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Test for Determining Achievement of 50 Part Per Billion Phosphorus Initial TBEL For Everglades Stormwater Treatment Areas

By

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Introduction

The Everglades Forever Act (EFA; Section 373.4592, Florida Statutes (F.S.)) and the Everglades Lawsuit Settlement Agreement (Case No. 88-1886-CIV-MORENO) require the construction and operation of Stormwater Treatment Areas (STAs) to achieve an initial design goal of a long-term average, flow-weighted mean total phosphorus concentration of 50 parts per billion (ppb) or less at points of discharge from the STAs to the Everglades Protection Area. The initial 50 ppb design goal is a technology-based effluent limitation (TBEL) in accordance with the EFA. The initial 50 ppb TBEL will be revised, consistent with the iterative adaptive implementation of Best Available Phosphorus Reduction Technology being implemented through the State's Long Term Plan under the EFA. Through this process, the initial 50 ppb TBEL will be revised as appropriate until such time as the TBEL can achieve compliance with the 10 ppb phosphorus criterion.

A methodology for determining achievement of the initial 50 ppb TBEL was first derived by Walker (1996). The 1996 Walker methodology estimated the year-to-year variability in performance of the STAs above and below the 50 ppb, based on the variability of phosphorus concentrations at inflows to the Everglades Protection Area at that time. Since STAs 1W, 2, 5 and 6 have now been constructed and have been operational for some number of years, phosphorus outflow data from the operational STAs can be used to update and refine the estimated year-to-year variability in performance above and below the 50 ppb TBEL. This document sets forth updated estimates of the variability in performance above the 50 ppb TBEL and a methodology for determining compliance. These methods may be rescaled as necessary to determine achievement of future lower TBELs at some level below the initial 50 ppb TBEL. All data and calculations used in the derivation of this methodology are included in the MS Excel spreadsheet attached as Appendix 1.

Detrending and Rescaling of Data Sets

Phosphorus concentration and flow data from STA-1W, STA-2, and STA-6 outflow structures were compiled for the following Water Years (May 1 through April 30): G-251 (STA-1W) – May 01, 1994 – April 30, 2004; G-310 (STA-1W) – May 1, 2000 – April 30, 2004; G-335 (STA-2) – May 1,

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2000 – April 30, 2004; and, STA-6[5] – May 1, 1998 – April 30, 2004. Since STA-5 is currently receiving flows and phosphorus loads in excess of those envisioned in its design, STA-5 is experiencing higher and more variable outflow concentrations than the other operational STAs. Therefore, STA-5 outflow concentrations were not used in this methodology, since their use would result in an elevated estimate of the true variability of an STA operating within its intended design. The data from the STA-1W, STA-2 and STA-6 outflow structures were then used to calculate the observed yearly flow-weighted mean phosphorus concentration for each of these outflow structures (Table 1).

Table 1 – Flows and phosphorus concentrations at STA outflow structures

Structure	Water Year	Q (acre-feet)	P (ppb)
G-251	1995	95334	23.1
G-251	1996	172416	23.9
G-251	1997	119199	18.7
G-251	1998	80987	21.2
G-251	1999	86378	19.2
G-251	2000	121231	25.1
G-251	2001	56429	26.7
G-251	2002	6834	20.3
G-251	2003	96524	44.4
G-251	2004	54678	45.0
G-310	2001	34089	58.7
G-310	2002	260795	37.4
G-310	2003	499484	54.8
G-310	2004	242930	47.0
G-335	2002	240689	16.4
G-335	2003	308302	17.8
G-335	2004	284784	14.3
STA-6	1999	24035	21.5
STA-6	2000	59262	14.9
STA-6	2001	26940	36.3
STA-6	2002	30467	16.4
STA-6	2003	35616	25.9
STA-6	2004	38682	11.7

To generate a random series for estimating variability from the STAs, trends in the yearly flow-weighted mean concentration data are removed using a 2nd order polynomial regression of the following form:

$$\ln(C_y) = a_0 + a_1 y + a_2 y^2 + r_y$$

$$\ln(C_t) = \text{Mean}\,(\ln(C_y)) + r_y$$

[5] For STA-6, flow and concentration measurements were taken at the G-606 structure for the period from May 1998 through February 2001, and at the G-354C and G-393B structures from March 2001 to the present. Annual flow-weighted mean values from the latter two structures are calculated as the combined annual flow-weighted means.

where,

C_y = observed yearly flow-weighted mean concentration (ppb)
C_t = yearly concentration with long-term variance component removed
y = water year (1995-2004)
a_1 = regression coefficient
r_y = residual (error) term for each water year
Mean = average over all water years

The resulting data were then rescaled to derive a data set representing a hypothetical STA with a long-term flow-weighted mean outflow concentration of 50 ppb. The rescaling was performed as follows:

$$C_m = \Sigma\, C_t Q_y / \Sigma\, Q_y$$

$$C_s = C_t(50/C_m)$$

where,

C_s = rescaled yearly flow-weighted mean concentration (ppb)
C_m = long-term flow-weighted mean concentration (ppb)
Q_y = flow for water year y (acre-feet)

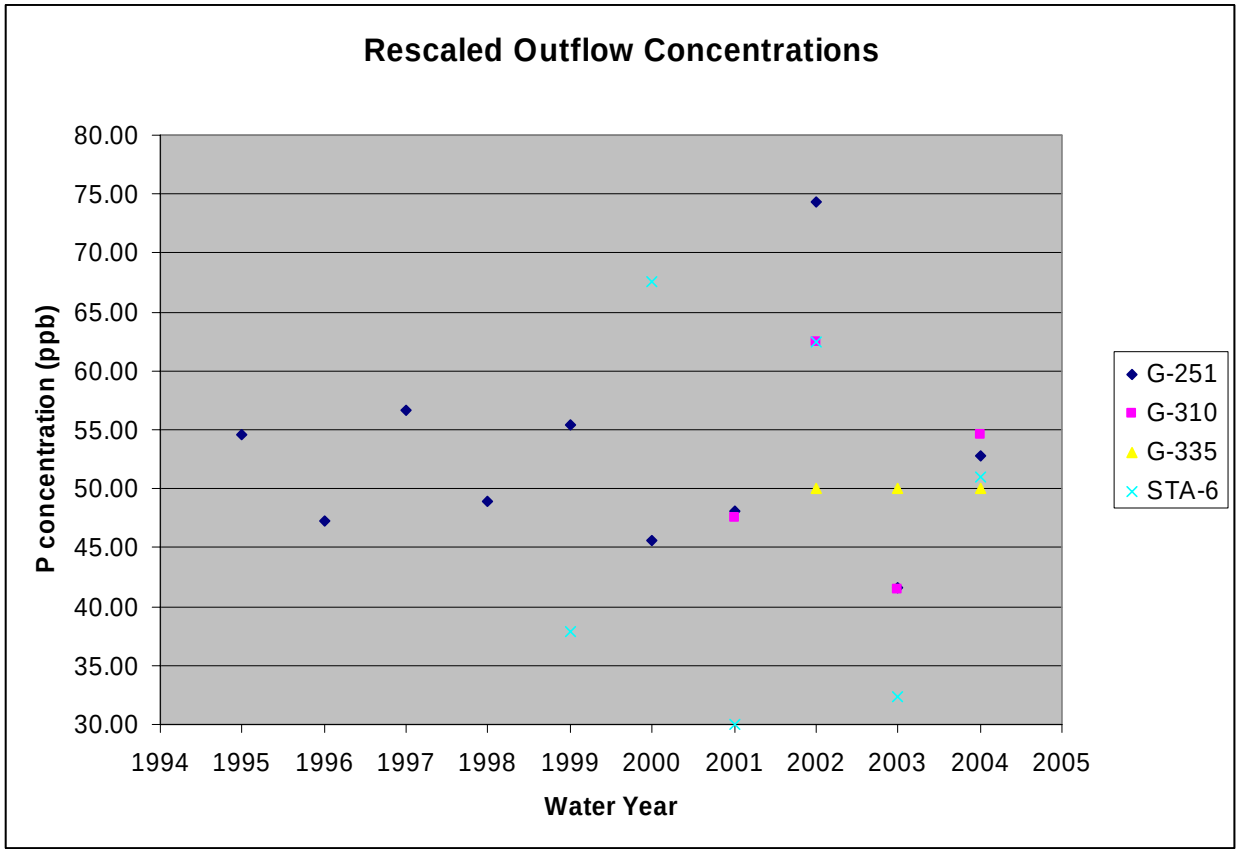
The resulting rescaled data set is shown in Table 2 and Figure 1.

Table 2 – Annual FWM phosphorus concentrations at STA outflow structures, rescaled to 50 ppb.

Structure	Water Year	FWM P (ppb)
G-251	1995	54.52
G-251	1996	47.30
G-251	1997	56.65
G-251	1998	48.95
G-251	1999	55.40
G-251	2000	45.58
G-251	2001	48.03
G-251	2002	74.33
G-251	2003	41.60
G-251	2004	52.78
G-310	2001	47.51
G-310	2002	62.50
G-310	2003	41.45
G-310	2004	54.52
G-335	2002	50.0
G-335	2003	50.0

G-335	2004	50.0
STA-6	1999	37.91
STA-6	2000	67.63
STA-6	2001	29.98
STA-6	2002	62.47
STA-6	2003	32.29
STA-6	2004	50.94

Figure 1 – Annual FWM phosphorus concentrations at STA outflow structures, rescaled to 50 ppb.



Calculation of Annual Limit

An annual limit was then calculated by fitting a lognormal frequency distribution to the rescaled annual flow-weighted mean concentration data for the combined data set from the stations as follows:

$$m = \Sigma \ln (C_s) / n\ k$$

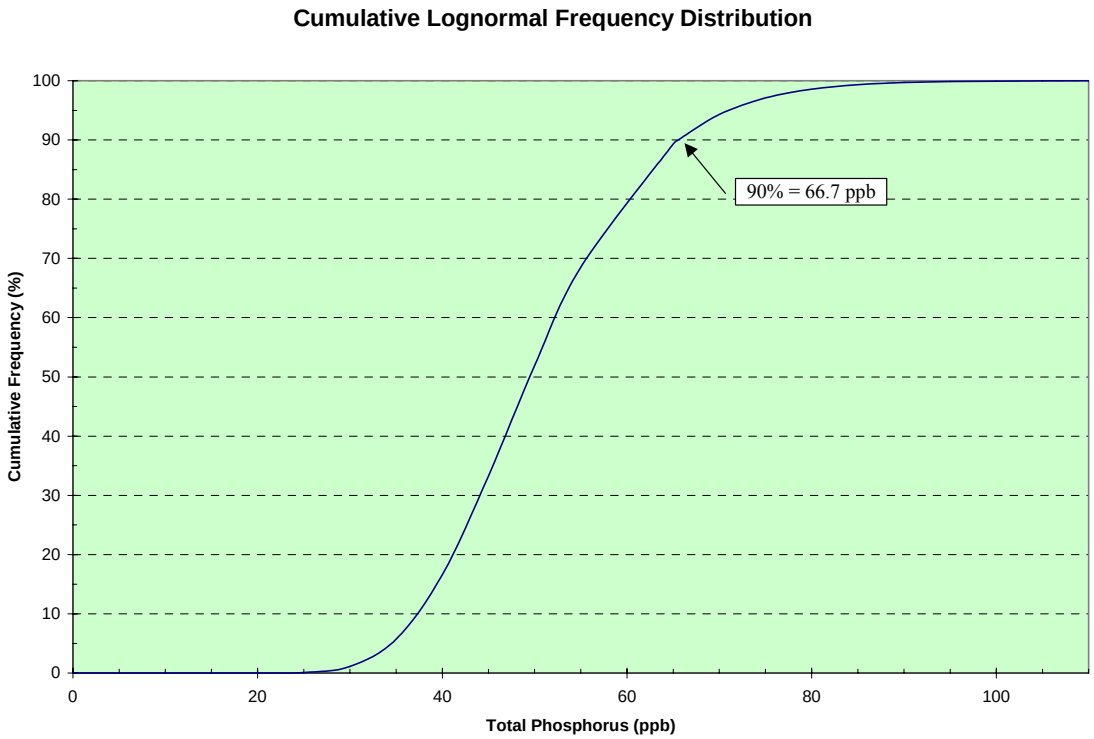
$$s^2 = \sum_{i=1}^{k}[\sum_{j=1}^{n_i}(X_{ij} - \overline{X}_i)^2]/(N-k)$$

$$d = k\,(n - 3)$$

$$L_p = \exp\,(m + s\,t_p)$$

where,

m = log mean
X_{ij}= i^{th} annual average of the j^{th} station
$\overline{Xi}$ = mean of the annual averages
N = total number of station years = 23
k = number of stations = 4
n = average number of years per station = 5.75
s = log standard deviation
d = degrees of freedom in s
L_p = limit concentration with exceedence probability P (ppb)
t_p = 1-tailed t statistic, significance level p
p = 0.10



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m = log mean	3.90
Significance Level (p)	0.1
Log Standard Deviation	0.2194
n=average samples per station	5.75
k=number of stations	4
df	11
One-tailed t	1.3634
90% Rejection Limit (ppb)	66.7

Application of Limit

The limit derived above will be applied as follows:

1. Compliance for each STA will be tested in each water year (May – April) using monitoring data from STA outflows and diverted flows (untreated runoff discharged directly to the Everglades Protection Area). The method may also be applied to grouped STAs, e.g. STA-1E and STA-1W combined outflow. The method may also be revised in the future as appropriate to reflect lower STA limits. The results of this compliance testing shall be reported by the District in the initial draft South Florida Environmental Report and shall be subject to peer review.

2. The STA will be deemed in compliance unless the annual flow-weighted mean phosphorus concentration at the outfall is greater than 66.7 ppb in any year or is greater than 50 ppb in three or more consecutive years.

3. Calculations will exclude flows bypassed for low level water supply deliveries. Low-level water supply deliveries shall be deliveries made when the respective receiving Water Conservation Area is below the following water elevation level:
   - WCA-1 – 14.5 ft. NGVD
   - WCA-2 – 11.0 ft. NGVD
   - WCA-3A – 8.0 ft. NGVD

   Or when water supply deliveries are otherwise required by the respective WCA regulation schedules.

4. STA compliance will not be tested in water years when the EAA adjusted rainfall, as defined in Rule 40E-63, Florida Administrative Code, exceeds 63.8 inches. STA compliance will also not be tested in water years when EAA rainfall is less than 35.1 inches, if sufficient supplemental flows are not available to maintain wet conditions in that STA. If a year is excluded based upon these criteria, results from adjacent years will be treated as consecutive in testing compliance.

5. STA bypasses resulting from extreme hydrological events shall not be combined with the STA outflows in calculating annual flow-weighted mean concentrations for use in testing compliance. Extreme hydrological events shall be defined as flow volumes or rainfall depths that exceed the values experienced during the 1979 to 1988 base period from each tributary basin. The maximum flow volumes experienced at the EAA pump stations for the base period are presented in Table 3 as a function of the duration. The maximum rainfall depths experienced at the EAA pump stations for the base period are presented in Table 4 as a function of the duration.

6. The District's operating philosophy is to avoid untreated bypass if possible, hence, bypass may not occur despite extreme hydrologic events. While this philosophy minimizes phosphorus loads to the Everglades, STA performance could suffer. To account for this, an additional compliance assessment will be made if the above steps do not yield compliance. If the inflow volume or rainfall depth is greater than the corresponding baseline period for

the 1-day, 2-day, 3-day, 7-day, 14-day or 30-day durations, the District will determine the cumulative effect on the STA performance of this extreme hydrologic event. Performance impacts of extreme hydrologic events occurring in the previous water years, if relevant, will be considered by the District in addition to those extreme hydrologic events occurring in the current water year.

Table 3. Summary of Base Period Maximum Flows as a Function of Duration. (Flow volumes reported in acre feet)

Station	1-day	2-day	3-day	7-day	14-day	30-day
STA-1E and STA-1W (Base period reference S-5A)	10,984	20,045	29,204	58,984	95,326	143,080
STA-2 (Base period reference S-6)	5,789	11,226	16,403	35,065	51,863	88,955
STA-3/4 G-370 (Base period reference S-7)	5,673	11,006	16,479	37,386	70,041	125,947
STA-3/4 G-372 (Base period reference S-8)	8,050	15,901	23,732	49,903	87,713	147,291

Note: STA-5 and STA-6 are excluded because they do not treat EAA runoff.

Table 4. Summary of Base Period Maximum Rainfall as a Function of Duration. (Rainfall depths reported in inches)

Station	1-day	2-day	3-day	7-day	14-day	30-day
S-5A	3.88	5.74	6.61	8.28	10.45	16.65
S-6	3.67	4.76	6.81	9.47	13.52	18.89
S-7	5.23	5.86	7.09	8.89	10.87	18.17
S-8	3.23	4.24	5.27	7.54	10.40	18.19

REFERENCES

Walker, William W., Jr. 1996. Test for Evaluating Performance of Stormwater Treatment Areas. Report prepared for U.S. Department of Interior.