Maximum Annual Discharge Limits to Achieve Compliance with the Consent Decree's Water Quality Requirements - Summary of Exhibits and Issues

prepared for

U.S. Dept of the Interior &
U.S. Environmental Protection Agency

by

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Everglades TOC Meeting

March 1, 2011

Objective of TOC Meeting

To make a recommendation on a "maximum annual (inflow) discharge limit" to achieve compliance with the consent decree's water quality requirements for the Refuge, as directed in the Special Master's January 4, 2011 report.

Recipe for Deciding on MADLs
Focus on Marsh, Data, & Future

Data

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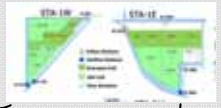
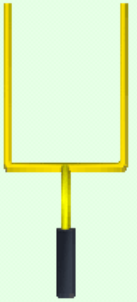
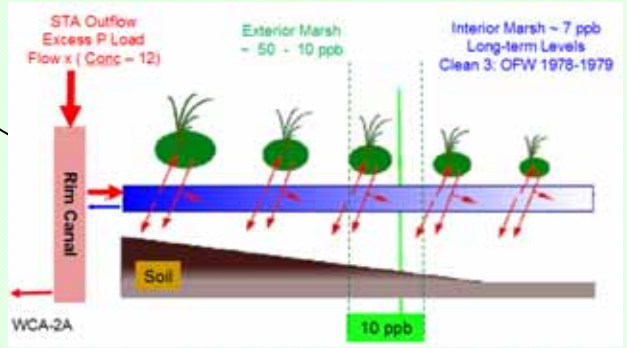


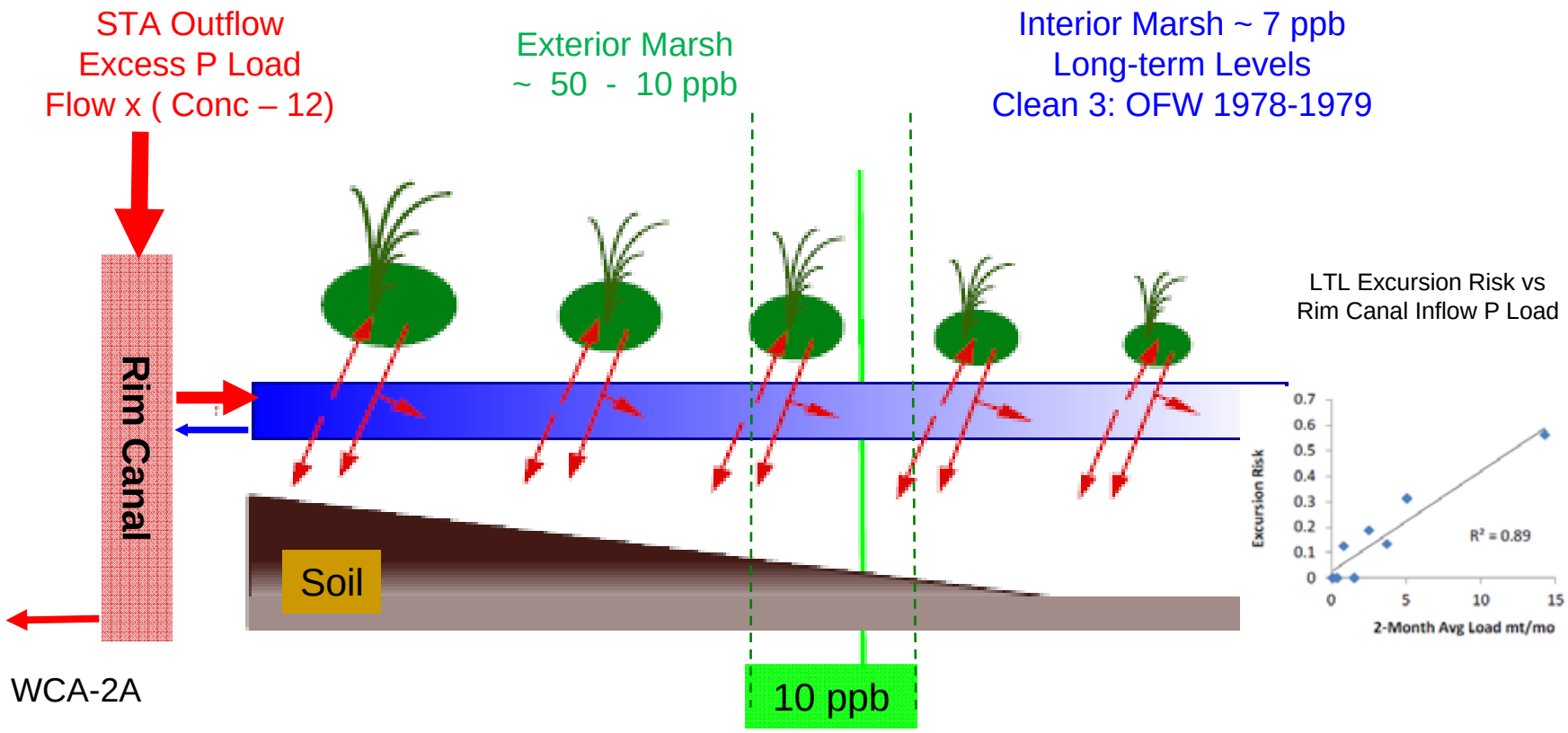
2015 + ?
Everglades Marsh
< 10 ppb
“Balanced”





TOC

Phosphorus Gradient in Refuge Marsh



16 - 9 ppb
Range of Ecological Response
Cattails – Invertebrates – Oxygen – Periphyton

Modified from WWW Rebuttal Exhibit 2309 & Figure 4

4-Part Test for Class III, Refuge Impacted Sites, 2006-2010

Area	Criterion Network	Water Year	Site	Sample Size (n)	Annual Site Geomean	≤15 Pass/ Fail	Network Annual Average Geomean	≤11 Pass/ Fail	Network Five-Year Average Geomean	≤10 Pass/ Fail
Refuge	Impacted	2006	LOXA101	8	14.5	Pass				
	Impacted	2006	LOXA105	8	15.5	Pass				
	Impacted	2006	LOXA124	11	10.6	Pass				
	Impacted	2006	LOXA130	11	14.8	Pass				
	Impacted	2006	LOXA137	12	13.6	Pass				
	Impacted	2006	LOXA140	9	11.8	Pass				
	Impacted	2006	X1	10	31.2	Fail				
	Impacted	2006	Z1	12	19.6	Fail				
	Impacted	**2006**	**Annual Network Average**				**16.5**	**Fail**		
	Impacted	2007	LOXA101	3	N/A (7.6)	N/A				
	Impacted	2007	LOXA105	2	N/A (14.7)	N/A				
	Impacted	2007	LOXA124	4	N/A (9.8)	N/A				
	Impacted	2007	LOXA130	4	N/A (8.7)	N/A				
	Impacted	2007	LOXA137	4	N/A (7.6)	N/A				
	Impacted	2007	LOXA140	2	N/A (7)	N/A				
	Impacted	2007	X1	7	31.8	Fail				
	Impacted	2007	Z1	9	35.9	Fail				
	Impacted	**2007**	**Annual Network Average**				**33.9**	**Fail**		
	Impacted	2008	LOXA101	9	14.0	Pass				
	Impacted	2008	LOXA105	9	14.9	Pass				
	Impacted	2008	LOXA124	10	13.0	Pass				
	Impacted	2008	LOXA130	11	11.1	Pass				
	Impacted	2008	LOXA137	11	9.4	Pass				
	Impacted	2008	LOXA140	8	7.8	Pass				
	Impacted	2008	X1	7	56.5	Fail				
	Impacted	2008	Z1	7	62.1	Fail				
	Impacted	**2008**	**Annual Network Average**				**23.6**	**Fail**		
	Impacted	2009	LOXA101	8	9.6	Pass				
	Impacted	2009	LOXA105	9	11.5	Pass				
	Impacted	2009	LOXA124	9	13.0	Pass				
	Impacted	2009	LOXA130	10	9.7	Pass				
	Impacted	2009	LOXA137	9	9.7	Pass				
	Impacted	2009	LOXA140	8	8.4	Pass				
	Impacted	2009	X1	10	61.0	Fail				
	Impacted	2009	Z1	12	27.8	Fail				
	Impacted	**2009**	**Annual Network Average**				**18.8**	**Fail**		
	Impacted	2010	LOXA101	11	13.0	Pass				
	Impacted	2010	LOXA105	11	12.1	Pass				
	Impacted	2010	LOXA124	11	12.5	Pass				
	Impacted	2010	LOXA130	11	10.3	Pass				
	Impacted	2010	LOXA137	11	10.7	Pass				
	Impacted	2010	LOXA140	11	10.8	Pass				
	Impacted	2010	X1	11	35.2	Fail				
	Impacted	2010	Z1	11	24.7	Fail				
	Impacted	**2010**	**Annual Network Average**				**16.1**	**Fail**		
	Impacted	**2006–2010**	**Five-Year Network Average**						**19.7**	**Fail**

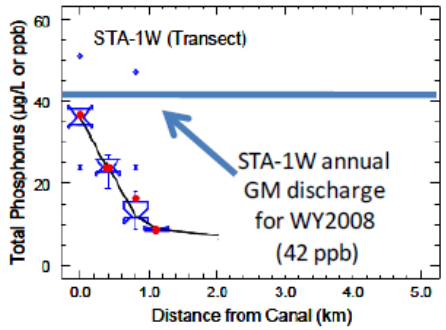
Site Yr > 15 ppb Spatial 1 Yr > 11 ppb Spatial 5 Yr > 10 ppb

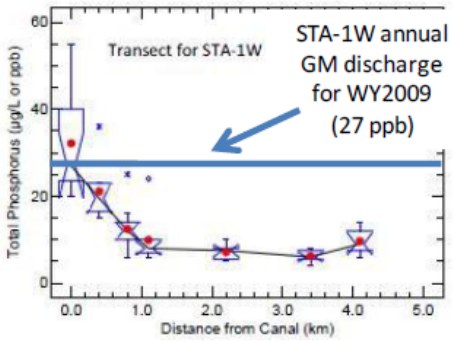
SFER, 2011

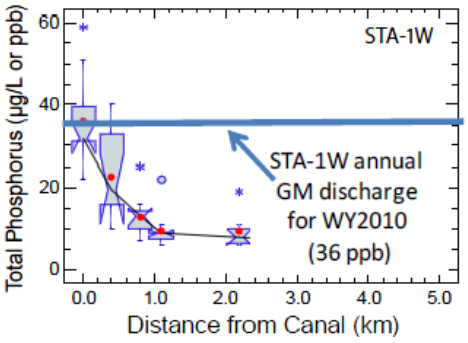
Figure 5-7. Locations of marsh transect stations in the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) and outflow structures from STA-1W and STA-1E.

Marsh P Gradient vs. STA Outflow P
Geometric Means, WY 2008-2010, SFER 2011
Rim Canal P ~ STA Outflow P : No Discontinuity in Gradient

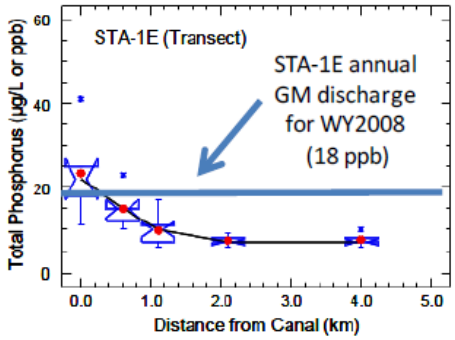
STA-1W

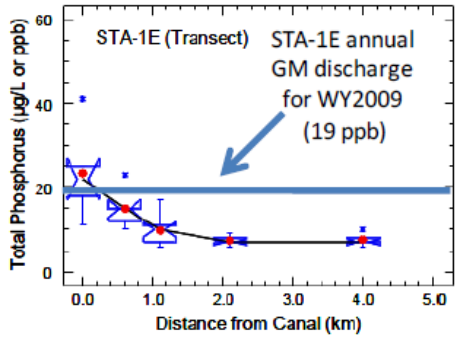


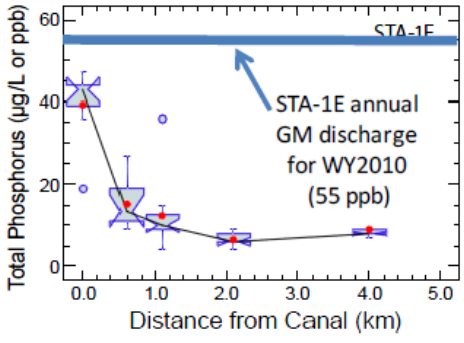


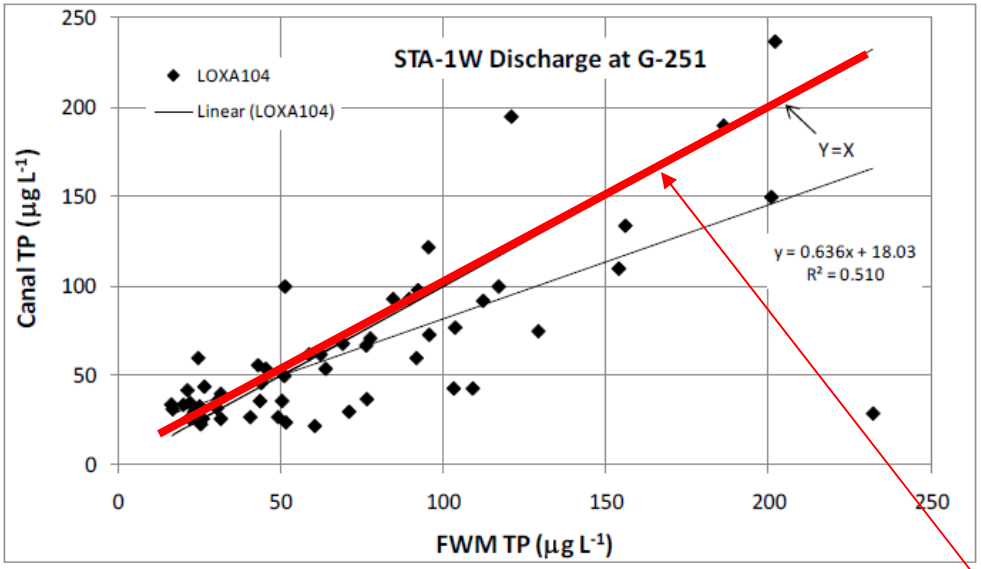


STA-1E









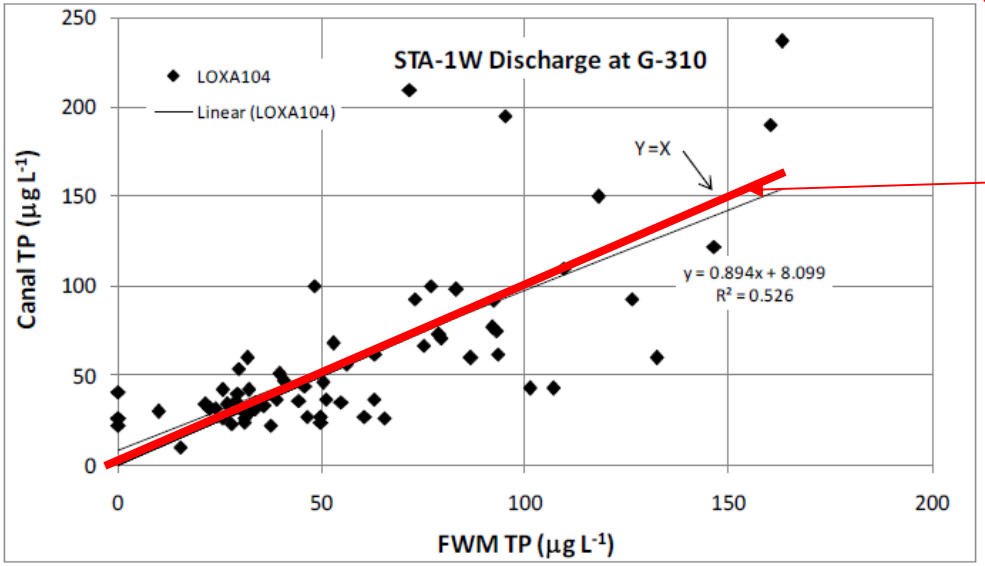


Figure 4. Relationship between STA-1W flow-weighted mean total phosphorus (FWM TP) discharges (top: G-251; bottom: G-310) plotted against canal TP concentrations at station LOXA104. Data from DBHydro. [U.S. Exh. 2276]

Rim Canal P Conc. vs. STA-1W Outflow P Conc.

LOXA 104 Rim Grabs Paired with 30-Day STA-1W Outflow FWMs (G251 & G310)

Rim Canal P ~ Inflow P

Evolution of WQBEL Estimates, 1996 - 2010				LTGM = 10 ppb		
Report	Annual Limit ppb	Multi-Year Limit	Percentile	LTFWM	Ln Std Dev	STA-Yrs
Walker, 1996 - 50 ppb Discharge Permits	76	< 3 Consec Yrs FWM > 50	90%	50	0.35	234 *
Walker, 1996 - Rescaled to 12 ppb	18	< 3 Consec Yrs FWM > 12	90%	12	0.35	234 *
FDEP, 2005	15.1 - 15.5	-	90%	10.9 - 11.2	0.27	27
Walker, 2005	15.1 - 16.0	-	90%	11.8	0.26	24
FDEP, 2008	16.6 - 18.3	-	90%	10.8 - 11.9	0.38	45
FDEP, 2010	17.2 - 19.1	-	90%	11.1 - 12.2	0.41	51
USEPA, 2010	18	< 3 Consec Yrs GM > 10	90%	12.0 - 12.3	0.33	50
Ericanin/SFWMD, 2010	19	5-Yr GM < 10	90%			50
Ericanin/SFWMD, 2010	21	5-Yr GM < 10	95%			45

* calibrated to data from EAA Pump stations and WCA Outflows

Replay 1996 Derivation of STA Discharge Permit Limits

76 ppb FWM Limit / 50 ppb Goal = WQBEL 18 Limit / 12 ppb Goal = 15 ppb Marsh Limit / 10 ppb Marsh Criterion = 1.5

Test for Evaluating Performance of Stormwater Treatment Areas

prepared for

U.S. Department of Interior

by

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Environmental Engineer
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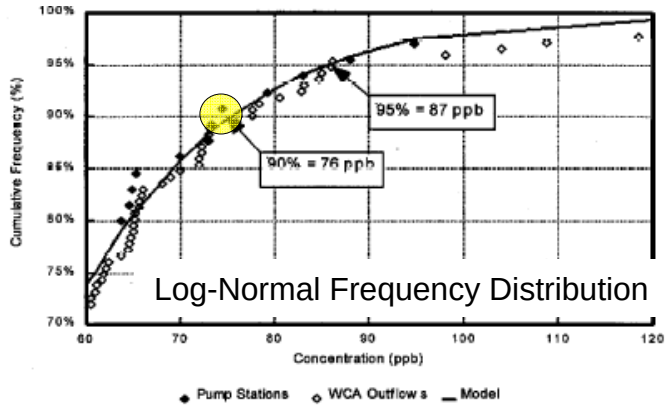
January 3, 1996



Log-Normal Frequency Distribution

Yearly Flow-Weighted-Mean Total Phosphorus Concentrations
Rescaled to Long-term Flow-Weighted Mean of 50 ppb

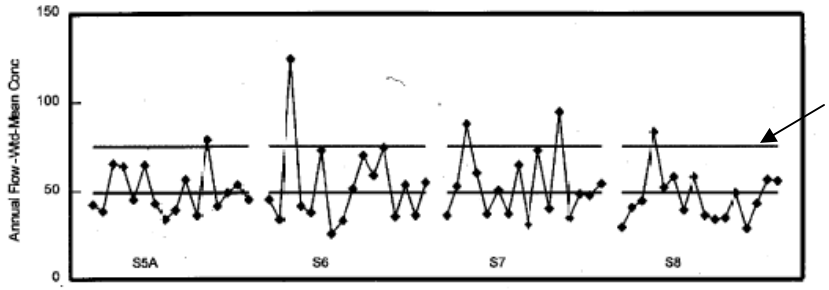
EAA Pump Stations (S5A, S6, S7, S8)	StationYrs	64
WCA Outflow Stations (S12's, S333, S11's, S10's)	StationYrs	170

Model = Lognormal Frequency Distribution

m = 3.871 s = 0.349

90th Pctl 76 95th Pctl 87

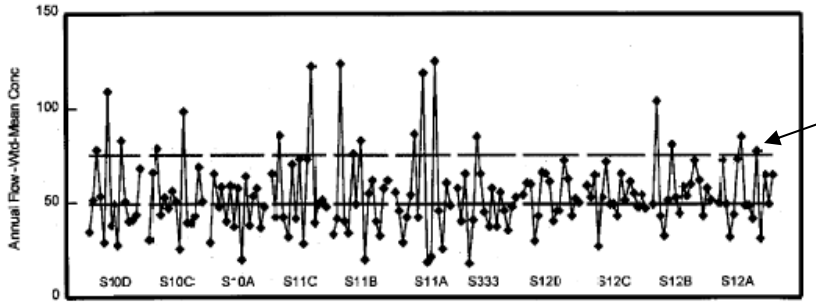
EAA Pump Data (64 Station-Yrs)



76 / 18

50 / 12

WCA Outflow Data (170 Station-Yrs)



76 / 18

50 / 12

Extracted from US Exhibit 1272

WQBEL Derivation, FDEP 2010
Annual FWM Limit = 18 ppb

Technical Support Document:

Derivation of the Water Quality Based Effluent Limit for Total Phosphorus in Discharges to the Everglades Protection Area

Prepared by:

Garry Payne, Kenneth Weaver, Frank Nearhoof, and Katie Hallas
Florida Department of Environmental Protection
Division of Environmental Assessment and Restoration

May 3, 2010

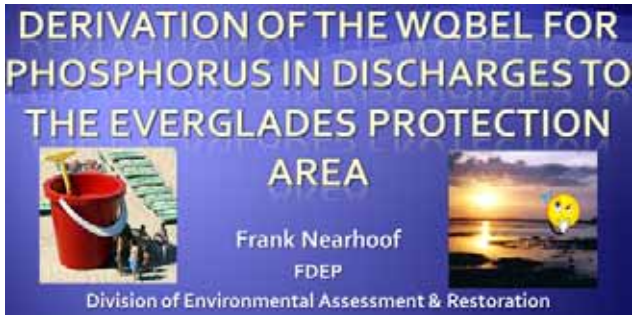


Table 3. Derivation of WQBEL for TP in discharges to the EPA.

Parameter	Rescaled Based on Average Annual GM	Rescaled Based on Period of Record GM
FWM Concentration (ppb)	11.0	12.2
Ln of FWM (Ln ppb)	2.319	2.420
Significance Level	0.10	0.10
Standard Deviation of LnTP	0.405	0.405
Site Years (N)	51	51
k (sites)	7	7
Df (N – k)	44	44
One-Tailed t	1.301	1.301
90% Rejection Limit (ppb): WQBEL as maximum annual FWM TP concentration	17.2	19.1

"All estimates of the WQBEL for TP in discharges to the EPA derived using multiple methods are very similar ranging from 15.1 ppb to 19.2 ppb. Therefore, based on the weight of evidence, including the Department's analysis of the existing data for the STAs rescaled based on the pooled geometric mean (a more extensive version of Walker's analysis), a TP WQBEL of 18 ppb expressed as a maximum annual FWM is recommended for incorporation into the permits for all discharges to the EPA to assure that the discharges do not cause or contribute to exceedances of the TP criterion in the downstream marsh receiving waters."

Technical Support Document
Derivation of the Water Quality Based Effluent Limit (WQBEL) for Phosphorus in Discharges to the Everglades Protection Area

United States Environmental Protection Agency
August 24, 2010

This report documents the United States Environmental Protection Agency's (USEPA) derivation of the Water Quality Based Effluent Limit (WQBEL) to be applied in National Pollutant Discharge Elimination System (NPDES) permits for discharges from the Stormwater Treatment Areas (STAs) into the Everglades Protection Area (EPA). The WQBEL is calculated to protect the designated use[1] of the Everglades by ensuring the State of Florida water quality criterion for total phosphorus of 10 parts per billion (ppb) as a long-term geometric mean is not exceeded in the receiving waters of the Everglades.

The WQBEL for STAs 1E, 1W, 2, 3/4, 5, 6, and other future STAs, has two components, both of which must be met. TP concentrations in the discharge from each STA may not exceed either:

Part 1: 10 ppb as an annual geometric mean in more than two consecutive years; or
Part 2: 18 ppb as an annual flow-weighted mean

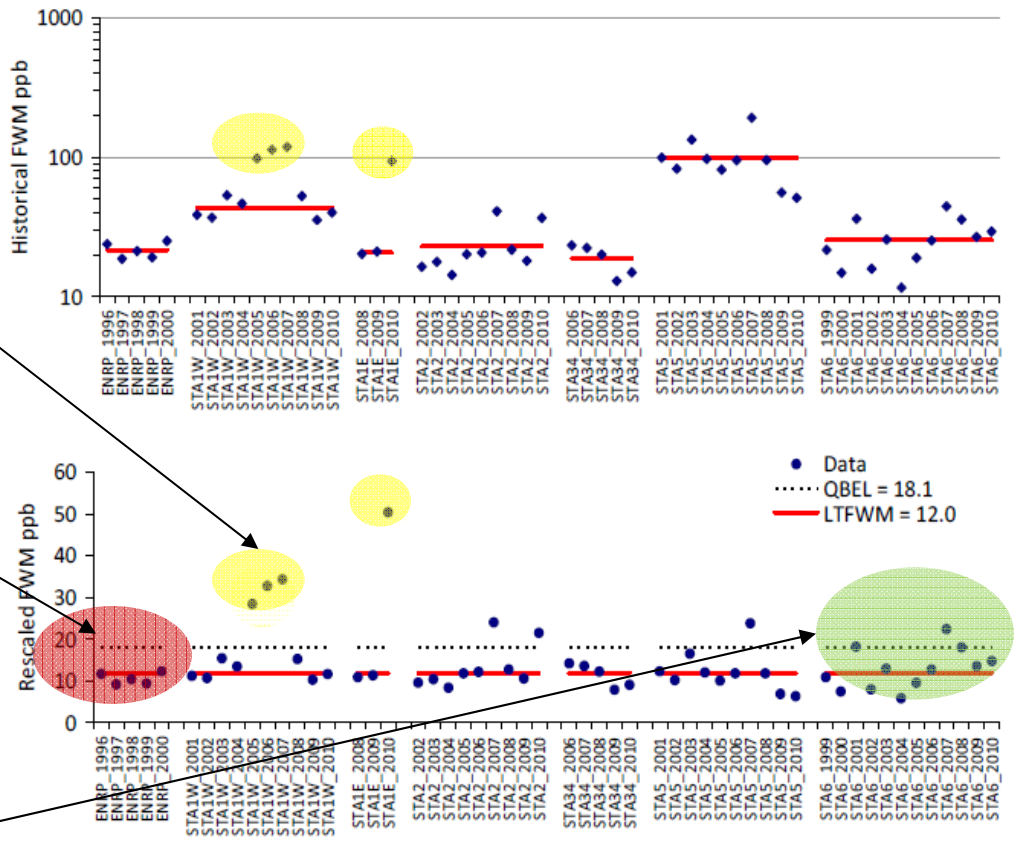
Both parts of the WQBEL are necessary to assure that the long-term criterion of 10 ppb is met at each STA. The background and statistical approach for derivation of each WQBEL component is described below.

Including data from damaged STA 1W & E in the WQBEL calibration would inflate the limit and weaken the test (make it less protective of the marsh). Discharge limits may not be applicable in those situations,depending upon permit language.

ENR inflows were less variable than STA inflows, but flow is not the only factor driving variability in STA performance. The AD design objective is to stabilize flows. Including ENR in the EPA and FDEP derivations is justified.

High Variability in STA-6 reflects dry-out, expansion, change in water source in 2007-2010; i.e. unstable operation;
AD alternatives designed to minimize Dry-out and stabilize inflows. Including the >2006 data for STA-6 in the EPA and FDEP dataset inflates the annual limit.

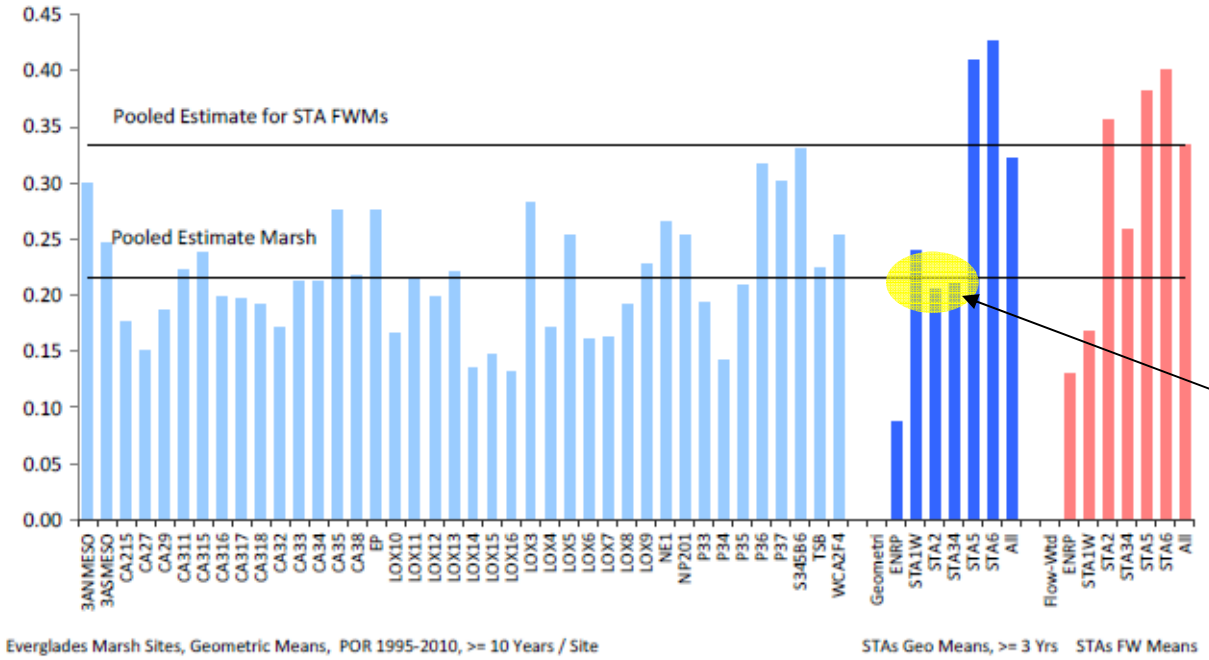
Figure 4. Period of record annual flow-weighted mean TP concentration for each STA.



Top: Annual flow-weighted means. Red bars are the long-term FWM mean for each STA.

Bottom: Annual FWMs rescaled so that each STA discharge has a long-term flow-weighted mean of 12 ppb, which is equivalent to a geometric mean of 10 ppb. Data outliers that were excluded from the WQBEL derivation because they do not represent STAs in stable operation include STA-1W in WY 2005-2007 (overloading, hurricane damage, and repair) and STA-1E in WY 2010 (vegetation loss and deterioration in performance due to construction problems resulting in excessive water depths).

Figure 6. Year-to-Year Variability in Marsh and STA Discharge Concentrations

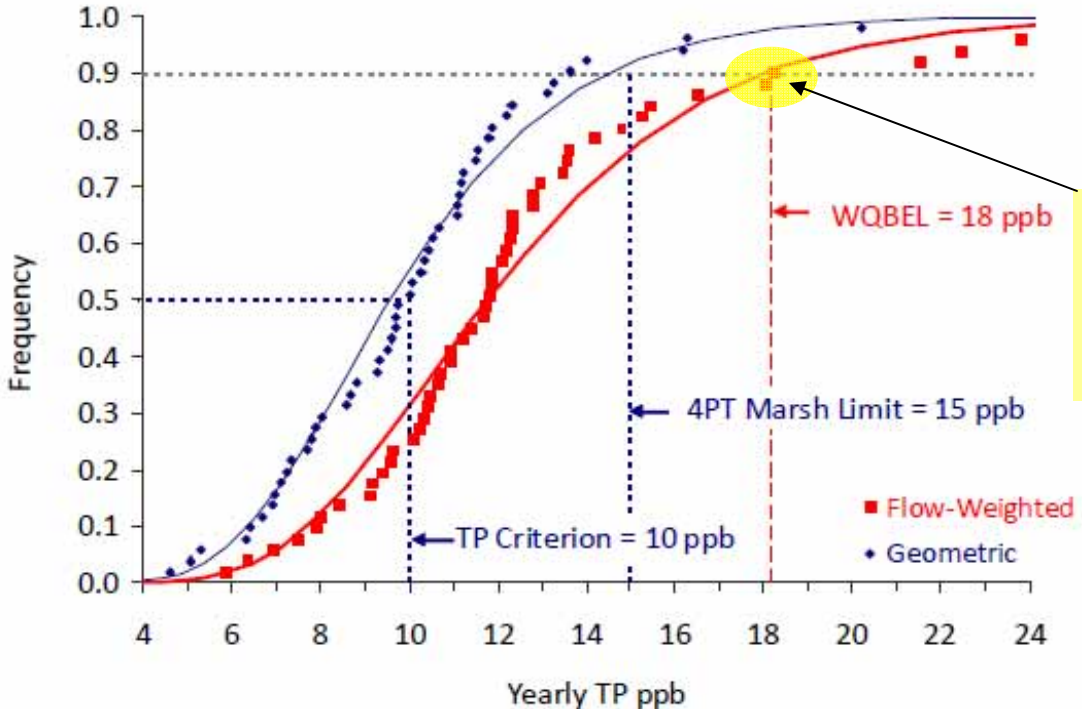


Variability Calibrated to All STAs & ENRP Used in Deriving the 18 ppb WQBEL Limit

Variability in the Best-Performing STAs (2 & 34) is similar to that of the marsh and closest that expected for STA discharges in compliance with the Criterion.

Year-to-year standard deviations in log-transformed TP concentrations. The y-axis is the natural logarithm of the standard deviation. Light blue bars represent marsh sites with at least 10 years of data. Geometric means (dark blue bars) and flow-weighted means (red bars) are shown at STA outflows with at least three years of data.

Figure 5. Frequency Distributions of Annual Geometric and Flow-Weighted Means for STA Discharges in Compliance with the P Criterion.



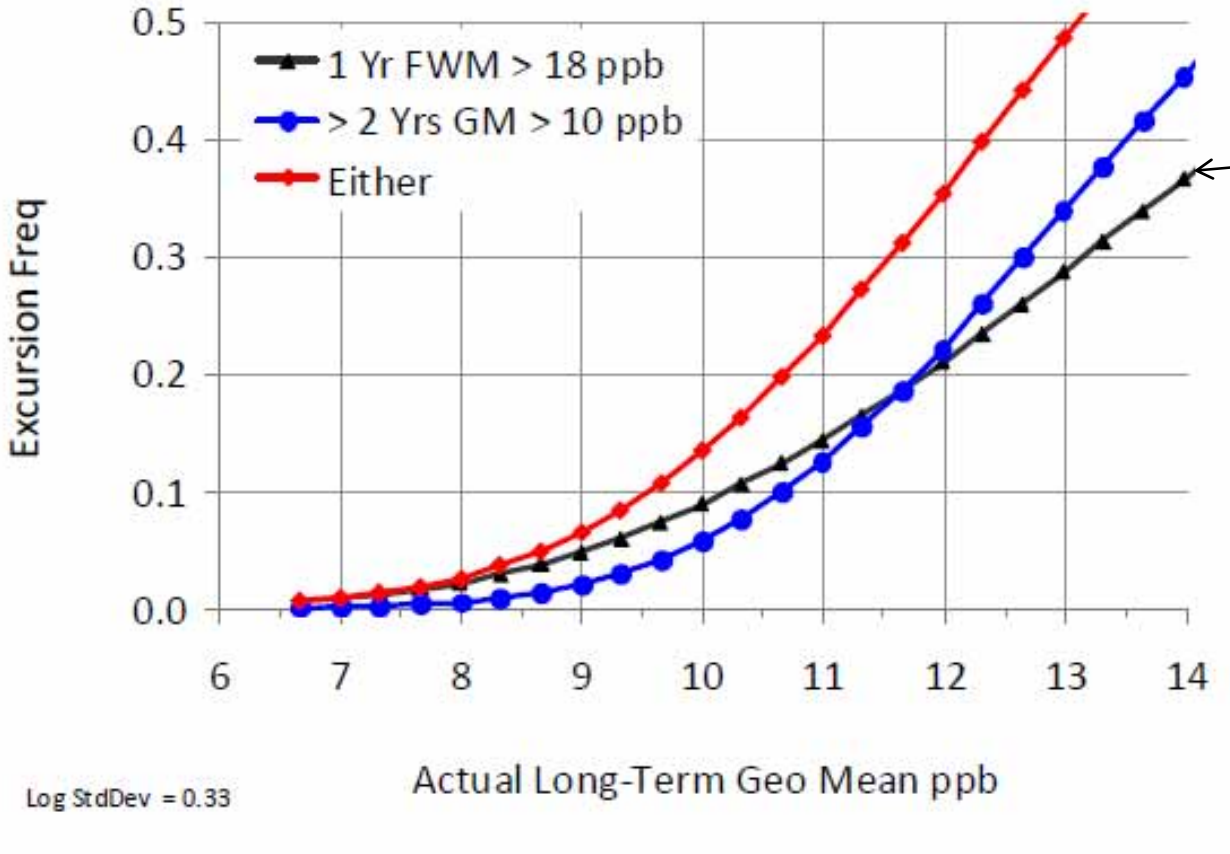
The 18 ppb Yearly Limit is Independent of the log-normal distribution assumption; i.e. the data points and line intersect at the 90th percentile.

Variations in annual FWMs (red) and GMs (blue) expected if the discharge had a long-term GM of 10 ppb or the equivalent long-term FWM of 12 ppb (12.0, Standard Error = 0.5 ppb). The difference between the distributions reflects the fact that at STA discharges FWMs are on average 23% higher than the GMs of STA Discharges (Figure 2). The solid line represents the statistical fit of rescaled STA data (log-normal distribution).

The 18 ppb WQBEL to be met each year is found at the intersection of the FWM distribution with the 90th percentile (18.2 with an estimated uncertainty of +/- 0.5 ppb).

The distribution of geometric means is similar to the distribution at marsh sites used to derive the phosphorus criterion. The vertical blue line indicates the 90th percentile of the GM, which is the 15 ppb annual limit for compliance with the phosphorus criterion at marsh sites.

Excursion Frequency vs. Marsh LTGM
For USEPA 2-Part WQBEL & FDEP 1-Part WQBEL
STA Variance, Monte-Carlo Simulation, 50,000 years



USEPA- Both Parts

USEPA Part 1
> 2 yrs GM > 10 ppb

FDEP & EPA(2)
1 Yr FWM > 18 ppb

The FDEP 1-Part WQBEL has high Type II Error (i.e. risk of not detecting a problem in the marsh). Would allow LTGM to exceed 10 ppb while meeting the annual limit.

Modified from USEPA – Amended Determination – Attachment G – Figure 9

Marsh Reference Sites Rescaled to LTGM = 10 ppb
vs. EPA & SFWMD Proposed Annual Limits

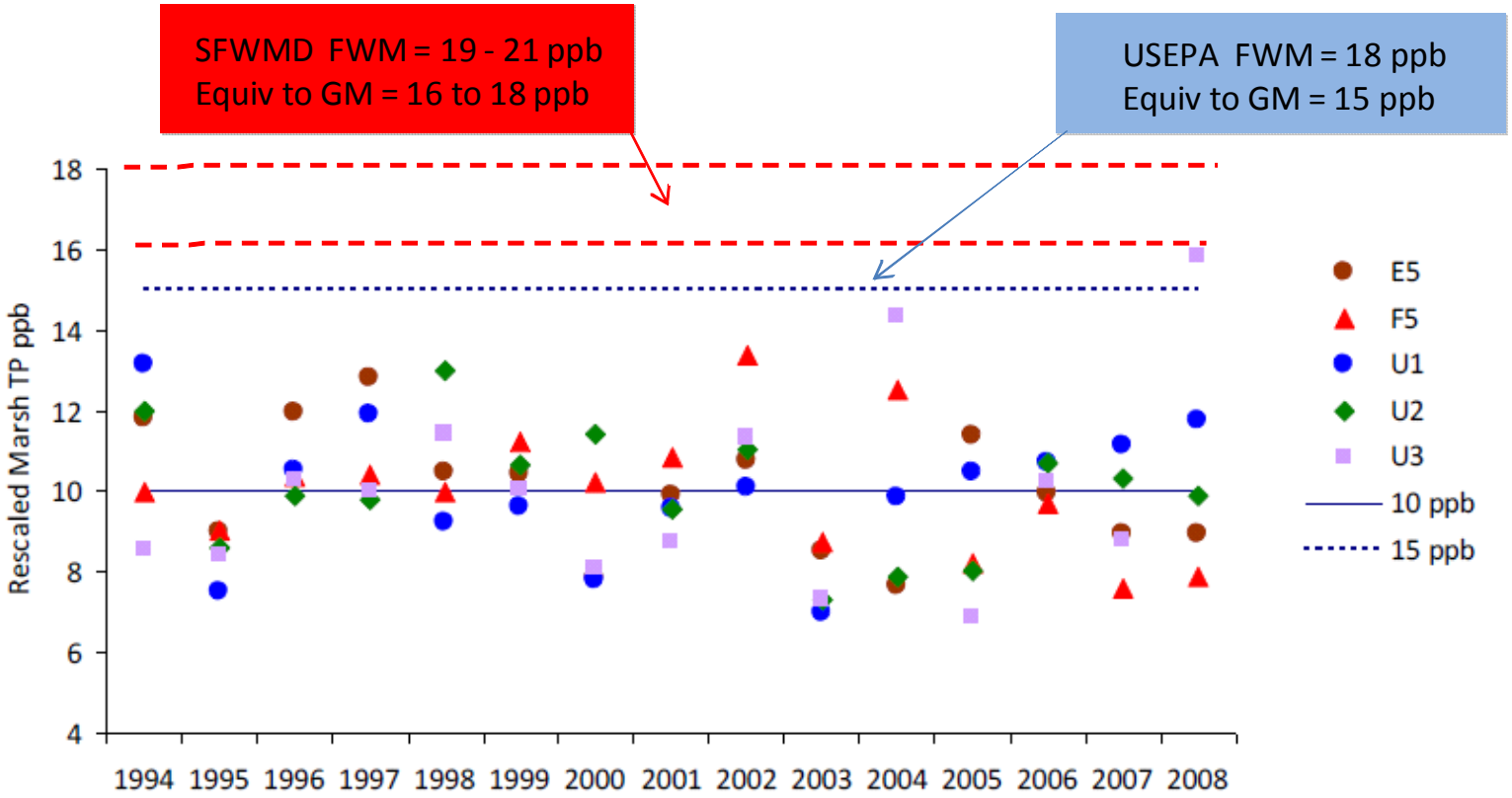
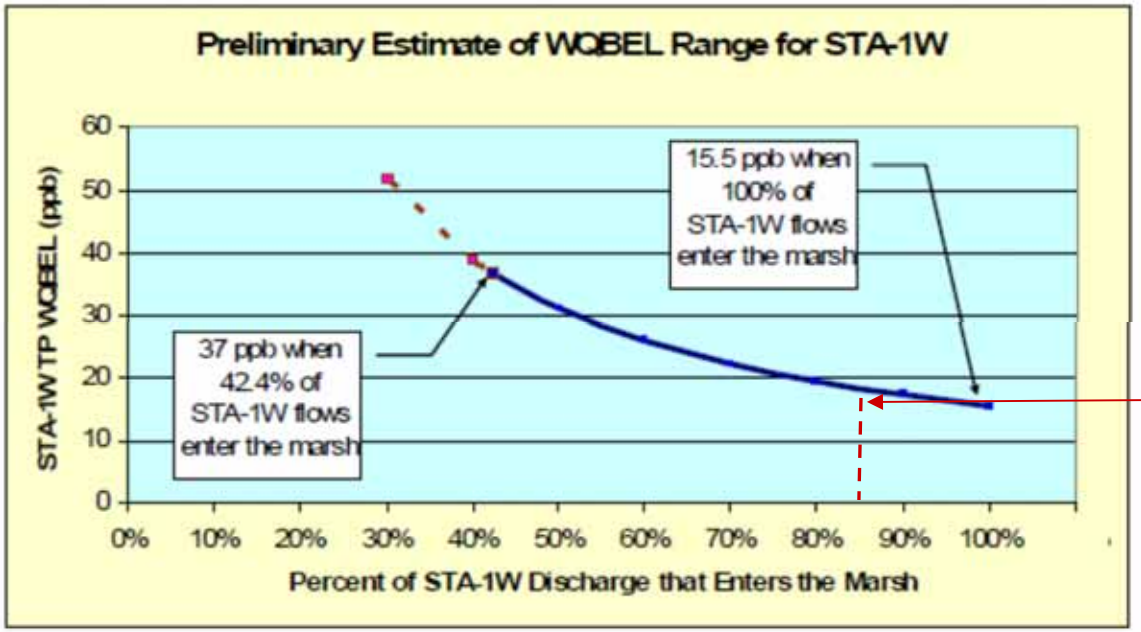


Figure 1. Marsh data at five remote marsh reference sites rescaled to the long-term criterion of 10 ppb. Annual geometric means vary above and below 10 ppb while still attaining the long-term criterion. [Adapted from WQBEL TSD, U. S. Exhibit 1220 at 2][U.S. Exhibit 1284].

DRAFT - PRELIMINARY ESTIMATE OF THE UPPER END OF THE WATER QUALITY BASED EFFLUENT LIMIT FOR WATER CONSERVATION AREA 1

Gary Goforth
Prepared for the South Florida Water Management District
August 27, 2006



EPA Limit 18 ppb

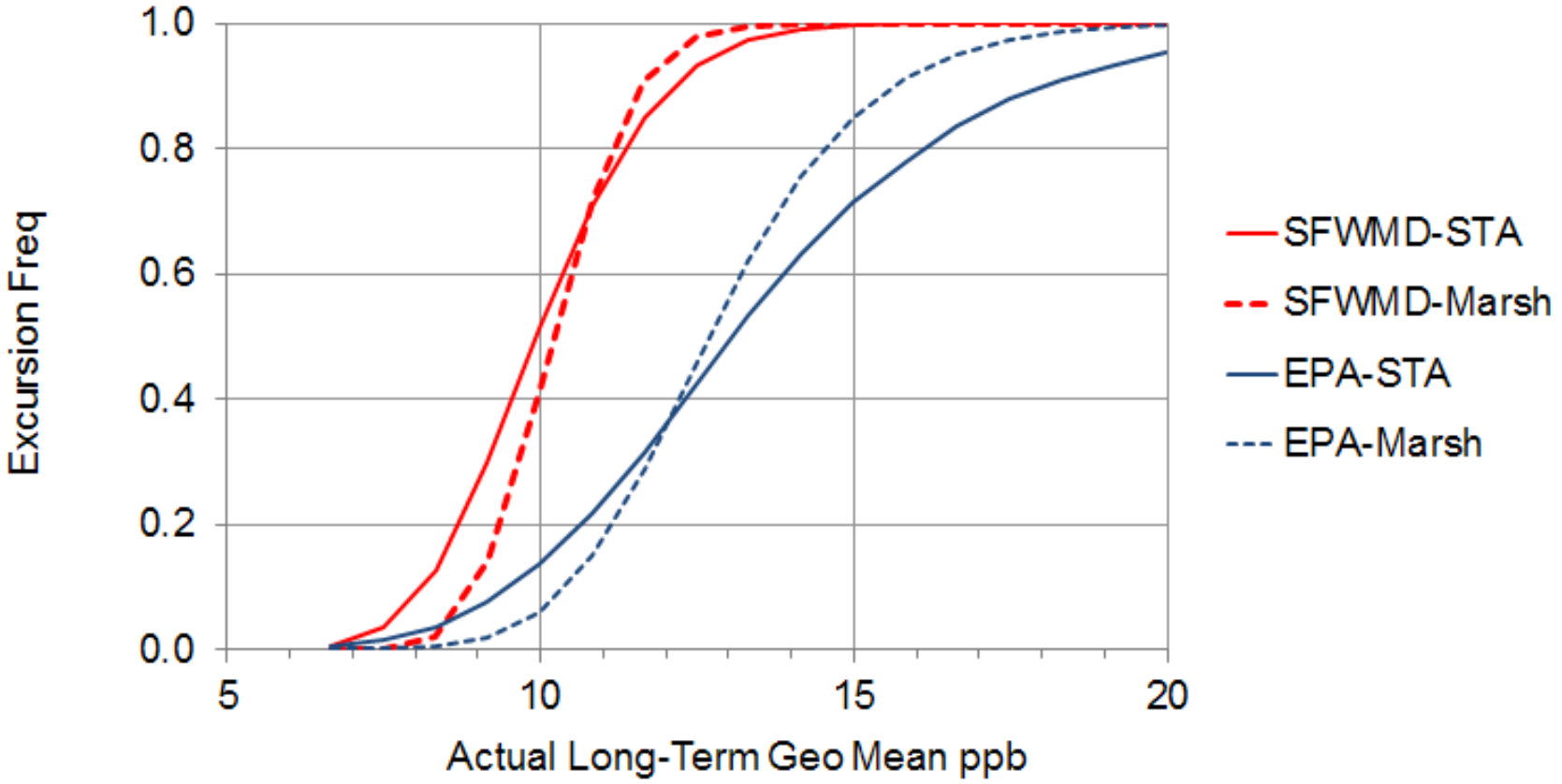
*At the present time, insufficient information is available to fully predict and evaluate the impact of the continued discharge on the water quality of the receiving water body (WCA-1).These impacts will vary depending on season, stage in WCA-1, stage in the rim canals, velocity and phosphorus assimilation in the rim canals, water and phosphorus exchange between the rim canals and the interior of WCA-1, volumes of discharge from the STAs, and discharges from WCA-1 outlet structures. As a result of the inability to fully predict and evaluate the impact of the continued discharge on the water quality of the receiving waterbody, insufficient information exists to determine the applicable range of phosphorus loadings that will not cause or contribute to violations in the phosphorus water quality standard. Hence, neither the process required by the State of Florida Chapter 62-650 Water Quality Based Effluent Limitations (WQBEL) for the renewal of an existing operation permit, nor that required by the Everglades Forever Act can be completed at this time. In the interim until the appropriate water quality study is completed, a preliminary estimate of the range of values for the WQBEL for WCA-1 has been derived. The Florida Department of Environmental Protection derived a preliminary estimate of **15.5 ppb** as the lower end of the range, and this paper presents two independent methods supporting a preliminary estimate of **37 ppb** as the upper end of the range. It is proposed that the range can be defined by the percentage of STA-1W discharge that actually enters the marsh, as depicted in the figure below.*

DISTRICT'S POST-HEARING MEMORANDUM REGARDING THE CLASS III PHOSPHORUS DISCHARGE LIMIT

If the Court concludes there is a sufficient technical basis by which the Water Quality Based Effluent Limit ("WQBEL") may be derived, however, the record establishes that it should be a two-part WQBEL comprised on an annual maximum limit between 19 ppb (if one were only to exclude the ENR data) to 21 ppb (if one were to use a 95th percentile or include all STA performance data), and a five year geometric mean of 10 ppb. *See generally*, SFWMD Exhibit 1042.1 Rebuttal Report of Iricanin at ¶¶16, 23, 26 and 33.

Excursion Frequency vs. Marsh LTGM TP Conc.
SFWMD vs. USEPA Proposed WQBELs
Sensitivity to Assumed Year-to-Year Variability

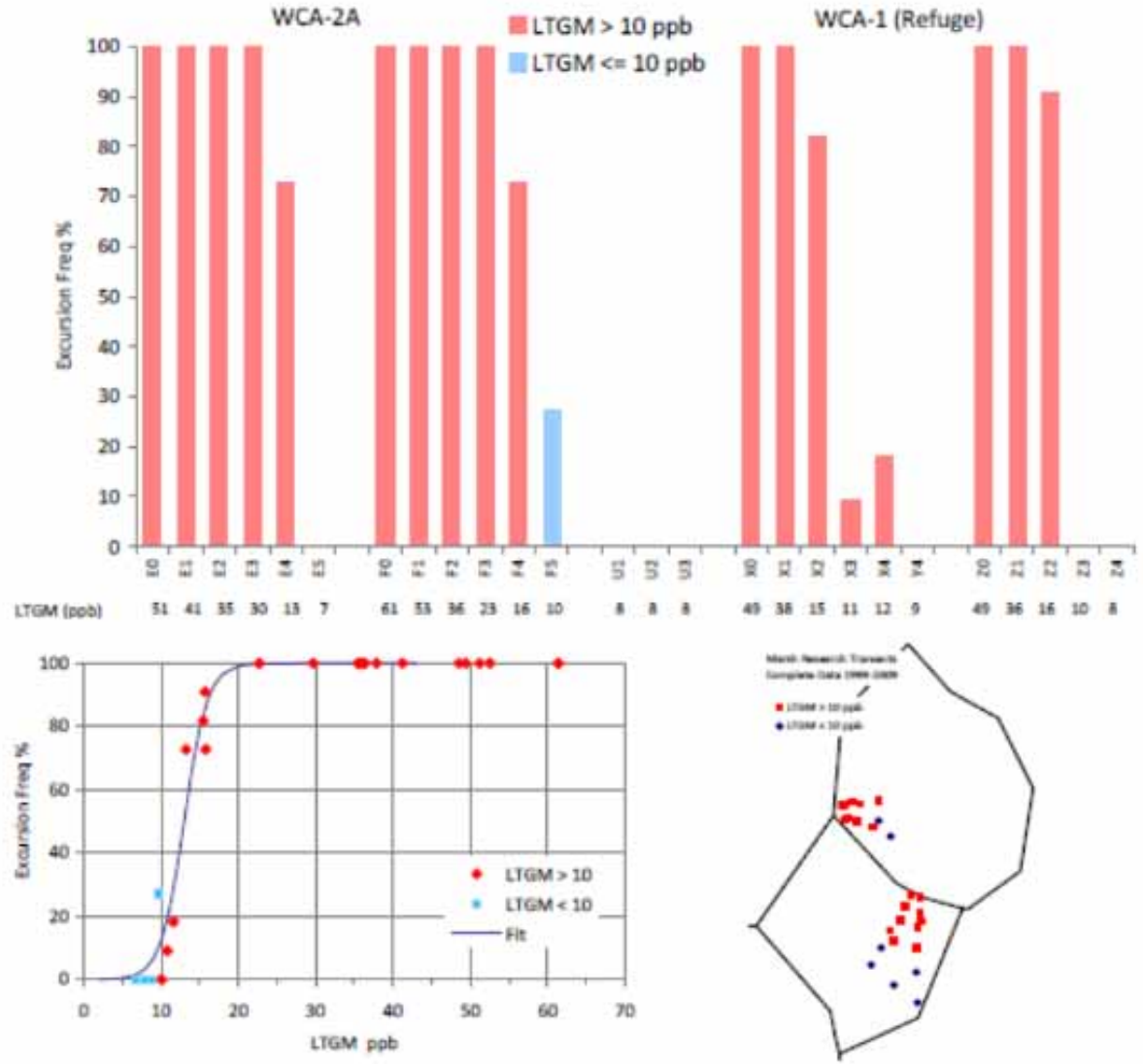
The SFWMD Proposed WQBEL is much more stringent than the USEPA Proposed WQBEL



SFWMD WQBEL: 1-Year FWM Limit = 20 ppb, 5-Year GM Limit = 10 ppb

USEPA WQBEL : 1-Year FWM Limit = 18 ppb, Maximum 2 Consecutive Years with GM > 10 ppb.

EPA WQBEL Applied to Data from Research Transects in WCA-1 & WCA-2A 1999-2009



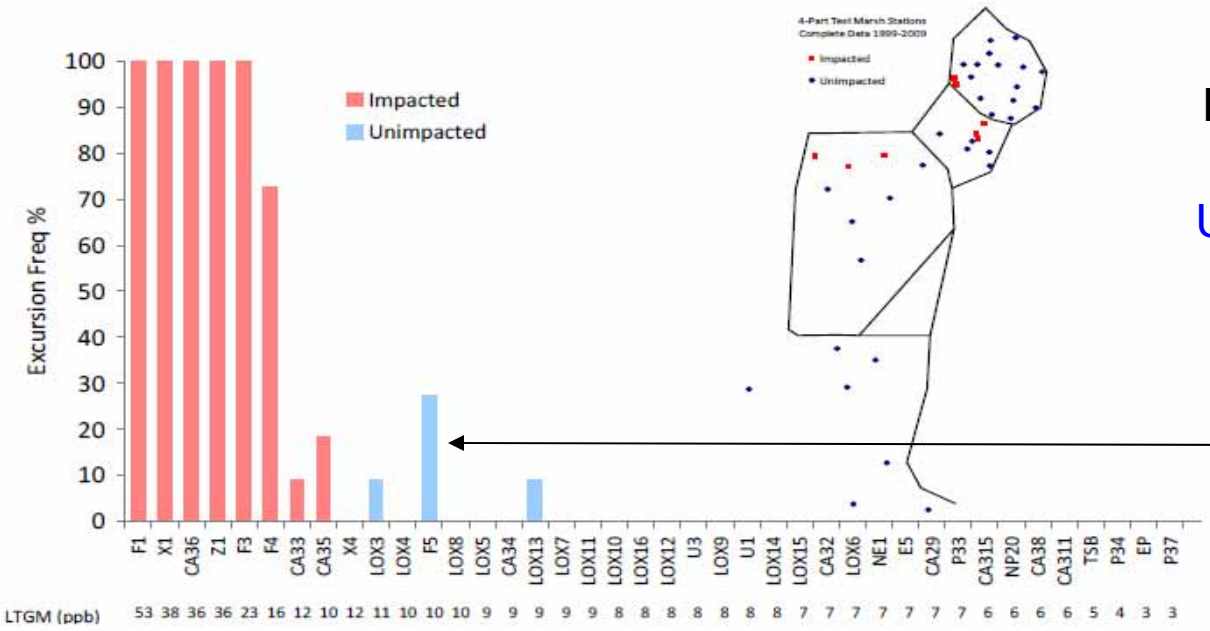
Period of Record: WY 1999-2009; Long-Term Sites with Data for Each Year; Transects Extend from Rim Canal into Interior Marsh.
15 ppb GM Annual Limit Used As Surrogate for WQBEL Part 2 - 18 ppb FWM Limit
Excursion Frequencies For Both WQBEL Parts Combined; X-axis Numbers = Long-Term Geometric Mean (ppb)
Sites sorted along separate transects in WCA-2A (E, F) and WCA-1 (X, Z)
Each transect Extend from Rim Canal into Interior Marsh. Data from SFWMD Research.
Red bars & symbols: LTGM > 10 ppb; Blue: LTGM <= 10 ppb; Sites without Bars have 0% Excursion Frequency.
Bottom Plots Excursion Frequencies Against the LTGM for Sites in Each Category.
The WQBEL successfully differentiates between sites above and below the 10 pbp Criterion along each transect.

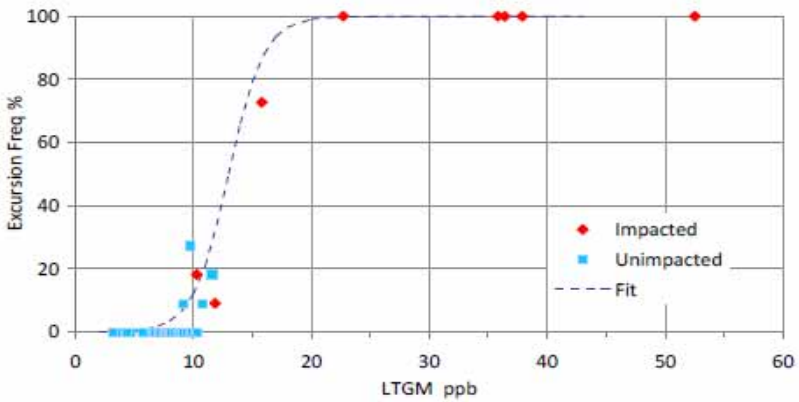
The USEPA WQBEL successfully differentiates research transect sites with LTGMs above & below 10 ppb based upon 11 years of data

LTGM > 10 ppb

LTGM < 10 ppb

EPA WQBEL Applied to Data from Impacted & Unimpacted Marsh Sites in Class III Network 1999-2009





Excursions at Unimpacted Sites (Type I Error) can be explained based upon trends in the data & hurricane disturbance

The USEPA WQBEL successfully differentiates Impacted from Unimpacted Sites in the Class III Network, originally identified based upon soil P concentration

Period of Record: WY 1999-2009; Long-Term Marsh Sites with Data for Each Year

15 ppb GM Annual Limit Used As Surrogate for WQBEL Part 2 - 18 ppb FWM Limit

Excursion Frequencies For Both WQBEL Parts Combined; X-axis Numbers = Long-Term Geometric Mean (ppb)

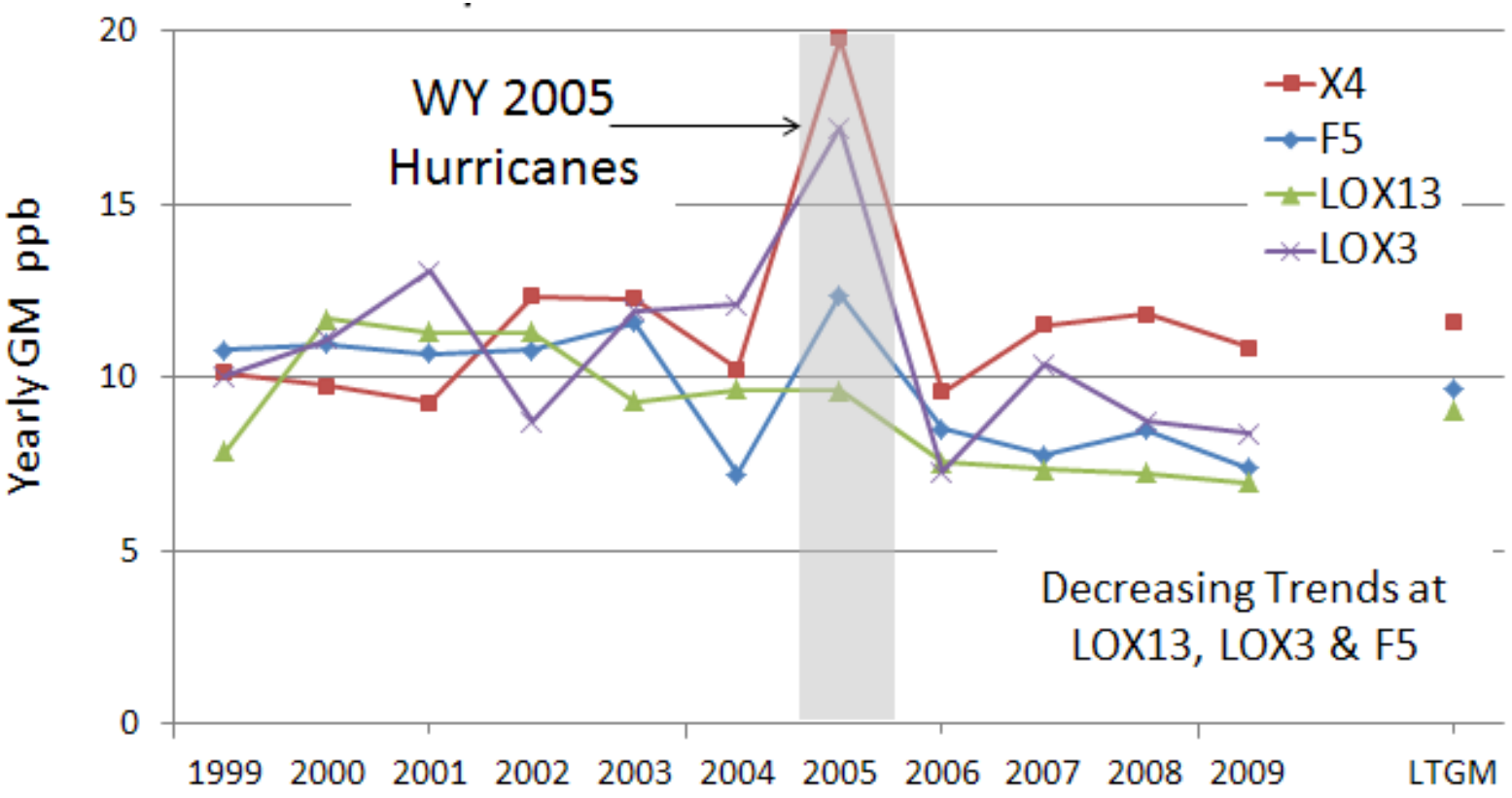
Sites sorted in order of decreasing LTGM concentrations within each category (Impacted = Red, Unimpacted = Blue)

Sites without bars have zero percent excursion rates (unimpacted). Data from SFWMD DBHYDRO databas.

Bottom Plots Excursion Frequencies Against the LTGM for Sites in Each Category.

The WQBEL successfully differentiates between the impacted and unimpacted marsh sites.

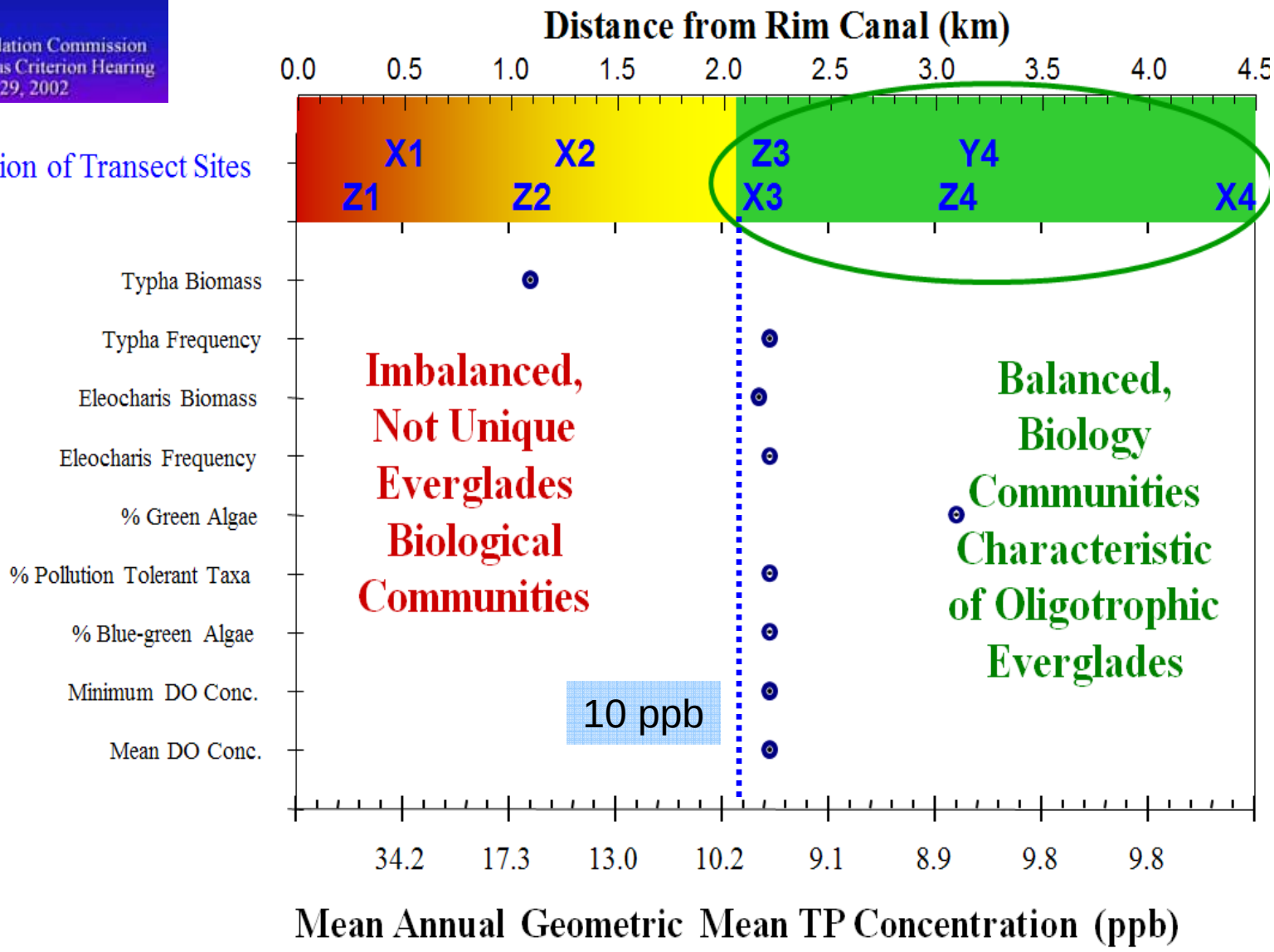
Excursions at Un-Impacted Sites (Type I Error) can be explained based upon trends in the data & hurricane disturbance



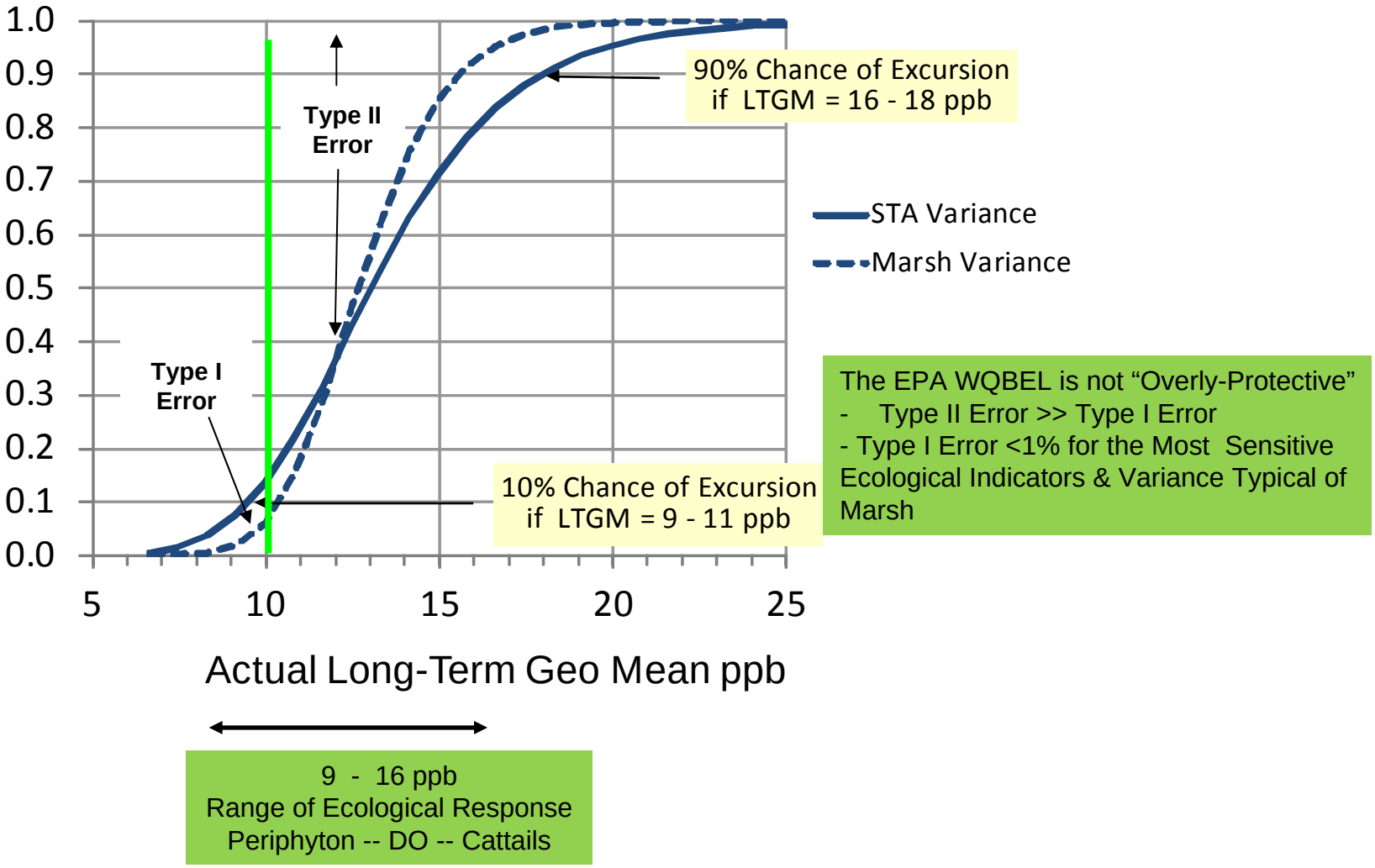
Criterion Derivation and Development of Measurement Methodology

Environmental Regulation Commission
Everglades Phosphorus Criterion Hearing
August 28-29, 2002

Imbalance in Refuge: Nearhoof, FDEP, 2002

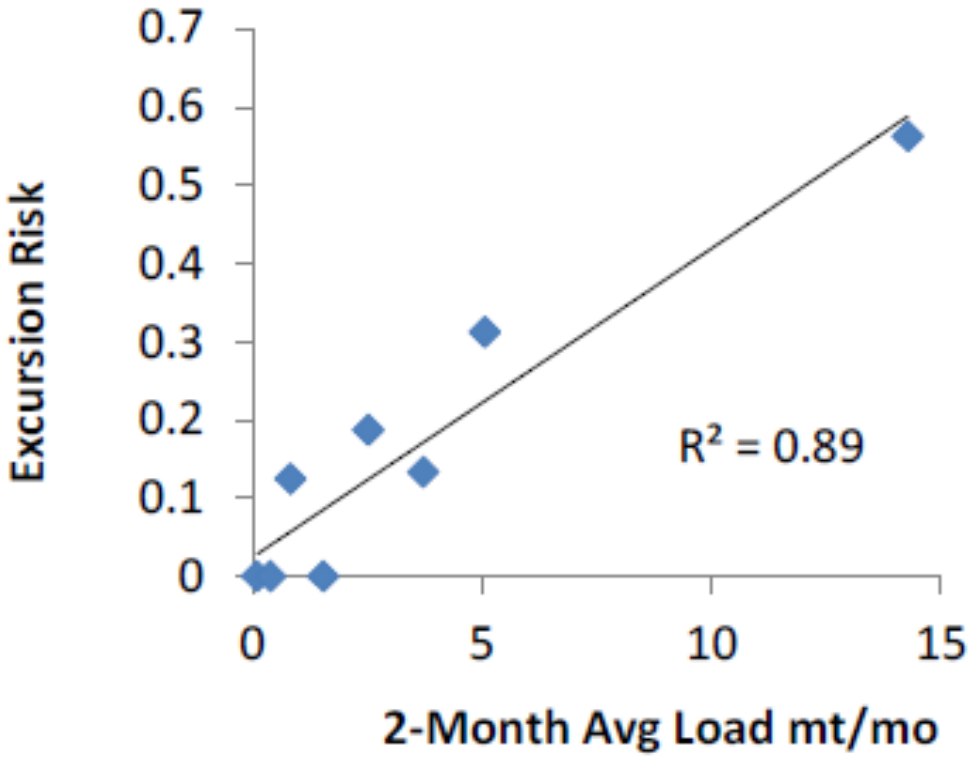


Excursion Frequencies for USEPA 2-Part WQBEL Sensitivity to Variance Estimates



Modified from USEPA – Amended Determination – Attachment G – Figure 9

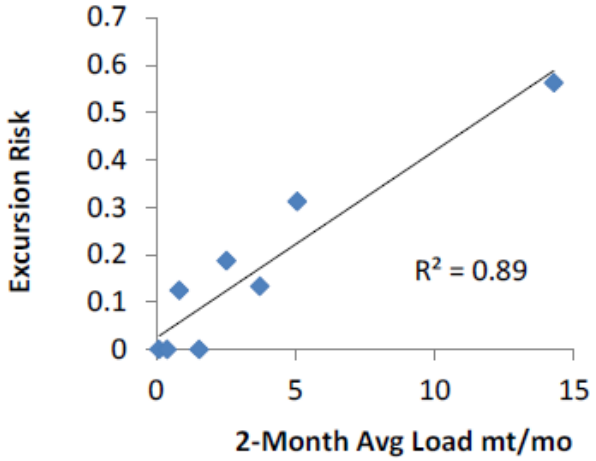
Excursion Risk for Appendix B Long-Term Levels vs. 2-Month TP Load to Refuge Rim Canal



Strong correlation is consistent with hypothesis that excess anthropogenic P loads from the STAs penetrate to the interior marsh and contribute to exceedances of LT Levels.

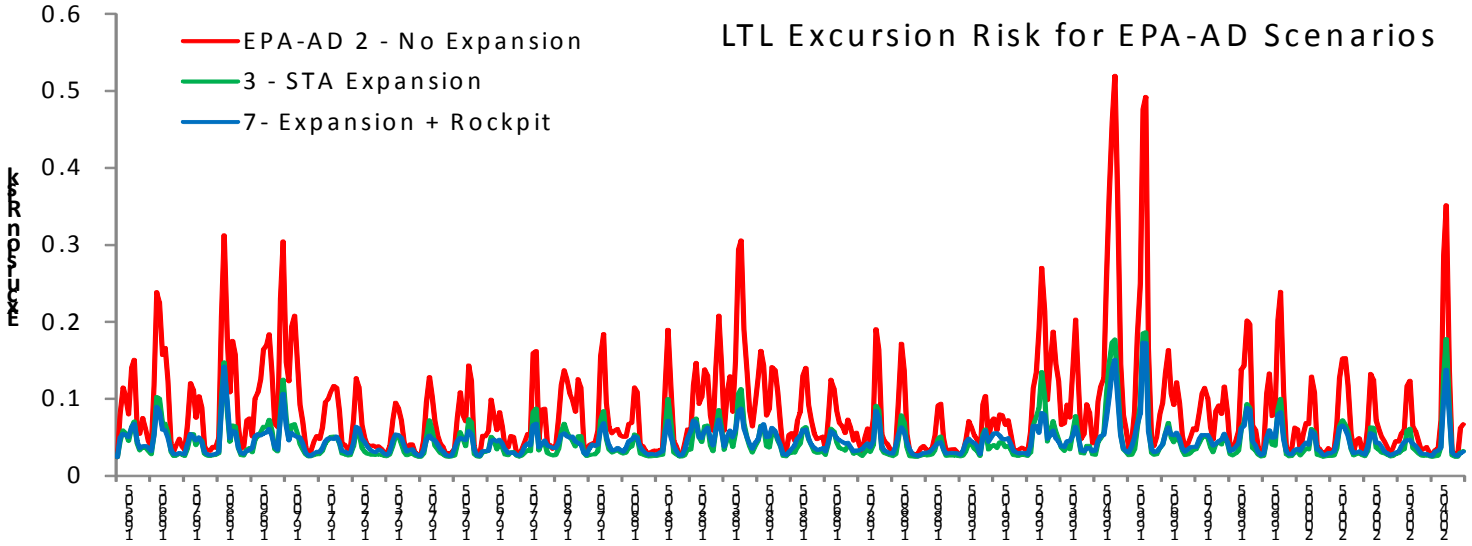
WWW Rebuttal - Feb 2010 – Figure 4; Feb 1999 – Oct 2010 Data

Excursion Risk for Appendix B Long-Term Levels vs. Monthly TP Load to Refuge Rim Canal

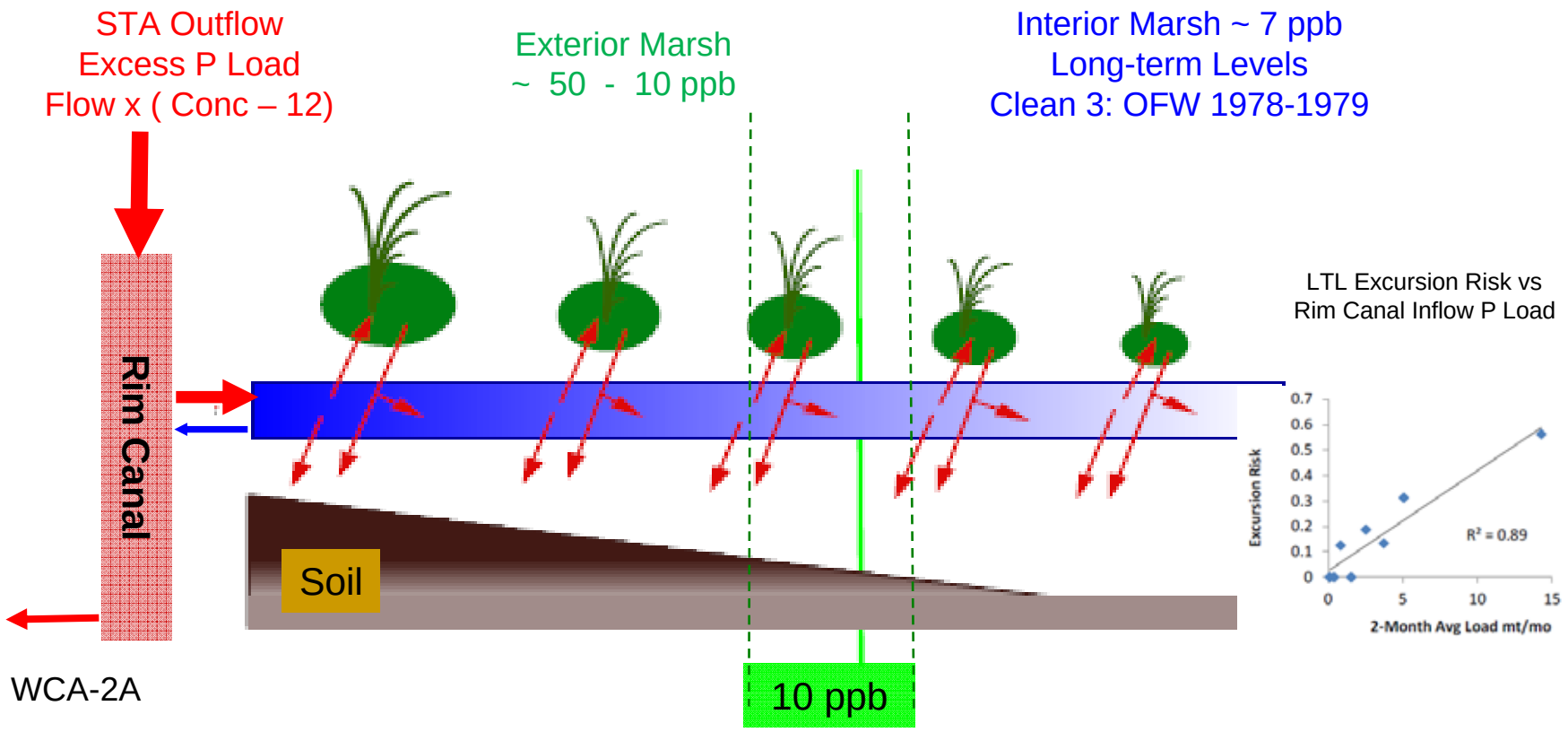


Left: WWW Rebuttal - Feb 2010 – Figure 4

Bottom: Risk vs. Load Regression Applied to DMSTA Monthly Output for EPA-AD Alternatives



Phosphorus Gradient in Refuge Marsh



16 - 9 ppb
Range of Ecological Response
Cattails – Invertebrates – Oxygen – Periphyton

Modified from WWW Rebuttal Exhibit 2309 & Figure 4