APPENDIX A3
EAA BASIN COMPLIANCE

INTRODUCTION

This Appendix sets forth the procedures the District shall follow to determine whether the entire EAA Basin has met the goal of reducing total phosphorus (TP) discharged by 25 percent, under any set of hydrologic conditions that could arise, after implementation of BMPs as described in Part I of Chapter 40E-63, F.A.C., The first determination was for the period, May 1, 1995 through April 30, 1996, and annually thereafter. The annual determination requires calculation of TP load leaving the structures from the EAA (locations shown in Table A1). The load calculation must include phosphorus carried into Lake Okeechobee through backpumping and adjust for pass-through flows released from Lake Okeechobee and other sources to Stormwater Treatment Areas, the Holey Land, Water Conservation Areas and the Lower East Coast.

Load is the amount of phosphorus carried past a monitoring point by the movement of water. Data on water quality concentration and water quantity (flow) are required to calculate the phosphorus load discharged from a monitoring point. Data on water quality and quantity at the EAA structures are available from several sources – the District, the U. S. Army Corps of Engineers, and the U.S. Geological Service. Several methods of collecting the data are also used. Accordingly, the best method of data collection and source of data to use in a load calculation must be identified.

The water quality and quantity collection sources and methods currently available are described below. Methods are improved as new equipment becomes available and technology changes. Annually, when the District reports the results of the determination of whether the EAA Basin has reduced total phosphorus load by 25% for the period of May 1 through - April 30, the sources and methods of data collection used in the calculation must be described and available for inspection. Any changes in methods from the prior year must be specified. Substantially affected persons will have an opportunity to request an administrative hearing. The District shall incorporate permanent changes in methods into this Appendix periodically through Chapter 120, Florida Statutes, rulemaking proceedings.

The load calculations involve detailed procedures, which have been automated by a computer program in FORTRAN language. A flow chart of the program is shown in Figure A3. The methods and equations used in the program are outlined in Appendix A3.1: FORTRAN Program for Calculating EAA Basin Flows and Phosphorus Loads (EAA Basin Compliance model), which is published by reference and incorporated into this Chapter. These methods and equations are also available electronically.

DATA COLLECTION SOURCES AND METHODS

Water Quantity – Flows

The South Florida Water Management District and the U.S. Geological Survey (USGS) compute flow at all the major water control structures in the Everglades Agricultural Area. Water control structures include pumps, gated spillways, and gated culverts. Pump stations S-2, S-3, and S-6 allow water to flow in the opposite direction of pumping by siphoning. All pump stations except S-6 have an adjacent gated spillway.

The SFWMD uses various methods to compute flow at control structures. Flow at pump stations is calculated using discharge rating equations provided by the pump manufacturer and calibrated by discharge measurements. Flow at gated spillways is calculated using formulae derived by the Corps of Engineers from the Bernoulli equation. Discharge through culverts is calculated using standard equations for weir flow, orifice flow, pipe flow, and open channel flow. Flow computation methods are outlined in Appendix A3.2, which is published by reference and incorporated into this Chapter.

The SFWMD obtains field measurements of stage and control operations through various means. Real-time stage and control operations data are collected via the telemetry system. Analog data is obtained from chart recorders. Digital data are provided by punch tapes and solid state data loggers. Pump station operators log readings of stage and control operations hourly during pumping operations. In addition, staff gauge readings, gate opening measurements, and flashboard elevation measurements are conducted by field personnel who routinely visit unmanned structures.

The SFWMD's hydrologic database stores multiple flow data sets at each structure. Each flow data set is created using a unique combination of sources of stage and control operations data. The USGS publishes one set of flow data for each structure. If convenient, the USGS presents combined flow data from different locations. The SFWMD uses the USGS's data as well as its own data to perform water budget analyses and estimation techniques to obtain a "preferred" flow data set at each structure. Table A1 shows all the flow data sets available in the SFWMD's hydrologic database (DBHYDRO).

Water Quality

A water sample collected in the field is called a "raw water sample", in differentiation with a "water sample" used in the chemistry laboratory. Current raw water sample collecting methods at different structures are listed in Table A2. All raw water samples collected in the EAA for compliance must be collected by automatic sampler. Automatic samplers must be programmed to take flow proportional composite samples. Where on-site real-time flow computation is impossible, time proportional composite samples will be taken. Grab samples must also be continued until the relationships between results from automatic and manual methods has been sufficiently established. After that time, grab samples must be taken when autosamplers are not functioning, or when necessary for other purposes.

Only a portion of a well-mixed raw water sample is used as a water sample in actual quantitative analysis of a given water quality parameter. The chemical analysis is performed by a certified laboratory using accepted standard methods. In case of change of laboratories or analytical methods, concurrent analyses shall be done until correlation between them can be established. Water quality parameters are identified by structure and collection site, project code, sample date, and serial number of the sample. The data are stored in DBHYDRO.

Rainfall

EAA rainfall is calculated from measurements at representative rainfall gauges. Rainfall gauges provide an estimate of rainfall at a “point” location. Since rainfall is expected to vary in intensity and duration over an area, rainfall data from representative gauges are area-weighted using the

Thiessen Polygon Method. Nine rainfall gauges have historically been used to estimate EAA rainfall. Daily rainfall data for each rainfall gauge are stored in the DBHYDRO database. The rainfall gauge station names, DBHYDRO identifiers and area-weights corresponding to each rainfall gauge station are listed in Table A3. EAA rainfall for the May 1 through April 30 period is calculated as the area-weighted sum of the daily rainfall measurements at each rainfall gauge.

Data Upgrades

There are three ways in which the quality and reliability of District flow data are being improved: (1) establishment of single time series of flow for each station from multiple sources of stage and control operations data, (2) verification and calibration of flow equations through intensified discharge measurements at all major EAA structures, and (3) calibration of Acoustic Velocity Meter (AVM) systems for future use as an additional source of flow data. A prioritized list of sources of stage and control operations data must be established for each flow station. Flow must be computed from the highest ranking sources. When the highest ranking source of data is missing, the next highest source must be used, and so on. This method ensures the calculation of the best flow values from all sources and minimizes missing data.

Stream gauging is being intensified to provide discharge measurements at all major EAA structures. Statistical analyses are conducted to verify or calibrate the discharge rating equations. The upgrading of stream gauging equipment, including a portable acoustic low velocity meter, as well as improved measuring techniques ensures valuable field measurements. Statistical analysis and calibration of rating equations will continue to increase the accuracy of the calculated flow values.

AVM systems are in place at most major EAA structures. Calibration of these systems is being performed by the USGS. When these systems are satisfactorily calibrated, the data are used to verify the District's flow computations. If these systems prove to be highly reliable and accurate, they may provide the highest ranking source of flow data for the prioritization of single time series.

If any upgrades in water quality sampling are undertaken in the future, concurrent samples must be taken by the existing methods to maintain data continuity, at least until the upgraded methods have been tested and documented as reliable.

DETERMINATION OF COMPLIANCE WITH 25% REDUCTION OF TOTAL PHOSPHORUS LOAD

TP load must be evaluated for compliance with the 25% TP load reduction requirement yearly as of April 30, a date which corresponds generally with the change from the dry to the wet rainfall periods. Hydrology, that is, discharge and rainfall, are dominant factors when computing TP loads. Because rainfall and stream flow are subject to large temporal and spatial variation in south Florida, the evaluation for compliance adjusts the TP load for hydrologic variability. Otherwise, the hydrologic variability could be large enough to obscure the effectiveness of BMPs to reduce TP loadings.

The adjustment for hydrologic variability includes two components:

1. A model to estimate future TP loads. The model estimates a future TP load of the EAA Basin by substituting future hydrologic conditions for the conditions that occurred during a base-period (1978 - 1988). The estimation is based on hydrologic data collected from future time period of May 1 - April 30. The estimation incorporates a calculation for the required 25% TP load reduction.

2. Accommodation for possible statistical error. This is accomplished by specifying a required level of statistical confidence in the prediction of the long-term average TP load. The 90th percentile confidence level is selected as reasonable.

Evaluation of the EAA Basin for compliance with the 25% TP load reduction requirement must be based upon the following:

1. If the actual measured TP loading from the EAA Basin (Actual TP Loading) in a future May 1 – April 30 period is less than the model TP load estimate (Target TP Loading), then the EAA Basin will be determined to be "In Compliance," that is, to have met the 25% TP load reduction requirement. After completion of the STAs or other regional projects, the actual percentage of the base period TP load which must be met to be determined "In Compliance" must be reduced to reflect land converted to STAs or regional projects no longer using the Works of the District within the EAA. However, the average unit area reduction required will be the same, both pre- and post-regional project completion.

2. If the Actual TP Loading from the EAA Basin exceeds the model TP load estimate (Target) in 3 or more consecutive May 1 – April 30 periods, then the EAA Basin will be determined to be "Not In Compliance" – that is, it will not have met the 25% load reduction requirement. If the Target is exceeded in a May 1 – April 30 period, and the District determines that the adjusted rainfall for the period exceeds 63.76 inches, the Target will be suspended for the EAA Basin will not be determined to be "Not In Compliance" for that period only. Any periods in which the Target is suspended must be excluded from the determination of whether the Target has been exceeded in 3 or more consecutive May 1 – April 30 periods, that is, the EAA Basin will be determined to be "Not In Compliance" when the Target is exceeded for 3 May 1 – April 30 periods, without an intervening May 1 – April 30 period in which the EAA Basin has been determined to be "In Compliance," even though the three periods may be interrupted by periods of suspension.

3. If the Actual TP Loading from the EAA Basin exceeds the “upper 90% confidence limit of the Target” (Limit), in any May 1-April 30 period, the EAA Basin will be determined to be "Not in Compliance," that is, it will not have met the 25% load reduction requirement. If the Limit is exceeded in a May 1 – April 30 period, and the District determines that the adjusted rainfall for the period exceeds 63.76 inches, the Limit must be suspended and the EAA Basin will not be determined to be "Not In Compliance" for that period only.

4. A determination of suspension under paragraphs 2 and 3 above determined, and a Notice of Rights to petition for a hearing under Section 120.57, Florida Statutes, and Section 373.114, Florida Statutes, shall be published in the Florida Administrative Weekly.

5. The Target and Limit must be calculated according to the following equations and explanation:

To reflect the required 25% reduction, POR TP loads are multiplied by 0.75 before performing the following regression:

$$1n(L) = -7.998 + 2.868\ X + 3.020\ C - 0.3355\ S$$

[Explained Variance = 90.8%, Standard Error of Estimate = .183]

Predictors (X, C, S) are calculated from the first three moments (m_1,m_2,m_3) of the 12 monthly rainfall totals (r_i, i=1,12, inches) for the current year:

$$m_1 = \text{Sum}\ [\ r_i\ ]\ /\ 12$$

$$m_2 = \text{Sum}\ [\ r_i - m_1\ ]^2\ /\ 12$$

$$m_3 = \text{Sum}\ [\ r_i - m_1\ ]^3\ /\ 12$$

$$X = 1n\ (12\ m_1)$$

$$C = [\ (12/11)\ m_2]^{.5}/m_1$$

$$S = (12/11)\ m_3\ /\ m_2^{\ 1.5}$$

where,

L = 12-month load attributed to EAA Runoff, reduced by 25% (metric tons)

X = natural logarithm of 12-month total rainfall (inches)

C = coefficient of variation calculated from 12 monthly rainfall totals

S = skewness coefficient calculated from 12 monthly rainfall totals

The first predictor (X) indicates that load increases approximately with the cube of total annual rainfall. The second and third predictors (C & S) indicate that the load resulting from a given annual rainfall is higher when the distribution of monthly rainfall has higher variance or lower skewness. For a given annual rainfall, the lowest load occurs when rainfall is evenly distributed across months and the highest load occurs when all of the rain falls in one month. Real cases fall in between.

Compliance must be tracked by comparing the measured EAA Load with:

Target = $\exp\ [\ -7.998 + 2.868\ X + 3.020\ C - 0.3355\ S\ ]$

Limit = Target $\exp\ (1.476\ SE\ F)$

SE = $.1833\ [1 + 1/9 + 5.125\ (X-X_m)^2 + 17.613\ (C-C_m)^2 + 0.5309\ (S-S_m)^2 + 8.439\ (X-X_m)\ (C-C_m) - 1.284\ (X-X_m)\ (S-S_m) - 3.058\ (C-C_m)\ (S-S_m)\ ]^{.5}$

where,

$_m$ =	subscript denoting average value of predictor in base period (X_m = 3.866, C_m = 0.7205, S_m = 0.7339)
Target =	predicted load for future rainfall conditions (metric tons/yr)
Limit =	upper 90% confidence limit for Target (metric tons/yr)
SE =	standard error of predicted 1n(L) for May-April interval
F =	factor to reflect variations in model standard error as a function of month (last in 12-month interval), calculated from base period:

Month:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
F:	1.975	1.609	1.346	1.000	1.440	1.238	1.321	2.045	2.669	2.474	2.420	2.216

Figure A3

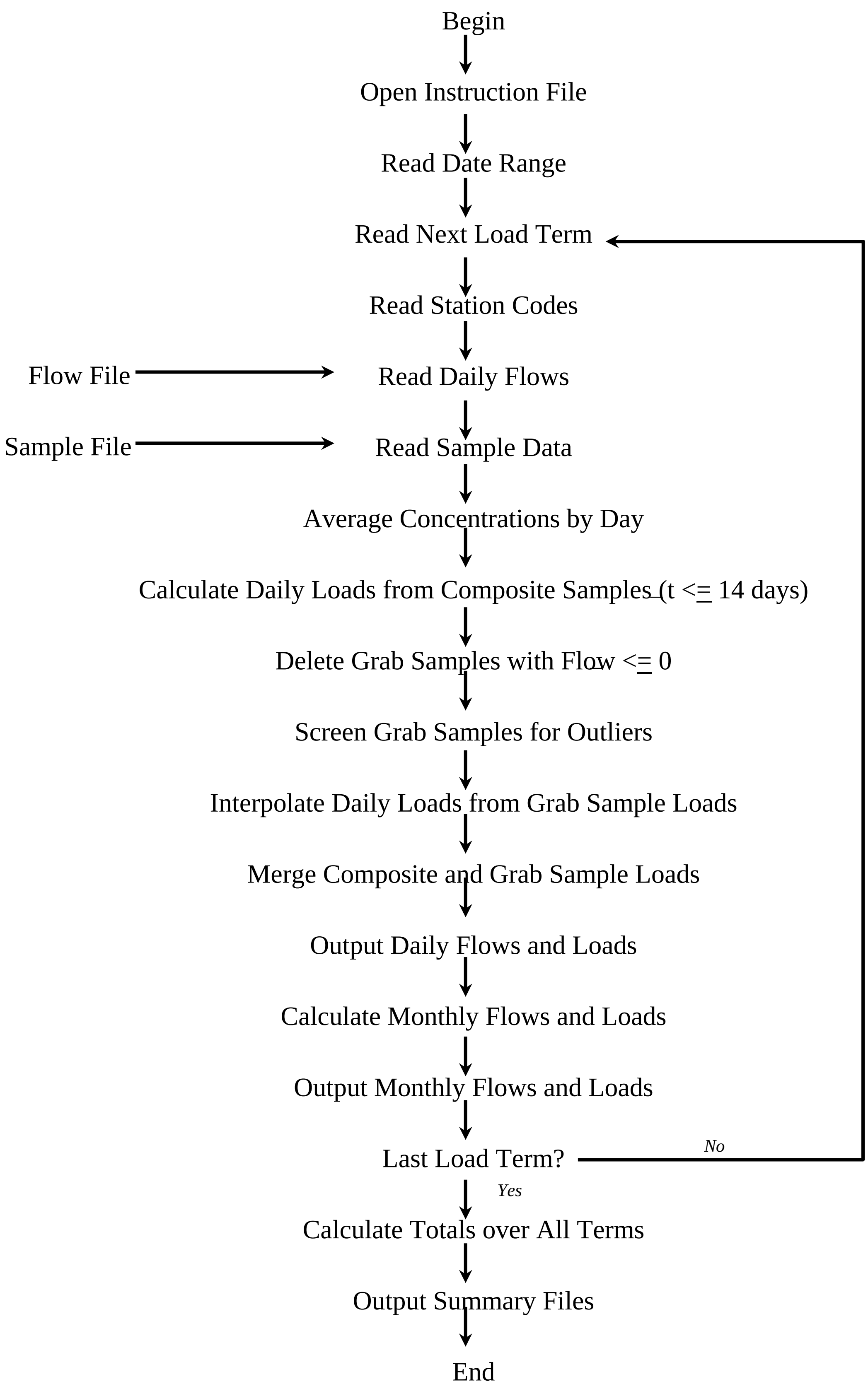
Begin
Open Instruction File
Read Date Range
Read Next Load Term
Read Station Codes
Flow File
Read Daily Flows
Sample File
Read Sample Data
Average Concentrations by Day
Calculate Daily Loads from Composite Samples (t <= 14 days)
Delete Grab Samples with Flow <= 0
Screen Grab Samples for Outliers
Interpolate Daily Loads from Grab Sample Loads
Merge Composite and Grab Sample Loads
Output Daily Flows and Loads
Calculate Monthly Flows and Loads
Output Monthly Flows and Loads
Last Load Term?
No
Yes
Calculate Totals over All Terms
Output Summary Files
End

TABLE A1
EAA BASIN DRAINAGE STRUCTURES
DATABASE KEYS TO FLOW DATA TIME SERIES

Structure	Preferred[1]	Effective Date[2]	Inactive Date[3] (if applicable)
S-352 Complex	15068	Base Period	
S-2 Complex	15021	Base Period	
S-3 Complex	15018	Base Period	
S-5A Complex	15031	Base Period	
S-6	15034	Base Period	
S-7	15037	Base Period	01/08/2005
S-150	15041	Base Period	01/08/2005
S-8	15040	Base Period	01/08/2005
G-88	15196	Base Period	06/30/2000
G-136	15195	Base Period	
G-200	15736	10/28/1991	01/08/2005
G-250	16222	01/25/1994	07/10/1999

Structure	Preferred[1]	Effective Date[2]	Inactive Date[3] (if applicable)
G-600	GG955	03/06/1997	04/30/2005
G-605	H3143	11/24/1997	06/30/2000
G-606	HD889	11/24/1997	06/30/2000
G-328	J0718	04/01/2000	
G-344A	J0719	10/01/1999	07/22/2005
G-344B	J0720	10/01/1999	07/22/2005
G-344C	J0721	10/01/1999	07/22/2005
G-344D	J0722	10/01/1999	07/22/2005
G-349B	JA353	10/01/1999	07/22/2005
G-350B	JA352	10/01/1999	07/22/2005
G-410	LX270	07/17/2001	07/22/2005
G-402A	LX264	07/17/2001	01/08/2005
G-402B	LX265	07/17/2001	01/08/2005
G-402C	LX266	07/17/2001	01/08/2005
G-402D	LX267	07/17/2001	03/30/2004
G-404	LX269	05/06/2000	01/08/2005
EBPS[4]	LX274	07/01/2001	04/30/2018
ESPS[4]	LX273	12/20/2001	04/30/2018
G-357	LX263	03/01/2001	01/08/2005
G-204	SG578	05/01/2003	01/08/2005
G-205	SG579	05/01/2003	01/08/2005
G-206	SG580	05/01/2003	01/08/2005
G-507	SJ382	12/01/2003	07/22/2005
G-370	TA438	10/01/2003	
G-372	TA437	10/01/2003	
G-376A	TA445	02/27/2004	01/08/2005
G-376D	TA446	02/27/2004	01/08/2005
G-379A	TA449	09/17/2004	01/08/2005
G-379D	TA450	09/17/2004	01/08/2005
G-381A	TA447	06/09/2004	01/08/2005
G-381C	TA448	06/09/2004	01/08/2005
SSDD[4]	TA459	06/01/2004	04/30/2018
SFCD[4]	TR998	08/01/2005	04/30/2018

Structure	Preferred[1]	Effective Date[2]	Inactive Date[3] (if applicable)
G-371	TS261	02/01/2006	
G-373	TS260	02/15/2006	
G-373BC	TS262	06/01/2005	07/21/2005
G-434	90327	11/01/2012	
G-435	90328	05/17/2013	
G-722	AM015	08/28/2015	
C-10[4]	15645	05/01/2018	
C-12A[4]	15647	05/01/2018	
C-12[4]	15646	05/01/2018	
C-4A[4]	15648	05/01/2018	
S236[4]	15644	05/01/2018	
EPD07[4]	AM706	05/01/2018	

[1] The reference numbers in the table are keys to the data sets, known as "dbkeys".
[2] The term "Base period" indicates that the structure was part of the EAA model boundary from October 1, 1978, through September 30, 1988. The format is Month – Day – Year.
[3] A date is indicated for those structures that are inactive as of the date of this amendment. The format is Month – Day – Year.
[4] These structures serve the Everglades Construction Project diversion basins for Lake Okeechobee discharges not included in the original regulated acreage of the EAA represented by the base period water quality and flow dataset described in Appendix 3. The Diversion Project drainage areas became regulated under this Chapter upon completion and operation of their associated diversion structures. Upon the effective date of this rule amendment, the original EAA base period water quality and flow data dataset will be adjusted using an acreage adjustment factor to account for these areas.

TABLE A2
EAA BASIN
WATER QUALITY SAMPLING METHODS

Structure	Collection Site	Instrument[1]	Effective Date[2]	Inactive Date (if applicable)[3]
S-352	GRAVITY	G	Base Period	
S-2	PUMP	A	Base Period	
	GRAVITY	G	Base Period	
S-3	PUMP	A	Base Period	
	GRAVITY	G	Base Period	
S-5A Complex	PUMP	A	Base Period	
	GRAVITY	G		
S-6	PUMP	A	Base Period	01/08/2005
	GRAVITY	G		
S-7	PUMP	A	Base Period	01/08/2005
	GRAVITY	G		
S-150	GRAVITY	G	Base Period	01/08/2005
S-8	PUMP	A	Base Period	06/30/2000
	GRAVITY	G		
G-88	GRAVITY	G	Base Period	
G-136	GRAVITY	A	10/28/1991	01/08/2005
G-200A	GRAVITY	G	01/25/1994	07/10/1999
G-250	PUMP	A	03/06/1997	04/30/2005

Structure	Collection Site	Instrument[1]	Effective Date[2]	Inactive Date (if applicable)[3]
G-600	PUMP	A	11/24/1997	06/30/2000
G-606	GRAVITY	A	11/24/1997	06/30/2000
G-328	PUMP	A	04/01/2000	
G-344A	GRAVITY	A	10/01/1999	07/22/2005
G-344B	GRAVITY	A	10/01/1999	07/22/2005
G-344C	GRAVITY	A	10/01/1999	07/22/2005
G-344D	GRAVITY	A	10/01/1999	07/22/2005
G-349B	PUMP	A	10/01/1999	07/22/2005
G-350B	PUMP	A	10/01/1999	07/22/2005
G-410	PUMP	A	07/17/2001	07/22/2005
G-402A	GRAVITY	G	07/17/2001	01/08/2005
G-402B	GRAVITY	G	07/17/2001	01/08/2005
G-402C	GRAVITY	G	07/17/2001	01/08/2005
G-402D	GRAVITY	G	07/17/2001	03/30/2004
G-404	PUMP	A	05/06/2000	01/08/2005
EBPS[4]	PUMP	A	07/01/2001	04/30/2018
ESPS[4]	PUMP	A	12/20/2001	04/30/2018
G-357	GRAVITY	A	03/01/2001	01/08/2005
G-204	GRAVITY	G	05/01/2003	01/08/2005
G-205	GRAVITY	G	05/01/2003	01/08/2005
G-206	GRAVITY	G	05/01/2003	01/08/2005
G-507	PUMP	A	12/01/2003	07/22/2005
G-370	PUMP	A	10/01/2003	
G-372	PUMP	A	10/01/2003	
G-376A	GRAVITY	A	02/27/2004	01/08/2005
G-376D	GRAVITY	A	02/27/2004	01/08/2005
G-379A	GRAVITY	A	09/17/2004	01/08/2005
G-379D	GRAVITY	A	09/17/2004	01/08/2005
G-381A	GRAVITY	G	06/09/2004	01/08/2005
G-381C	GRAVITY	G	06/09/2004	01/08/2005
SSDD[4]	PUMP	A	06/01/2004	04/30/2018
SFCD[4]	PUMP	A	08/01/2005	04/30/2018
G-371	GRAVITY	G	02/01/2006	
G-373	GRAVITY	G	02/15/2006	
G-373_BC	GRAVITY	G	06/01/2005	07/21/2005
G-434	PUMP	A	11/01/2012	

Structure	Collection Site	Instrument[1]	Effective Date[2]	Inactive Date (if applicable)[3]
G-435	PUMP	A	05/17/2013	
G-722	GRAVITY	A	08/28/2015	
CULV10[4]	PUMP	G	05/01/2018	
CULV12A[4]	PUMP	G	05/01/2018	
CULV12[4]	PUMP	G	05/01/2018	
CULV4A[4]	PUMP	G	05/01/2018	
S236[4]	PUMP	G	05/01/2018	
EPD07[4]	PUMP	G	05/01/2018	

[1] G = grab sample primary method
A = automatic sampler primary method, grab sample back-up
[2] The term “Base period” indicates that the structure was part of the EAA model boundary from October 1, 1978, through September 30, 1988. The format is Month – Day – Year.
[3] A date is indicated for those structures that are inactive as of the date of this amendment. The format is Month – Day – Year.
[4] These structures serve the Everglades Construction Project diversion basins for Lake Okeechobee discharges not included in the original regulated acreage of the EAA represented by the base period water quality and flow dataset described in Appendix 3. The Diversion Project drainage areas became regulated under this Chapter upon completion and operation of their associated diversion structures. Upon the effective date of this rule amendment, the original EAA base period water quality and flow data dataset will be adjusted using an acreage adjustment factor to account for these areas.

TABLE A3
EAA BASIN
RAINFALL STATIONS

Identifier[1]	Station	Theissen Weight
15197	ALICO_R	0.0974
15198	MIAMI LO_R	0.1076
15199	SOUTH BA_R	0.0844
15200	BELLE GL_R	0.1617
15201	PAHOKEE1_R	0.1438
15202	S5A_R	0.0989
15203	S6_R	0.0763
15204	S7_R	0.0592
15205	S8_R	0.1743

[1] The identifiers are also referred to as "dbkeys".