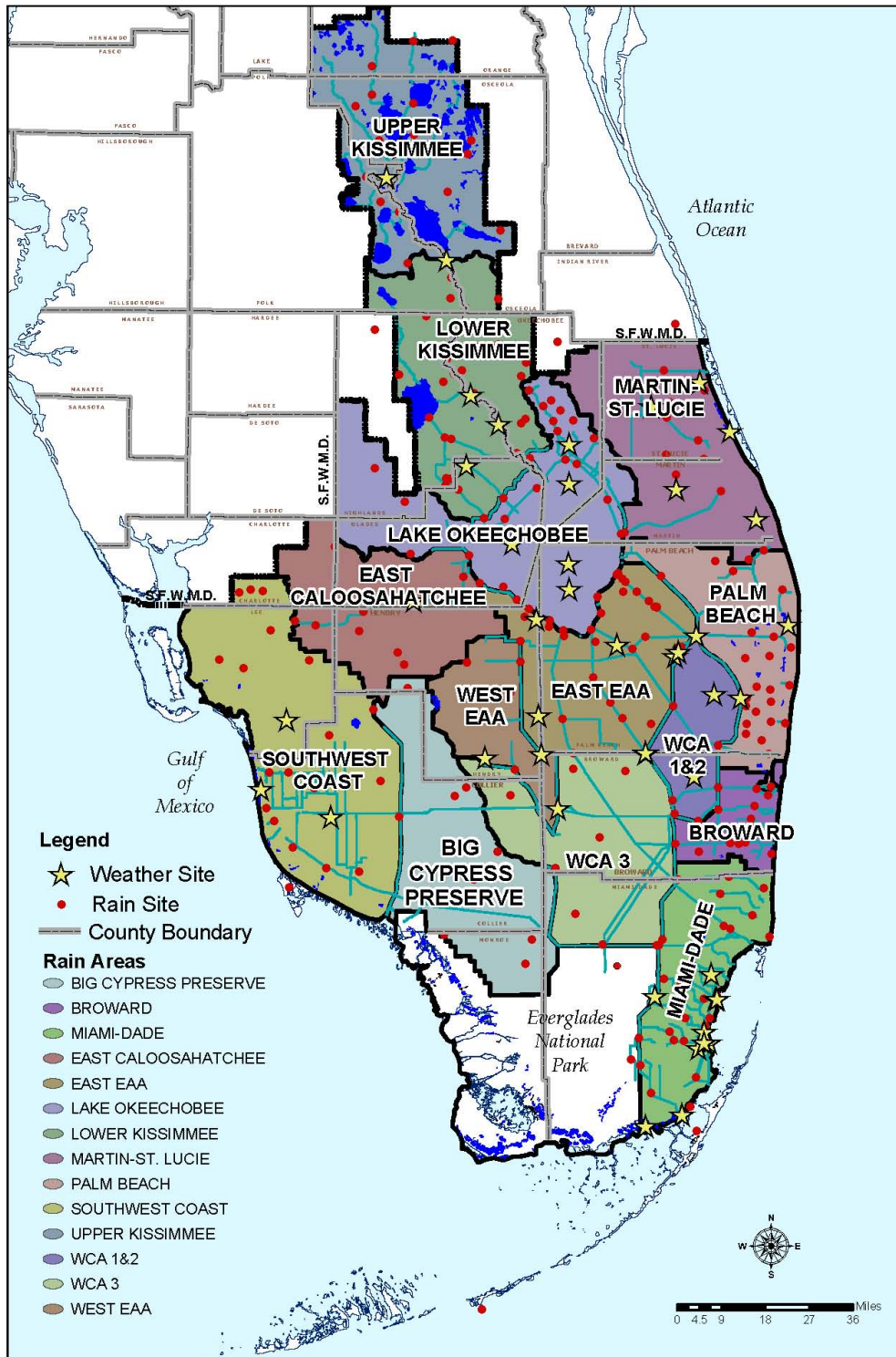


Figure 2-2. SFWMD rainfall areas.

Table 2-2. SFWMD water pumping volumes for Fiscal Year 1995-1996 through Fiscal Year 2015-2016.

Fiscal Year	Volume of Water Pumped (ac-ft)
1995-1996	2,480,000
1996-1997	1,840,000
1997-1998	2,020,000
1998-1999	2,090,000
1999-2000	2,517,000
2000-2001	2,131,000
2001-2002	3,131,000
2002-2003	3,339,000
2003-2004	3,404,000
2004-2005	3,938,000
2005-2006	3,583,000
2006-2007	1,281,000
2007-2008	3,767,700
2008-2009	3,660,000
2009-2010	3,031,622
2010-2011	1,584,057
2011-2012	3,254,308
2012-2013	4,419,510
2013-2014	3,445,573
2014-2015	3,023,409
2015-2016	5,825,827
Average	3,036,476

STORAGE OF LAKES AND IMPOUNDMENTS

Storage is required for both flood control and water supply in the regional water management system. The amount of storage volume available varies significantly from year to year due to large variations in rainfall and runoff both temporally and spatially. The impact of variation in rainfall amount and timing is reduced by managing available storage. Regulation schedules provide guidance for water level and storage management of lakes and impoundments. The regulation schedule for each water body is covered in the following sections where WY2017 water levels are discussed. Temporary modifications from normal regulation schedules for WY2017, if any, are also presented. Regulation schedule deviations include environmental needs, such as those of the Everglade snail kite (*Rostrhamus sociabilis plumbeus*), and construction and maintenance activities.

The combined average storage of the major lakes and impoundments is over 5.2 million ac-ft; Lake Okeechobee provides about 68% of this storage volume. During wet conditions and high flow periods, storage between the actual stage and maximum regulatory stage is limited and water must be released. The successful operation of the system depends on timely water management decisions and the constant movement of water. Excess water is mainly discharged to the Gulf of Mexico, St. Lucie Estuary, Atlantic Ocean, and Florida Bay. Stage-storage relationships of lakes and impoundments are critical information for managing water levels and storage and computing average hydraulic residence time. Appendix 2-2 in the 2007 SFER – Volume I (Abteu et al. 2007a) presents the compiled charts for stage-storage for the major lakes and impoundments and stage-area relationships where data are available.

SELECTED HYDROLOGIC COMPONENTS

During WY2017, the District regions received below average rainfall. Descriptions of these areas are summarized in this section, while specific hydrology and structure flow information for each is presented in the *Water Management in Water Year 2017* section of this chapter.

Upper and Lower Kissimmee Basins

The Upper Kissimmee Basin comprises the Kissimmee Chain of Lakes with a drainage area of 1,596 square miles (Guardo 1992). Historically, the Kissimmee Chain of Lakes is hydraulically connected to the Kissimmee River; during the wet season, the lakes overflow into surrounding marshes and then into the river (Williams et al. 2007). Water from the Upper Kissimmee Basin is discharged into the Lower Kissimmee Basin as the outflow of Lake Kissimmee. The Lower Kissimmee Basin has a drainage area of 727 square miles (Abteu 1992). Flows are through the restored segments of the Kissimmee River and C-38 canal. Along the reaches of the river, there are three water control structures (S-65A, S-65D, and S-65E) that regulate the river stage. At the terminal of the Kissimmee River, discharge from the S-65E structure flows into Lake Okeechobee as the main source of inflows to the lake. Overall, the Kissimmee Basin is an integrated system consisting of several lakes with interconnecting canals and flow control structures (see also Chapter 9 of this volume).

Lake Okeechobee

Lake Okeechobee is the largest lake in the southeastern United States. It is relatively shallow with an average depth of 8.9 ft and surface area of 436,300 acres at the average water surface elevation of 14.02 ft NGVD29. Water levels are regulated through numerous water control structures operated according to a seasonally varying regulation schedule. The lake serves multiple functions for flood control, water supply, recreation, and environmental restoration efforts. Chapter 8B of this volume discusses the status of Lake Okeechobee.

Everglades Agricultural Area

The EAA is an agricultural irrigation and drainage basin where, generally, ground elevation is lower than the surrounding area. During excess rainfall, runoff must be pumped out of the area; during dry times, irrigation water supply is needed. Irrigation water supply during dry seasons comes mainly from Lake Okeechobee, with the WCAs as secondary sources. On average, about 900,000 ac-ft of water is discharged from and through the EAA to the south and southeast, historically, mostly discharging into the EPA (Abteu and Khanal 1994, Abteu and Obeysekera 1996). Four primary canals (Hillsboro, North New River, Miami, and West Palm Beach) and three connecting canals (Bolles, Cross, and Ocean) facilitate runoff removal and irrigation water supply. Currently, runoff and drainage from the EAA is discharged to the Everglades STAs for treatment and released to the EPA. Additional information on the EAA and Everglades STAs is presented in Chapters 4 and 5B of this volume, respectively.

Upper East Coast

The main canal in the UEC is the St. Lucie River (C-44 canal). It runs from Lake Okeechobee to the St. Lucie Estuary. Inflows to the St. Lucie River are runoff from the basin and releases from Lake Okeechobee by operation of the S-308 structure according to regulation procedures described by USACE (2008). Downstream of S-308 is a gated spillway, S-80, that also receives inflows from the local watershed to the west and discharges to the estuary. The C-23 canal discharges into the North Fork of the St. Lucie River at structure S-48. The C-24 canal discharges into the same fork at the S-49 structure. The C-25 canal discharges into the southern part of the Indian River Lagoon at structure S-50.

Lower East Coast

The LEC includes urban areas in Palm Beach, Broward, and Miami-Dade counties. The purposes of the major canals in the LEC are flood control, prevention of overdrainage in the area and groundwater recharge, water supply, prevention of saltwater intrusion into groundwater, and conveyance of runoff to ENP when available. The system is also intended to improve water supply and distribution to ENP. It was designed to supply water during a 10-year drought and deliver minimum water needs to Taylor Slough and the C-2, C-4, C-1, C-102, C-103, and C-113 basins. The stages in canals are usually allowed to recede before supplemental water is introduced. Flow releases during major flood events are made according to established guidelines (USACE 1995). Lake Okeechobee is connected to the LEC through the major canals. During dry periods, flows from the WCAs and Lake Okeechobee are released to raise canal and groundwater levels. During wet periods, the canal network is used to move runoff to the ocean as quickly as possible.

Lower West Coast

The main canal in the LWC is the Caloosahatchee River (C-43 canal). It runs from Lake Okeechobee to the Caloosahatchee Estuary. Inflows to the Caloosahatchee River are runoff from the basin and releases from Lake Okeechobee by operation of the S-77 structure according to regulation procedures described by USACE (2008). Downstream of S-77 is a gated spillway, S-78, that also receives inflows from the local watershed. The outflow from the Caloosahatchee River (downstream of S-78) is discharged into the estuary via S-79, a gated spillway and lock operated by USACE. The operations of S-79 include managing stormwater runoff from the Caloosahatchee Watershed. The LWC includes large areas outside the drainage basin of the Caloosahatchee River.

WATER YEAR 2017 EXTREME HYDROLOGIC EVENTS AND DROUGHT CONDITIONS

MAY 2016 AND FEBRUARY 2017 HIGH RAINFALL EVENTS

High rainfalls are characterized with local daily or a few days of above average rainfall. May 4 and May 17–19, 2016, had high rainfall events.

On May 4, 2016, rainfall was a one inch average for the entire District but there were high rainfall events in the southeast with some areas receiving over 3 inches (**Figure 2-3a**). On May 16 to 19, 2016, the District received an average rainfall of 3.2 inches (**Figure 2-3b**). Most of the rainfall was on May 17. Some areas received over 5 inches of rainfall.

The February 22, 2017, high rainfall event produced District-wide average rainfall of 0.8 inches with sites in eastern Palm Beach receiving over 2 inches. This is 34% of the average rainfall for February District-wide. Even with this rainfall, February 2017 was a 1-in-5-year drought throughout most of the District area.

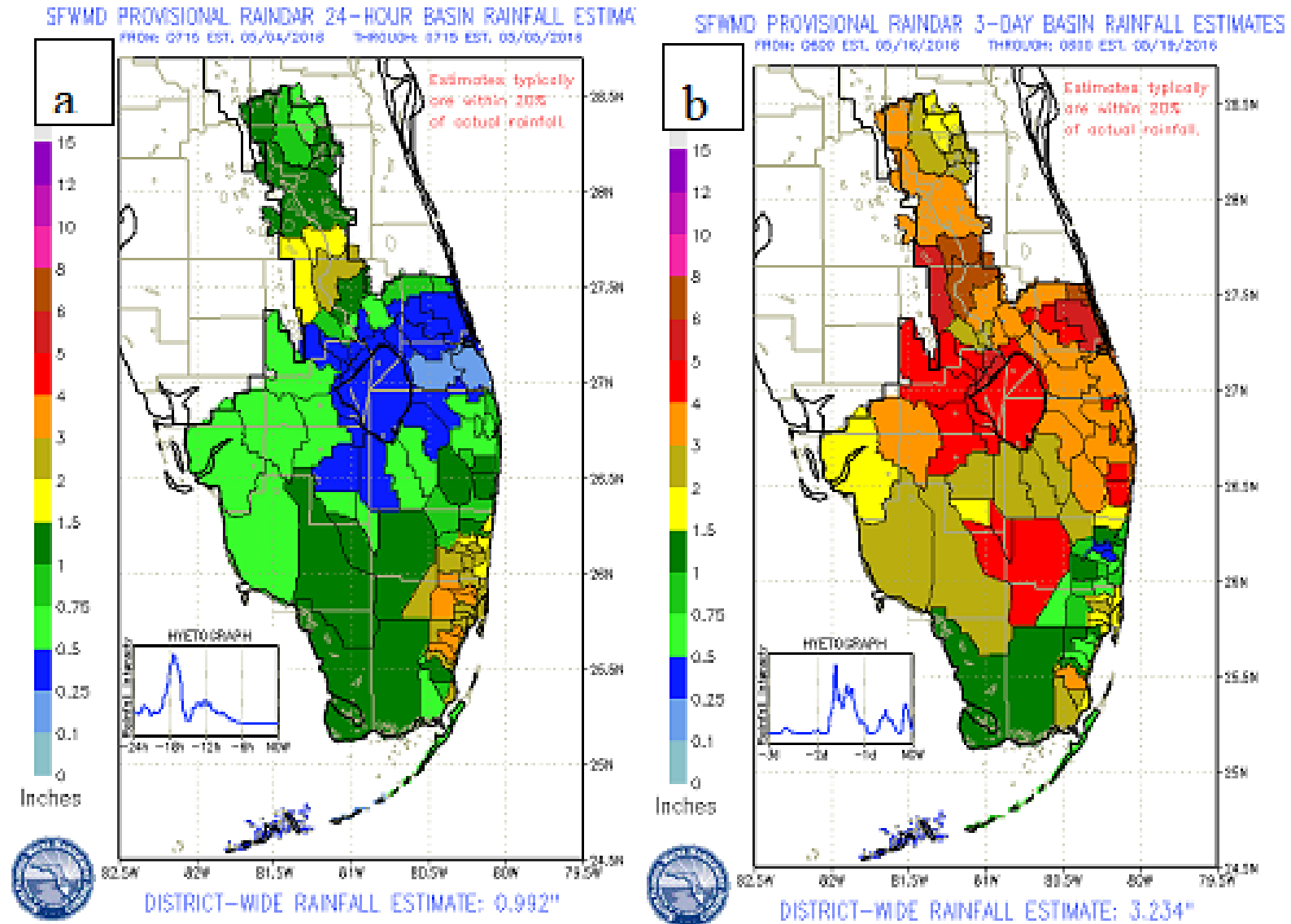


Figure 2-3. May 2016 high rainfall events: (a) May 4 and (b) May 16–19.

THE APRIL 23, 2017, HIGH RAINFALL EVENT

While South Florida was under drought conditions, a system of rainfall moved across from the Gulf of Mexico in the southwest to the Atlantic to the east drenching the area as it passed through. Most of the rainfall was on the east coast from St. Lucie County to Key West (**Figure 2-4** and **Table 2-3**). The rainfall was limited to south of Lake Okeechobee with a District average of 1.06 inches. It provided temporary relief to dry conditions south of the lake.

SFWMD PROVISIONAL RAINDAR 3-DAY RAINFALL ESTIMATES

FROM: 0630 EST, 04/21/2017 THROUGH: 0630 EST, 04/24/2017

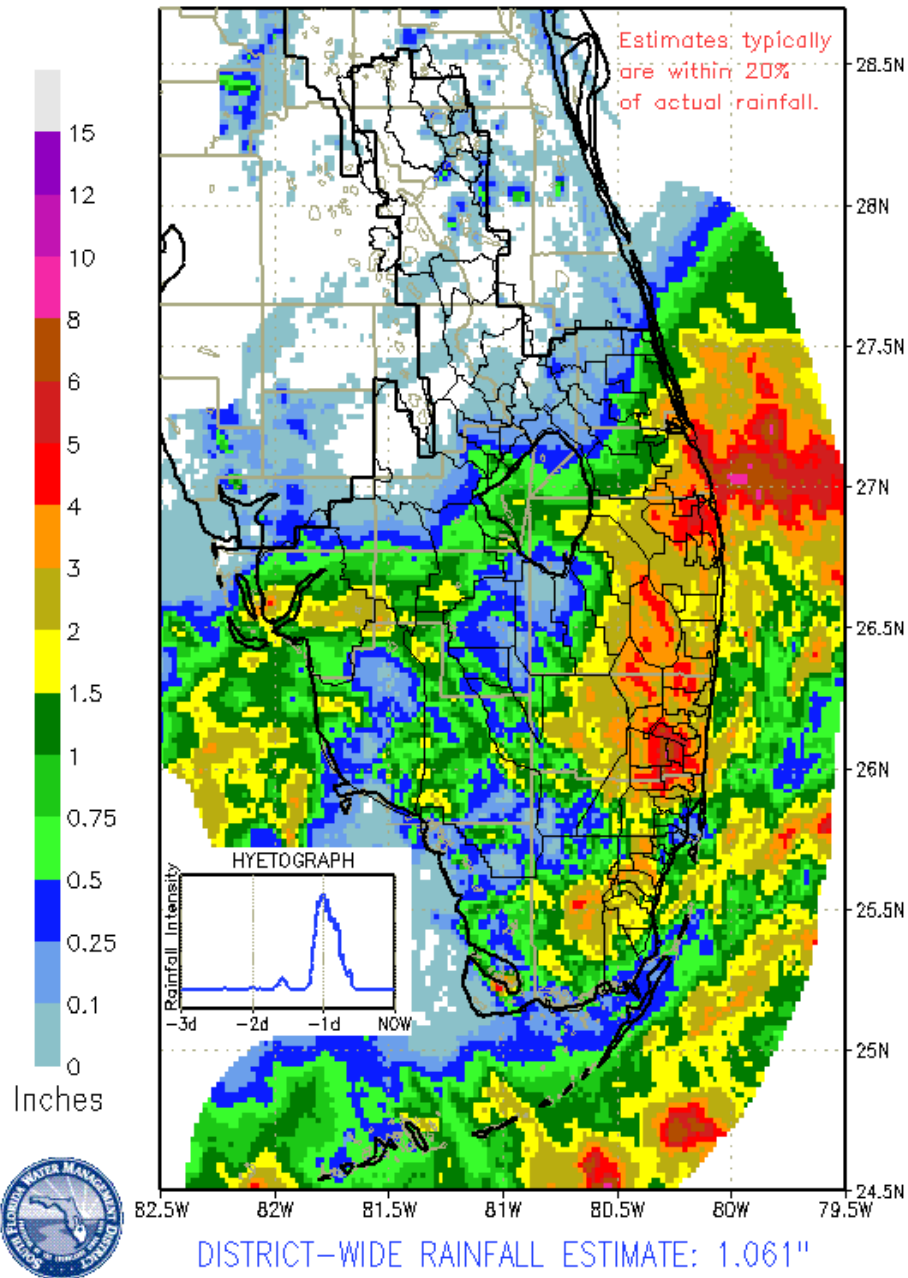


Figure 2-4. Rainfall from the April 23, 2017, event.

Table 2-3. Rain area average and site peak rainfall from the April 23, 2017, event.

Rain Area	Rain Area Average (inches)	Peak Rainfall Station	Peak Rainfall (inches)
Martin/St. Lucie	1.37	S46	5.77
Palm Beach	3.21	S46	5.77
Broward	3.75	FTLF1	6.21
Miami-Dade	2.28	S29Z	4.73
WCA-1 & WCA-2	3.55	S125	4.64
WCA-3	2.82	G3ANE	3.75

THE METEOROLOGICAL DROUGHT OF WY2017 DRY SEASON

Drought concern progressively increased from October 2016 to April 2017 (Tables 2-4 and 2-5 in the *Water Year 2017 Hydrology* section and Figure 2-5). Rainfall deficit continued month after month and water level consistently declined in lakes and WCAs. The Governing Board of the District issued a drought warning at its monthly meeting on April 13, 2017, to bring awareness of the dry conditions and encourage water conservation. The purpose of the warning was to urge voluntary water conservation. The dry condition is reflected in the continuous drawdown of Lake Okeechobee and the WCAs (Figure 2-6).

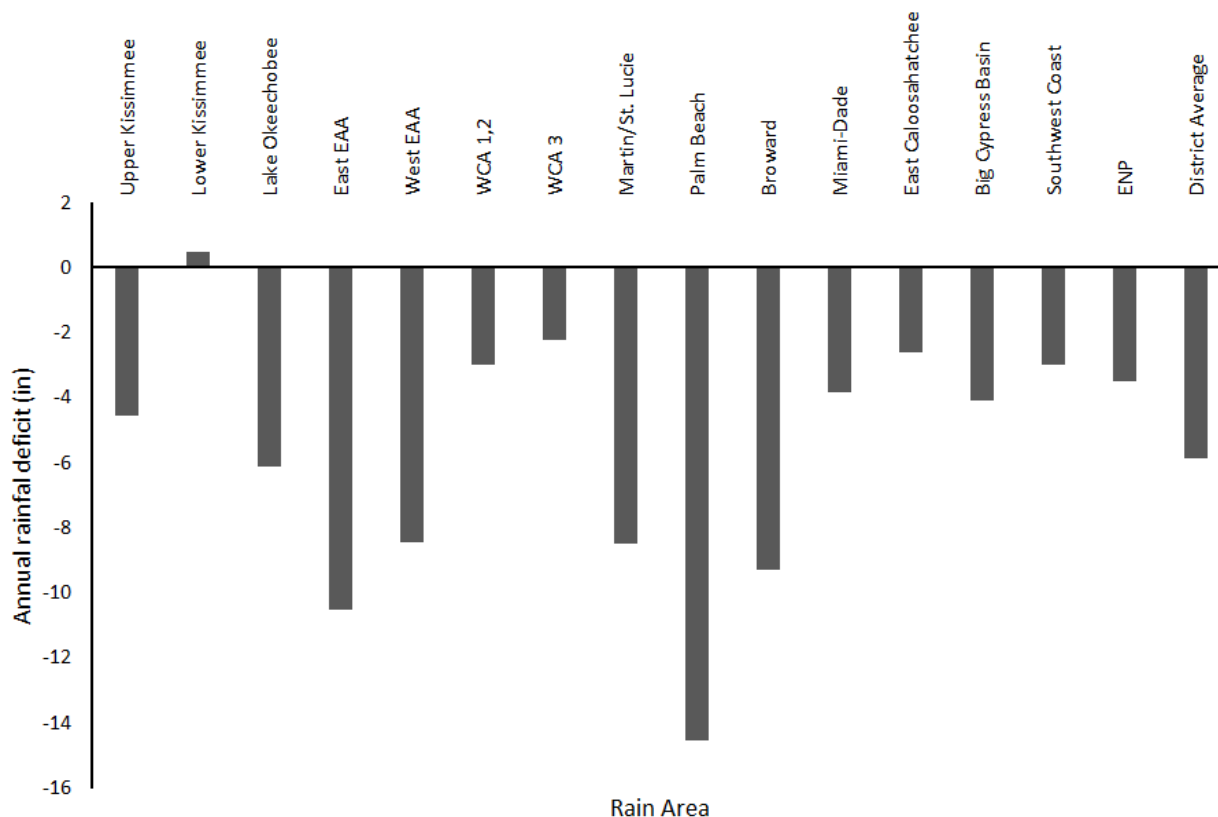


Figure 2-5. WY2017 annual rainfall deficit in inches (in).

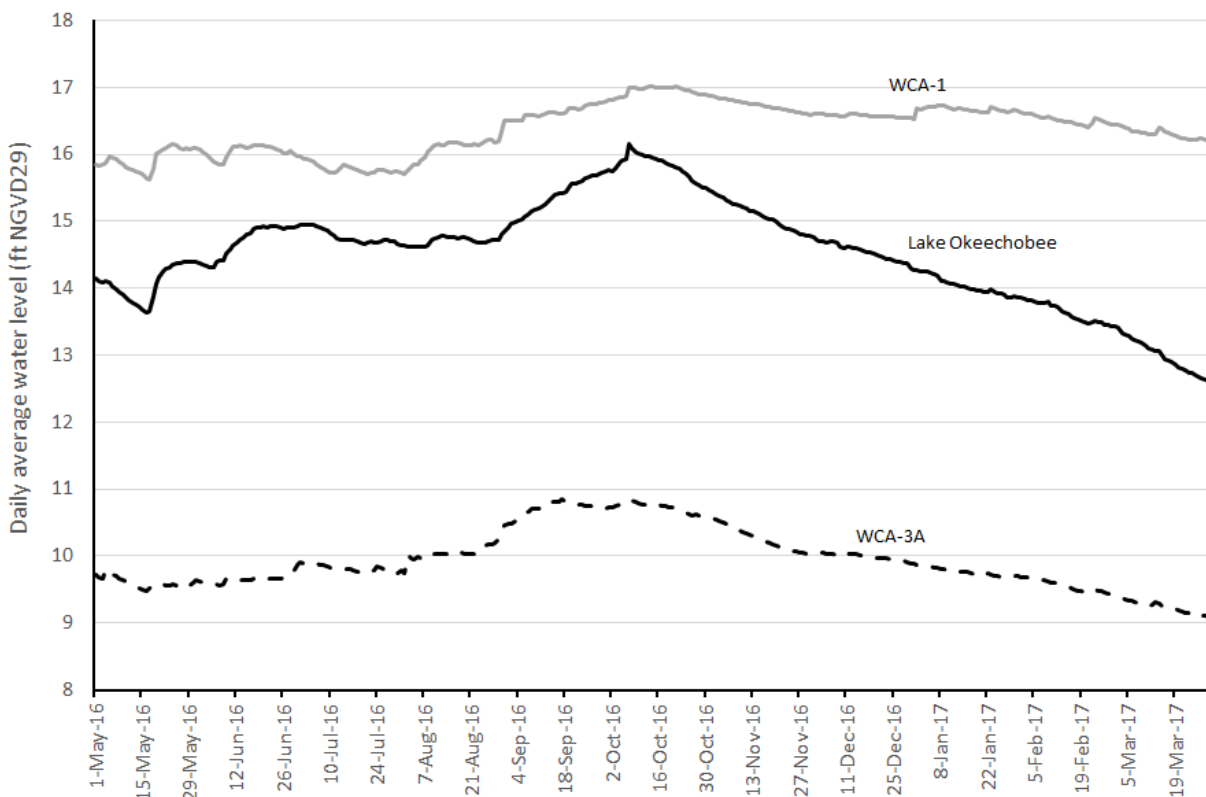


Figure 2-6. Lake Okeechobee, WCA-1 and WCA-3A water level decline due to drought condition since October 2016

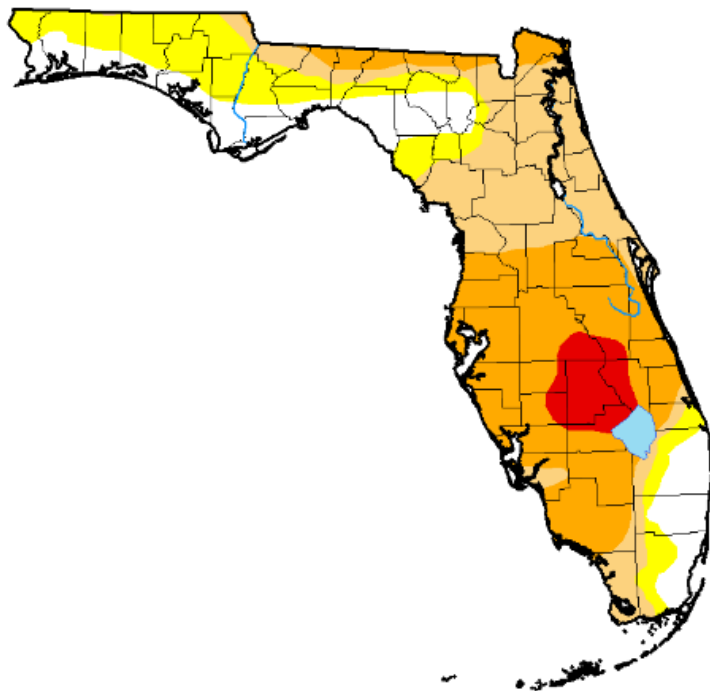
Rainfall in all rain areas and average of the District was below average except in the Lower Kissimmee rain area, which had close to average annual rainfall because of wetter than average May, June, August, and September 2016 (Tables 2-4 and 2-5 in the *Water Year 2017 Hydrology* section and Figure 2-5). But the area was in severe drought for the last six months of the water year, November 2016 to April 2017, with only 4.92 inches of rainfall. WY2017 rainfall deficit ranged from -2.23 in WCA-3 to -14.54 inches in the Palm Beach rain area. On average, eight months of the year were drier than average. July 2016 was drier than average; most of October 2016 to April 2017 was drier than average (Table 2-5). The April 23, 2017, high rainfall event, partially relieved the drought impact for the southeast while other areas were still under abnormally dry to extreme drought condition (Figure 2-7). The drought did not develop into a hydrologic drought due to sufficient storage in lakes and conservation areas with Lake Okeechobee being at 15.76 ft NGVD29 stage at the beginning of October 1, 2016, when dry conditions were widely observed. Groundwater conditions were normal. As a result, there was no immediate concern for agricultural or urban water supply.

U.S. Drought Monitor

Florida

May 2, 2017
 (Released Thursday May 4, 2017)
 Valid 8 a.m. EDT

Statistics type: Traditional Percent Area Export table: [PNG](#) [CSV](#) [XLS](#)



Week	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current 2017-05-02	15.97	84.03	66.00	39.42	5.53	0.00
Last Week 2017-04-25	23.50	76.50	57.43	33.45	0.00	0.00
3 Months Ago 2017-01-31	37.90	62.10	0.00	0.00	0.00	0.00
Start of Calendar Year 2016-12-27	9.16	90.84	14.29	0.00	0.00	0.00
Start of Water Year 2016-09-27	92.99	7.01	0.00	0.00	0.00	0.00
One Year Ago 2016-05-03	93.53	6.47	0.00	0.00	0.00	0.00

Estimated Population in Drought Areas: **12,548,449**

[View More Statistics](#)

Download: [PNG](#) [PDF](#) [JPG](#)

[View drought planning resources](#)

Intensity:

- D0 (Abnormally Dry)
- D2 (Severe Drought)
- D4 (Exceptional Drought)
- D1 (Moderate Drought)
- D3 (Extreme Drought)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying [text summary](#) for forecast statements.

Author(s):

Brian Fuchs, National Drought Mitigation Center

Figure 2-7 Drought conditions by the end of WY2017. (Note: EDT – Eastern Daylight Time.)

THE 2016 HURRICANE SEASON

WY2017 (2016 hurricane season) Atlantic, Gulf of Mexico, and Caribbean tropical activities were above average. The Tropical Meteorology Project predicted most probable numbers of tropical events was 12 to 15 named storms, 6 to 8 hurricanes, and 2 to 3 major hurricanes (Klotzbach 2015). The prediction matched with the actual 15 named storms with 7 hurricanes, 4 being major hurricanes (**Figure 2-8**). The first named storm occurred in January, Hurricane Alex, a rare event occurring in January (January 12–15). According to the Weather Underground, this is the second January hurricane since 1938. Four of the tropical systems had varying amounts of rainfall contribution to the District area, Tropical Storm Colin (June 5–8), Hurricane Hermine (August 27–30), Tropical Storm Julia (September 12–15), and Hurricane Matthew (October 4–8).

Tropical Storm Colin started as a tropical wave from the west coast of Africa on May 27, 2016 (**Figure 2-8**). Passing through the western Caribbean and the east coast of the Yucatan Peninsula, it later developed into a tropical storm in the Gulf of Mexico on June 5, 2016. As it crossed to the Atlantic from the Gulf of Mexico through north Florida, it produced heavy rainfall across north and central Florida as high as 10 inches in some areas (Pasch and Penny 2017). Tropical Storm Colin contributed about 1 inch of rainfall from June 5 to June 8, 2016, over the District area (**Figure 2-9a, b**).

Hurricane Hermine lasted from August 27 to September 3, 2016, from tropical depression to a hurricane as it moved to the Atlantic from the Gulf of Mexico through North Florida, east Georgia, South Carolina, and North Carolina (**Figure 2-8**). It landed along the Big Bend coast of Florida. It is the first hurricane to make landfall in Florida since Wilma in 2005 (Berg 2017). The maximum rainfall was near Tarpon Springs, Pinellas County, southwest Florida, which was 22.36 inches between August 30 and September 2, 2016. The District received over 2.4 inches of rainfall from the tropical system and related systems (**Figure 2-10**).

Tropical Storm Julia started as a wave west off Africa on September 1, 2016. By September 12, convection increased when the trough moved south of the northwestern Bahamas (**Figure 2-8**). On September 13, moving north along the east coast of South Florida, Julia made landfall near Jensen Beach as a Tropical Depression. The depression strengthened moving north to southeast Georgia and to the sea (Blake 2017). Julia contributed some rainfall to South Florida on September 12 to 13, 2016 (**Figure 2-11**).

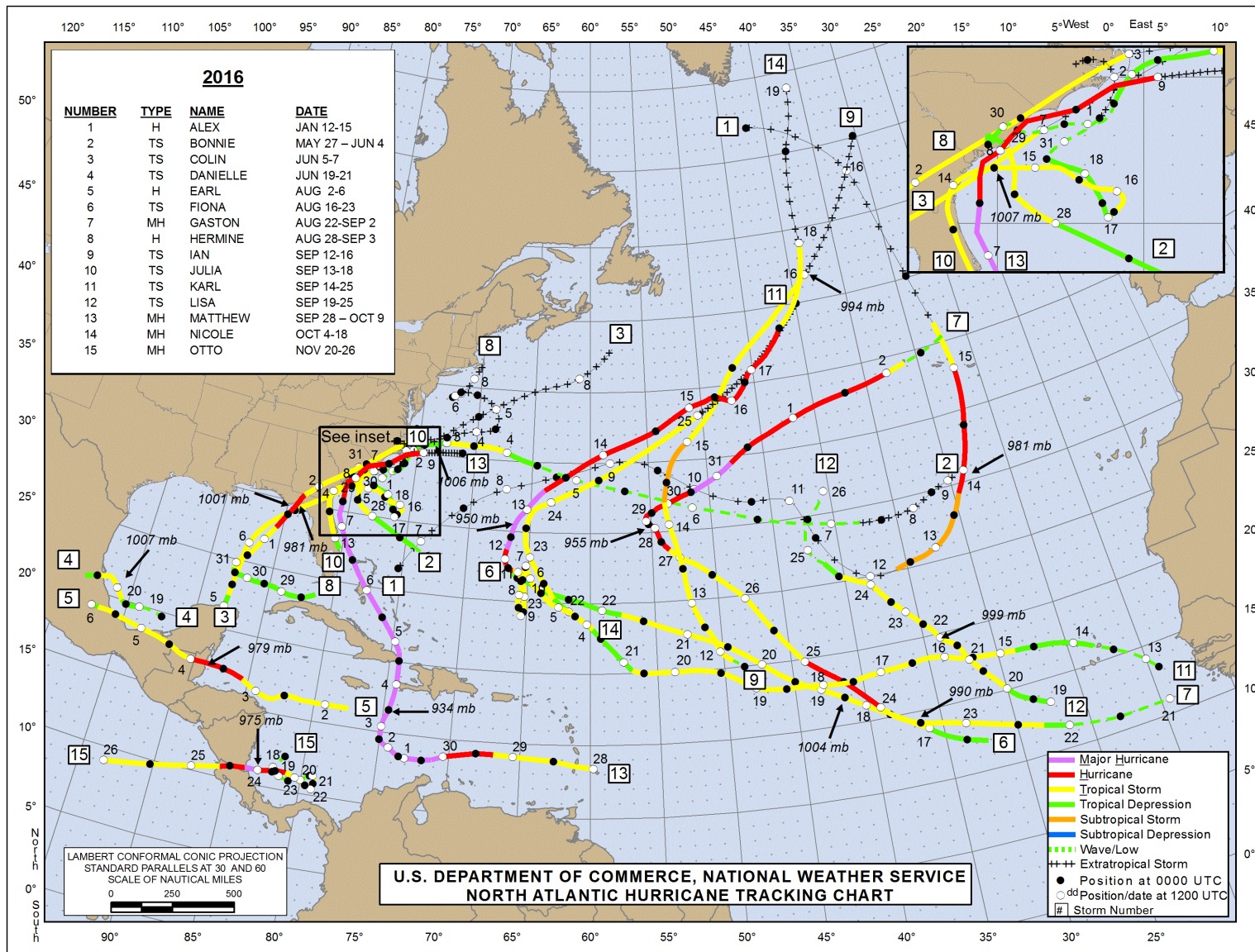


Figure 2-8. 2016 tropical systems tracks and durations (<http://www.nhc.noaa.gov/data/tracks/tracks-at-2016.png>). (Note: UTC – Coordinated Universal Time.)

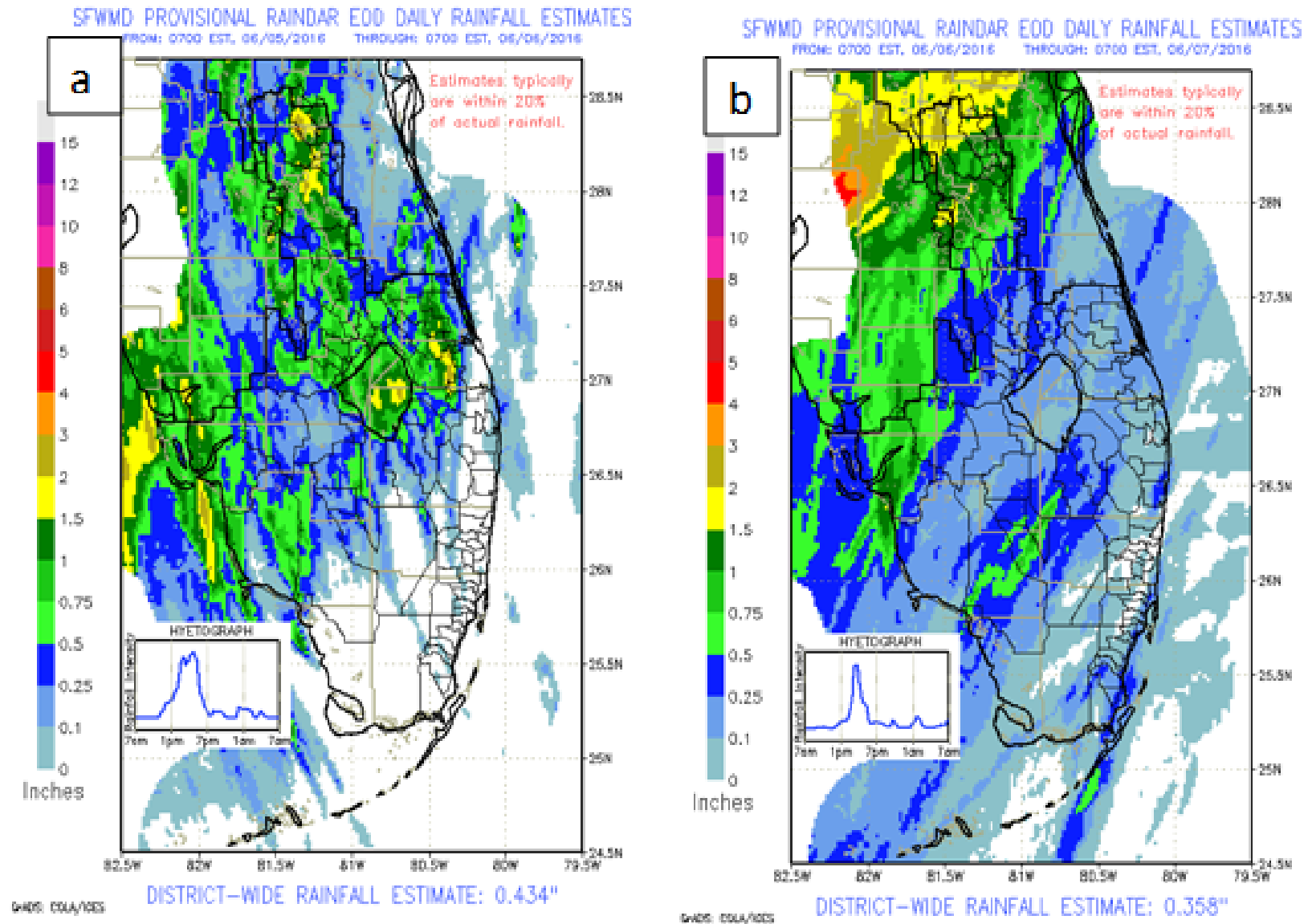


Figure 2-9. Tropical Storm Colin related rainfall: (a) June 5–6 and (b) June 6–7, 2016.

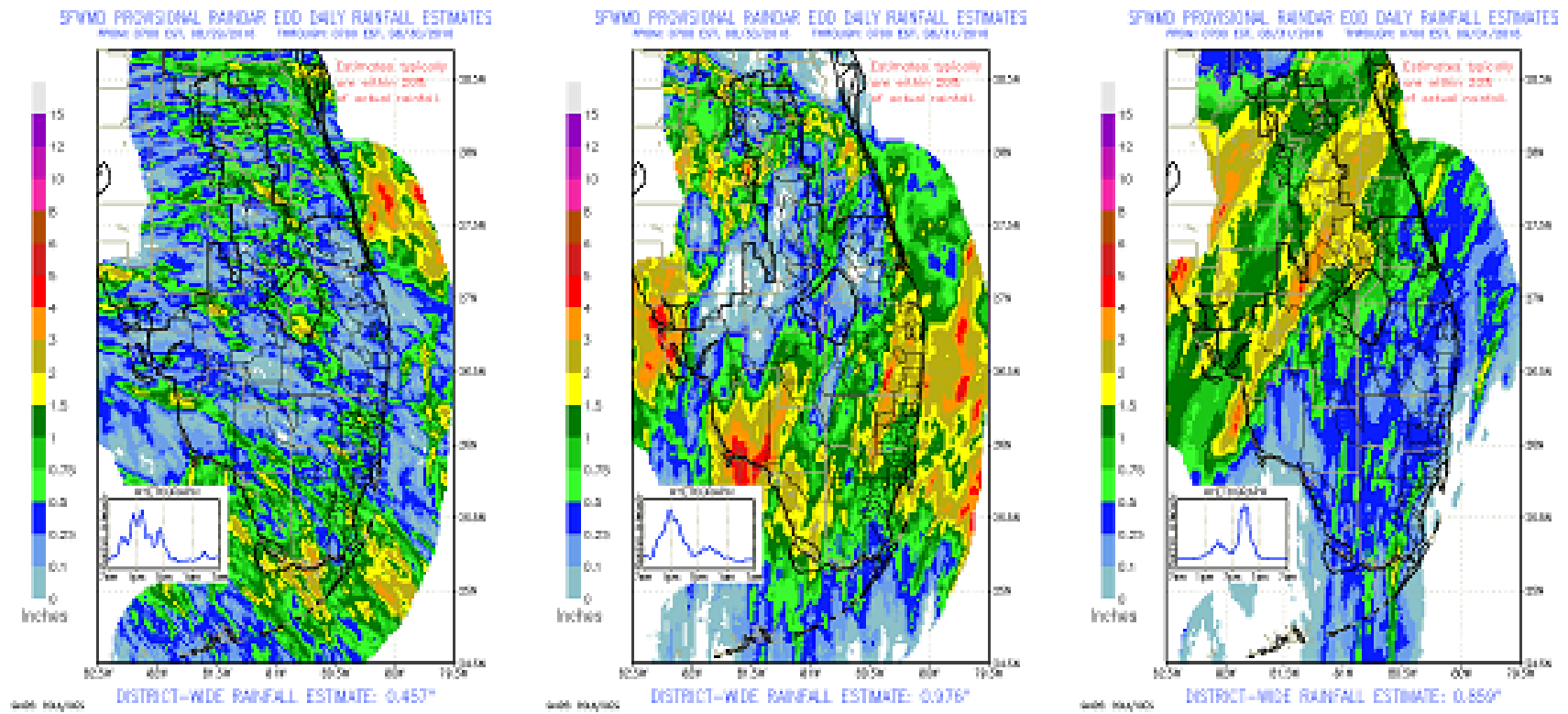


Figure 2-10. Hurricane Hermine related rainfall (August 27–September 1, 2016).

SFWMD PROVISIONAL RAINDAR EOD DAILY RAINFALL ESTIMATES

FROM: 0700 EST, 09/12/2016 THROUGH: 0700 EST, 09/13/2016

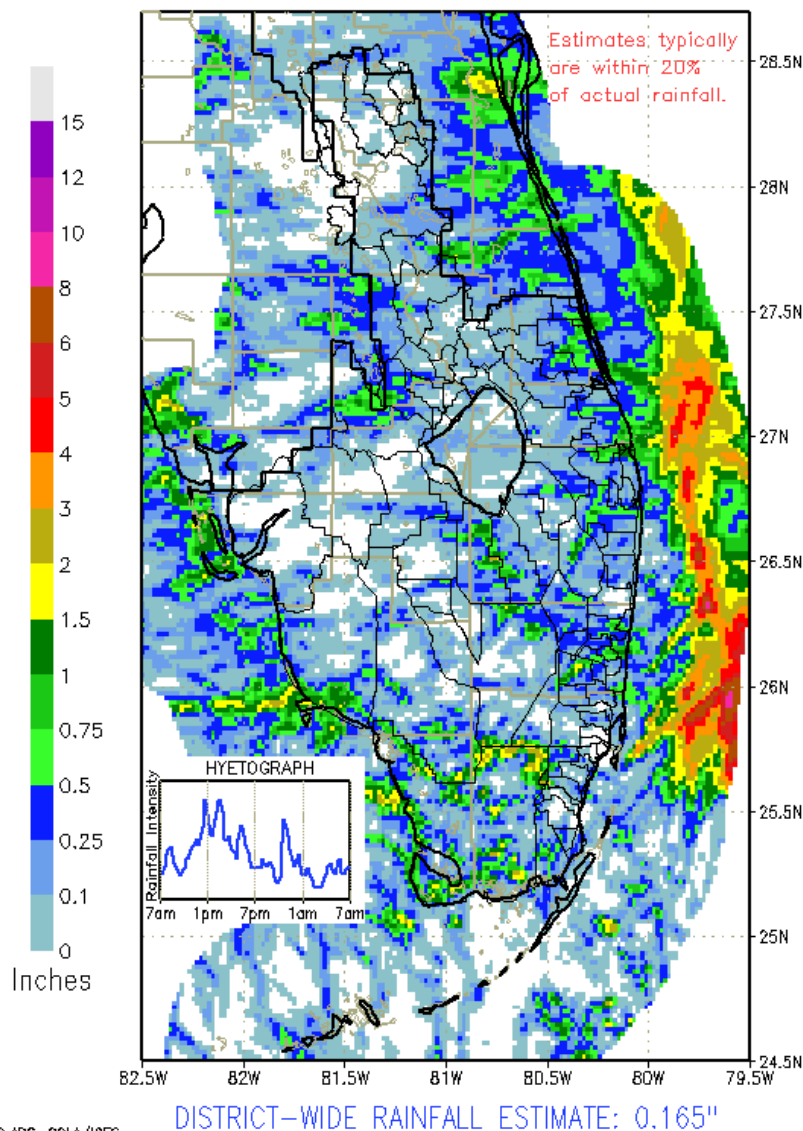


Figure 2-11. Tropical Storm Julia related rainfall September 12–13, 2016.

As reported by S.R. Stewart of the National Hurricane Center (2017), Hurricane Matthew started from the west coast of Africa on September 23, 2016. As it reached the deep and warm water of the Caribbean Sea on September 29, it developed into a Category 5 major hurricane. The hurricane later decreased in intensity. Hurricane Matthew made landfall on October 4 along the southwestern coast of Haiti resulting in over 500 deaths and loss of properties. On October 5, the hurricane passed across eastern Cuba moving west of the Bahamas. The mountainous terrain slowed it down to Category 3. The hurricane passed just east of the Florida coast as a major hurricane making landfall on the South Carolina coast as a Category 1 (**Figure 2-8**). The District received, on the average, over 2 inches of rainfall from October 4 to 7, 2016, from the Hurricane Matthew related system. As shown in **Figure 2-12**, most of the rainfall was offshore. The most affected rain areas in the District were Palm Beach, Martin/St. Lucie, East EAA, Big Cypress, and West EAA.

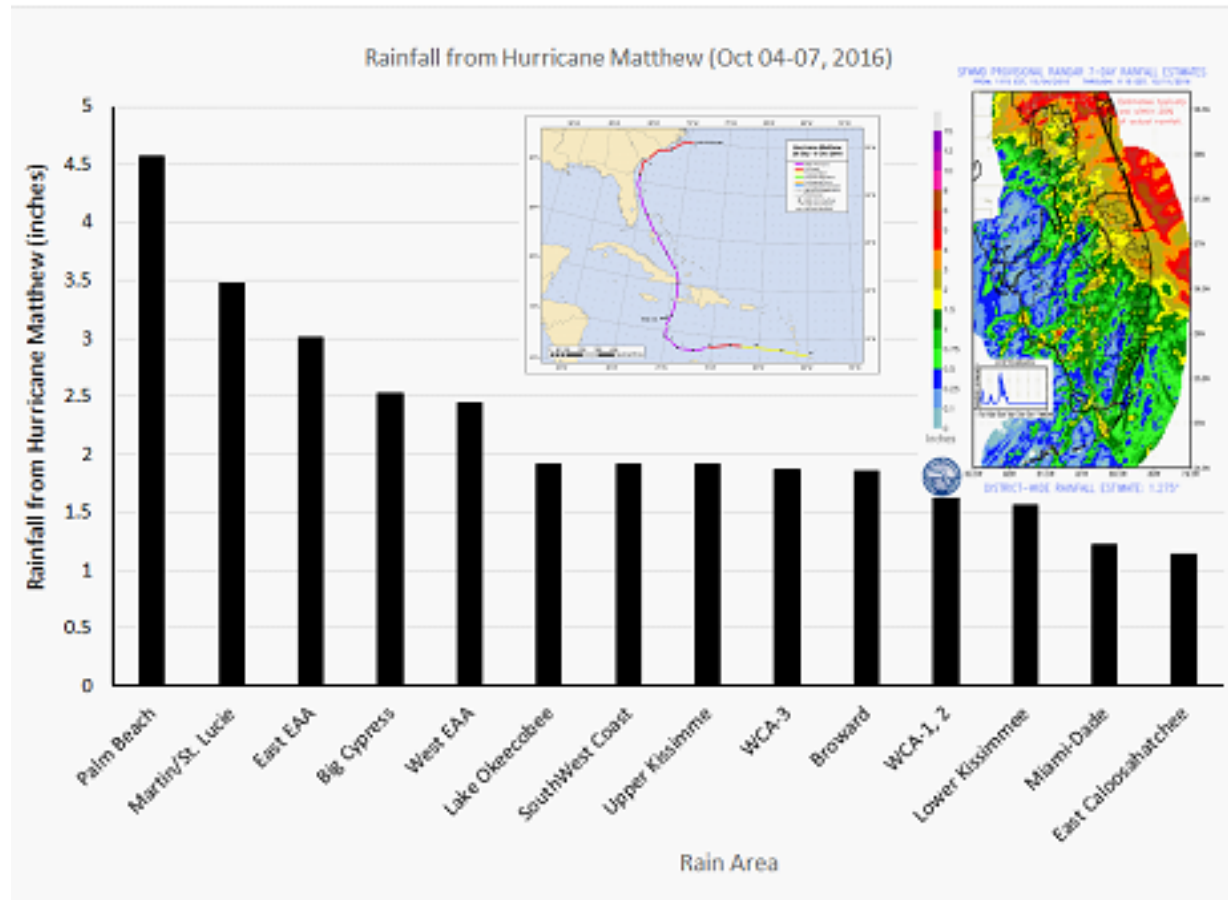


Figure 2-12. Rainfall from Hurricane Matthew (October 4–7, 2016).

2017 EL NIÑO SOUTHERN OSCILLATION

ENSO is an ocean-atmosphere phenomenon that is reflected in the warming or cooling of the eastern Pacific compared to average temperature. An El Niño event occurs when the cooler equatorial eastern Pacific warms up once every 2 to 7 years and sea surface temperature (SST) increases. The increase in temperature at the equatorial eastern Pacific is attributed to the weakening of the easterly trade winds that result in warm water from the western Pacific moving to the east. On the contrary, strong easterly trade winds bring cooler water to the surface and create a La Niña event. During El Niño years, the South Florida dry season gets wetter and during La Niña the dry season gets drier more pronouncedly when the events are strong (Abteu and Trimble 2010).

The Pacific SST cooling condition that started in June 2016 continued to February 2017 and switched to warming. Positive SST anomalies started in March 2017 at Niño Region 3.4, which is commonly used for ENSO tracking. By May 2017, all four Niño regions (Niño 1+2, Niño 3, Niño 3.4, and Niño 4) across the tropical Pacific west of Peru showed a positive SST anomaly, a sign of warming and an El Niño trend. **Figure 2-13** depicts a cumulative SST tracking index where positive values indicate the presence of El Niño and negative values indicate La Niña; values closer to zero indicate a neutral condition (Abteu et al. 2009, Abteu and Trimble 2010). Strong El Niño is indicated by above 5 degrees Celsius (° C) cumulative SST and strong La Niña is indicated by cumulative SST of less than -5° C. El Niño conditions create wind shear that weakens Atlantic tropical systems and influence the path of tropical storms to curve to the north and east away from the land mass of the eastern United States. The impending El Niño condition in 2017 was the basis of below normal number of tropical storm prediction. But later, as El Niño strength decreased, the predicted number of storms was increased. La Niña conditions create favorable conditions for Atlantic tropical storms. The 2017 ENSO development parallels 1994, which is a mild El Niño year (**Figure 2-13**).

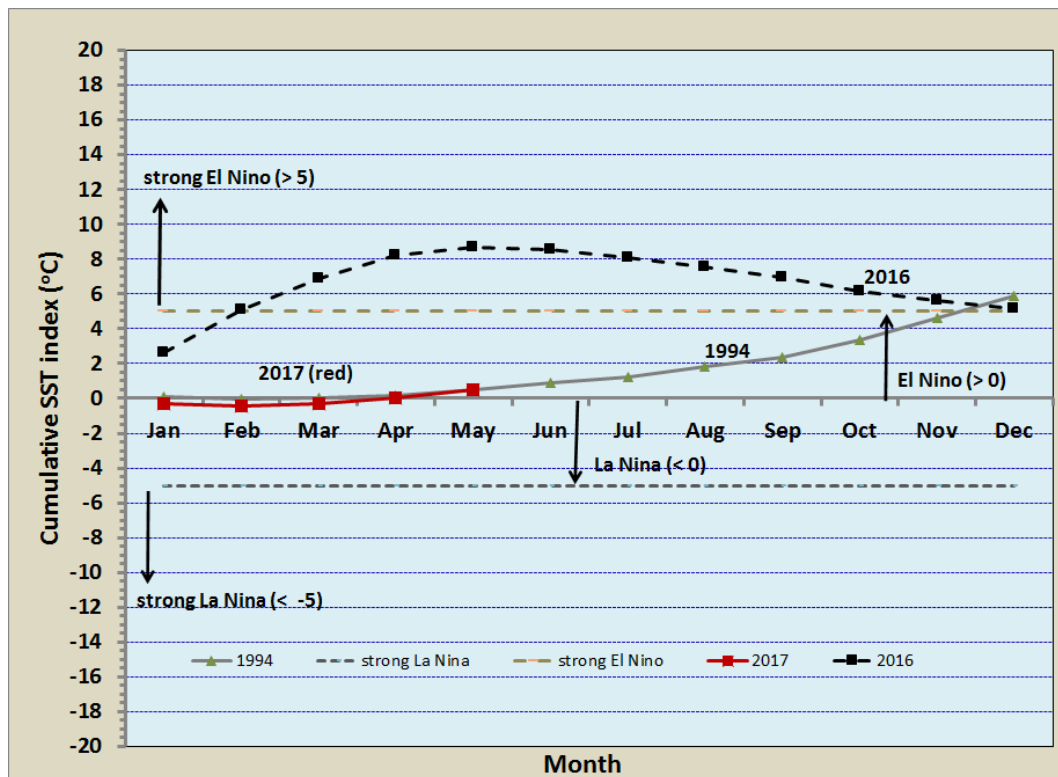


Figure 2-13. 2016 cumulative SST index showing cooling off for the second part of 2016 and 2017 warming ENSO development that parallels 1994 ENSO developments.

WATER YEAR 2017 HYDROLOGY

RAINFALL AND EVAPOTRANSPIRATION

WY2017 was a meteorologically dry year (46.89 inches) with close to 6 inches rainfall deficit from the average (52.75 inches). It followed the above average rainfall year of WY2016 (+2.6 inches). Most of the District regions were drier than average. Except for the Lower Kissimmee rain area, all rain areas and ENP had a rainfall deficit: Upper Kissimmee (-4.55 inches), Lower Kissimmee (+0.48 inches), Lake Okeechobee (-6.13 inches), East EAA (-10.51 inches), West EAA (-8.44 inches), WCA-1 and WCA-2 (-2.97 inches), WCA-3 (-2.23 inches), Martin/St. Lucie (-8.47 inches), Palm Beach (-14.54 inches), Broward (-9.3 inches), Miami-Dade (-3.83 inches), East Caloosahatchee (-2.61 inches), Big Cypress Basin (-4.09 inches), Southwest Coast (-3.0 inches), and ENP (-7.40 inches).

Table 2-4 depicts monthly rainfall for each rainfall area and ENP for WY2017. **Table 2-5** presents dry and wet return periods of monthly rainfall in each rainfall area during WY2017, showing each month's state in each area. As shown in **Table 2-5**, most months were drier than average rainfall at different frequency of occurrence. On the average, more than eight months were drier than average. November 2016 was extremely dry. In WY2017, four tropical systems contributed rainfall to the District area directly or by influence; Tropical Storm Julia (June 5–7, 2016), Hurricane Hermine (August 27–September 2, 2016), Tropical Storm Julia (September 12–13, 2016), and Hurricane Matthew (October 4–7, 2016).

District rainfall areas daily rainfall data was acquired from the District's Operations rain gauge network available online at https://my.sfwmd.gov/sfwmd/common/images/weather/site_frm.html. ENP rainfall was acquired from the 24 ENP rain gauge network for which data is available in the District's corporate environmental database, DBHYDRO (www.sfwmd.gov/dbhydro).

Regionally, the balance between rainfall and evapotranspiration maintains the hydrologic system in either a wet or dry condition. ETp is potential evapotranspiration or actual evaporation for lakes, wetlands, and any feature that is wet year round. In South Florida, most of the variation in evapotranspiration is explained by solar radiation (Abteu 1996, Abteu and Melesse 2013). Regional estimates of average ETp from open water and wetlands that do not dry out range from 48 inches in the District's northern section to 54 inches in the Southern Everglades (Abteu et al. 2003, Abteu 2005). Available ETp data from the closest site to a rainfall area was used to estimate ETp for the area. **Table 2-6** shows monthly ETp for each rainfall area, ENP, and District average. **Table 2-7** summarizes WY2016, WY2017, and historical average annual rainfall; WY2017 ETp; and WY2017 rainfall anomalies. Appendix 2-1 of this volume compares WY2016 and WY2017 monthly rainfall, historical average rainfall, and WY2017 ETp for each rainfall area.

Table 2-4. WY2017 monthly rainfall for each rainfall area. (Note: Data from each rainfall area is from the District’s Operations rainfall database, which accumulates daily rainfall data from 7:00 a.m. of the previous day through 6:59 a.m. of the data registration day, both in Eastern Standard Time. ENP rainfall is the average of 24 stations located in ENP.)

Year	Month	Rainfall (inches)															
		Upper Kissimmee	Lower Kissimmee	Lake Okeechobee	East EAA	West EAA	WCA-1 & WCA-2	WCA-3	Martin/St Lucie	Palm Beach	Broward	Miami-Dade	East Caloosahatchee	Big Cypress Preserve	Southwest Coast	District Average	ENP
2016	May	8.46	9.69	7.33	5.75	5.8	7.12	7.49	8.19	6.52	5.25	6.97	7.17	6.3	5.37	7.11	5.72
2016	June	7.61	8.3	7.87	8.1	11.63	6.16	8.2	7.17	6.46	5.78	6.44	12.1	9.55	11.61	8.63	6.74
2016	July	5.66	4.96	4.01	4.4	5.36	3.73	4.67	3.16	3.14	4.01	4.17	7.18	7.97	8.67	5.38	5.38
2016	August	7.61	7.73	7.6	8.92	8.45	12.34	11.33	8.37	8.61	9.79	10.58	7.48	10.6	9.94	9.04	9.13
2016	September	7.3	6.89	6.63	6.26	7.21	6.18	5.97	6.72	6.1	6.82	7.3	7.75	6.4	7.67	6.87	6.85
2016	October	2.77	2.45	2.36	3.72	2.83	2.95	3.22	4.78	5.04	4.42	5.87	1.57	3.33	2.38	3.21	4.36
2016	November	0.14	0.12	0.07	0.03	0.03	0.2	0.11	0.32	0.3	0.88	0.59	0.04	0.07	0.04	0.14	0.23
2016	December	1.68	0.66	0.63	0.68	0.56	1.05	1.34	1.15	1.65	2.79	2.91	0.67	0.33	0.38	1.01	1.28
2017	January	1.81	1.03	0.91	1.5	1.54	2.17	1.91	1.25	1.66	1.91	1.97	1.12	1.77	1.49	1.49	2.07
2017	February	1.51	0.84	0.62	0.79	0.86	1.34	0.93	1.52	2.37	1.3	1.12	0.93	0.93	1.2	1.13	1.09
2017	March	0.48	0.97	0.73	0.61	0.73	1.62	1.27	1.03	1.49	1.74	2.55	0.4	1.08	0.69	0.98	1.81
2017	April	0.51	1.29	1.08	2.21	1.51	4.13	2.57	2.01	3.66	4.14	2.81	1.67	1.71	1.68	1.9	2.48
Total		45.54	44.93	39.84	42.97	46.51	48.99	49.01	45.67	47.00	48.83	53.28	48.07	50.03	51.12	46.89	47.15

Table 2-5. WY2017 monthly rainfall dry and wet return periods for each rainfall area (derived from Ali and Abteu 1999). (Note: yr – year.)

Year	Month	Upper Kissimmee	Lower Kissimmee	Lake Okeechobee	East Everglades Agricultural Area	West Everglades Agricultural Area	Water Conservation Areas 1,2	Water Conservation Area 3	Martin/St Lucie	Palm Beach	Broward	Miami-Dade	East Caloosahatchee	Big Cypress Preserve	Southwest Coast
2016	May	> 10-yr wet	>20-yr wet	<5-yr wet	<5-yr wet	<5-yr wet	<5-yr wet	5-yr wet	10-yr wet	< 5-yr wet	≈average	< 5-yr wet	<10-yr wet	> 5-yr wet	>5-yr wet
2016	Jun	average	< 5-yr wet	<5-yr wet	<average	<5-yr wet	><5-yr dry	average	< 5-yr wet	<5-yr dry	<5-yr dry	<5-yr dry	>5-yr wet	>average	5-yr wet
2016	Jul	5-yr dry	5-yr dry	> 5-yr dry	> 10-yr dry	5-yr dry	<10-yr dry	<5-yr dry	10-yr dry	<10-yr dry	5-yr dry	5-yr dry	≈average	<5-yr dry	average
2016	Aug	< 5-yr wet	5-yr wet	< 5-yr wet	< 5-yr wet	< 5-yr wet	50-yr wet	20-yr wet	5-yr wet	< 5-yr wet	<5-yr wet	<10-yr wet	average	5-yr wet	< 5-yr wet
2016	Sep	< 5-yr wet	5-yr wet	≈average	<5-yr dry	average	<average	<average	< 5-yr wet	<5-yr dry	<5-yr dry	<5-yr dry	>average	<5-yr dry	<5-yr dry
2016	Oct	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry
2016	Nov	<20-yr dry	<50-yr dry	20-yr dry	100-yr dry	50-yr dry	>20-yr dry	>50-yr dry	20-yr dry	50-yr dry	<10-yr dry	<20-yr dry	50-yr dry	20-yr dry	50-yr dry
2016	Dec	5-yr dry	5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	>average	5-yr wet	<5-yr dry	<10-yr dry	5-yr dry
2017	Jan	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<average	<average	<5-yr dry	<5-yr dry	<5-yr dry	<average	<5-yr dry	<average	<5-yr dry
2017	Feb	<5-yr dry	10-yr dry	<5-yr dry	5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<average	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry
2017	Mar	<20-yr dry	5-yr dry	<10-yr dry	10-yr dry	10-yr dry	<5-yr dry	<5-yr dry	>5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry
2017	Apr	10-yr dry	<5-yr dry	<5-yr dry	<average	<average	>5-yr wet	>average	>5-yr dry	>average	< 5-yr wet	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry
dry months		8	7	7	9	7	8	7	7	8	9	9	6	8	7
extreme dry			1	1	1	1	1	1	1	1			1	1	1
wet months		3	3	4	2	4	2	3	4	3	3	3	3	3	4
extreme wet			1				1	1							
≈ average		1											2		
dry = < average															
extreme dry >= 20 yr dry															
wet = > average															
extreme wet >= 20-yr															

Table 2-6. WY2017 monthly ETp for each rainfall area.

Year	Month	ETp (inches)															
		Upper Kissimmee	Lower Kissimmee	Lake Okechobee	East EAA	West EAA	WCA-1 & WCA-2	WCA-3	Martin/St Lucie	Palm Beach	Broward	Miami-Dade	East Caloosahatchee	Big Cypress Preserve	Southwest Coast	ENP	District Average
2016	May	6.33	5.85	6.05	6.18	5.91	5.51	5.46	5.82	6.18	5.46	5.46	6.27	5.46	5.96	5.46	5.82
2016	June	5.36	4.88	5.22	5.19	4.67	4.71	4.76	5.31	5.19	4.76	4.76	5.12	4.76	4.87	4.76	4.95
2016	July	5.86	5.54	5.68	5.68	4.98	5.39	5.40	6.32	5.68	5.40	5.40	5.40	5.40	4.81	5.40	5.49
2016	August	4.63	4.44	4.81	4.89	4.67	4.58	4.49	4.82	4.89	4.49	4.49	4.86	4.49	4.31	4.49	4.62
2016	September	4.36	4.35	4.37	4.36	4.06	3.98	3.91	4.25	4.36	3.91	3.91	4.33	3.91	4.01	3.91	4.13
2016	October	3.95	3.93	4.03	3.91	3.79	3.55	3.75	3.84	3.91	3.75	3.75	4.08	3.75	3.94	3.75	3.84
2016	November	3.36	3.34	3.49	3.22	3.60	3.43	3.69	3.67	3.22	3.69	3.69	3.61	3.69	3.71	3.69	3.54
2016	December	2.82	2.81	2.83	2.62	2.99	3.01	3.21	3.11	2.62	3.21	3.21	2.85	3.21	3.11	3.21	2.99
2017	January	2.96	3.51	3.16	3.25	3.41	3.53	3.74	3.53	3.25	3.74	3.74	3.39	3.74	3.44	3.74	3.48
2017	February	3.60	3.98	3.54	3.51	3.86	3.81	4.03	4.00	3.51	4.03	4.03	3.88	4.03	4.04	4.03	3.86
2017	March	5.19	5.40	5.05	4.85	5.07	4.85	4.75	5.12	4.85	4.75	4.75	5.18	4.75	5.46	4.75	4.99
2017	April	5.86	5.76	5.44	5.27	5.16	4.81	5.08	5.81	5.27	5.08	5.08	5.58	5.08	5.17	5.08	5.30
	Total	54.28	53.78	53.67	52.92	52.17	51.17	52.26	55.60	52.92	52.26	52.26	54.55	52.26	52.84	52.26	53.01

Table 2-7. WY2017, WY2016, and historical average annual rainfall; WY2017 ETp; and WY2017 rainfall deviation from historical average (inches) for each rainfall area.

Rainfall Area	WY2017 Rainfall	WY2016 Rainfall	Historical Average Rainfall	WY2017 ETp	WY2017 Rainfall Deviation
Upper Kissimmee	45.54	52.19	50.09	54.28	-4.55
Lower Kissimmee	44.93	52.77	44.45	53.78	0.48
Lake Okeechobee	39.84	49.35	45.97	53.67	-6.13
East EAA	42.97	46.28	53.48	52.92	-10.51
West EAA	46.51	54.34	54.95	52.17	-8.44
WCA-1 & WCA-2	48.99	55.56	51.96	51.17	-2.97
WCA-3	49.01	54.79	51.24	52.26	-2.23
Martin/St. Lucie	45.67	56.78	54.14	55.60	-8.47
Palm Beach	47	54.63	61.54	52.92	-14.54
Broward	48.83	55.2	58.13	52.26	-9.3
Miami-Dade	53.28	60.24	57.11	52.26	-3.83
East Caloosahatchee	48.07	56.43	50.68	54.55	-2.61
Big Cypress Basin	50.03	57.44	54.12	52.26	-4.09
Southwest Coast	51.12	65.62	54.12	52.84	-3
ENP ^a	47.15	51.05	54.55	52.26	-7.40
SFWMD Spatial Average	46.89	55.35	52.75	53.01	-5.86

a. ENP historical average (1941–2016).

WILDFIRES

The dry condition in WY2017 dry season has caused several wildfire incidences in Florida. The governor declared an emergency on April 11, 2017, to manage the condition. One of drought's impacts on the South Florida environment is creating conditions that promote and spread wildfires. The size and number of wildfires are generally correlated to dry conditions. Generally, drought years have above average total number of acres burned and number of acres burned per fire. For instance, the area burned by wildfire in WY1989, WY1990, WY2001, and WY2007, which were all drought years, was high. **Figure 2-14** depicts the number of acres burned per water year in the SFWMD area from wildfires that were 10 acres or larger from WY1982 to WY2017. For the most part, major droughts correspond to larger areas burned by wildfire. The number of acres burned in WY2017 was 53,748 acres. The average area burned in a year was 102,589 acres.

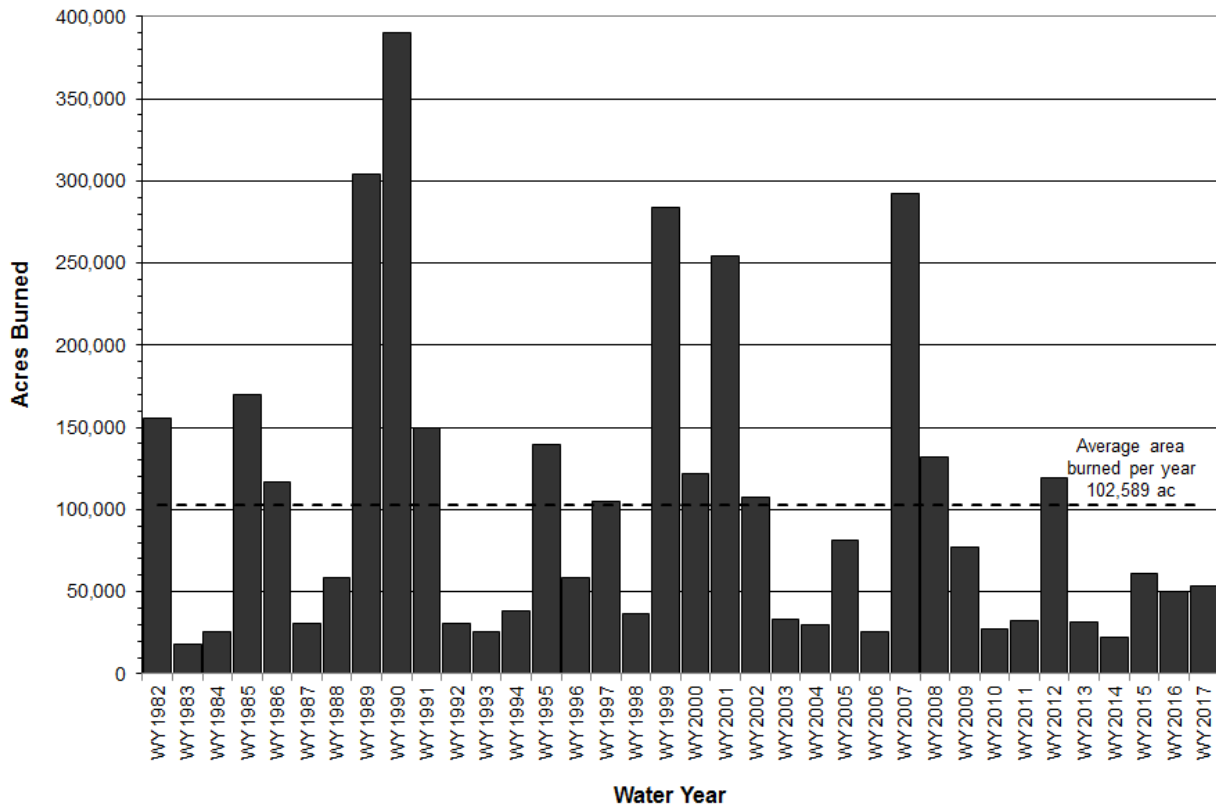


Figure 2-14. Number of acres (ac) burned per water year in the SFWMD area from wildfires that were 10 acres or larger (WY1982–WY2017).

GROUNDWATER

The District is divided into four major water resource planning regions: Kissimmee Basin, Upper East Coast (UEC), Lower East Coast (LEC) and Lower West Coast (LWC); see Appendix 2-2, Figure 1. Each has aquifers that provide water for agricultural, commercial, industrial, and domestic use. The LEC principal groundwater source is the surficial Biscayne aquifer. The UEC principal source of groundwater is the surficial aquifer. The LWC relies on three aquifer systems for water supply: the surficial aquifer system, the intermediate aquifer system, and the Floridan aquifer system. The Lower Tamiami aquifer is part of the surficial aquifer system. The sandstone and the mid-Hawthorne aquifers are part of the intermediate aquifer system (SFWMD 2006). The Kissimmee Basin is served by a surficial or shallow aquifer and a deep aquifer, the Floridan aquifer system.

In general, WY2017 groundwater levels reflect regional rainfall conditions, increasing during the wet season and declining during the below average rainfall dry season with some wells reaching below the lowest ten percentile class. Representative groundwater level fluctuation observations from the United States Geological Survey are shown in Appendix 2-2 for the stations shown in Figure 1 of the same appendix.

WATER MANAGEMENT IN WATER YEAR 2017

OVERVIEW

District-wide water management operations depend largely on the spatial and temporal distribution of rainfall across the South Florida region and antecedent conditions. Although water management of SFWMD facilities is performed according to prescribed operation plans, there are various constraints that are considered while developing and implementing shorter-term operating strategies. Flood control operations are conducted in the wet season and tropical storm events occur in this season. Inflow and outflow operations were regularly conducted to bring water levels of the major water bodies closer to the respective regulation schedules. The water management system was operated both in flood control and water supply mode based on weather and antecedent conditions. WY2017 was a meteorologically dry year (46.89 inches) with close to 6 inches rainfall deficit from the average (52.75 inches). Most of the District regions were drier than average: Except for the Lower Kissimmee rain area, all rain areas and ENP had a rainfall deficit (**Table 2-5**).

Water management is performed by using previously established regulation schedules that integrate different purposes. Regulation schedules are rule curves designed to manage regional storage. To broadly satisfy flood control and water supply needs on a long-term basis, daily water level regulation schedules for each of the regional water bodies were developed by USACE and SFWMD in cooperation with other agencies and stakeholders. The regulation schedules for the regional lakes and WCAs are published in detail in the 2007 SFER – Volume I, Appendix 2-6 (Abteu et al. 2007b). At times, deviations from the regular regulation schedules are made for a specific lake or WCA to manage water under for a given infrastructural, environmental, or weather-related condition. In WY2016, on February 11, 2016, FDEP issued an emergency final order authorizing SFWMD and USACE to take immediate action to deviate from permitted water management practices to move significant volumes of flood water out of WCA-3A to ENP through Shark River Slough. The reason was extreme rainfall events in December 2015 and January 2016, associated with the 2015-2016 El Niño, that resulted in WCA-3A water level rising dramatically with severe impacts to natural resources. Immediate drawdown was necessary and undertaken as described and the order was accomplished from February 12 to May 11, 2016. This period extended into WY2017 by 11 days (May 1–11, 2016). An additional 21,233 ac-ft was discharged from WCA-3A during this period. Stage in WCA-3A reached 9.64 ft NGVD29 just below the regulation line on May 9, 2016. The 2016 Emergency Final Order operation report can be accessed in Appendix 2-1 of Chapter 2, 2017 SFER – Volume I (http://apps.sfwmd.gov/sfwmd/SFER/2017_sfer_final/v1/appendices/v1_app2-1.pdf)

Initiated in May 2008, the current regulation schedule for Lake Okeechobee, known as LORS2008 (USACE 2008), incorporates current and future (outlook) climatic information in the decision-making process. The regulation schedule has three main bands (**Figure 2-15**): High Lake Management Band, Operational Band, and Water Shortage Management Band. The Operational Band is further divided into High, Intermediate, Low, Base Flow, and Beneficial subbands or use categories. In the High Lake Management Band, large flood control releases may be required and outlet canals may be maintained above their optimum water management elevations. In the Operational Band, substantial flood control releases may be implemented and outlet canals should be maintained within their optimum water management elevations. In the Water Shortage Management Band, outlet canals may be maintained below optimum water management elevations and water supply releases from the lake are restricted according to the severity of prolonged dry climate conditions. More information on LORS2008 is also presented in the *Lake Okeechobee* subsection of this section.

Water supply releases are made for various beneficial uses that include water supply for municipal and industrial use, irrigation for agriculture, deliveries to ENP, salinity control, estuarine management, and other environmental releases. Releases are made to the St. Lucie Canal and Caloosahatchee River to maintain navigation depths if sufficient water is available in Lake Okeechobee. The outflows from Lake

Okeechobee are received by the St. Lucie Canal, Caloosahatchee River, EAA, LEC, and the WCAs through the Everglades STAs. **Figure 2-15** depicts Lake Okeechobee daily water level, regulation schedule, and water management decisions. Based on the lake water level and other relevant factors, various water management decisions are depicted on the figure. Release from the lake through the S-308 structure into the St. Lucie Canal, which discharges into the St. Lucie Estuary through the S-80 structure; releases from the lake through the S-77 structure and into the Caloosahatchee River, which discharges into the Caloosahatchee Estuary through the S-79 structure; and regulatory releases to the WCAs are also shown on the figure. Further details of these subregion flows are provided in the *Water Levels and Flows* subsection of this section and Appendices 2-5 and 2-6 of this volume.

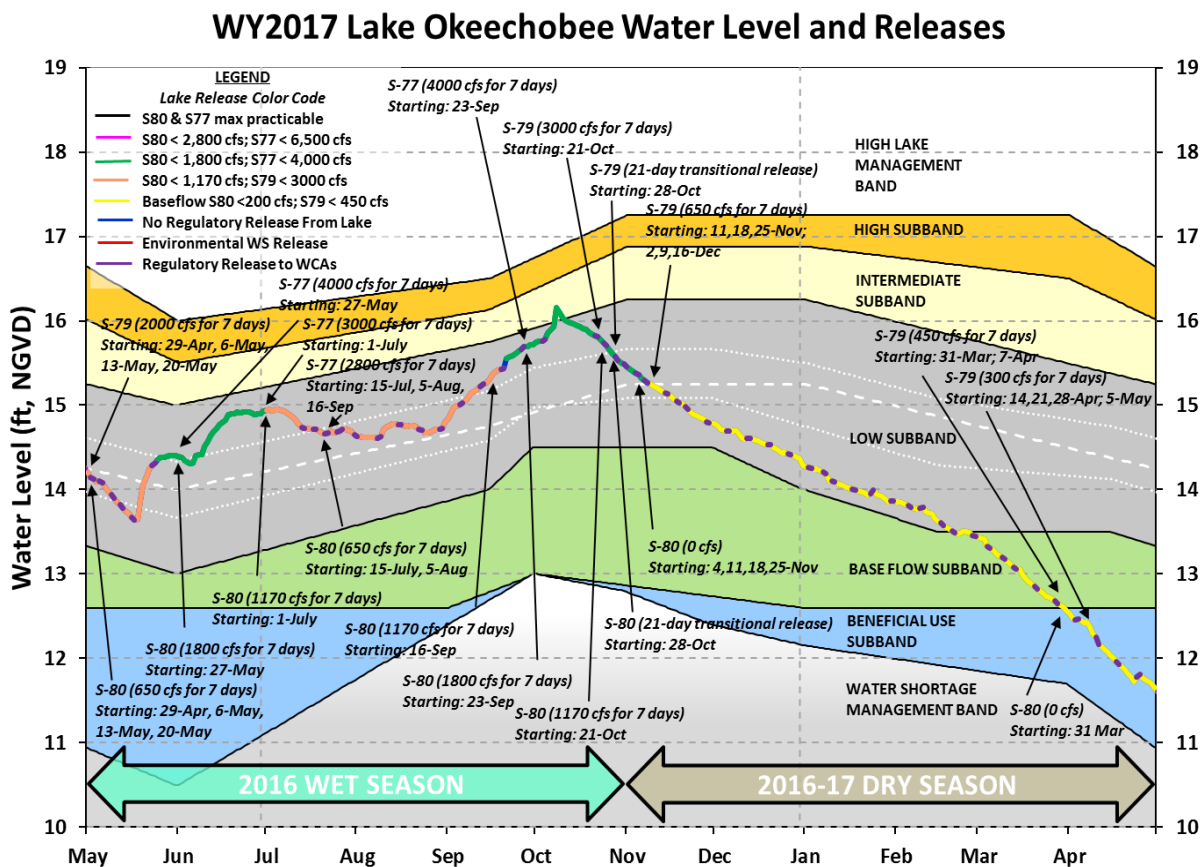


Figure 2-15. Daily Lake Okeechobee water levels, regulation schedule, and water management decisions in WY2017. (Note: Apr – April; cfs – cubic feet per second; Feb – February; Jan – January; Jun – June; Mar – March; max – maximum; NGVD – feet National Geodetic Vertical Datum of 1929; Nov – November; and WS – water supply.)

During WY2017, water managers, scientists, and engineers from the District, USACE, and other federal and state agencies met weekly to discuss the state of the regional system and possible operational scenarios. Reports on the ecological and hydrological status of various areas (e.g. Kissimmee Basin, Lake Okeechobee, St. Lucie and Caloosahatchee estuaries, Everglades STAs, Everglades, water supply, and groundwater conditions) were presented. How well the objectives of the Central and Southern Florida Flood Control Project (water supply, flood control, and protection of fish and wildlife) were met were also discussed. The meeting starts with the previous week’s weather report and coming week’s rainfall predictions, followed by climate forecast. The previous week’s Lake Okeechobee operations and the rest

of the water management system were reported in each meeting. Operational recommendations were given to District managers for approval and then submitted to USACE in a *Weekly Environmental Conditions for Systems Operations* memoranda.

In WY2017, there was about 5 inches of rainfall contribution from tropical systems that directly impacted District area or the area was under their influence. There were non-tropical high rainfall events in February, May, and April 2016. Lake Okeechobee was at 14.15 ft NGVD29 on May 1, 2016, at the start of WY2017. The lake level rose to a maximum of 16.16 ft NGVD29 by October 7, 2016, from runoff generated by rainfall of preceding months. Since the dry season was drier than normal in the lake watershed, only 10% of the lake inflows were in the dry season months of November 2016 through April 2017 (see Appendix 2-5, Table 2).

WATER LEVELS AND FLOWS

For parts of the WY2017 wet and dry seasons, most water control structures were operated for water supply during dry conditions and flood control during the wet season and other high rainfall events. Period of record daily mean water levels (stage) graphs for the lakes, impoundments, and ENP are shown in Appendix 2-3. All water levels are expressed in ft NGVD29 in these and related publications. **Table 2-8** depicts WY2017, WY2016, and historical mean, maximum, and minimum stages. WY2017 average water levels were higher than historical averages except for WCA-2A average water levels. The average Lake Okeechobee water level was 0.2 ft higher than WY2016 and 0.30 ft higher than the historical average. Comparison of monthly historical averages, WY2016, and WY2017 water levels are shown in Appendix 2-4. Water levels are also a measure of the amount of stored water. Relationships of water levels (stage) and storage for lakes and impoundments are presented in the 2007 SFER – Volume I, Appendix 2-2 (Abteew et al. 2007a).

WY2017 surface water flow statistics were also compared to WY2017 and historical flow records. WY2017 flows were higher than historical mean flows except for the WCAs inflows and outflows. In comparison to WY2016 flows, WY2017 flows were lower except for a few cases. **Table 2-9** depicts WY2017, WY2016, and historical flow statistics for major impoundments and canals. Monthly flows by structure are shown in Appendix 2-5. Comparison of historical, WY2016, and WY2017 monthly flows are shown in Appendix 2-6. Maps showing water control structures, canals, water bodies, and hydrologic units are available in previous SFERs.

Table 2-8. WY2017, WY2016, and historical stage statistics for regional major lakes and impoundments.

Lake or Impoundment	Beginning of Record ^a	Historical Mean Stage (ft NGVD)	WY2017 Mean Stage (ft NGVD)	WY2016 Mean Stage (ft NGVD)	Historical Maximum Stage (ft NGVD)	Historical Minimum Stage (ft NGVD)
Alligator Lake	1993	62.65	63.05	63.10	58.13	64.33
Lake Myrtle	1993	60.87	61.10	60.97	58.45	65.22
Lake Mary Jane	1993	60.10	60.36	60.12	57.19	62.16
Lake Gentry	1993	60.73	60.97	60.90	58.31	61.97
East Lake Tohopekaliga	1993	56.64	56.86	56.70	54.41	59.12
Lake Tohopekaliga	1993	53.74	53.94	53.87	48.37	56.63
Lake Kissimmee	1929	50.39	50.81	50.33	42.87	56.64
Lake Istokpoga	1993	38.79	38.87	38.92	35.84	39.78
Lake Okeechobee	1931	14.02	14.32	14.12	8.82	18.77
WCA-1	1953	15.69	16.34	16.29	10.00	18.16
WCA-2A	1961	12.51	12.24	12.38	9.33	15.64
WCA-3A	1962	9.60	9.85	9.93	4.78	12.79
ENP, Slough	1952	6.03	6.57	6.42	2.01	8.08
ENP, Wet Prairie	1953	2.20	3.08	2.78	-2.69	7.10

a. Calendar years (January 1–December 31).

Table 2-9. WY2017, WY2016, and historical flow statistics for major impoundments, lakes, and canals.

Lake, Impoundment, or Canal	Beginning of Record ^a	Historical Mean Flow (ac-ft)	WY2017 Flow (ac-ft)	Percent of Historical Mean	WY2016 Flow (ac-ft)	Historical Maximum Flow (ac-ft)	Historical Minimum Flow (ac-ft)
Lake Kissimmee Outflow	1972	724,624	856,145	118%	941,604	2,175,297	16,195
Lake Istokpoga Outflow	1972	233,356	429,180	184%	498,502	637,881	26,559
Lake Okeechobee Inflow	1972	2,133,844	2,460,826	115%	2,984,077	4,905,838	377,671
Lake Okeechobee Outflow	1972	1,480,827	2,672,499	180%	2,323,597	3,978,904	176,568
St. Lucie (C-44 Canal) Inflow at S-308	1972	259,854	394,728	152%	388,303	1,117,159	4,061
St. Lucie (C-44 Canal) Outflow at S-80	1972	312,956	417,032	133%	558,412	1,192,782	0
Caloosahatchee River (C-43 Canal) Inflow at S-77	1972	555,202	1,231,755	223%	972,904	2,175,765	42,301
Caloosahatchee River (C-43 Canal) Outflow at S-79	1972	1,265,296	1,940,819	153%	1,929,150	3,615,526	86,895
WCA-1 Inflow	1972	461,401	236,245	51%	351,943	1,307,517	152,641
WCA-1 Outflow	1972	428,535	164,088	38%	350,425	1,433,399	14,812
WCA-2 Inflow	1972	646,745	545,850	84%	864,470	1,754,710	113,225
WCA-2 Outflow	1972	647,179	499,918	77%	872,912	1,729,168	93,564
WCA-3A Inflow	1972	1,178,455	990,095	84%	1,575,428	2,177,198	393,233
WCA-3A Outflow	1972	1,016,490	1,169,431	115%	1,368,423	2,581,129	245,951
ENP Inflow	1972	1,009,206	1,340,883	133%	1,566,604	2,838,481	165,372
UEC C-23 Canal Outflow at S-48	1995	122,328	65,890	54%	106,701	297,214	33,644
UEC C-24 Canal Outflow at S-49	1972	132,850	97,944	74%	176,615	274,827	10,591
UEC C-25 Canal Outflow at S-50	1972	137,888	186,166	135%	189,671	249,159	21,154

a. Calendar years (January 1–December 31).

Kissimmee Chain of Lakes

The Upper Kissimmee Basin is an integrated system of several lakes with interconnecting canals and flow control structures (Abtew et al. 2011). The major lakes are shallow with depths from 6 to 13 ft (Guardo 1992). The Upper Kissimmee Basin structures are operated according to regulation schedules. The details of the water control plan for the Kissimmee River are presented in the *Master Water Control Manual for Kissimmee River – Lake Istokpoga* (USACE 1994). Average stage for WY2017, WY2016, and historical observation statistics for the Kissimmee Chain of Lakes are shown in **Table 2-8**. Stages were higher than historical average. Historical daily water levels are shown in Appendix 2-3. Monthly historical average, WY2017, and WY2016 water levels for the lakes are shown in Appendix 2-4. In WY2017, the Upper Kissimmee Basin produced above average flow volume (856,145 ac-ft), 118% of the historical average. Monthly inflows and outflows by structure are shown in Appendix 2-5. Appendix 2-6 contains monthly historical average, WY2017 and WY2016 flows for each water body or canal.

The Upper Kissimmee Basin received below average rainfall (-4.55 inches). There was discharge from Lake Kissimmee to the Kissimmee River throughout the water year. **Table 2-9** depicts WY2017, WY2016, and historical flow statistics for major impoundments. WY2017 monthly flows are shown in Appendix 2-5, Table 1. Monthly historical average, WY2016, and WY2017 flows are presented in Appendix 2-6, Figure 1.

Alligator Lake

The outflows from Alligator Lake, and Lakes Center, Coon, Trout, Lizzie, and Brick are controlled by two structures: S-58 and S-60. S-58 is located in the C-32 canal that connects Lakes Trout and Joel, and S-60 is located in the C-33 canal between Alligator Lake and Lake Gentry. Culvert S-58 maintains stages in Alligator Lake upstream from the structure, while the S-60 spillway is operated to main the optimum lakewide stage. These lakes are regulated between elevations 61.5 and 64.0 ft NGVD29 on a seasonally varying schedule. Daily water level observations for Alligator Lake over the last 24 years show that the most significant change in water levels occurred during the 2000-2001 drought, with water levels showing a big drop (Appendix 2-3, Figure 1). **Figure 2-16a** shows the WY2017 daily average stage at the headwater of S-60, daily rainfall, and flood regulation schedule for Alligator Lake. Generally, water levels were lower than the regulation schedule in the dry season where rainfall was below average. WY2017 average stage (63.05 ft NGVD29) was lower than WY2016 and higher than the historical average (**Table 2-8**). Monthly historical average, WY2017, and WY2016 water levels for the lake are shown in Appendix 2-4, Figure 1.

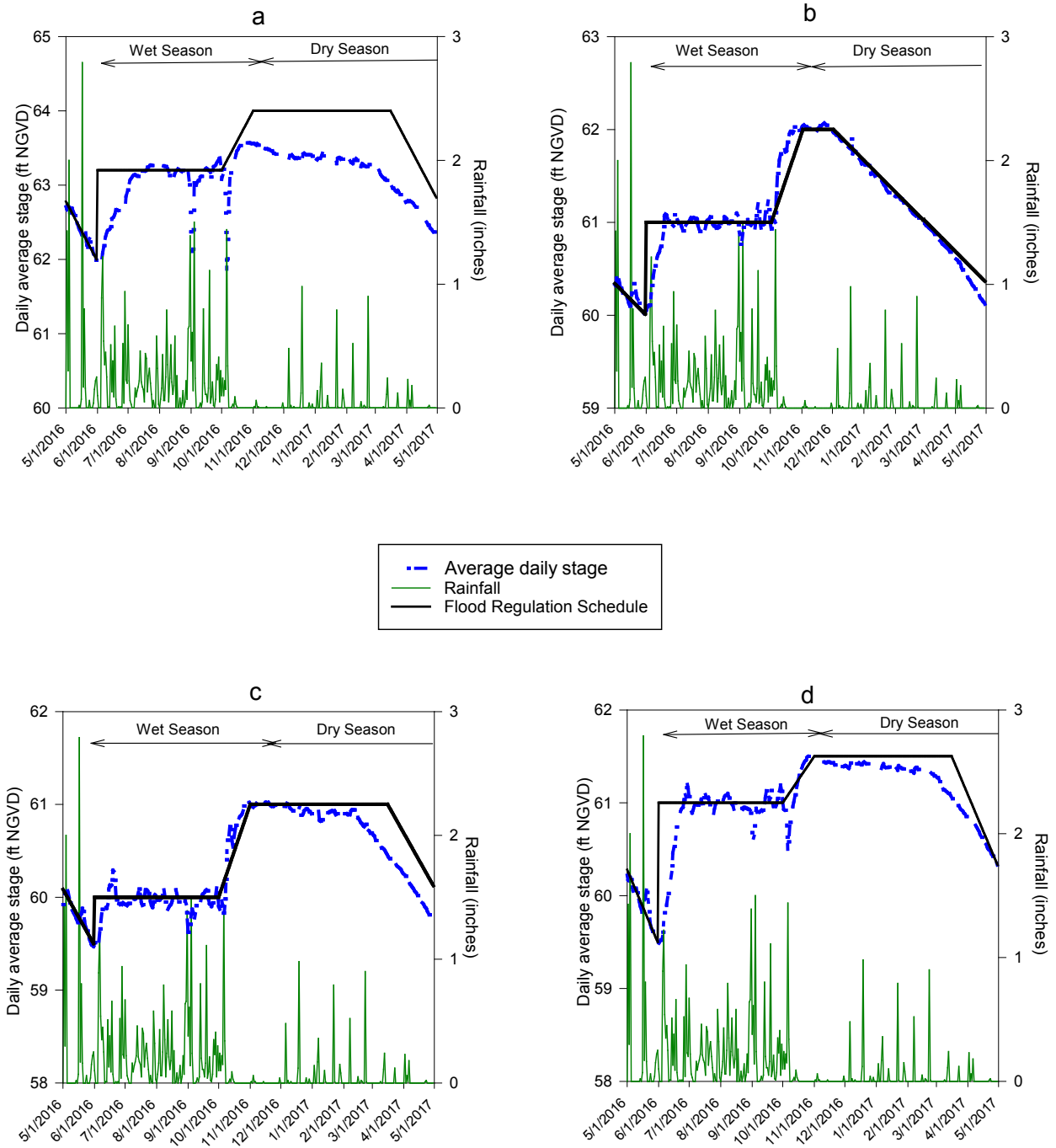


Figure 2-16. Average daily water levels (stage), regulation schedule, and rainfall for (a) Alligator Lake, (b) Lake Myrtle, (c) Lake Mary Jane, and (d) Lake Gentry. (Note: NGVD – National Geodetic Vertical Datum of 1929.)

Lakes Joel, Myrtle, and Preston

Lakes Joel, Myrtle, and Preston are regulated by structure S-57. The S-57 culvert is located in the C-30 canal that connects Lakes Myrtle and Mary Jane. The lakes are regulated between 59.5 and 62.0 ft NGVD29 on a seasonally varying schedule. **Figure 2-16b**, shows the WY2017 daily average stage at the headwater of S-57, daily rainfall, and regulation schedule for Lake Myrtle. Generally, water levels were at the regulation schedule. Daily water level observations for Lake Myrtle over the last 24 years show that the most significant drop in water level occurred in the 2000-2001 and 2010-2011 drought years (Appendix 2-3, Figure 2). WY2017 average stage for Lake Myrtle (61.10 ft NGVD29) was higher than WY2016 and the historical average (**Table 2-8**). Monthly historical average, WY2017, and WY2016 water levels for the lake are shown in Appendix 2-4, Figure 2.

Lakes Hart and Mary Jane

Lakes Hart and Mary Jane are regulated by structure S-62. The S-62 spillway is located in the C-29 canal that discharges into Lake Ajay. The lakes are regulated between elevations of 59.5 and 61.0 ft NGVD29 according to a seasonally varying schedule. **Figure 2-16c** shows the WY2017 daily average stage at the headwater of S-62, daily rainfall, and flood regulation schedule for Lake Mary Jane. The stages mostly were on the regulation schedule before the dry season and below the regulation line in the dry season. Flow releases were made based on water supply needs and flood control. Daily water level observations for Lake Mary Jane over the last 24 years show that the most significant drop in water level occurred in May 2001 during a severe drought year (Appendix 2-3, Figure 3). WY2017 average stage for Lake Mary Jane (60.36 ft NGVD29) was higher than WY2016 and the historical average (**Table 2-8**). Monthly historical average, WY2017, and WY2016 water levels for the lake are shown in Appendix 2-4, Figure 3.

Lake Gentry

Lake Gentry is regulated by the S-63 structure, located in the C-34 canal at the south end of the lake. The stages downstream of S-63 are further lowered by S-63A before the canal discharges into Lake Cypress. The lake is regulated between elevations of 59.0 and 61.5 ft NGVD29 according to a seasonally varying schedule. **Figure 2-16d** shows the WY2017 daily average stage at the headwater of the S-63 spillway, daily rainfall, and flood regulation schedule for Lake Gentry. Water levels were generally close to the regulation schedule and declined during the dry season. Daily water level observations for Lake Gentry over the last 24 years show the most significant drop in water level occurred in May 2001 during a severe drought year (Appendix 2-3, Figure 4). WY2017 average stage for Lake Gentry (60.97 ft NGVD29) was higher than WY2016 and the historical average (**Table 2-8**). Monthly historical average, WY2017, and WY2016 water levels for the lake are shown in Appendix 2-4, Figure 4.

East Lake Tohopekaliga

East Lake Tohopekaliga and Lake Ajay are regulated by structure S-59, located in the C-31 canal between East Lake Tohopekaliga and Lake Tohopekaliga. The lakes are maintained between elevations 54.5 and 58.0 ft NGVD29 on a seasonally varying schedule. A weir structure was built downstream of the S-59 spillway to control the tailwater elevation at S-59. The weir crest is at an elevation of 51.0 ft NGVD29. The weir is often submerged and therefore, the tailwater influences the headwater of S-59. **Figure 2-17a** shows the WY2017 daily average stage at the headwater of S-59, daily rainfall, regulation schedule, and ecological regulation schedule for East Lake Tohopekaliga. The stages for the dry season were below the regulation schedule. Flow releases were based on water supply needs, flood control, and maintaining the regulation schedule whenever possible. Daily water level observations for East Lake Tohopekaliga in the last 24 years are shown in Appendix 2-3, Figure 5. WY2017 average stage for Lake East Tohopekaliga (56.86 ft NGVD29) was higher than WY2016 and the historical average (**Table 2-8**). Monthly historical average, WY2017, and WY2016 water levels for the lake are shown in Appendix 2-4, Figure 5.

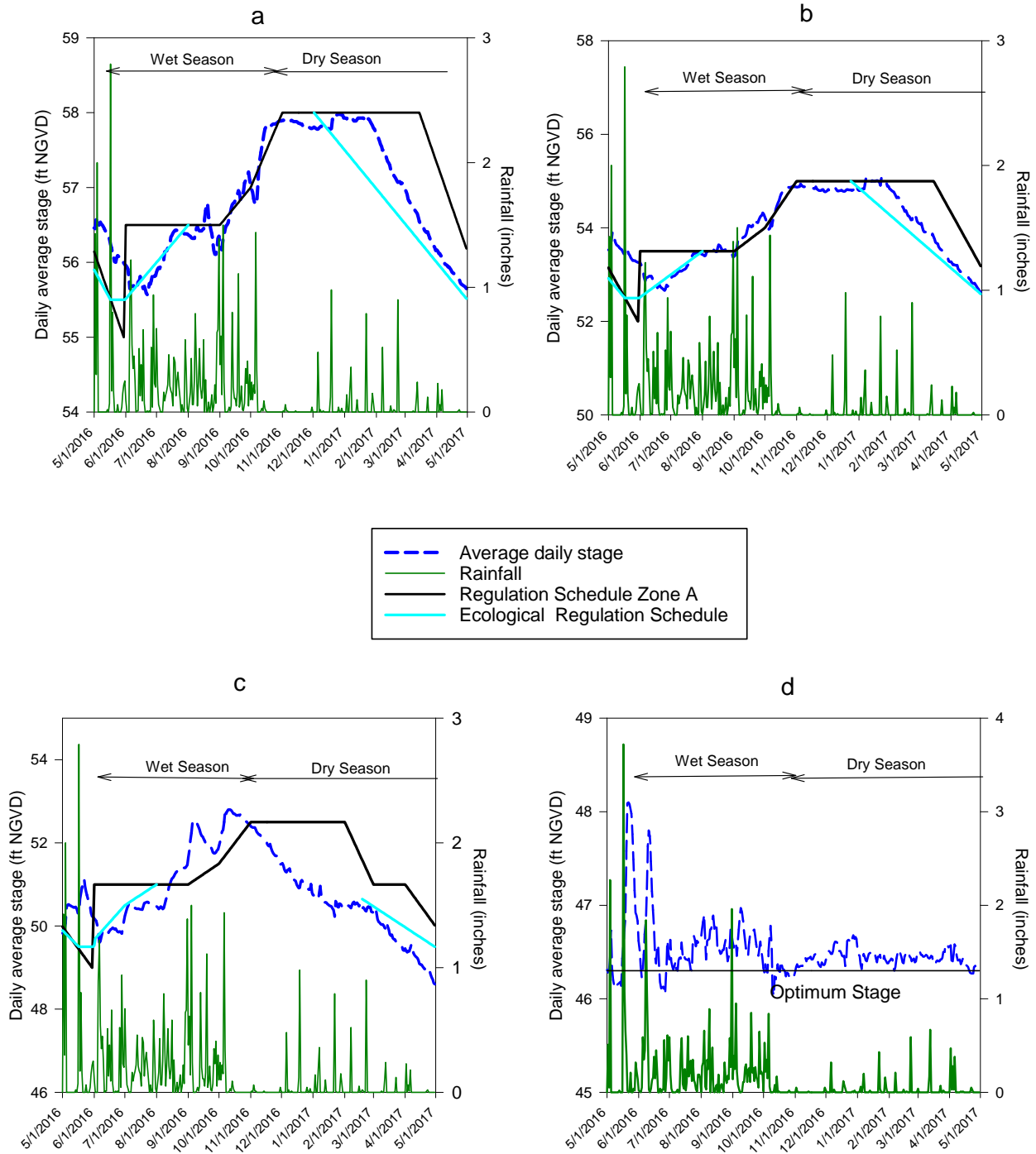


Figure 2-17. Average daily water levels (stage), regular regulation schedule, temporary modifications, and rainfall for (a) East Lake Tohopekalgiga, (b) Lake Tohopekalgiga, (c) Lake Kissimmee, and (d) Pool A. (Note: NGVD – National Geodetic Vertical Datum of 1929.)

Lake Tohopekaliga

Lake Tohopekaliga is regulated by structure S-61, located in the C-35 canal at the south shore of the lake. The lake is regulated between the elevations of 51.5 and 55.0 ft NGVD29 on a seasonally varying schedule. The S-61 structure is used to maintain the optimum stage in Lake Tohopekaliga. **Figure 2-17b** shows the WY2017 daily average stage at the headwater of S-61, daily rainfall, regulation schedule, and ecological regulation schedule for Lake Tohopekaliga. The stages fall below the regulation schedule in the dry season. Daily water level observations for Lake Tohopekaliga over the last 24 years show the most significant drop in water level occurred in June 2004 during the lake drawdown (Appendix 2-3, Figure 6). WY2017 average stage for Lake Tohopekaliga (53.94 ft NGVD29) was a bit higher than WY2016 and the historical average (**Table 2-8**). Monthly historical average, WY2017, and WY2016 water levels for the lake are shown in Appendix 2-4, Figure 6.

Lakes Kissimmee, Hatchineha, and Cypress

Lakes Kissimmee, Hatchineha, and Cypress are regulated by the S-65 spillway and lock structure located at the outlet of Lake Kissimmee and the head of the Kissimmee River (C-38 canal). Lake Kissimmee covers approximately 35,000 acres and is regulated between 48.5 and 52.5 ft NGVD29 on a seasonally varying schedule. **Figure 2-17c**, shows the daily average stage at the headwater of S-65, daily rainfall, regulation schedule, and ecological regulation schedule for Lake Kissimmee during WY2017. The stages generally followed the ecological regulation schedule but mostly were below the regulation schedule. Releases were made based on downstream water needs and flood control. Appendix 2-3, Figure 7 shows daily water levels (1929–2017). WY2017 average stage for Lake Kissimmee (50.81 ft NGVD29) was higher than WY2016 and the historical average (**Table 2-8**). Monthly historical average, WY2017, and WY2016 water levels for the lake are shown in Appendix 2-4, Figure 7.

Lower Kissimmee System

In WY2017, The Lower Kissimmee System consists of the Kissimmee River (C-38 canal) and four structures (S-65A, S-65C, S-65D, and S-65E) as S-65B was removed previously for canal refilling as part of the Kissimmee restoration project. In WY2017, structure S-65C was removed from controlling water for the same project. Currently, only three water control structures are left (S-65A, S-65D, and S-65E). These structures are operated according to optimum stages. Optimum stages for S-65A, S-65D, and S-65E are 46.3, 26.8, and 21.0 ft NGVD29, respectively (Abteu et al. 2011). WY2017 conditions in the Kissimmee River system are covered in detail in Chapter 9 of this volume.

Pool A

Stages in Pool A are controlled by the S-65A gated spillway and lock, and the pool is downstream of the S-65 structure. In addition to S-65A, a culvert structure is located through the east tieback levee at the natural channel of the Kissimmee River. During water supply periods, minimum releases are made to satisfy water demands and maintain navigation downstream. The culvert also provides water to the oxbows of the natural river channel. **Figure 2-17d** shows the daily average stage at the headwater of S-65A, daily rainfall, and optimum stage for Pool A during WY2017. Stages remained higher than the optimum stage of 46.3 ft NGVD29 for the water year.

Pool C

Until recently, stages downstream of Pool A (S-65A structure), were controlled by the S-65C gated spillway and lock downstream. Stage and flow monitoring at S-65C were stopped on January 2017, when backfilling and degrading began. Removal of the S-65C structure and backfilling of seven miles of the C-38 canal is the last phase of the Kissimmee River restoration. The structure was locked fully open in January 2017, then demolished in May 2017, with Pool D left south of Pool A.

Pool D

Stages in Pool D were controlled by the S-65D gated spillway and lock downstream of S-65C through January 2017 when S-65C was no longer a control. During WY2017, headwater stages at S-65D ranged from 26.56 to 28.83 ft NGVD29 with mean stage of 27.63 ft NGVD29.

Pool E

Stages in Pool E are controlled by the S-65E gated spillway and lock, which is downstream of S-65D. During WY2017, minimum and maximum headwater stages at S-65E were 20.84 and 21.16 ft NGVD29, respectively with mean stage of 21 ft NGVD29.

Lake Istokpoga

Lake Istokpoga has a surface area of approximately 27,700 acres. Stages in Lake Istokpoga are maintained in accordance with a regulation schedule that varies seasonally. The S-68 spillway, located at the south end of the lake, regulates the lake stage and discharges water to the C-41A canal (the Slough Canal). The C-41 canal (Harney Pond Canal), C-40 canal (Indian Prairie Canal), and C-39A canal (State Road 70 Canal) provide secondary conveyance capacity for the regulation of floods in the Lake Istokpoga Water Management Basin. The C-40 and C-41 canals flow into Lake Okeechobee, whereas the C-41A canal flows into the Kissimmee River, which flows into Lake Okeechobee. Details of Lake Istokpoga water control plan is available in the *Master Water Control Manual for Kissimmee River – Lake Istokpoga Basin* (USACE 1994).

Figure 2-18a shows the daily average stage at the headwater of S-68, daily rainfall, and regulation schedules for Lake Istokpoga during WY2017. Appendix 2-3, Figure 8, shows daily water levels from 1993 to 2017. Stages were close to the regulation schedule before the dry season and were below the regulation schedule in the dry season. WY2017 average stage for Lake Istokpoga (38.87 ft NGVD29) was lower than WY2016 and higher than the historical average (**Table 2-8**). Minimum releases, based on water supply needs, were made during drier periods and flood control releases during wet periods. WY2017 flows (429,180 ac-ft) were higher than the historical average (184%) and lower than WY2016 (**Table 2-9**). Monthly historical average, WY2017, and WY2016 water levels are shown in Appendix 2-4, Figure 8. WY2017 monthly flows are shown in Appendix 2-5, Table 1. Monthly historical average, WY2016, and WY2017 flows are presented in Appendix 2-6, Figure 2. **Table 2-9** depicts WY2017, WY2016, and historical flow statistics for major impoundments.

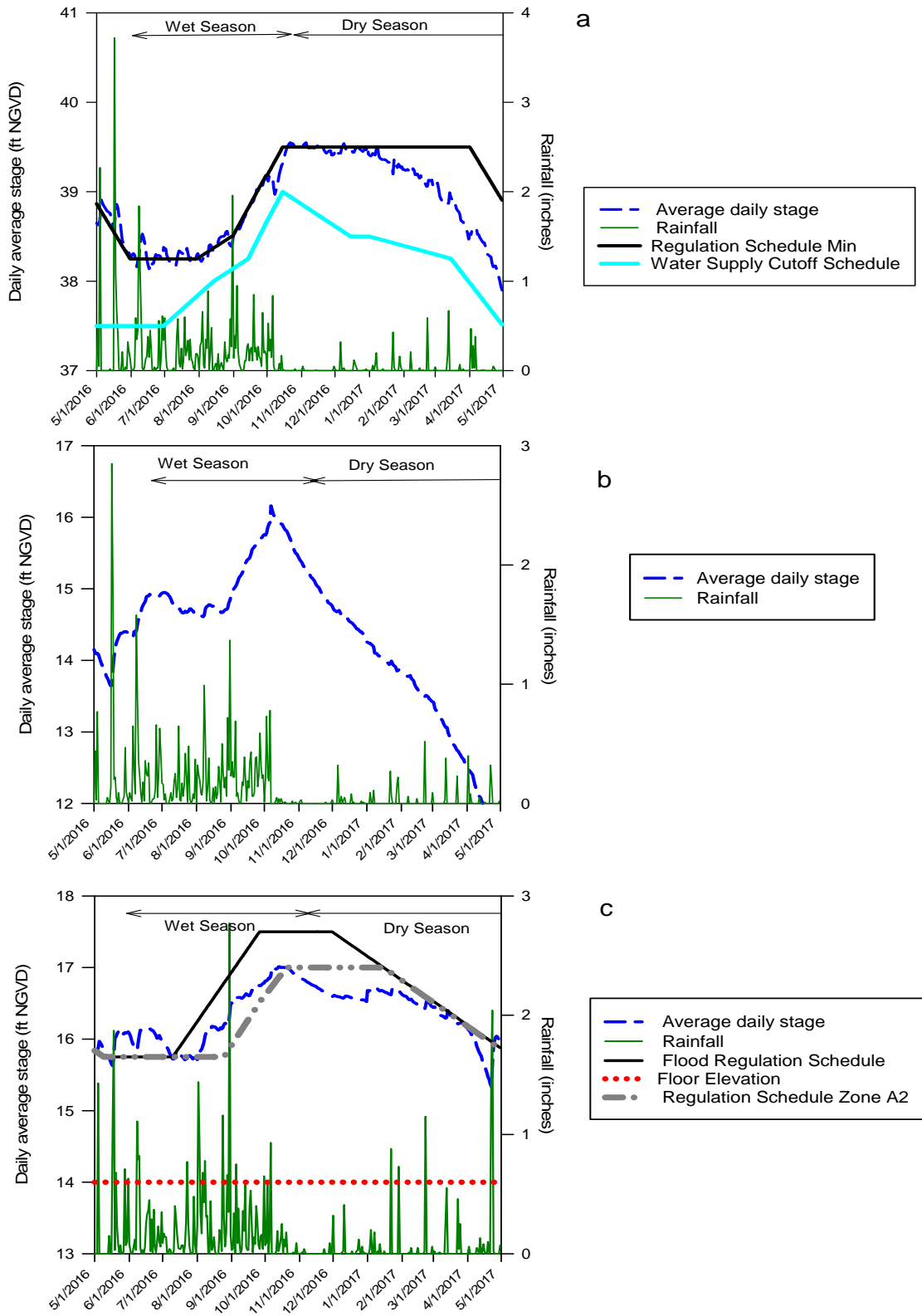


Figure 2-18. Average daily water levels (stage), regulation schedule, and rainfall for (a) Lake Istokpoga, (b) Lake Okeechobee, and (c) WCA-1. (Note: NGVD – National Geodetic Vertical Datum of 1929.)

Lake Okeechobee

Lake Okeechobee's water level is regulated to provide (1) flood control; (2) navigation; (3) water supply for agricultural irrigation, municipalities and industry, the EPA, and the Everglades STAs; (4) regional groundwater control; (5) salinity control; (6) enhancement of fish and wildlife; and (7) recreation (Abtew et al. 2011). The regulation schedule accounts for varying and often conflicting purposes. The lake was regulated under a different regulation schedule in previous water years (Abtew et al. 2007b). An updated regulation schedule was adopted on April 28, 2008, for Lake Okeechobee, which was implemented on May 1, 2008 (USACE 2008). Details of the current regulation schedule are discussed below and shown in **Figure 2-19**.

Lake Okeechobee has an approximate surface area of 436,300 acres at the historical average stage of 14.02 ft NGVD29 (1931–2017). At the beginning of WY2017, the lake stage was 14.15 ft NGVD29 and the average stage was 14.32 ft NGVD29 for the water year, 0.3 ft higher than the historical average (**Table 2-8**). Stage at the end of the water year was 11.61 ft NGVD29 due to below average rainfall in the dry season. **Figure 2-18b** shows the daily average stage and daily rainfall for Lake Okeechobee during WY2017. **Figure 2-15** shows lake regulation schedule, daily water level, and water management decisions. Water levels started in the Low Subband and briefly rose to the Intermediate Subband in October 2016, then remained in the Low subband for months before falling to the Baseflow Subband and then into the Beneficial Use Subband by March 2017. Appendix 2-3, Figure 9, shows daily water levels for Lake Okeechobee for the period of record, 1931–2017. WY2017 average stage for Lake Okeechobee (14.32 ft NGVD29) was higher than WY2016 and the historical average (**Table 2-8**). Monthly historical average, WY2016, and WY2017 water levels are shown in Appendix 2-4, Figure 9. **Table 2-8** depicts WY2017, WY2016, and historical mean, maximum, and minimum stages.

WY2017 inflow into Lake Okeechobee (2,460,826 ac-ft) was 115% of the historical average inflow (2,133,844 ac-ft; **Table 2-9**). WY2017 outflow of 2,672,499 ac-ft was 180% of historical annual outflow (1,480,827 ac-ft) since 1972 (**Table 2-9**). During the dry season (November 2016 to April 2017), surface water inflows into the lake were 240,767 ac-ft, 10% for the water year as the dry season was dry. At the same time, 1,089,372 ac-ft was discharged from the lake. The maximum monthly discharge was 398,900 ac-ft in October 2016 when the lake stage was maximum for the water year. **Table 2-9** depicts WY2017, WY2016, and historical flow statistics for major impoundments. WY2017 monthly inflows and outflows are shown in Appendix 2-5, Tables 2 and 3, respectively. Monthly historical average, WY2016, and WY2017 inflows and outflows are shown in Appendix 2-6, Figures 3 and 4, respectively. Culvert 5A structure is being rebuilt.

As previously noted in the *Overview* subsection of this section, the current regulation schedule for Lake Okeechobee is divided into three major bands: High Lake Management Band, Operational Band, and Water Shortage Management Band (**Figure 2-19**). The regulation schedule was developed by USACE based on several key considerations including the lake's ecology and environmental needs, Caloosahatchee and St. Lucie estuaries' environmental needs, Everglades environmental needs, water supply, flood control, structural integrity of the Herbert Hoover Dike, and potential danger from hurricanes. While this regulation schedule attempts to balance the multipurpose needs of flood control, water supply, navigation, enhancement of fish and wildlife resources, and recreation, the dominant objective is public health and safety related to dike structural integrity. Notably, LORS2008 has expanded operational flexibility throughout the year and allows Lake Okeechobee to be managed at lower levels than the previous regulation schedule. It is implemented through a decision tree that considers lake water level, WCA water levels, tributary hydrologic conditions, multi-season climatic and hydrologic outlook, and downstream estuary conditions. The decision tree for establishing allowable lake releases to the WCAs and to tide (estuaries) can be found in Abtew et al. (2011).

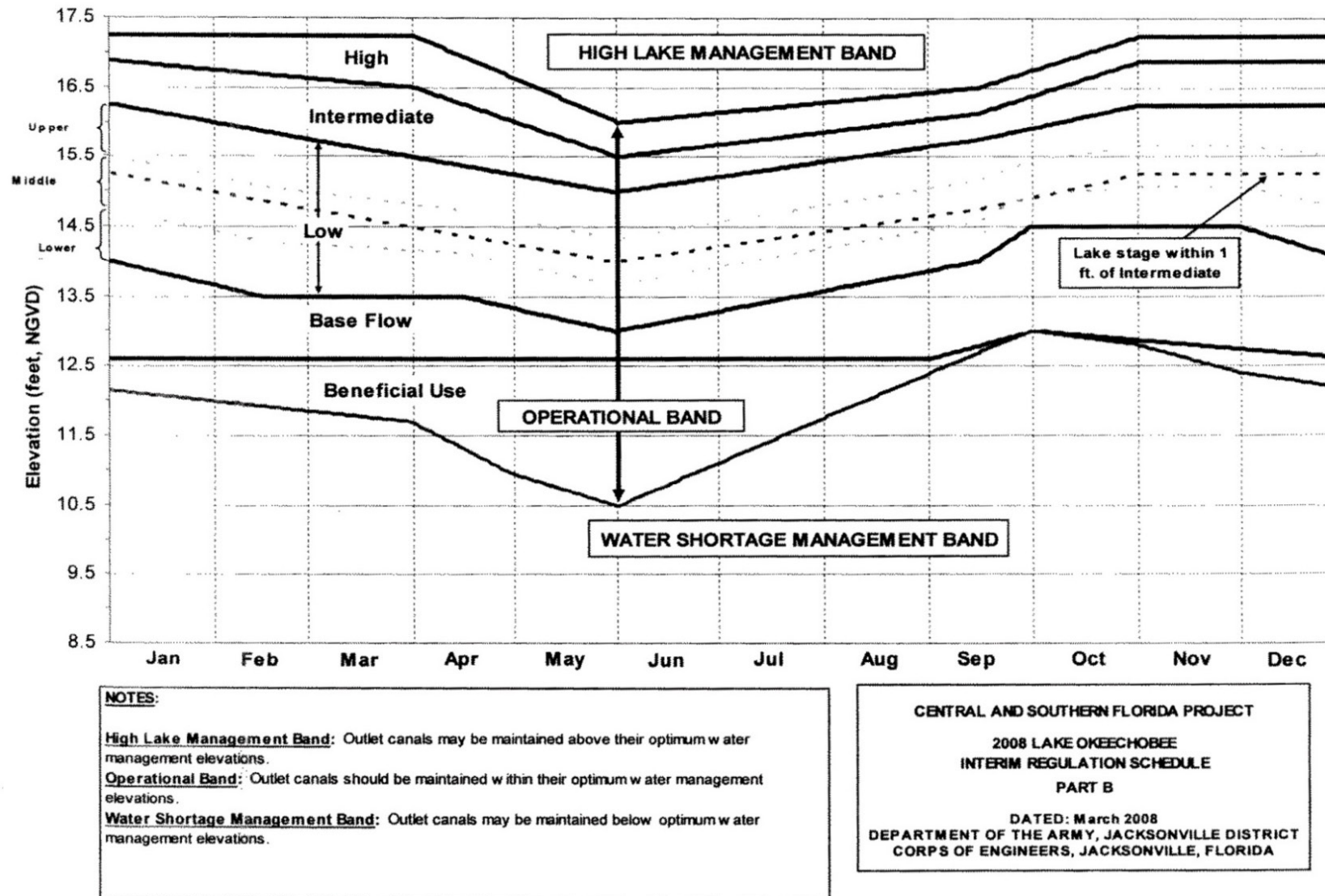


Figure 2-19. Lake Okeechobee's current regulation schedule (LORS2008).

Upper East Coast and St. Lucie Canal and Estuary

Inflows to the St. Lucie Canal are received from Lake Okeechobee by operation of S-308, a gated spillway, the Port Mayaca lock, and runoff from the basin (Abtew et al. 2011). The optimum water control elevations for the St. Lucie Canal vary between 14.0 and 14.5 ft NGVD29. When the lake stage is below 14.5 ft NGVD29 and the S-308 structure is open, runoff from the C-44 (St. Lucie Canal) basin flows back to the lake with the C-44 canal stage relatively higher. The outflow from the St. Lucie Canal that is not used in the basin for water supply or canal stage maintenance is discharged into the estuary via the S-80 structure. Runoff from the basin (C-44) is discharged to the estuary through the S-80 structure. WY2017 flows from Lake Okeechobee to the St. Lucie Canal were 394,728 ac-ft while inflow into the St. Lucie Estuary through S-80 was 417,032 ac-ft (**Table 2-9**). Lake Okeechobee discharge through S-308 in to the St. Lucie Canal that is not used for water supply and is discharged to the estuary was estimated at 338,207 ac-ft (**Table 2-1**). The estimated basin runoff discharged to the estuary was 78,825 ac-ft (**Table 2-1**). As salinity is an important measure of estuary viability, volume and timing of freshwater flow at S-80 is a key feature of water management activities.

The C-23 canal discharges into the North Fork of the St. Lucie River at structure S-48. The C-24 canal discharges into the same fork at structure S-49. The C-25 canal discharges into the southern part of the Indian River Lagoon at structure S-50. Structure S-80 discharges water from the St. Lucie Canal into the South Fork of the St. Lucie River. Rainfall in the Martin/St. Lucie rainfall area was far below average (-8.47 inches) for WY2017. Outflows from the C-23 canal (S-48), C-24 Canal (S-49), C-25 canal (S-50), and St. Lucie Canal (S-80) were lower than WY2016 (**Table 2-9**). WY2017 monthly flows for S-48, S-49, S-50, and S-80 are shown in Appendix 2-5, Table 4. Monthly historical average, WY2016, and WY2017 flows are shown in Appendix 2-6, Figures 5 through 8. Water management decision regulating releases through S-80 into the St. Lucie River is shown in **Figure 2-15**.

Lower West Coast

Inflows to the Caloosahatchee River (C-43 canal) are runoff from the basin watershed and releases from Lake Okeechobee by operation of S-77, a gated spillway and lock structure (Abtew et al. 2011). Structure S-77 operations use regulation procedures described in USACE (2008). Environmental water supply releases from the lake to the Caloosahatchee River occurred at various times (**Figure 2-15**). WY2017 flows from Lake Okeechobee to the Caloosahatchee River were 1,231,755 ac-ft, which is 223% of the historical and 127% of WY2016 flows (**Table 2-1**). WY2017 monthly Lake Okeechobee flows through S-77 are shown in Appendix 2-5, Table 5.

Downstream of S-77, S-78 is a gated spillway that also receives runoff from the East Caloosahatchee Watershed, its local watershed. The optimum water control elevation for this portion of the Caloosahatchee Canal (upstream of S-78 and downstream of S-77) is between 10.6 and 11.5 ft NGVD29. The outflow from the Caloosahatchee Canal (downstream of S-78) is discharged into the estuary via S-79, a gated spillway and lock operated by USACE. The operations of S-79 include runoff from the West Caloosahatchee and Tidal Caloosahatchee watersheds. The optimum water control elevations near S-79 range between 2.8 and 3.2 ft NGVD29. Because salinity is an important measure of estuary viability, the volume and timing of freshwater flow at S-79 is an important feature of water management activities. Water management decision regulating releases through S-79 into the Caloosahatchee Estuary is shown in **Figure 2-15**. WY2017 discharge through S-79 to the coast, 1,940,819 ac-ft, is 153% of the historical average (1972–2017) and close to WY2016 (**Table 2-9**). Lake Okeechobee inflow into the Caloosahatchee Canal that is not used for water supply in the basins or canal stage maintenance is discharged into the estuary via the S-79 structure passing through S-78 along the route. Runoff from the basins (West Caloosahatchee and Tidal Caloosahatchee) is also discharged to the estuary. Lake Okeechobee discharge through S-77 that passed through S-78, not used for water supply, but discharged to the estuary, was estimated at 1,010,066 ac-ft (**Table 2-1**). The estimated basin runoff discharged to the estuary was 930,753 ac-ft (**Table 2-9**). WY2017

monthly flows for S-77 and S-79 are shown in Appendix 2-5, Table 5. Monthly historical average, WY2016, and WY2017 outflows at S-79 are shown in Appendix 2-6, Figure 9. **Table 2-9** depicts WY2017, WY2016, and historical flow statistics.

Everglades Agricultural Area

Four major canals pass through the EAA: West Palm Beach, Hillsboro, North New River, and Miami. Flows from Lake Okeechobee and runoff from the EAA are discharged via these four canals to relieve flooding for the local drainage area and into the Everglades STAs for water quality improvement. Discharges to the east coast occur through the West Palm Beach Canal. At times, when conditions do not allow for the STAs to treat all runoff water, diversion to the WCAs could occur. The inflows from Lake Okeechobee to these canals are from structures S-351, S-352, and S-354. These structures are gated spillways with a maximum tailwater elevation not to exceed 12 ft NGVD29 for Lake Okeechobee operation. The optimum tailwater control elevations for S-351 and S-354 range between 11.5 and 12.0 ft NGVD29. During WY2017, daily average tailwater elevations at S-351 ranged from 9.68 to 12.21 ft NGVD29, at S-354 ranged from 9.19 to 11.90 ft NGVD29, and at S-352 ranged from 9.18 to 12.04 ft NGVD29. The outflows from the four canals to the STAs are discharged through pump structures S-5A, S-319, S-6, G-370, G-372, and G-434. Outflows from STAs are inflows into WCAs. During the dry season and drier-than-normal wet seasons, water supply for agricultural irrigation is provided by these four primary canals, mainly through gravity release from Lake Okeechobee. During droughts, when Lake Okeechobee levels are low, forward pumping is required to withdraw water from the lake. At times, water is also supplied to the EAA from the WCAs. Farmers utilize a set of secondary and tertiary farm canals to distribute water from several gated culverts and pumps to their respective fields. During extreme flooding potential or conditions in the EAA, water is pumped into the lake following guidelines. In WY2017, 85 ac-ft was pumped through the S-2 pump station and 135 ac-ft through the S-3 pump station into the lake from the EAA (Appendix 2-5, Table 2). These small volumes are probably pump maintenance related.

Everglades Protection Area

Water Conservation Area 1

The primary objectives of the WCAs are to provide (1) flood control; (2) water supply for agricultural irrigation, municipalities, industry, and ENP; (3) regional groundwater control and prevention of saltwater intrusion; (4) enhancement of fish and wildlife; and (5) recreation. A secondary objective is the maintenance of marsh vegetation in the WCAs, which is expected to provide a dampening effect on hurricane-induced wind tides (Abtew et al. 2011). WCA-1 covers approximately 141,440 acres with a daily average water level of 15.69 ft NGVD29 (1960–2017). WCA-1 is regulated mainly by outflow structures S-10A, S-10C, S-10D, and S-39; the regulation schedule for WCA-1 is provided by the *Master Water Control Manual – Water Conservation Areas, Everglades National Park, and ENP-South Dade Conveyance System* (USACE 1996). The main inflow structures are the G-251, G-310, and S-362 pump stations. Water supply releases are made through the G-94A, G-94C, G-300, G-301, and S-39 structures. S-39 is also used to discharge excess water to the coast through the Hillsboro Canal. The regulation schedule varies from high stages in the late fall and winter to low stages at the beginning of the wet season (Abtew et al. 2007b). The seasonal range allows runoff storage during the wet season and water supply during the dry season and fulfills ecological needs. Water levels in WCA-1 started at 15.84 ft NGVD29 on May 1, 2016, and ended the year at 15.98 ft NGVD29. Water level rose to a maximum of 17.01 ft NGVD29 in October 2016 and generally gradually declined the rest of the water year with few reversals due to high rainfall events. The mean water year stage was 16.34 ft NGVD29, 0.5 ft higher than WY2016 and 0.65 ft higher than the historical average. Four gauges (1-8C, 1-7, 1-8T, and 1-9) are used for stage monitoring. Daily water levels were compiled from the four gauges based on their regulation schedule uses. Site 1-8C was used from January 1 to June 30, while the remaining sites (1-7, 1-8T, and 1-9) were used to calculate the average water level for the year, but only if the average was lower than that of site 1-8C. **Figure 2-18c**

depicts the WY2017 daily average water level, daily rainfall, and regulation schedule for WCA-1. Daily average historical water levels are shown in Appendix 2-3, Figure 10, for the period of record (1960–2017). Monthly historical average, WY2016, and WY2017 water levels are shown in Appendix 2-4, Figure 10. **Table 2-8** depicts WY2017, WY2016, and historical mean, maximum, and minimum stages.

The main inflows into WCA-1 are from STA-1 West (STA-1W) through the G-251 and G-310 pump stations and from STA-1 East (STA-1E) via pump station S-362. There are three diversion structures that can flow in both directions (G-300, G-301, and G-338). The main outflow from WCA-1 is to WCA-2 through the S-10 structures and S-39 to the east urban areas and to the coast. The two diversion structures (G-300 and G-301) may also be used to discharge water from WCA-1 to the north to the L-8 and C-51 canals via the STA-1 inflow basin under extreme events. S-39 discharges to the east via the Hillsboro Canal. The G-94A and G-94C structures are used to make water supply releases to the east urban area.

Historical flows through each structure have varying lengths of periods of record because new structures come online, or because existing structures may no longer contribute to the inflow and outflows. The structures related to the Everglades STAs are relatively recent additions. WCA-1 is regulated between 14.00 and 17.50 ft NGVD29. WY2017 inflows into WCA-1 (236,245 ac-ft) were 51% of the historical average (**Table 2-9**). In WY2017, 57% of the inflow was from STA-1E through pump station S-362, and 43% was from STA-1W through pump stations G-251 and G-310 (Appendix 2-5, Table 6). No backflows occurred through the G-94s or S-10s. No inflow occurred through G-338. There was no flood diversion inflow through G-300 and G-301. WY2017 monthly inflows are shown in Appendix 2-5, Table 6. Monthly historical average, WY2016, and WY2017 inflows are shown in Appendix 2-6, Figure 10.

WY2017 outflows from WCA-1 (164,088 ac-ft), were 38% of the historical average, for the analysis period from 1972 to 2017 (**Table 2-9**). Outflows from WCA-1 were mainly to the east through the S-39 structure and the Hillsboro Canal (88%), and no backflow through the G-300 and G-301 structures for water supply into the L-8 or C-51 canals (Appendix 2-5, Table 7). Flow to the east through G-94A was 10%. **Table 2-9** depicts WY2017, WY2016, and historical flow statistics. WY2017 monthly outflows are shown in Appendix 2-5, Table 7. Monthly historical average, WY2016, and WY2017 outflows are shown in Appendix 2-6, Figure 11.

Water Conservation Area 2

WCA-2 is located south of WCA-1. An interior levee across the southern portion of the area subdivides it into WCA-2A and WCA-2B, reducing water losses due to seepage into the extremely pervious aquifer that underlies WCA-2B and precludes the need to raise existing levees to the grade necessary to provide protection against wind tides and wave run-up. Combined, WCA-2A and WCA-2B have a total area of 133,400 acres, with 80% of the area in WCA-2A. The regulation schedule for WCA-2A is provided by the *Master Water Control Manual – Water Conservation Areas, Everglades National Park, and ENP-South Dade Conveyance System* (USACE 1996). A regulation schedule is not used for WCA-2B because of high seepage rates. Releases to WCA-2B from S-144, S-145, and S-146 are terminated when the indicator stage gauge 99 in WCA-2B exceeds 11.0 ft NGVD29. Discharges from WCA-2B are made from spillway structure S-141 to the North New River Canal when the pool elevation in WCA-2B exceeds 11.0 ft NGVD29. For WY2017, the water level in WCA-2A started at 11.58 ft NGVD29 and reached a maximum of 13.58 ft NGVD29 in October 2016 and ended at 11.72 ft NGVD29 by the end of the water year. Water level stayed above the regulation schedule throughout the water year. The average stage was 12.24 ft NGVD29 (**Table 2-8**). Appendix 2-3, Figure 11, shows the daily water level for the period 1961–2017. **Figure 2-20a** depicts WY2017 daily average water level, daily rainfall, and regulation schedule for WCA-2A. **Table 2-8** depicts WY2017, WY2016, and historical mean, maximum, and minimum stages. Monthly historical average, WY2016, and WY2017 water levels are shown in Appendix 2-4, Figure 11.

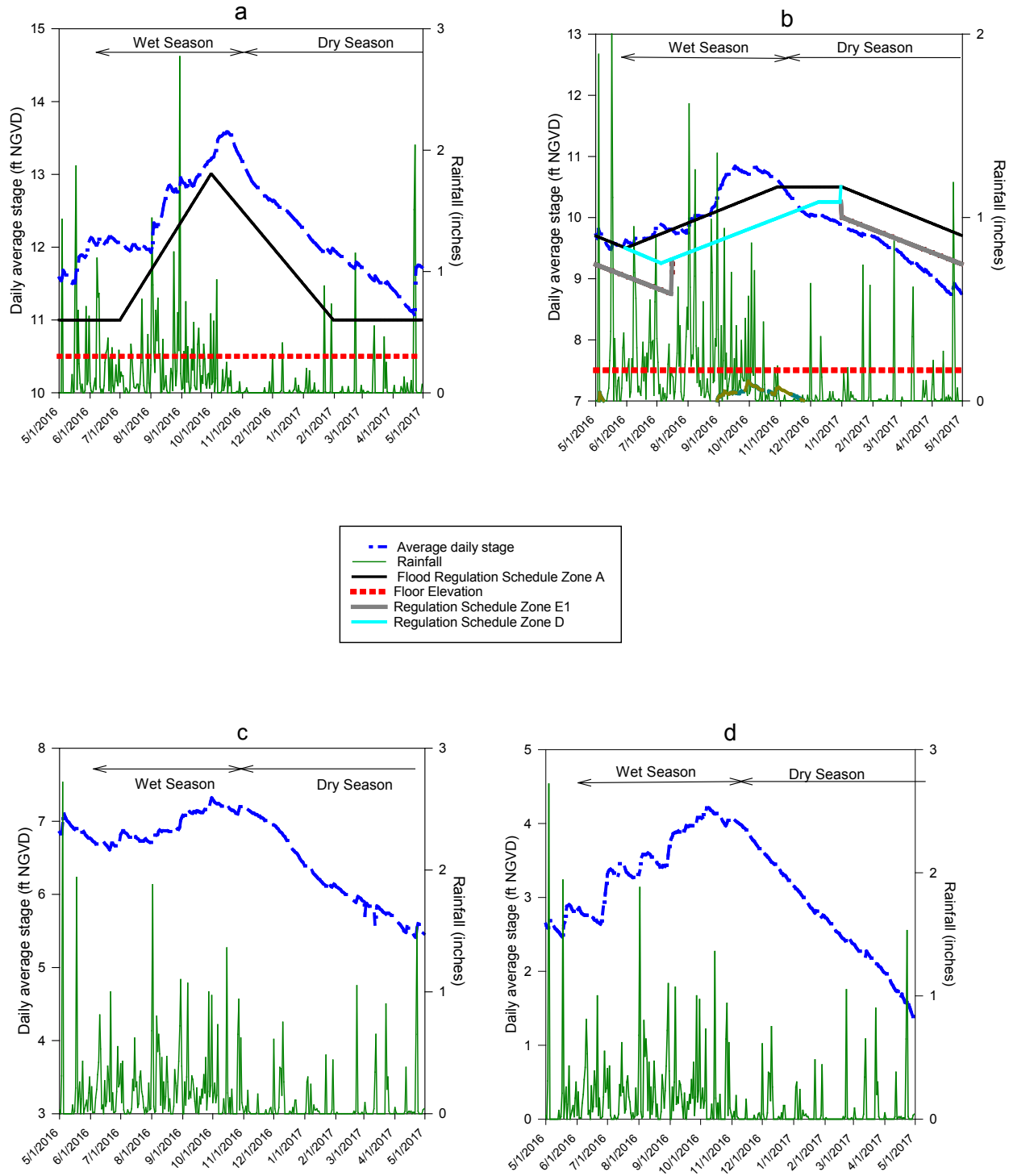


Figure 2-20. Average daily water levels (stage), regulation schedule, temporary deviation, and rainfall for (a) WCA-2A, (b) WCA-3A, (c) ENP gauge P-33, and (d) ENP gauge P-34.

WY2017 inflows into WCA-2 (545,850 ac-ft) were 84% of the historical average and lower than WY2016 inflows (**Table 2-9**). The major inflows to WCA-2A were STA-2 discharges through pump station G-335 and G-436 (58%), STA-3/4 discharges through the S-7 pump station (39%), outflow from WCA-1 through the S-10 structures (1%), flows through S-142 (3%), and no flow through G-339 (Appendix 2-5, Table 8).

WY2017 outflows from WCA-2 (499,918 ac-ft) were 77% of the historical average and 57% of WY2016 outflows (**Table 2-9**). Outflows from WCA-2 were primarily into WCA-3A through structures S-11A, S-11B, and S-11C (46%) and discharge to canals 13 and 14 through structure S-38 (43%), S-34 (10%), and minor outflow through S7 and S339 (Appendix 2-5, Table 9). A small discharge to WCA-3A occurred through S-142. WY2017 monthly inflows and outflows are shown in Appendix 2-5, Tables 8 and 9, respectively. Monthly historical average, WY2016, and WY2017 inflows and outflows are shown in Appendix 2-6, Figures 12 and 13, respectively. **Table 2-9** depicts WY2017, WY2016, and historical flow statistics.

Water Conservation Area 3

WCA-3 is located south and southwest of WCA-2A. Two interior levees across the southeastern portion of the area subdivide it into WCA-3A and WCA-3B. These levees reduce water losses due to seepage into the extremely pervious aquifer that underlies WCA-3B. WCA-3A and WCA-3B combined have a total area of 585,560 acres, with 83% of the area in WCA-3A. The regulation schedule for WCA-3A is provided in the *Master Water Control Manual – Water Conservation Areas, Everglades National Park, and ENP-South Dade Conveyance System* (USACE 1996). A regulation schedule is not used for WCA-3B because of high seepage rates. Indicator gauge 3B-2 is used for WCA-3B. Flow releases into WCA-3B are from the S-142 and S-151 structures, while releases from WCA-3B are through S-31 or S-337. S-151 permits releases of water from WCA-3A to supply water needs to south Miami-Dade County and along the Miami (C-6), C-7, and C-8 canals during the dry season. Discharges from WCA-3B are rarely made from culvert L-29-1 for water supply purposes.

In the last water year (WY2016), the dry season was wet and the water level in WCA 3A was too high; therefore, on February 11, 2016, FDEP issued an emergency final order to SFWMD and USACE to lower water levels deviating from existing water management practice. The order was accomplished in 90 days resulting in lowered water levels in WCA-3A and a report is published in the 2017 SFER – Volume I, Appendix 2-1. The order extended into WY2017 for eleven days (May 1–11, 2016); 21,223 ac-ft more water was discharged from WCA-3A during this period. The water level declined to the Zone A regulation level on May 9, 2016.

Figure 2-20b depicts the WY2017 daily average water level, daily rainfall, and regulation schedule for WCA-3A. The previous regulation schedule, which was known as the Interim Operational Plan for the Protection of the Cape Sable Seaside Sparrow, was replaced by a new regulation schedule known as the Everglades Restoration Transition Plan as of October 19, 2012. Water levels in WCA-3 were above the flood regulation schedule in WY2017 during September and October 2016 but continuously receded as the dry season was drier than normal. The average stage was 9.85 ft NGVD29 (**Table 2-8**) with a maximum of 10.84 ft NGVD29 and minimum of 8.72 ft NGVD29. The average water level was lower than WY2016 levels. Appendix 2-3, Figure 12, shows the daily water level for the period 1962–2017. Monthly historical average, WY2016, and WY2017 water levels are shown in Appendix 2-4, Figure 12. **Table 2-8** depicts WY2017, WY2016, and historical mean, maximum, and minimum stages.

WY2017 inflows into WCA-3A (990,095 ac-ft) were 84% of historical average (**Table 2-9**). The major inflows to WCA-3A in WY2017 were from STA-3/4 through structures S-8 (25%) and through S-11A, S-11B, and S-11C (23%) from WCA-2 (Appendix 2-5, Table 10). Other inflows were through the S-9 pumps (14%), S-140 (10%), S-150 (8%), and S-190 (7%). Inflows through the northwest gap opening were estimated at 4% with STA-5/6 contributions through the gap estimated at 9%. L-4 borrow canal gap or

opening into the L-3 extension canal that is currently not gauged has a bottom width of 150 ft at an elevation of 3 ft NGVD29 (SFWMD 2002). Water released from the Miami Canal through the G-404 pumps into the L-4 canal but not released to the west through G-409 is estimated as inflow to WCA-3A through the gap. Also, outflows from STA-5/6 are considered inflows into WCA-3A through the gap as reported in Chapter 3A of this volume.

WY2017 outflows from WCA-3A (1,169,431 ac-ft) were 115% of the historical average (**Table 2-9**). Outflows from WCA-3A into ENP were through structures S-12A, S-12B, S-12C, and S-12D (40%); S-151 (14%); S-333 (19%) with potential flow to ENP to the south or flow east through S-334; S-344 and S-343 (7%); S-31 (7%); S-337 (5%); S-30 (1%); and S-142 (1%) (Appendix 2-5, Table 11). There was no backflow through S-8 and S-150. WY2017 monthly inflows and outflows are shown in Appendix 2-5, Tables 10 and 11, respectively. Monthly historical average, WY2016, and WY2017 inflows and outflows are shown in Appendix 2-6, Figures 14 and 15, respectively. **Table 2-9** depicts WY2017, WY2016, and historical flow statistics.

Everglades National Park

ENP is located south of WCA-3A and WCA-3B. Criterion for water delivery into ENP is the new Everglades Restoration Transition Plan regulation schedule, which replaced the Interim Operational Plan for the Protection of the Cape Sable Seaside Sparrow as of October 19, 2012. Water level monitoring at sites P-33 and P-34 has been used in previous reports as representative of slough and wet prairie, respectively (Sklar et al. 2003). Station elevations for P-33 and P-34 are 5.06 and 2.09 ft NGVD29, respectively (Sklar et al. 2000). Historical water level data for sites P-33 (1952–2017) and P-34 (1953–2017) were obtained from DBHYDRO. WY2017 water level at both sites were higher than WY2016 and historical averages (**Table 2-8**). WY2017 average water level at P-33 was 6.57 ft NGVD29 and at P-34 was 3.08 ft NGVD29 (**Table 2-8**). **Figure 2-20c** and **d** depict the daily average water level and rainfall at P-33 and P-34, respectively, for WY2017. WY2017 daily and historical average water levels for P-33 and P-34 are shown in Appendix 2-3, Figures 13 and 14, respectively. Monthly historical average, WY2016, and WY2017 water levels for P-33 and P-34 are shown in Appendix 2-4, Figures 13 and 14, respectively. **Table 2-8** depicts WY2017, WY2016, and historical mean, maximum, and minimum stages.

WY2017 inflow into ENP (1,340,883 ac-ft) was 133% of the historical average and 86% of WY2016 inflows (**Table 2-9**). Inflow into ENP is mainly through structures S-12A, S-12B, S-12C, S-12D, S-18C, S-332B, S-332C, S-332D, S-333, S-199, and S-200. The major inflow (35%) was through the S-12 structures. The other structures contributed the following percentages of inflow: S-332B, 11%; S-332C, 15%; S-332D, 15%; S-18C, 9%; S-333, 5%; S-200, 4%; S-199, 6%; and some flow through S35B and S356 (Appendix 2-5, Table 12). WY2017 monthly inflows are shown in Appendix 2-5, Table 12. Monthly historical average, WY2016, and WY2017 inflows are shown in Appendix 2-6, Figure 16. **Table 2-9** depicts WY2017, WY2016, and historical flow statistics.

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