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

By

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May 2005

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 initial 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. The method 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 the ENR Project, STA-1W, STA-2, STA-5 and STA-6 outflow structures were compiled for the following Water Years (May 1 through April 30): G-251 (ENR & STA-1W) – May 01, 1994 – April 30, 2004; G-310 (STA-1W) – May 1, 2000 – April 30, 2004; G-335 (STA-2) – May 1, 2000 – April 30, 2004; G-344 A,B,C, & D

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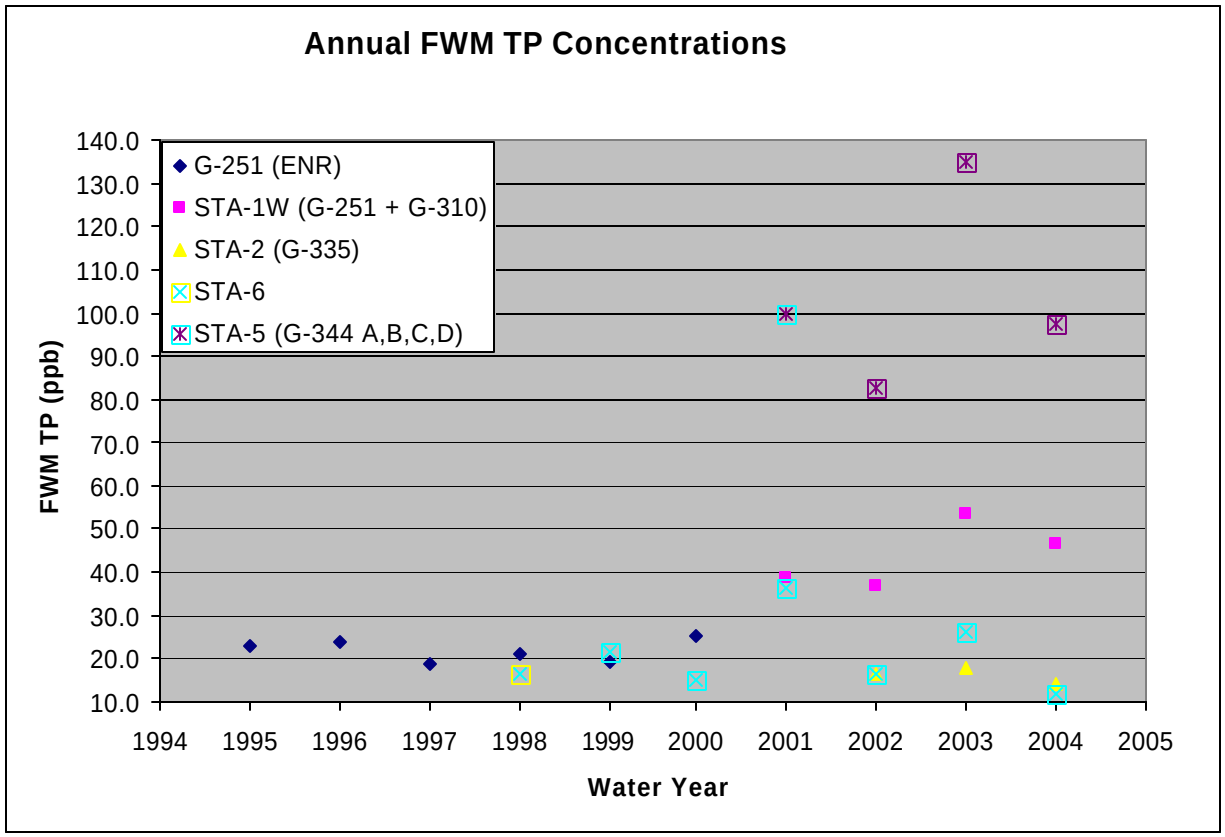
(STA-5) – May 01, 2001 – April 30, 2004; and, STA-6[5] – May 1, 1998 – April 30, 2004. The G-251 structure operated as a part of the Everglades Nutrient Removal Project (ENR) for the period from WY 1995 through WY 2000, during which period the project was operated in approximately a steady-state mode as opposed to the pulsed-flow mode of operation of the facility as a result of its conversion to an STA, which is reflected in the performance of the facility. Therefore, for the purposes of this method discharges from that structure were grouped and evaluated independently for the period 1995-2000 (ENR) and combined with the discharges from the G-310 structure for the period 2001-2004. The data from the ENR, STA-1W, STA-2, STA-5 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; Figure 1).

Table 1 – Flows and phosphorus concentrations at STA outflow structures

Structure	Water Year	Q (acre-feet)	P (ppb)
ENR (G-251)	1995	95334	23.1
ENR (G-251)	1996	172416	23.9
ENR (G-251)	1997	119199	18.7
ENR (G-251)	1998	80987	21.2
ENR (G-251)	1999	86378	19.2
ENR (G-251)	2000	121231	25.1
STA-1W (G-251 + G-310)	2001	90518	38.8
STA-1W (G-251 + G-310)	2002	267628	37.0
STA-1W (G-251 + G-310)	2003	596008	53.1
STA-1W (G-251 + G-310)	2004	297608	46.6
STA-2 (G-335)	2002	240689	16.4
STA-2 (G-335)	2003	308302	17.8
STA-2 (G-335)	2004	284784	14.3
STA-5 (G-344 A,B,C,D)	2001	39976	99.9
STA-5 (G-344 A,B,C,D)	2002	126182	83.1
STA-5 (G-344 A,B,C,D)	2003	160520	134.8
STA-5 (G-344 A,B,C,D)	2004	136468	97.5
STA-6[5]	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

[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.

Figure 1 – Annual FWM phosphorus concentrations at STA outflow structures



The resulting data from the STAs 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:

$$C_m = S\ C_y Q_y / S\ Q_y$$

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

where,

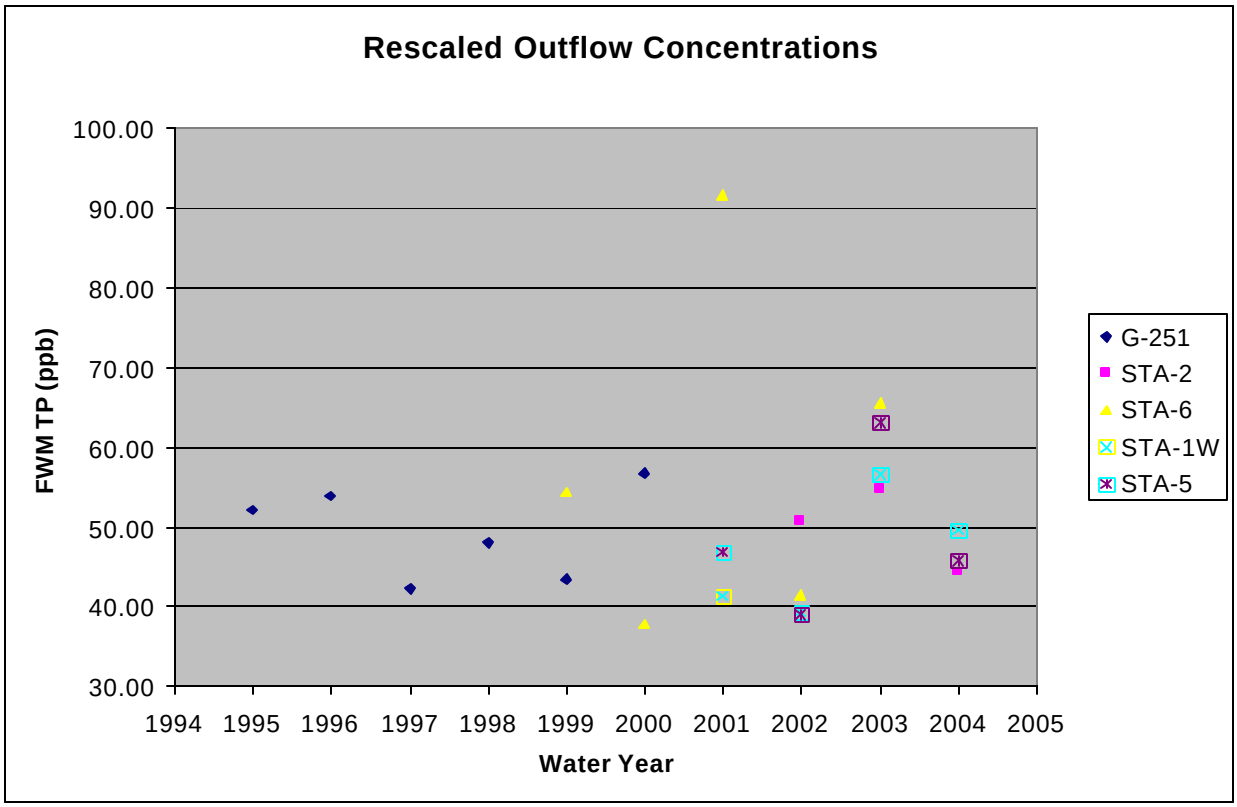
C_s = rescaled yearly flow-weighted mean concentration (ppb)
C_m = long-term flow-weighted mean concentration (ppb)
Q_y = flow for water year y (acre-feet)

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

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

Structure	Water Year	FWM P (ppb)
ENR (G-251)	1995	52.11
ENR (G-251)	1996	53.87
ENR (G-251)	1997	42.19
ENR (G-251)	1998	47.90
ENR (G-251)	1999	43.41
ENR (G-251)	2000	56.61
STA-1W (G-251 + G-310)	2001	41.15
STA-1W (G-251 + G-310)	2002	39.24
STA-1W (G-251 + G-310)	2003	56.43
STA-1W (G-251 + G-310)	2004	49.49
STA-2 (G-335)	2002	50.6
STA-2 (G-335)	2003	54.8
STA-2 (G-335)	2004	44.2
STA-5 (G-344 A,B,C,D)	2001	46.83
STA-5 (G-344 A,B,C,D)	2002	38.93
STA-5 (G-344 A,B,C,D)	2003	63.16
STA-5 (G-344 A,B,C,D)	2004	45.69
STA-6	1999	54.29
STA-6	2000	37.68
STA-6	2001	91.70
STA-6	2002	41.37
STA-6	2003	65.55
STA-6	2004	29.65

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:

$$m = S \ln (C_s) / N$$

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

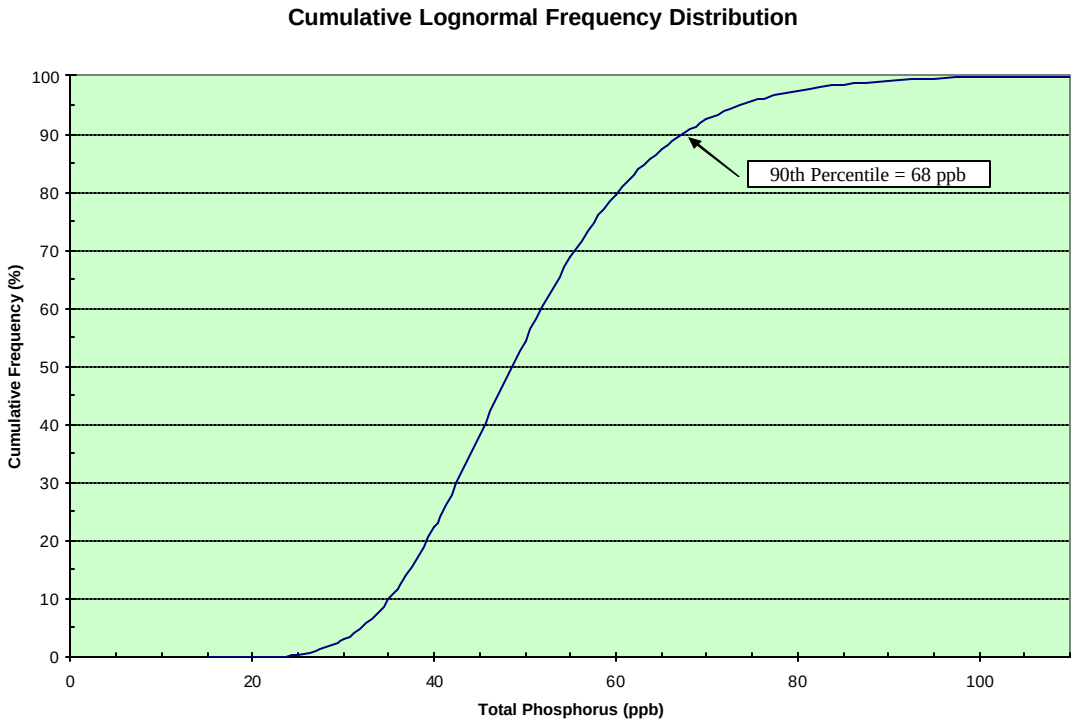
$$df = N - k$$

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

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 = 5
s = log standard deviation
df = degrees of freedom in s
L_p = limit concentration with exceedance probability P (ppb)
t_p = 1-tailed t statistic, significance level *p*
p = 0.10



Ln Flow-weighted mean P Concentration (ppb)	3.88
Significance Level (p)	0.1
St. Dev. Ln TP	0.255
Site-years (N)	23
k (sites)	5
df (N-k)	18
One-tailed t	1.330
90% Rejection Limit (ppb)	68.2

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.

2. The STA will be deemed in compliance unless the annual flow-weighted mean phosphorus concentration at the outfall is greater than 68 ppb in any year or is greater than 50 ppb in three or more consecutive years.

3. Calculations will exclude flows bypassed for low flow water supply deliveries. For the purpose of this method, low-flow water supply deliveries shall be deliveries made when water levels in the respective receiving Water Conservation Area (WCA) is less than six inches above the floor of the respective Water Conservation Area regulation schedule. Specific levels and the gauges at which they are applied are as follows:
   - WCA-1 – 14.5 ft. NGVD (mean of 1-7, 1-8 and 1-9 gauges)
   - WCA-2 – 11.0 ft. NGVD (2-17 gauge)
   - WCA-3A – 8.0 ft. NGVD (mean of site 63, 64 and 65 gauges)

   This method will also exclude water supply deliveries required by the respective WCA regulation schedules.

4. STA compliance will not be tested in water years when rainfall in the basin tributary to that STA exceeds the maximum annual basin rainfall from Water Years 1979-1988. 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 7-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	7-day	30-day
STA-1E and STA-1W (Base period reference S-5A)	58,984	143,080
STA-2 (Base period reference S-6)	35,065	88,955
STA-3/4 G-370 (Base period reference S-7)	37,386	125,947
STA-3/4 G-372 (Base period reference S-8)	49,903	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	7-day	30-day
S-5A	8.28	16.65
S-6	9.47	18.89
S-7	8.89	18.17
S-8	7.54	18.19

7. **REFERENCES**

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