Alternative Method for Assessing the Load Reduction Expectations of the Settlement Agreement

Technical Oversight Committee
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Objective

- To describe an alternative method for assessing the *load reduction* expectations of the Settlement Agreement

- Paper posted on TOC website
  - Revision dated 2/22/07 corrected typo on page 10 and in figure legends (Figures 5 and 6)
  - 88.9 metric tons corrected to 89.0 metric tons
  - Did not affect calculations or findings

Expectation of Settlement Agreement

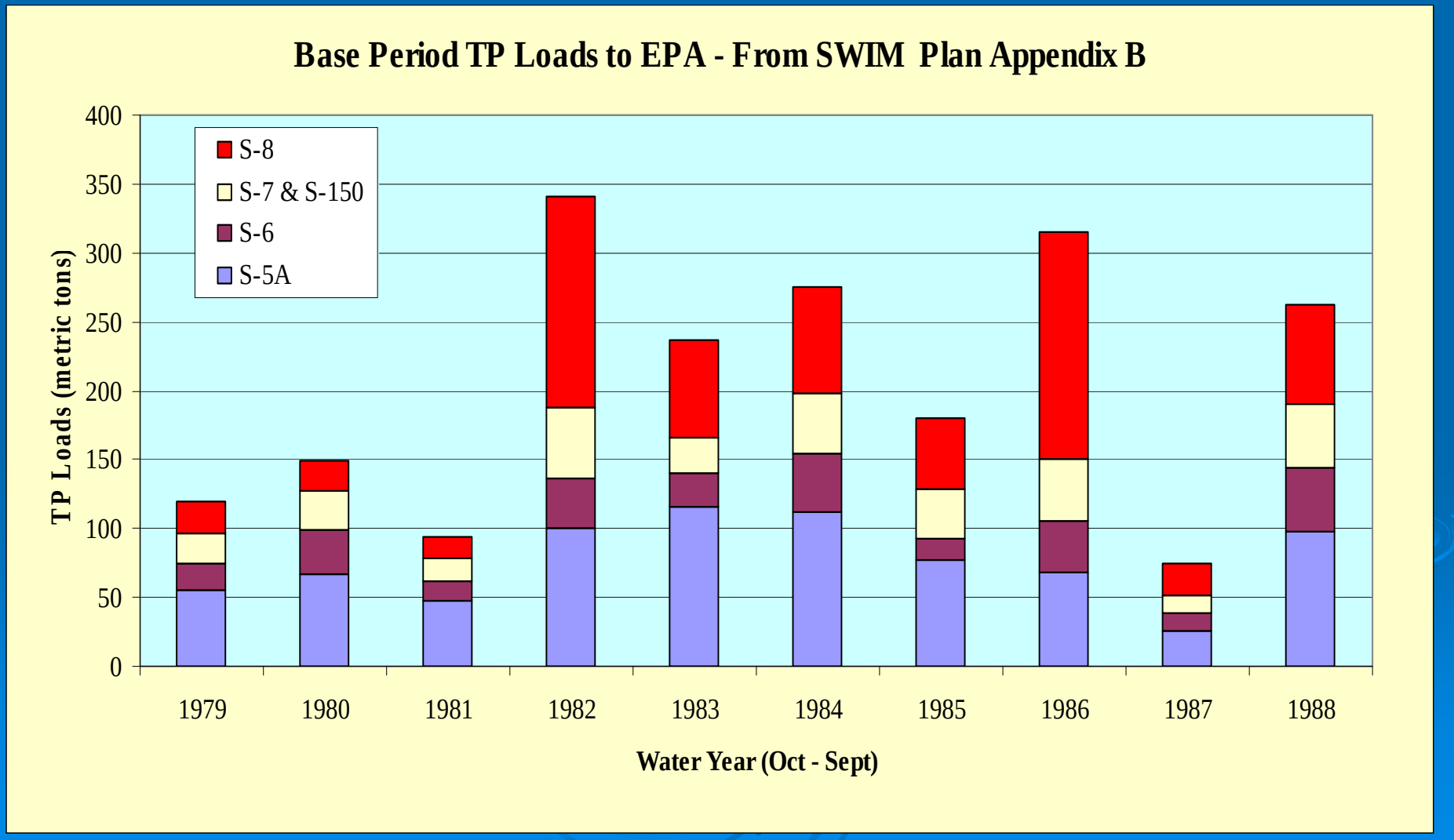
- The control program is designed to achieve approximately an 80% reduction in phosphorus loads from the Everglades Agricultural Area (EAA) to the Everglades Protection Area (EPA) by October 1, 2003 and greater than an 85% reduction in phosphorus loads to the Refuge by December 31, 2006, relative to the average annual loads measured in Water Years 1979 through 1988. (p. C-1 of Appendix C)

- This is a *load reduction* expectation – not a load expectation as has been interpreted in the past

1979-1988 Base Period loads

To EPA: 204.7 metric tons/yr, with range of 74.2 – 340.2 mt/yr

To Refuge: 104.6 mt/yr, with range of 38.0 – 153.9 mt/yr



Load Reduction Assumptions

(from App. B of Everglades SWIM Plan)

Load Reduction Component	To EPA (mtons/yr)	To Refuge (mtons/yr)
Reduction due to diversion of S-6		27.87
Reduction to exclude water supply loads	10.90	0.96
Reduction for land use conversion	15.30	7.70
25% reduction due to EAA BMPs	44.63	17.02
70% reduction due to STAs	93.72	35.73
Total load reduction	164.5	89.3

Load reduction to the EPA ~80% “approximately 80%”

Load reduction to the Refuge 85.4% “greater than 85%”

Assessment of Expectations

- The Settlement Agreement provides no guidance on how to assess these long-term load reduction expectations,
  - frequency of assessment,
  - how to incorporate annual variability,
  - round-off protocol, e.g., round to the nearest 0.1 metric ton or whole metric ton,
  - how to account for impacts of hurricanes and other factors outside the control of the Settling Parties.
- Or how to modify the expectations due to
  - revisions in regional flow patterns and discharge locations made after the Settlement Agreement was executed, or
  - inaccurate assumptions.

Current Method

- TOC adopted a concentration-based assessment
  - compliance is assumed if STA discharges are less than or equal to 76 ppb, with at least 1 of 3 years at 50 ppb.
  - Doesn't apply to STA-5, as STA-5 does not treat loads "from the EAA"
- At the May 25, 2004 TOC meeting, four issues identified:
  - clarification of "low-flow water supply deliveries"
  - clarification of "extreme hydrological events"
  - revision of the annual phosphorus limit based on current data
  - method is contingent on flows through the STAs being within the range contemplated in the amended Settlement Agreement
- Which Water Year should be used for compliance: Oct-Sep or May-April?

Recent Activity

- TOC assigned working group to research areas of evaluate areas of concern. Met several times, exchanged ideas, but could not reach consensus.
- In 2005, Frank Nearhoof presented to the TOC a refinement of the current methodology that addressed most of the issues and was to be implemented in the STA-1E operations permit, however, the TOC did not take any action on that methodology.
- The following section describes one alternative to the current assessment methodology.

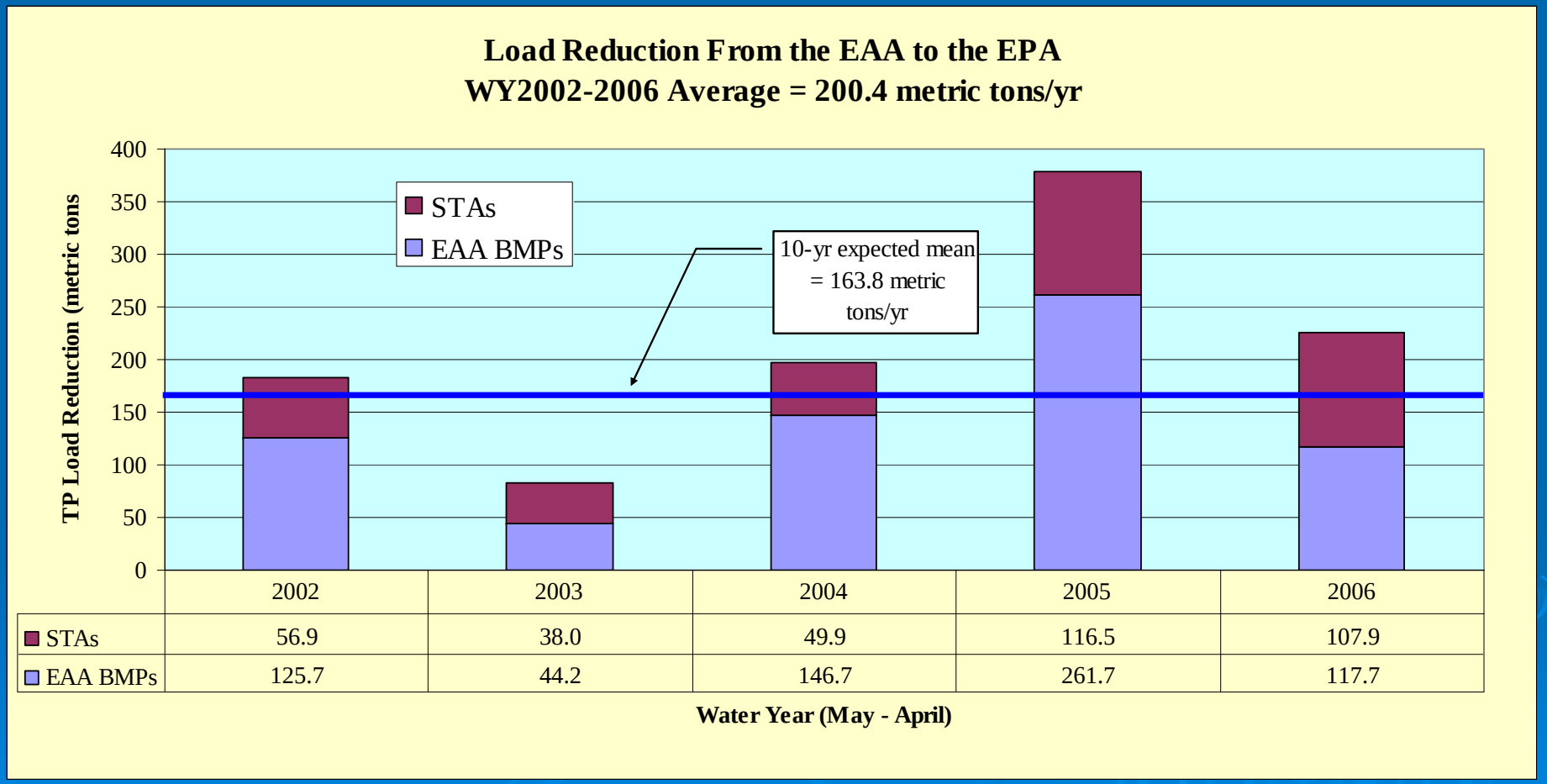
Load Reduction From the EAA to the EPA

- An 80% reduction in loads from the EAA to the EPA would be approximately **163.8 metric tons/yr with a 90% confidence interval of ± 39.3 metric tons/yr**.

- The load reduction from the EAA to the EPA can be calculated as
  - the load reduction due to EAA BMPs, and
  - the EAA load reduction through the STAs.

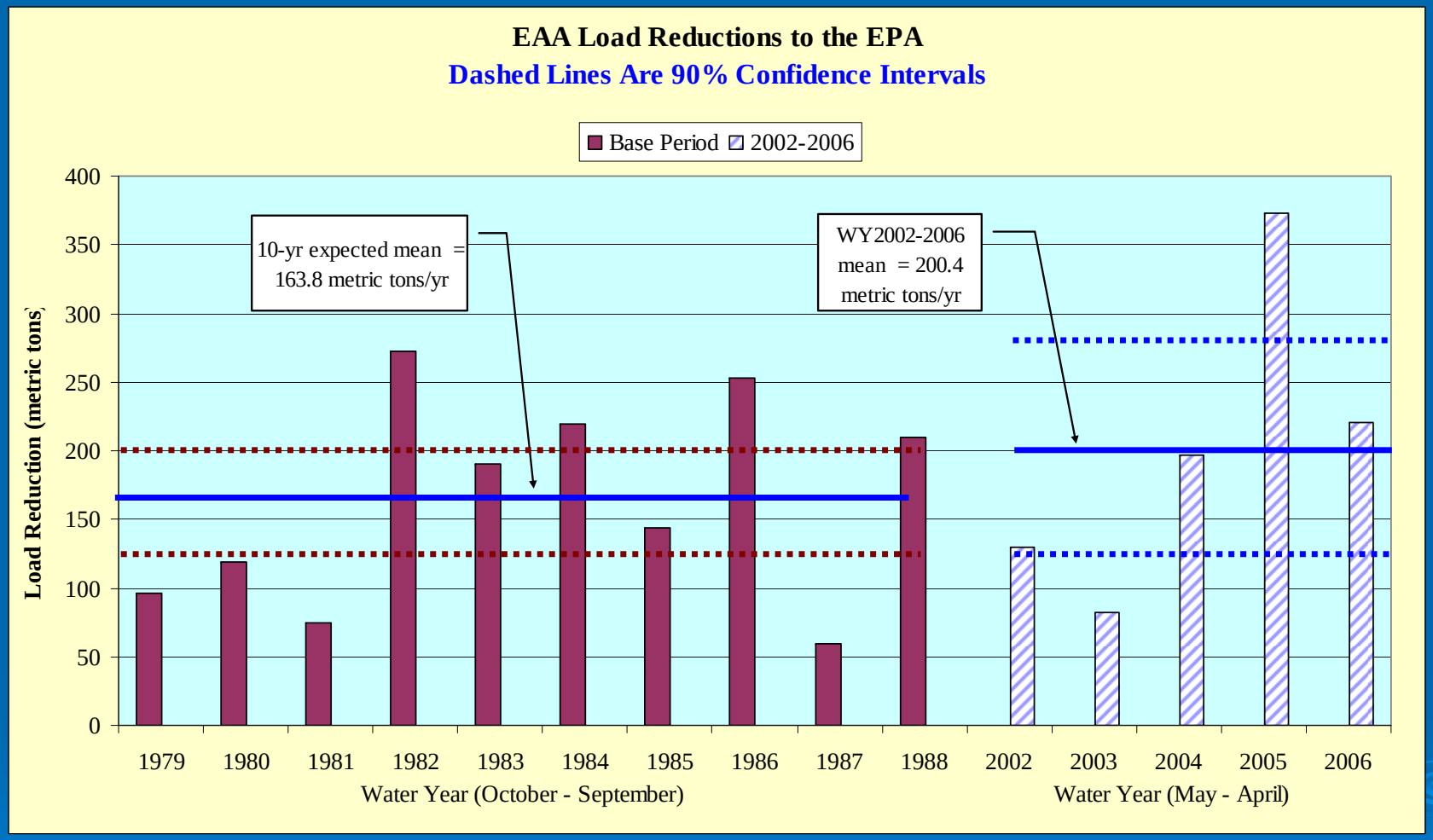
- Each year, the District estimates the TP load reductions attributable to the EAA BMPs using May – April Water Year.
  - The annual load reduction for EAA-wide flows going south can be calculated by excluding loads discharged to Lake Okeechobee

Load Reduction From the EAA to the EPA



	2002	2003	2004	2005	2006
STAs	56.9	38.0	49.9	116.5	107.9
EAA BMPs	125.7	44.2	146.7	261.7	117.7

Alternative Load Reduction Assessment Method



Summary: WY2002-2006 load reduction from the EAA to the EPA achieved the expectation of the Settlement Agreement.

Could conduct statistical test to determine if the difference in the means is significant, but regardless of outcome, the expectation was met.

Load Reduction From the EAA to the Refuge

- Individual EAA sub-basin load reduction values are not calculated as part of EAA BMP program. However, Appendix A4 to Rule 40E-63 describes the algorithm to calculate farm scale load reductions as a function of area, and that algorithm was modified for application at the S-5A Sub-basin level as follows:

Predicted Load = Geometric Mean of Base Period Load * $(R_{am} / R_a)^{2.868}$ * Area / $\text{Area}_{\text{Base Period}}$

$$R_a = \exp [X + 1.053 (C-C_m) - 0.1170 (S-S_m)]$$

where,

R_a = Adjusted sub-basin rainfall in current year (inches)

X = natural logarithm of annual rainfall

C = coefficient of variation of monthly rainfall

S = skewness of monthly rainfall

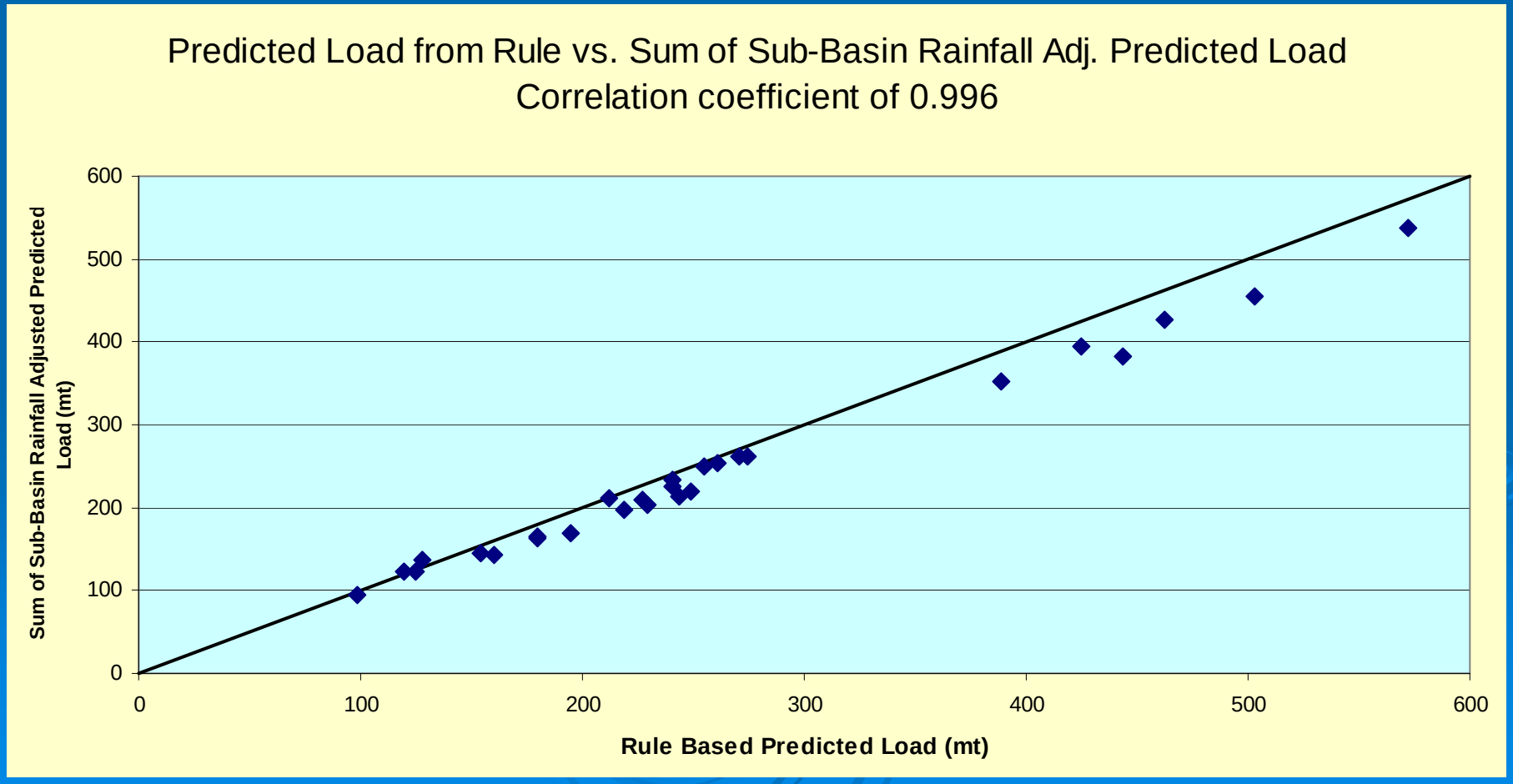
m = subscript denoting average value of rainfall statistic in Base Period for EAA sub-basin (C_m = 0.7636, S_m = 0.9999)

R_{am} = base period adjusted rainfall for EAA Sub-basin = 50.31 inches for S-5A sub-basin

Applying method to individual EAA Sub-basins for WY 1980-2006

- Method predicts very similar total EAA loads as Rule
- Method under-predicts EAA loads by ~6%, hence ***load reductions*** will also be lower

load reduction = predicted - observed



Summary of S-5A Sub-basin Load Reduction Calculations

Water Year (May - April)	S-5A Sub-basin Area (acres)	S-5A Sub-basin Load (mtons)	S-5A Sub-basin Flow (AF)	S-5A Sub-basin Rainfall (inches)	S-5A Sub-basin Rainfall Coeff. Of Variation	S-5A Sub-basin Rainfall Skewness	S-5A Sub-basin Adjusted Rainfall (inches)	S-5A Sub-basin Load Adjustment Factor	S-5A Sub-basin Predicted Load (mtons)	Difference Between Predicted and Measured Loads (mtons)
1980	121,831	63.227	276,377	53.21	0.653	1.614	44.08	1.46	92.38	29.15
1981	121,831	34.811	169,680	40.00	0.866	0.988	44.61	1.41	49.15	14.34
1982	121,831	65.082	198,103	48.29	0.957	1.816	53.80	0.83	53.70	-11.38
1983	121,831	146.851	458,731	62.95	0.556	0.214	55.48	0.76	110.90	-35.95
1984	121,831	52.447	230,384	56.39	0.729	0.609	56.91	0.70	36.82	-15.62
1985	121,831	67.695	223,376	42.52	0.876	0.774	49.14	1.07	72.40	4.71
1986	121,831	57.308	273,352	53.13	0.695	0.312	53.55	0.84	47.93	-9.38
1987	121,831	40.891	262,681	52.77	0.698	1.238	47.89	1.15	47.10	6.21
1988	121,831	40.735	224,015	47.47	0.843	1.433	49.05	1.08	43.82	3.09
2002	114,140	30.549	257,496	52.09	0.728	0.509	53.15	0.85	63.31	32.76
2003	114,140	38.821	291,826	50.27	0.650	0.735	46.00	1.29	41.84	3.02
2004	114,140	37.034	259,286	50.17	0.825	1.040	53.27	0.85	63.73	26.70
2005	114,140	86.569	332,410	56.66	1.003	1.414	69.43	0.40	136.27	49.71
2006	114,140	44.535	180,159	42.93	0.696	-0.029	45.08	1.37	39.48	-5.05
WY1980-1988 Ave.	121,831	63.228	257,411	50.75	0.7636	1.000	50.50	1.03	57.74	-1.65
WY2002-2006 Ave.	114,140	47.501	264,235	50.43	0.780	0.734	53.39	0.95	61.89	21.43

Notes:
1. Sub-basin area, flows and TP loads came from the SFWMD Everglades Regulation Division.
2. All rainfall values and statistics came from the EAA Model per Rule 40E-63
3. The Base Period average predicted load is reported as a geometric mean consistent with Appendix A4 of Rule 40E-63.

Estimated Load Reduction from the EAA to the Refuge

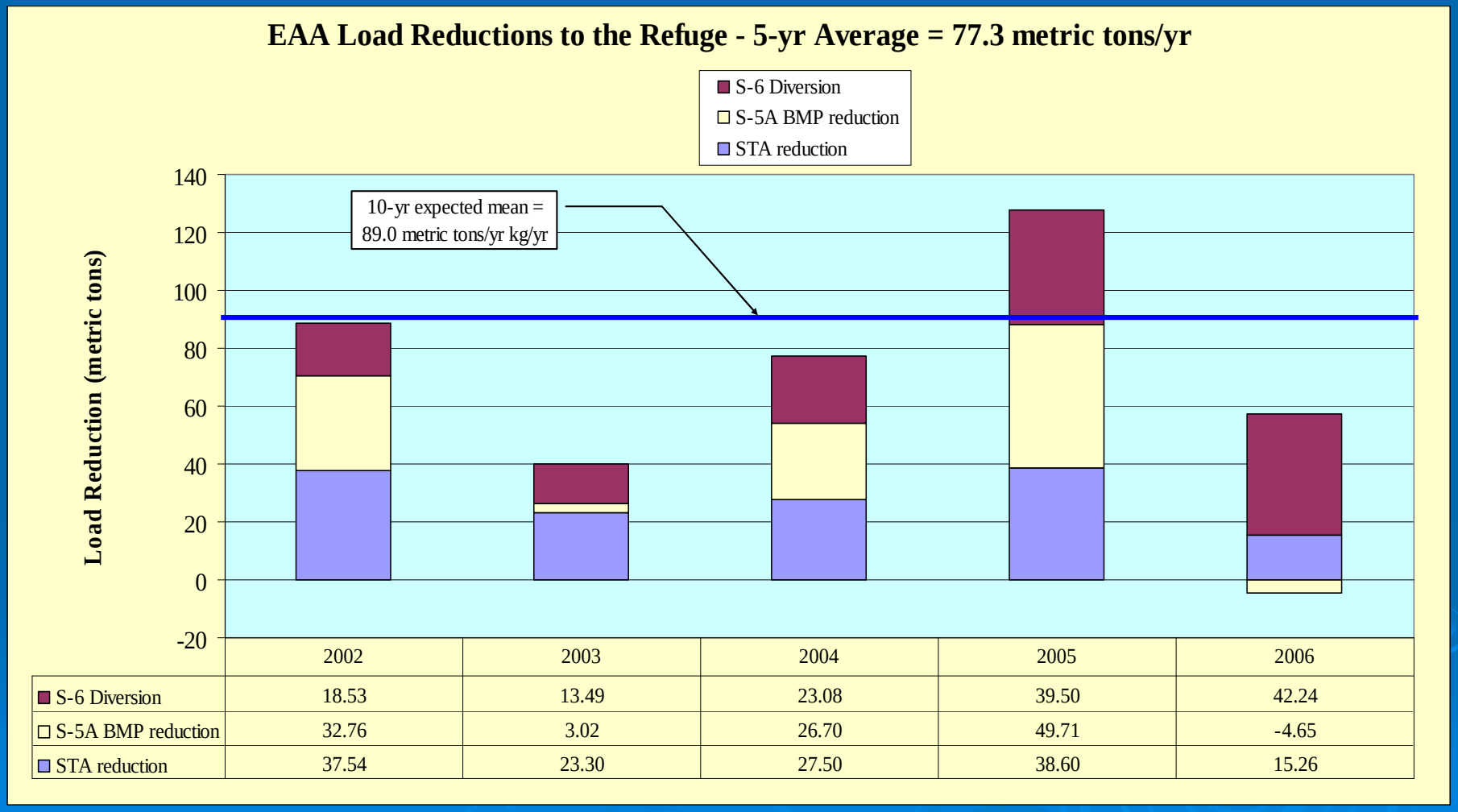
Total load reduction = red. within STAs + S-6 diversion + EAA BMP reduction

WY	EAA Load Reduction Within STA-1W and STA-1E (see Table 5) (mtons)	Loads in S-6 Discharge (mtons)	EAA Portion of S-6 Loads (%)	EAA Loads Reduced By S-6 diversion (mtons)	Observed Load from S-5A Basin (mtons)	Predicted Load from S-5A Basin (mtons)	EAA Load Reduction Due to BMPs in S-5A Basin (see Note) (mtons)	Total EAA Reduction to Refuge (mtons)
2002	37.54	18.59	100%	18.53	30.55	63.31	32.76	88.83
2003	23.30	21.66	62%	13.49	38.82	41.84	3.02	39.81
2004	27.50	23.80	97%	23.08	37.03	63.73	26.70	77.28
2005	38.60	47.74	83%	39.50	86.57	136.27	49.71	127.80
2006	15.26	42.99	98%	42.24	44.53	39.48	-4.65	52.84
Average	28.44	30.96	88%	27.37	47.50	68.93	21.51	77.3

Excludes load reduction in water discharged to Lake Okeechobee (3.54 mt in WY2006)

Includes minor correction to observed loads and load reductions from paper

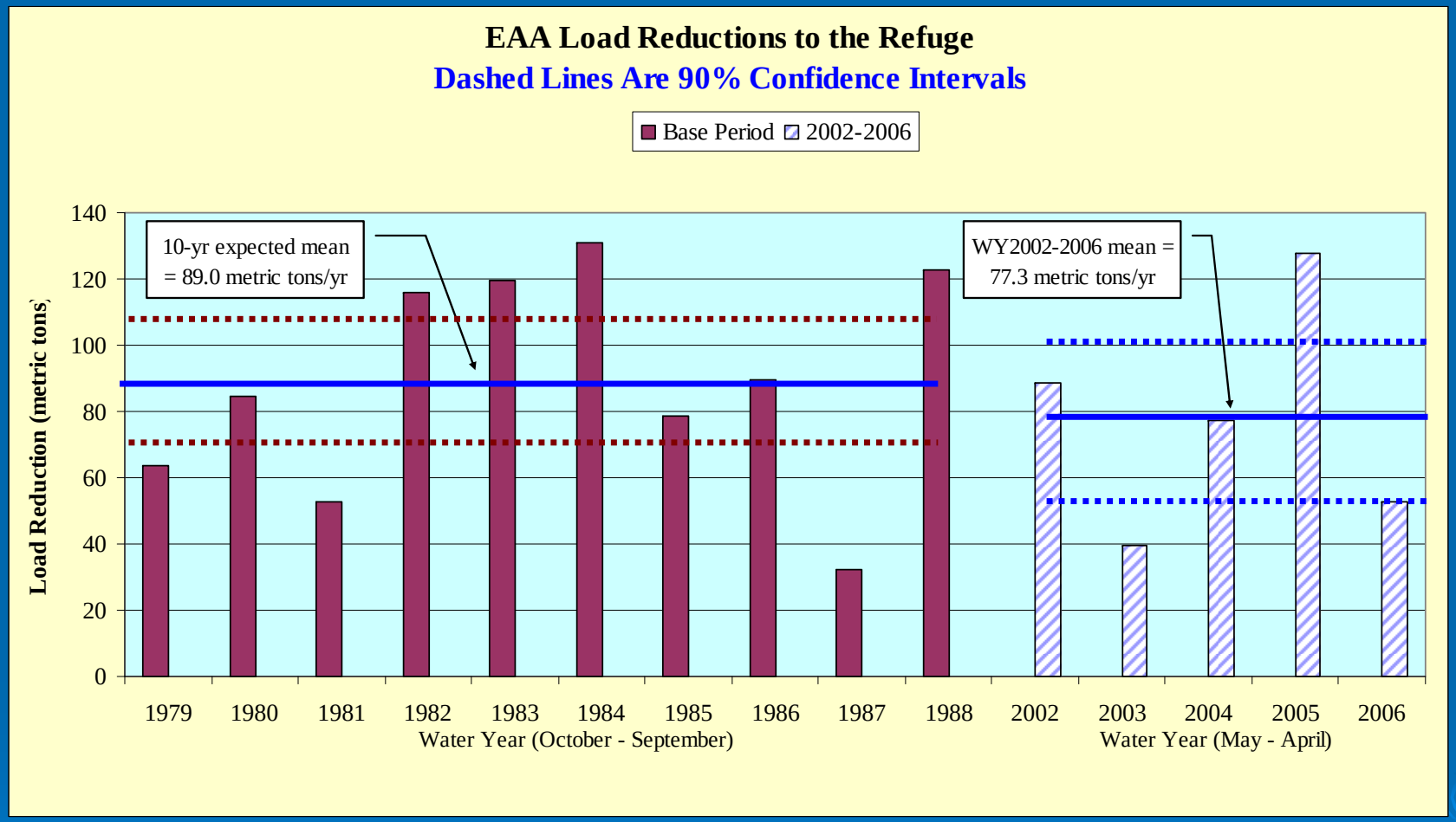
Load Reduction From the EAA to the Refuge



	2002	2003	2004	2005	2006
S-6 Diversion	18.53	13.49	23.08	39.50	42.24
S-5A BMP reduction	32.76	3.02	26.70	49.71	-4.65
STA reduction	37.54	23.30	27.50	38.60	15.26

Includes minor correction to observed loads and load reductions from paper

Alternative Load Reduction Assessment Method



Conducted t-test to determine if the difference in the means are significant: difference is not significant at the 90% confidence level

Hence, the “greater than 85% load reduction” expectation was achieved

Perceived Weakness of Proposed Approach

- The use of a Student's t-test can be criticized as a weak statistical test when comparing the means of two populations with small sample sizes and large variability.
- However, those are the constraints of the situation at hand – comparing a long-term (i.e., 10-yr) average expectation against the short-term performance of regional phosphorus control programs in light of extremely variable meteorological and hydrologic conditions.
- This approach is considered more desirable than waiting until an equivalent 10 year period of data are available after the effective dates.
- As more annual performance data are generated over time, the sample size will increase, and the strength of the method will increase.

Related TOC Issues

1. Clarification of “low-flow water supply deliveries” – this method looks at just loads “from the EAA” so it is not necessary to track “low-flow water supply deliveries”.

2. Clarification of “extreme hydrological events” Nearhoof et al. (2005) contains reasonable measures, including
   - Extreme hydrological events shall be defined as 7-day or 30-day flow volumes or rainfall depths that exceed the values in the period of record used for design
   - Cumulative effect on the STA performance of extreme hydrologic events

3. Revision of the annual phosphorus concentration limit – not applicable

4. Flows through the STAs – this method tracks actual load reductions from the EAA, so there is no restriction on the use of the method.

5. Which 12-month period should be used for compliance? This method uses the May – April Water Year, consistent with the EAA BMP Program, current State reporting requirements, and Everglades P Rule.

6. When to consider “low-flow water supply deliveries”? not necessary

Summary

- Alternative method developed that directly addresses the *load reduction* expectations of the Settlement Agreement
- Uses EAA load reduction calculations that are consistent with the EAA BMP Rule calculations
- Less restrictions and constraints than current method
- Incorporates statistical test to address short period of record and high variability; test will increase in strength as more performance data become available