DRAFT
Preliminary ERTP WQ Analysis

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1.0 INTRODUCTION

An analysis was performed to determine the impact of proposed operational changes to the South Dade Conveyance system on Flow-Weighted Mean (FWM) Total Phosphorus concentrations and loads to Shark River Slough (SRS). The evaluation was performed using simulated hydrologic results from the South Florida Water Management Model for four alternatives LORSS T3, Run7AB, Run8D, and Run9E1. The LORSS T3 run represents the existing operating conditions which are referred to as the "Interim Operating Plan" or "IOP". The alternative operating schemes are devised to increase flow to SRS as well as to slightly lower water stages within Water Conservation Area 3A (WCA-3A). In general, increasing flow to SRS and lowering WCA-3A stages is expected to result in some change to flow weighted mean (FWM) total phosphorus (TP) concentration and load delivered to SRS. The analyses presented here compare with- and without project predicted FWM concentrations to the Long-Term-Limit (LTL) FWM for Shark River Slough (SRS) as defined by the Settlement Agreement (SA) (USA et al., 1992).

2.0 METHODOLOGY

Five methods were used to calculate the average annual FWM TP concentrations for each year of the 35 year simulation period for comparison to the LTL FWM concentrations. The following data was extracted from the latest versions of each of these model runs: Stage (3A-3, 3A-4, 3A-28), Flows (S12A, S12B, S12C, S12D, S333, S334, S334FC). Annual flow weighted mean (FWM) total phosphorus (TP) concentrations for each simulated year were calculated using regression equations prepared by William Walker, PhD (Walker 2010) as well as other methodologies. The methods all assume that changes to the distribution, source, and timing of flows into WCA-3A are minimal for the considered alternatives relative to the base condition and that such changes will not materially alter water quality conditions within the compartment. To calculate daily TP concentrations at S333 and the S12s, the Walker ERTP equations and historic flow-weighted mean concentrations at the relevant structures were used to calculate annual FWM TP concentrations for SRS for comparison against the Long-Term-Limit FWM TP concentrations. The annual FWM concentrations were computed by dividing the annual total SRS load by the annual total SRS flow for each year using flows and loads from the S12 structures and the net Northeast Shark River Slough (NESRS) Flows and loads. The NESRS flows and loads are as defined as the net of S333 – S334. The advantages and disadvantages of the five methods used to estimate annual FWM concentrations are provided in Table 1. Short descriptions of each method are provided below.

Walker Equations: This methodology was used as prescribed by Walker's May 2010 report to the Department of Interior (Walker 2010). The equations were provided by William Walker in the form of VBA coding which was copied into new spreadsheets. Walker developed the VBA coding in Excel 2003 and conversion for use in Excel 2007 required that the Julian date VBA equation be dimensioned "As Double". No other change to the equation coding was required. These regression equations predict daily TP for S12x (all the S-12 structures) and for S-333 using the day of the year (Julian date), the stage, and the change in stage over the previous 30 days. To use these equations, daily simulated stages for each alternative from the 2x2 model were averaged for stations 3A-3, 3A-4, and 3A-28. The Julian date was computed using the incorporated Julian function provided in Walker's VBA code. The change in stage (rise) was computed using the daily average stage minus the daily average stage from 30 days prior. Confirmation of the correct application of these equations was done by comparing results provided in the Corps spreadsheet against results provided by an "ERTP Analysis" spreadsheet provided by Dr. William Walker, PhD. (A copy of the equations in VBA code is provided in Appendix A.)

Stage Neutral Analysis: The historic TP concentrations and stage data for WCA-3A are inversely correlated. That is to say that lower stages are usually accompanied by higher TP concentrations under the present operating scheme. The Walker ERTP equations incorporate this inverse correlation via a negative sign on the regression coefficients applied to the stage component of the equations. However, it is likely that a different relationship between stage and TP concentration will develop under a future operating scheme. The Stage Neutral Analysis methodology was performed to isolate the effect of changed stages from the effect of flow augmentation and redistribution on SRS FWM TP concentrations and

TP loads as predicted by the Walker ERTP equations. This was done by computing the daily TP concentrations at S333 and S12x using the Walker ERTP equations for the LORSS T3 stages in WCA 3A and applying these same daily concentrations to the alternatives Run7AB, Run8D, and Run9E1.

Partial Stage Neutral Analysis: Total phosphorus concentrations in WCA-3A tend to be higher during periods when the stage is less than 9.5 ft (Walker 2004). The Stage Neutral Analysis methodology does not account for the possibility that TP concentrations will be higher under a given operating plan as a result of further lowering of stages during periods when stages in WCA-3A are usually already low. The Partial Stage Neutral Analysis methodology accounts for increased TP concentrations for each of the alternatives during periods when the simulated WCA-3A stage is less than 9.5 ft but uses the predicted LORSS T3 TP data for periods when the simulated stage is greater than 9.5 ft. Below is a pseudo equation that represents the calculation method used to estimate the daily stage input for Walker's ETRP Equations for the Partial Stage Neutral Analysis:

Daily_Stage(i) = IF (daily_stage_ALTX(i) < 9.5 ft,

Then daily_stage_ALTX (i)

Else daily_stage_LORRS(j)

Where: ALTX is an alternative other than LORSS.

The estimates for stage rise used in Walker's ERTP equations were calculated using the resulting time series of daily stage records.

Structure FWM Analysis: This methodology includes the calculation of annual FWM concentrations for SRS flows based upon FWM TP concentrations for S333, S12A, S12B, S12C, and S12D computed using historic flow and TP data for the 2000 to 2009 water years (October 1^{st} through September 30^{th}). This methodology allows an investigation of the effect on SRS FWM concentrations of shifting water between the S12s. The potential for impacting SRS TP loads by shifting the distribution of flow deliveries between the S12 structures is evident from the S12x flows shown in Table 2 and the FWM structure concentrations shown in Table 4. This analysis cannot be done using the Walker ERTP equations since only a lumped S12x TP regression equation is available. (The lack of structure specific regression equations is probably a result of limited flow and TP datasets for the S12A, S12B, and S12C structures.)

Seasonal Structure FWM Analysis: This methodology is similar to the Structure FWM Analysis except that seasonal FWM concentration estimates were developed from the historical dataset (Water Years 2000 through 2009). The dry season was defined as November 1^{st} through May 31^{st}, and the wet season was defined as June 1^{st} through October 31^{st}. Relative to the "Structure FWM" calculations, this analysis is intended to provide a more refined estimate of annual FWM TP concentrations given the differences in the seasonal FWM TP concentrations at each of the S12s and at S333 as shown in Table 4.

3.0 RESULTS

3.1 Hydrologic Differences Between Alternatives

The total flow for the S12x, S333, S334, and NESRS that occurred during the simulation period (1965-2000) is shown in Table 2 and Table 3. The simulated total flow for SRS varies from 28,501 Kac-ft for LORSS T3 to 30,409 Kac-ft for Run8D. Relative to the LORSS, the increase in flow to SRS over the simulation period varies from 4 percent for Run9E1 to 7 percent for Run8D.

The distribution of flow between the S12 structures and S333 is an important factor in the overall FWM TP concentration of loads sent to SRS. Since the S12 structures generally have lower TP concentrations than the S333 structure sending more water through the S12s would provide a lower overall FWM concentration to SRS. The bottom of Table 3 shows that Run7AB sends a lower percentage of total flow through the S12s as compared to any of the other with project alternatives (Run8D and Run9E1). Run9E1 sends the greatest proportion of flow through the S12 structures. Given that each of the proposed alternatives will increase flows, the total TP load to SRS will increase unless the flow distribution is changed such that significantly greater proportion of the flow is delivered through the S12 structures. (This statement assumes that FWM concentrations at each of the structures will not change significantly as a result of flow redistribution.)

The data in Tables 2 and 4 show that the difference in S12 structure FWM TP concentrations and the split in flow distribution across the S12 structures will influence the overall TP load delivered at the S12 structures. In Table 2, the S12D fraction of total S12x flows is 51 percent for the existing operating plan (LORSS T3) and approximately 42 percent for the alternative operating plans (Run7AB, Run8D, Run9E1). As shown in Table 4, the FWM average TP concentrations for the S12 structures varies from approximately 7 ppb at structures S12B and S12C to 10 ppb at S12D.

Stage frequency curves of WCA-3A for the four operating plans are shown in Figure 1. These curves are shown to demonstrate the differences between the alternatives for the fraction of time that the stage is below 9.5 ft in WCA-3A. Stages below 9.5 ft have been identified as having a greater risk of being coincident with higher TP concentrations (Walker 2010). The stage frequency curves for Run8D and Run9E1 closely match the LORSS T3 stage frequency curve for stages below 9.0 ft; however, there is some divergence between these curves from 9.0 ft to 9.5 ft indicating that there may be some increased risk of higher TP concentrations and loads delivered under these two alternatives. The overall fraction of time that stages remain below

9.5 ft varies from 40 percent for LORSS T3 and Run8D to 45 percent for Run7AB. WCA-3A stages are below 9.5 ft approximately 42 percent of the time for Run9E1.

Flow frequency curves for total discharge to SRS are shown in Figure 2 for each of the alternatives. For daily flow less than 1,000 cfs, the LORSS T3, Run8D, and Run9E1 are very similar. The exceedance frequency curve for Run7AB is higher than the other alternatives for flows below 1,000 cfs indicating that this alternative delivers more flow during periods of lower stages in WCA-3A since flow rate and WCA-3A stage are positively correlated. Figure 3 shows that Run7AB indeed has much greater total annual flow to SRS for periods when the WCA-3A stage is less than 9.5 ft. For the most part, alternatives Run8D and Run9E1 provide similar annual flows for low stage periods as that provided by the LORSS T3 operating conditions. Since lower stages in WCA-3A are coincident with higher TP concentrations, alternative Run7AB is likely to provide higher TP loads than the other alternatives.

Table 7 shows that flows through the S151 structure increase under the Run7AB and Run9E1 alternatives relative to the LORSS T3 flows and that net WCA-3B flows also increase under these two alternatives. It is likely that the marginal increase in flow through the S151 structure under Run7AB and Run9E1 is largely matched by a reduction in flow directly down the L-67A canal.

3.2 Water Quality Effects of the Alternatives

The average of annual FWM TP concentrations and the number of years of potential violation of the Settlement Agreement Long-Term-Limit (LTL) are shown in Table 5 for each alternative as estimated using the five calculation methods. Table 6 shows the total TP load and the change in TP load to SRS for each alternative as estimated using the five calculation methods. The graphs in Figure 4 show the annual FWM concentration and the long-term limit for each of the alternatives as calculated using the Walker Equations. Figures 5 through 9 show the annual difference between the FWM concentrations and the LTL for each of the calculation methodologies. Exceedance frequency plots of the difference between the FWM and LTL are shown in Figures 10 through 14.

The average FWM concentration for the period of record calculated using the Walker Equations indicates an increase of 0.4 ppb for Run7AB and an increase of 0.3 ppb for Run9E1 over the LORSS T3 estimate of 11.1 ppb. The number of years of violation of the SA out of the 35 water years simulated increases to 32 for the Run7AB operations; however, the other proposed alternatives have identical number of years of violation (31) as compared to the LORSS T3 results. The average difference between the FWM and the LTL for each of the alternatives appears to increase from 1.5 ppb for the LORSS T3 to around 2.0 ppb for the other operating schemes. Relative to LORSS T3, the TP load to SRS increases 7 percent with Run9E1, and 9 percent for Run7AB, and Run8D. The annual difference between the FWM TP concentrations and the LTL for SRS computed using the Walker Equations, is shown in Figure 5. Figure 10 shows the exceedance frequency plot of the difference between the FWM and the LTL. On both of these figures, it appears that Run8D and Run9E1 are very similar to LORSS T3 while Run7AB results in greater differences between FWM and the LTL.

The Stage Neutral results show a minimal increase in the average FWM concentration of 0.1 ppb over the LORSS T3 average FWM and no increase in the number of years of violation of the SA. The increase in TP load to SRS predicted by the Stage Neutral method shows an increase of 4, 6, and 4 percent for the Run7AB, Run8D, and Run9E1 respectively as compared to the increase in flow of 6, 7, and 4 percent, respectively. The average difference between the annual FWM and the LTL is around 1.5 ppb for each of the alternatives. The differences between the FWM and the LTL for the Stage Neutral analysis are shown in Figure 6 and 11.

The Partial Stage Neutral results show very little increase in the average annual FWM concentration (11.1 to 11.2 ppb) for each of the alternative operating schemes and no increase in the number of years of SA violations. The average difference between the FWM and LTL for the Partial Stage Neutral analysis is around 1.5 ppb for any of the operating alternatives. Relative to LORSS T3, the total TP load to SRS increases 5 percent with Run9E1, 6 percent with Run7AB, and 7 percent for Run8D. The differences between the FWM and the LTL for the Partial Stage Neutral analysis are shown in Figure 7 and 12.

The Structure FWM results show a decrease in the average FWM TP concentration from 10.6 ppb for LORSS T3 to 10.2 ppb for Run8D and Run9E1. The number of years of SA violation decreases from 27 under LORSS T3 to 25 for Run8D and Run9E1; however, the Run7AB number of violations increases to 30 out of 34 years. The average difference between the FWM and LTL for the Structure FWM analysis decreases from around 1.1 ppb for LORSS T3 to 0.7 ppb for Run9E1. Relative to LORSS T3, the total TP load to SRS shows no increase for Run9E1, an increase of 4 percent with Run7AB, and an increase of 2 percent for Run8D. The differences between the FWM and the LTL for the Structure FWM analysis are shown in Figure 8 and 13.

The Seasonal Structure FWM results show a decrease in the average FWM TP concentration from 10.7 ppb for LORSS T3 to 10.3 ppb for Run8D and Run9E1. The number of years of SA violation decreases from 32 under LORSS T3 to 30 for Run7AB and Run9E1. The average difference between the FWM and LTL for the Structure FWM analysis decreases from around 1.1 ppb for LORSS T3 to 0.8 ppb for Run9E1. Relative to LORSS T3, the total TP load to SRS shows an increase of 1 percent for Run9E1, an increase of 2 percent with Run7AB, and an increase of 3 percent for Run8D. The differences between the FWM and the LTL for the Seasonal Structure FWM analysis are shown in Figure 9 and 14.

The increase in net flow to WCA-3B for Run7AB and Run9E1 as shown in Table 7 likely results in more TP load to the northeast corner of WCA-3B relative to the LORSS T3 operating condition. Most of the increase in net flow to WCA-3B occurs during periods when WCA-3A stages are above 9.5 ft which are coincident with lower TP concentrations. It is likely that the additional water passing through S151 normally would have passed down the L67A canal under the LORSS T3 scenario on its way to SRS. For this reason, actual water quality loads delivered to SRS under the Run7AB and Run9E1 scenarios may be somewhat less than predicted here because of a marginal increase in TP removal due to passing the water through WCA-3B rather than sending it more directly to the S12s and S333 structures.

4.0 DISCUSSION

The five analysis presented here show a range of potential impacts of the considered operating schemes. The following statements can be made about the results presented in this paper:

1.0 The SA equation used to predict the LTL has an inverse relationship between total annual flow and annual FWM LTL. Since the proposed alternatives all result in an increase in total flows to SRS, the resulting LTL concentrations are somewhat lower. The average annual LTL for LORS T3 is 9.6, for Run7AB and Run8D it is 9.4, and for Run9E1 it is 9.5.

2.0 With the Walker Equation methodology, it appears that none of the considered alternatives will result in an increase in the frequency of exceedance of the SA LTL for SRS. The Structure FWM methodologies indicate that there is a potential that the number of exceedances of SA violations will decrease under the alternative operating schemes.

3.0 For three (Walker Equations, Structure FWM, and Seasonal Structure FWM) of the five methods, the results indicate that Run7AB is inferior to any of the other operating schemes from a SRS WQ perspective as indicated by Average annual FWM, Number of years of violation, average difference between FWM and LTL, and total TP load.

4.0 High TP concentrations coincident with low WCA-3A stages results in a disproportionate fraction of total load being delivered during low stage periods. For instance, the proportion of total TP load delivered to SRS when WCA-3A stages are less than 9.5 ft are 14.1, 17.1, 14.1, and 14.6 percent of total load for LORSS, Run7AB, Run8D, and Run9E1, respectively as predicted with the Walker ERTP equations. The proportion of total flow when WCA-3A stages are less than 9.5 ft are 8.8, 12, 9, and 9.4 percent of total flow, for LORSS, Run7AB, Run8D, and Run9E1. The higher fraction of flow during low stage periods that occurs under Run7AB relative to the other operating schemes is likely to result in higher TP loads to SRS as shown in these results.

5.0 While Run8D provides similar results to Run9E1 for most of the metrics shown in Tables 5 and 6, the increase in total TP load for Run9E1 is less than that of Run8D for all of the calculation methods. This is an indication that Run9E1 likely will result in fewer SRS WQ impacts than Run8D.

6.0 The results from the Structure FWM and the Seasonal Structure FWM methods for Run9E1 show that increases in total TP load to SRS over LORSS T3 loads are minimized by sending the increased flow through the S12A, S12B, or S12C structures rather than the S12D or S333 structure which both have relatively higher TP concentrations.

7.0 The S334 bypass flow is 9 to 12 percent of the S333 flows in the simulated data for LORSS T3, Run7AB, Run8D, and Run9E1. The historical percentage of S333 bypass flow is 38% for the 2000 to 2009 time period. As Walker points out, if the S334 flow is not decreased as predicted by these model results once a selected operating scheme is invoked, the results provided here would be conservative since actual net NESRS flows and loads would be less than predicted thus resulting in a lower annual FWM TP concentration.

8.0 Passing additional flow through S151 may increase TP loads to the northestern portion of WCA-3B; however, the net impact on SRS should be a slight decrease in TP concentrations.

5.0 CONCLUSIONS

Five methodologies were used to compute the annual FWM TP concentrations for SRS to determine which of the considered alternatives would have the least impact on SA compliance. All of the methods predict that excursions of the SA LTL will be frequent (>60 percent of time) under any of the operating plans unless further improvement in TP concentrations within WCA-3A occurs in the future. Recent water quality trends in WCA-3A indicate that FWM TP concentrations and SRS loads are decreasing (Walker 2010) which means that the frequency of LTL excursions is likely to be less than that predicted here.

None of the methodologies used here indicate that the preferred operating plan (Run9E1) will result in an increase in the number of years of SA LTL excursions. This is the most important factor in determining whether the new operating plan is acceptable. The results provided by the Partial Stage Neutral and the Seasonal Structural FWM method are preferred by the author. The Partial Stage Neutral method incorporates the Walker ERTP equations but limits the effect of operationally induced lower stages on predicted TP concentrations to only those periods when low WCA-3A stages occur. The methodology appears to be a viable compromise between using the Walker Equations directly which imposes the historic relationship between stage and TP concentrations and the Stage Neutral methodology which does not account for any change to TP concentrations related to reductions of stage relative to the LORSS conditions. The Seasonal Structure FWM method incorporates the ability to evaluate the effect of distributing the S12 flows differently across the S12A, S12B, S12C, and S12D structures; however, the use of seasonal FWM concentrations applied over the entire simulation period rather than using daily estimates of TP concentrations (via Walker type equations) likely provides some increase in uncertainty in the results.

If the two preferred methods are relied upon, then it appears that the selection of Run9E1 would provide the potential for either a small increase (0.1 ppb) or a small decrease (0.4 ppb) in average annual FWM concentrations, no change in the number of years of LTL exceedances, up to a 0.2 ppb increase in the average difference between the FWM and LTL, and between 1 and 5 percent increase in the total TP load to SRS.

The reduction of the uncertainty inherent with the predictions made in this paper likely require a more sophisticated approach such as the application of a calibrated and verified finite element or finite difference water quality model of WCA-3A.

6.0 REFERENCES

USA, SFWMD, Florida DER, Everglades Settlement Agreement, Case No. 88-1886-CIV / Hoeveler, U.S. District Court, Southern District of Florida, 1992.

Walker, W.W., Preliminary Evaluation of the Potential Water Quality Impacts of Implementing a New Rainfall-Driven Formula for Guiding Flow Deliveries to Shark River Slough, Prepared for the US Department of the Interior, May 17, 2010.

Table 1. Advantages and Disadvantages of the Five Evaluation Methodologies

Method	Advantages	Disadvantages
Walker Equations	Robust equations developed by the leading WQ expert for Everglades Water Quality Compliance. The equations predict daily TP concentrations based on stage, short-term change in stage, and the day of the year so they can be used to predict the effect on WQ of altering WCA-3A stages.	These equations may not be robust predictors of the relationship between stage and water quality under future operating schemes. For instance, since the considered alternatives all result in lower stages within WCA-3A, the equations will predict higher TP concentrations over all ranges of stages, not just the range of stage (below 9.5 ft) known to be coincident with higher TP concentrations. Additionally, since the Walker equations have a single equation to predict daily S12x concentration rather than individual equations for each of the S12 structures, the effect of shifting S12x flows between the different S12 structures cannot be tested by this method.
Stage Neutral	This analysis relies upon the Walker ERTP equations to predict daily TP concentrations for the LORSS T3 existing conditions alternative but applies these same TP concentrations to all of the alternatives. The assumption is that that daily TP concentrations will not be affected by changed operations so the methodology quantifies the effect of changing flow magnitude and source to SRS.	This method does not take into account the potential for increased TP concentrations during periods when the WCA-3A stage is less than 9.5 ft. Additionally, since the Walker equations have a single equation to predict daily S12x concentration rather than individual equations for each of the S12 structures, the effect of shifting S12x flows between the different S12 structures cannot be tested by this method.
Partial Stage Neutral	This method relies upon the Walker ERTP equations. The advantage of this analysis is that it does no penalize alternatives by computing higher TP concentrations except for periods when WCA-3A stages are below 9.5 ft.	Since the Walker equations have a single equation to predict daily S12x concentration rather than individual equations for each of the S12 structures, the effect of shifting S12x flows between the different S12 structures cannot be tested by this method.
Structure FWM	This method relies upon FWM concentrations at each structure so it is capable of evaluating the effect of shifting water between the S12 structures.	Applying a single FWM concentration across the entire simulation period does not account for seasonality or stage effects on TP concentrations so it is likely a less robust method than the application of Walker's ERTP equations.
Seasonal Structure FWM	This method relies upon FWM concentrations at each structure so it is capable of evaluating the effect of shifting water between the S12 structures. The use of seasonal FWM concentrations provides some representation of seasonal effects on TP concentrations in WCA-3A.	Applying seasonal FWM concentrations across the entire simulation period does not account for stage effects on TP concentrations so it is likely a less robust method than the application of Walker's ERTP equations.

Table 2. S12x Flows Under Four Scenarios

Total Flow from SFWMM (1965-2000 Kac-ft)					
	12A	12B	12C	12D	12x
LORSS T3	1,364	3,800	5,426	10,864	21,454
Run7AB	1,334	3,548	7,573	9,453	21,909
Run8D	1,435	3,990	7,929	9,574	22,929
Run9E1	1,382	3,932	7,822	9,437	22,572
Change in Flow from LORSS T3					
LORSS T3	-	-	-	-	-
Run7AB	(30)	(252)	2,147	(1,410)	455
Run8D	71	190	2,502	(1,289)	1,475
Run9E1	18	132	2,396	(1,427)	1,119
Fraction of Total S12x Flows					
	12A	12B	12C	12D	12x
LORSS T3	6%	18%	25%	51%	75%
Run7AB	6%	16%	35%	43%	73%
Run8D	6%	17%	35%	42%	75%
Run9E1	6%	17%	35%	42%	76%

Table 3. Shark River Slough (SRS) Flows for Each Alternative

Total Flow from SFWMM (1965-2000 Kac-ft)					
	12x	s333	S334	NESRS	Total
LORSS T3	21,454	7,706	659	7,047	28,501
Run7AB	21,909	9,267	1,073	8,194	30,102
Run8D	22,929	8,128	648	7,480	30,409
Run9E1	22,572	7,788	653	7,135	29,707
Fraction of Total Flow to SRS (SFWMM 1965-2000)					
	12x	s333	S334	NESRS	
LORSS T3	75%	27%	2%	25%	
Run7AB	73%	31%	4%	27%	
Run8D	75%	27%	2%	25%	
Run9E1	76%	26%	2%	24%	

Table 4. Flow Weighted Mean Concentrations (Historic Data 2000-2009 Water Years)

FWM Concentrations (Historic Data 2000-2009 WY)					
	12A	12B	12C	12D	S333
Annual	8.1	6.8	7.4	10.3	13.5
Dry Season	10.4	6.9	6.0	8.4	11.2
Wet Season	7.7	6.7	8.1	11.5	17.5

Table 5. Average Annual FWM TP Concentration and Number of Years SRS LTL Is Exceeded for Four Alternatives Estimated Using Five Methods.

Alternatives	Average FWM (ppb TP)	Average Difference Between FWM and LTL (ppb)	Average Difference Between FWM and LTT (ppb)	Number of LTL Exceedance Years
Walker Eqns				
LORSS	11.1	1.5	3.5	31
Run7AB	11.5	2.1	4.0	32
Run8D	11.3	1.9	3.8	31
Run9E1	11.4	1.9	3.8	31
Stage Neutral				
LORSS	11.1	1.5	3.5	31
Run7AB	11.0	1.6	3.5	31
Run8D	11.0	1.6	3.5	31
Run9E1	11.1	1.5	3.5	31
Partial Stage Neutral				
LORSS	11.1	1.5	3.5	31
Run7AB	11.2	1.8	3.7	31
Run8D	11.1	1.7	3.6	31
Run9E1	11.2	1.7	3.6	31
Structure FWM				
LORSS	10.6	1.1	3.0	27
Run7AB	10.5	1.1	3.0	30
Run8D	10.2	0.8	2.7	25
Run9E1	10.2	0.7	2.6	25
Seasonal Structure FWM				
LORSS	10.7	1.1	3.0	32
Run7AB	10.4	1.0	2.9	30
Run8D	10.3	0.9	2.8	32
Run9E1	10.3	0.8	2.7	30

Table 6. Flows and TP Loads for Four Alternatives Estimated Using Five Methods.

	Total SRS Flow (Kac-ft/yr)	Total SRS Load (1,000 Kg TP)	Change in Load (1,000 Kg TP)	Annual Change in Load (Kg/yr)	Change in Total Load (%)
Walker Equations					
LORSS	28,501	390	0	0	0.0
Run7AB	30,102	427	36	1010	9%
Run8D	30,409	425	34	947	9%
Run9E1	29,707	418	28	765	7%
Stage Neutral					
LORSS	28,501	390	0	0	0.0
Run7AB	30,102	407	17	459	4%
Run8D	30,409	414	24	661	6%
Run9E1	29,707	406	15	417	4%
Partial Stage Neutral					
LORSS	28,501	390	0	0	0.0
Run7AB	30,102	414	24	667	6%
Run8D	30,409	418	27	762	7%
Run9E1	29,707	410	19	539	5%
Structure FWM					
LORSS	28,501	374	0	0	0.0
Run7AB	30,102	389	14	402	4%
Run8D	30,409	382	8	215	2%
Run9E1	29,707	373	-1	-27	0%
Seasonal Structure FWM					
LORSS	28,501	375	0	0	0.0
Run7AB	30,102	384	9	260	2%
Run8D	30,409	387	12	323	3%
Run9E1	29,707	378	2	66	1%

Table 7. Analysis of Flows Through S151 Structure.

	S151 (Kacft)	S337 (Kacft)	S31 (Kacft)	NET 3B Inflows (Kacft)	S151 Flow when 3A Gage Average < 9.5 ft (Kacft)	Increase in S151 Flow when Stage < 9.5 (Kacft)	Percent Increase in S151 for low stage periods
LORSS	9572	4756	152	4664	568	0	0%
RUN7AB	9761	4539	129	5093	497	-71	-13%
RUN8D	8597	4461	97	4039	594	26	5%
RUN9E1	10789	4535	173	6081	590	22	4%

Figure 1. Stage Frequency Analysis of WCA-3A Stages from SFWMM Simulation Results for Average of Gauge Stations 3A-3, 3A-4, 3A-28.

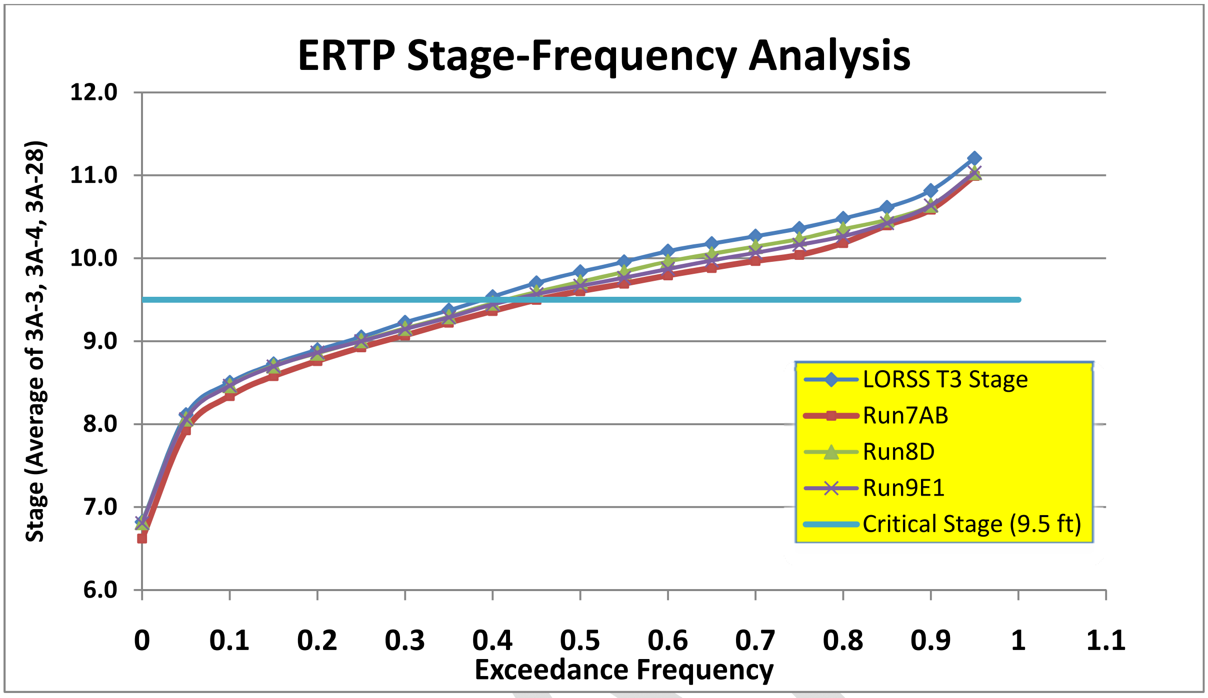


Figure 2. ERTP Flow Exceedance Curves(S12s+NESRS) for Four Alternatives

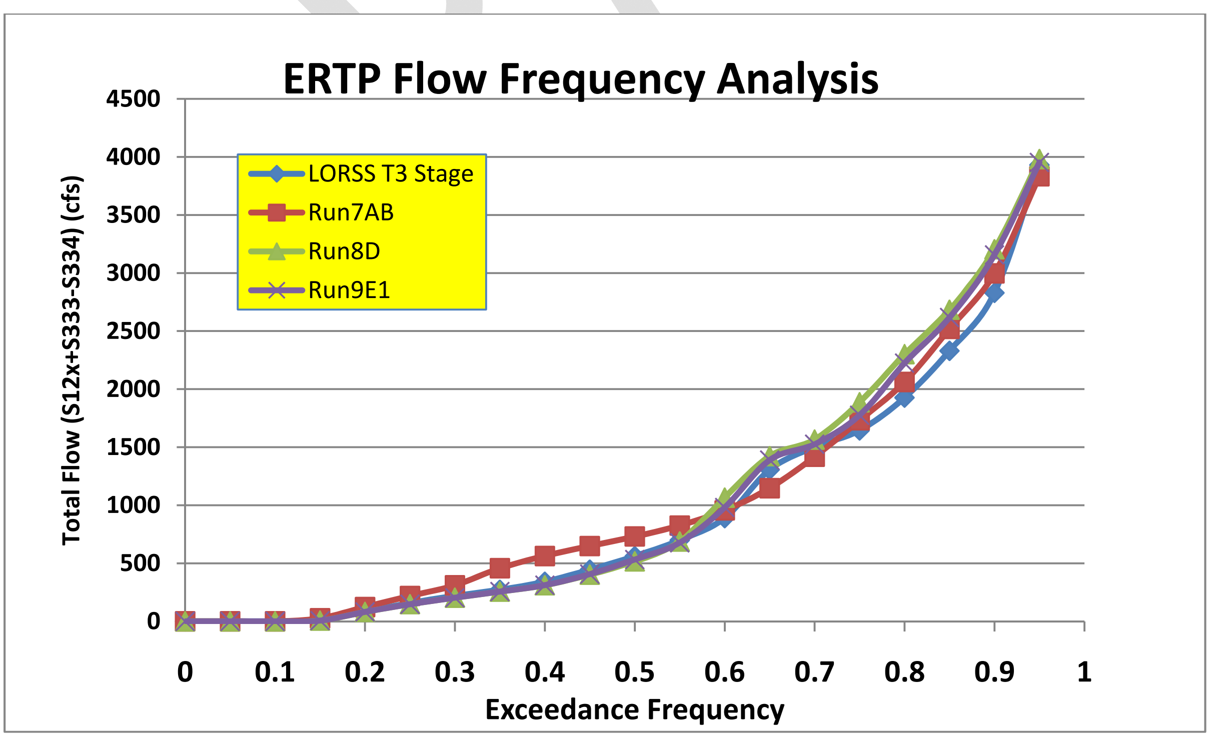


Figure 3. Annual Shark River Slough Flows for Periods When WCA-3A Stages are Below 9.5 ft.

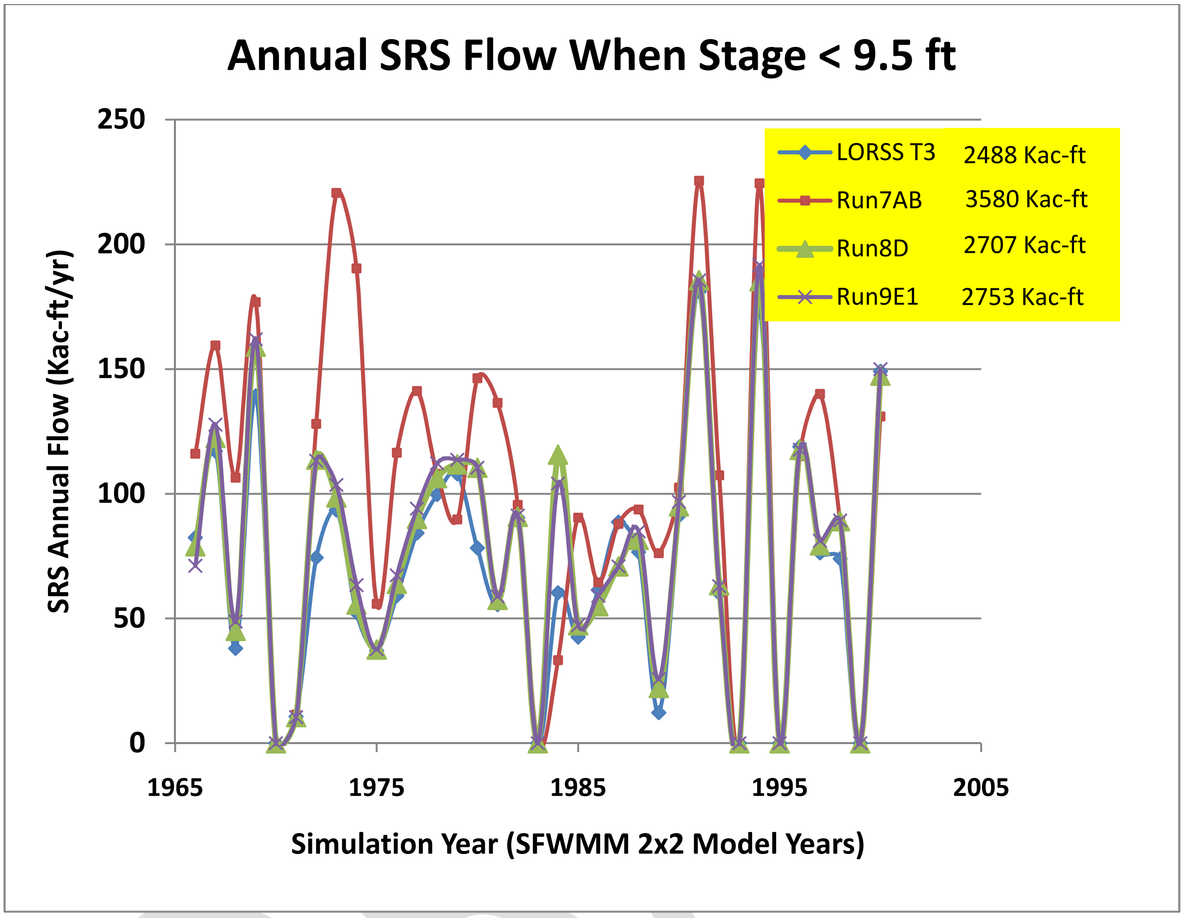


Figure 4. Annual FWM TP Computed Using Walker ERTP Equations for Four Alternatives

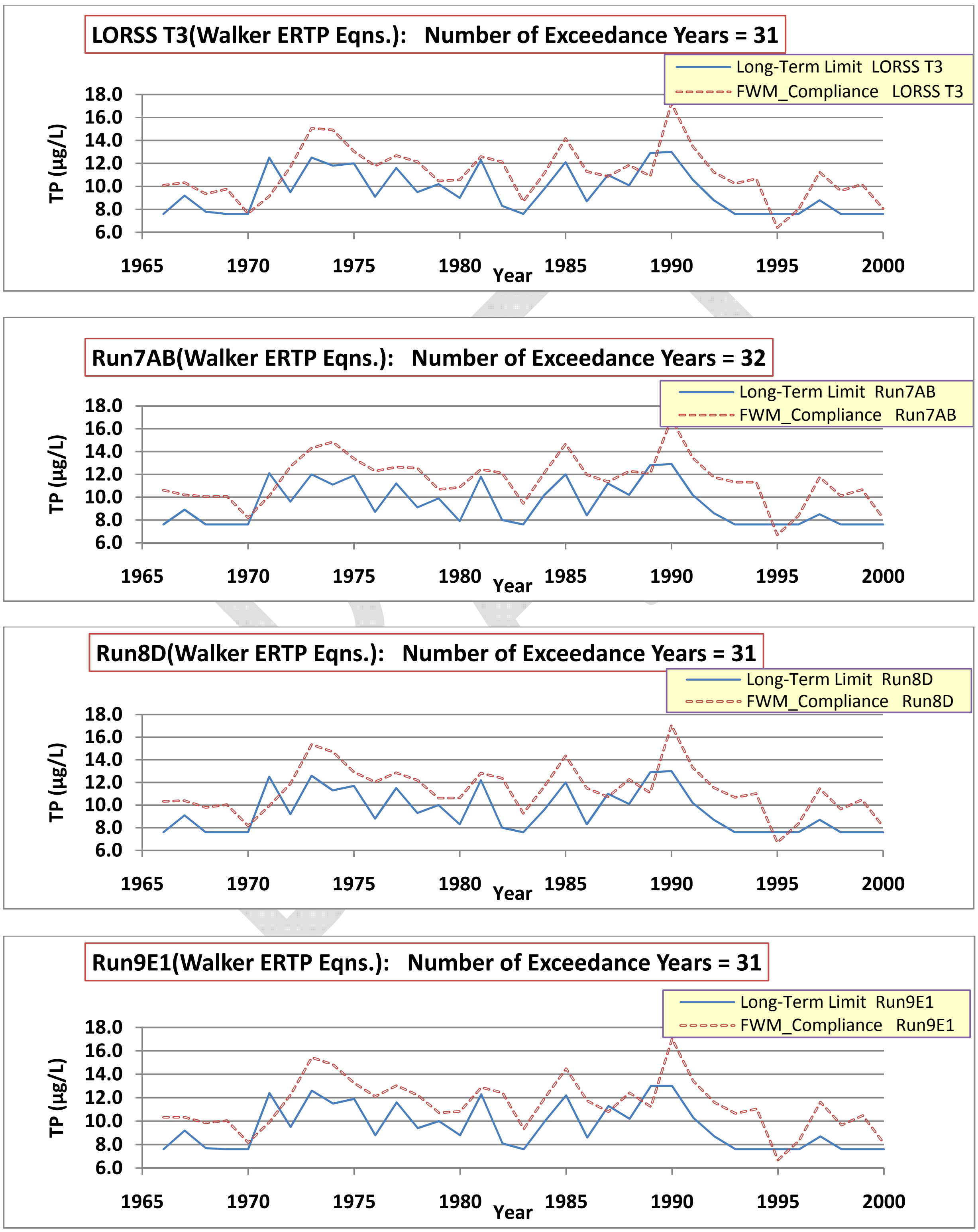


Figure 5. Difference Between Annual Flow-Weighted Mean TP Concentrations and Long-Term Limit for Four Alternatives Computed Using Walker ERTP Equations.

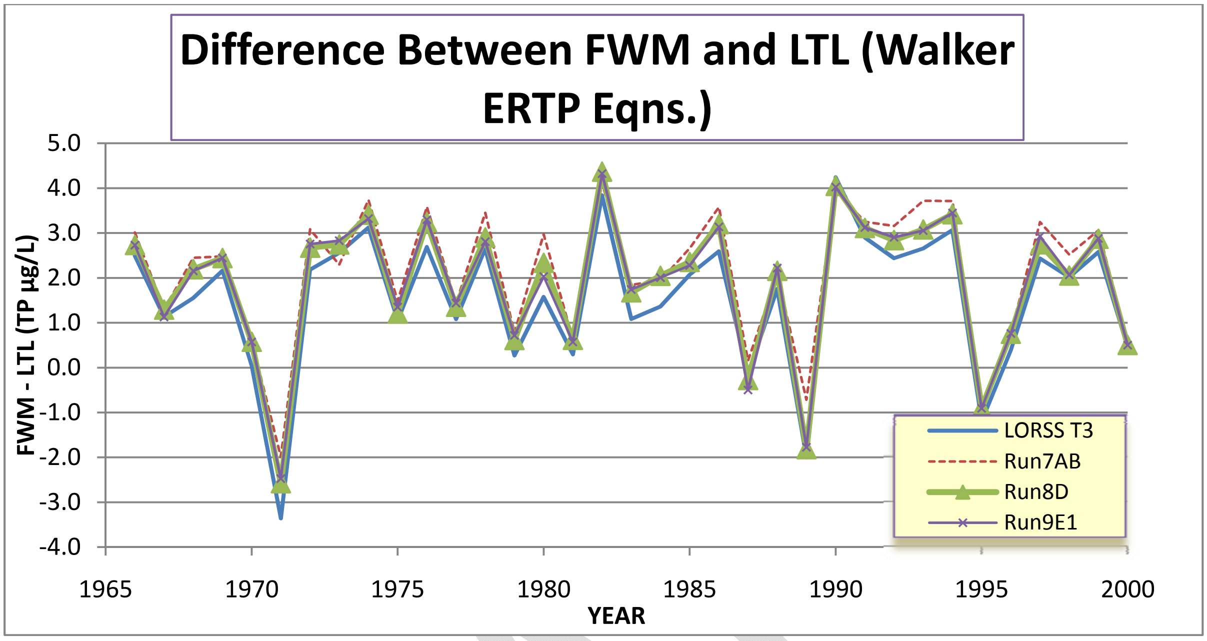


Figure 6. Difference Between Annual Flow-Weighted Mean TP Concentrations and Long-Term Limit for Four Alternatives Computed Using Stage Neutral Analysis.

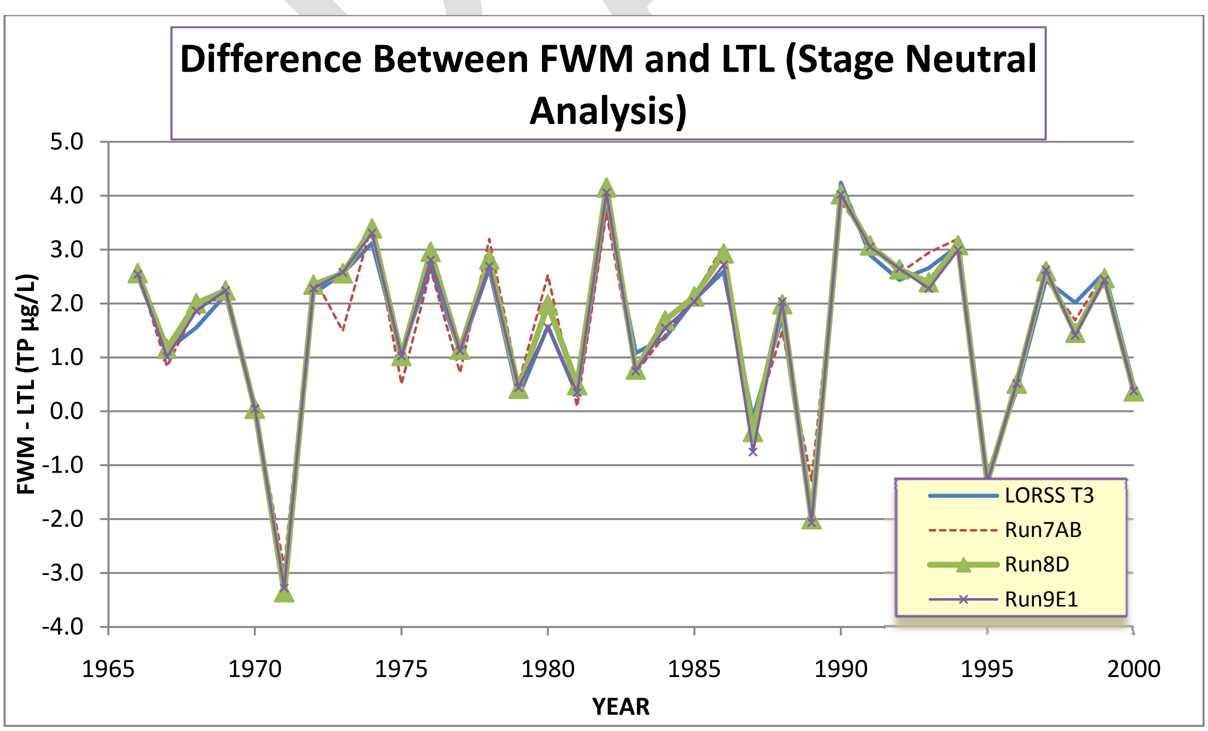


Figure 7. Difference Between Annual Flow-Weighted Mean TP Concentrations and Long-Term Limit for Four Alternatives Computed Using Partial Stage Neutral Analysis.

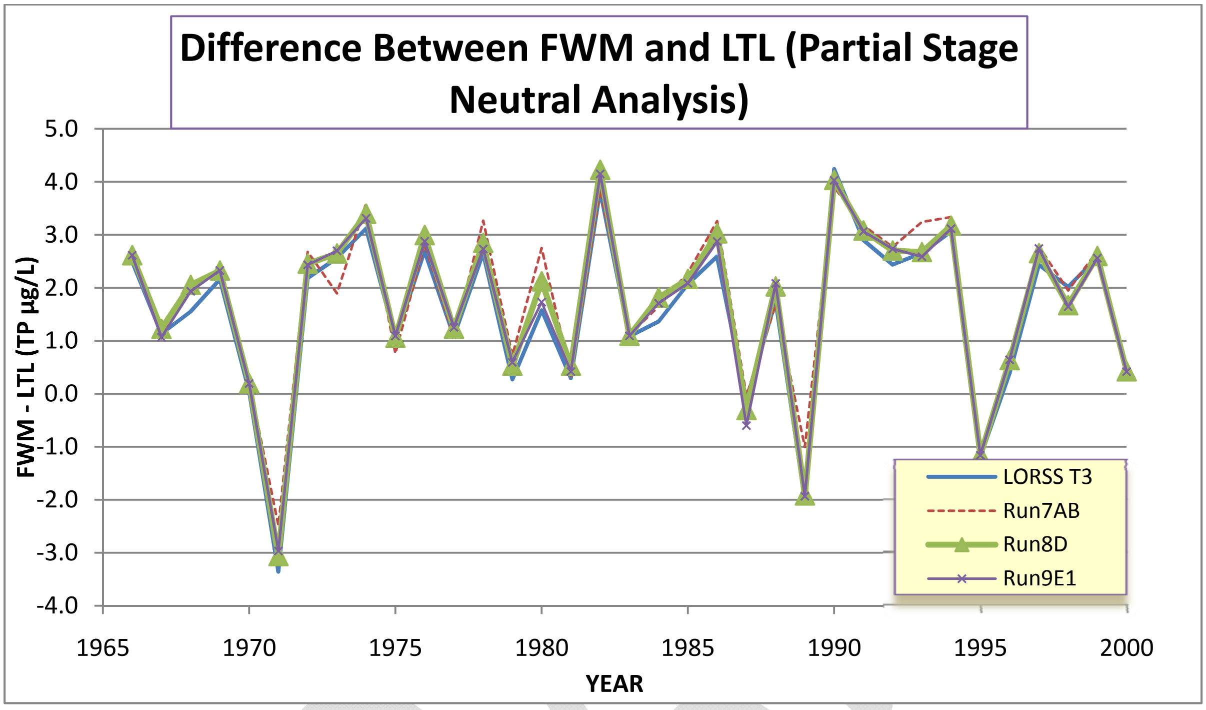


Figure 8. Difference Between Annual Flow-Weighted Mean TP Concentrations and Long-Term Limit for Four Alternatives Computed Using FWM Structure Concentrations.

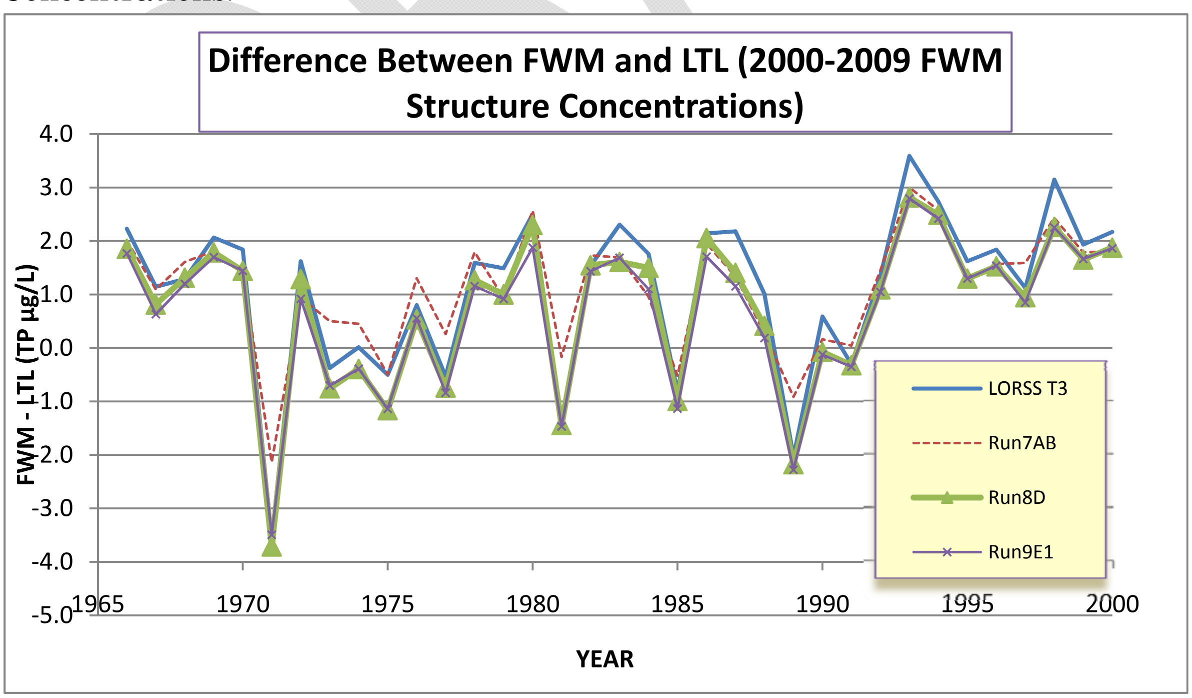


Figure 9. Difference Between Annual Flow-Weighted Mean TP Concentrations and Long-Term Limit for Four Alternatives Computed Using Seasonal FWM Structure Concentrations.

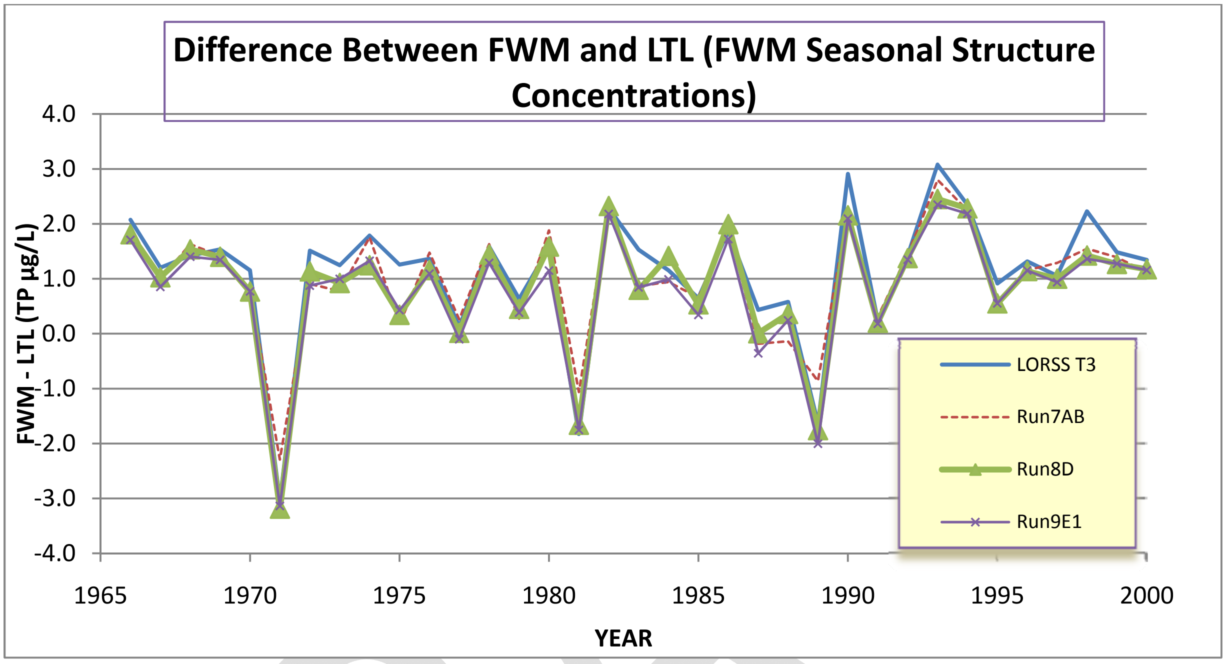


Figure 10. Exceedance Frequency Plot of Difference Between Annual Flow-Weighted Mean TP Concentrations and Long-Term Limit for Four Alternatives Computed Using Walker ERTP Equations.

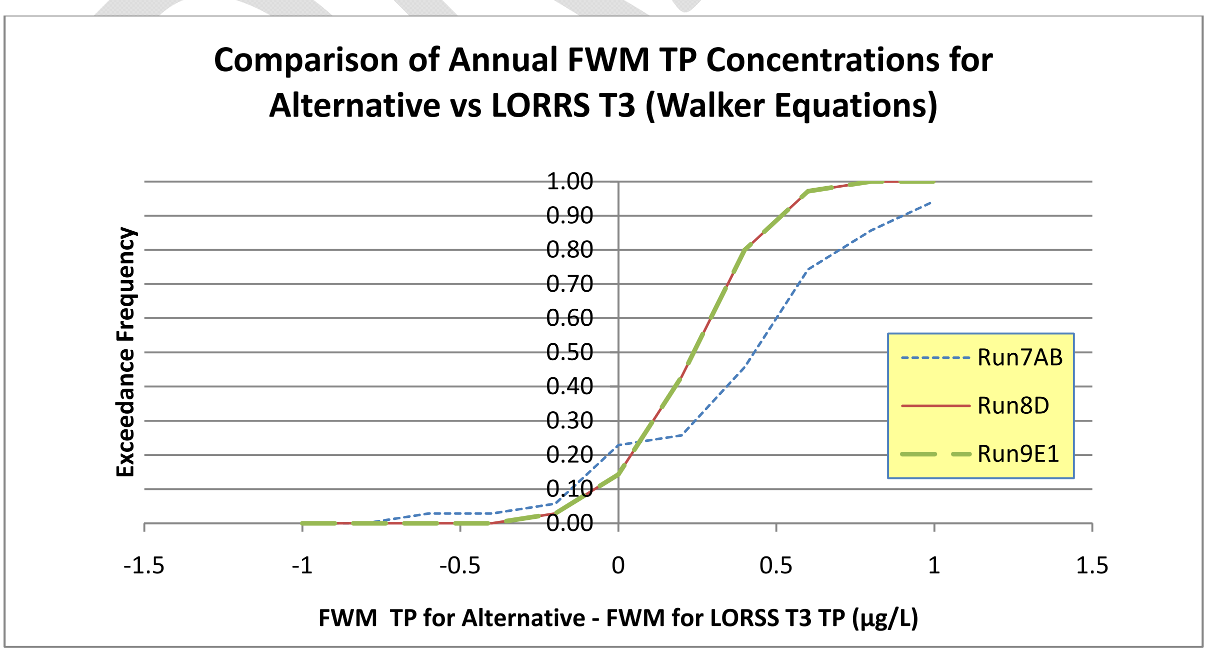


Figure 11. Exceedance Frequency Plot of Difference Between Annual Flow-Weighted Mean TP Concentrations and Long-Term Limit for Four Alternatives Computed Using Stage Neutral Analysis

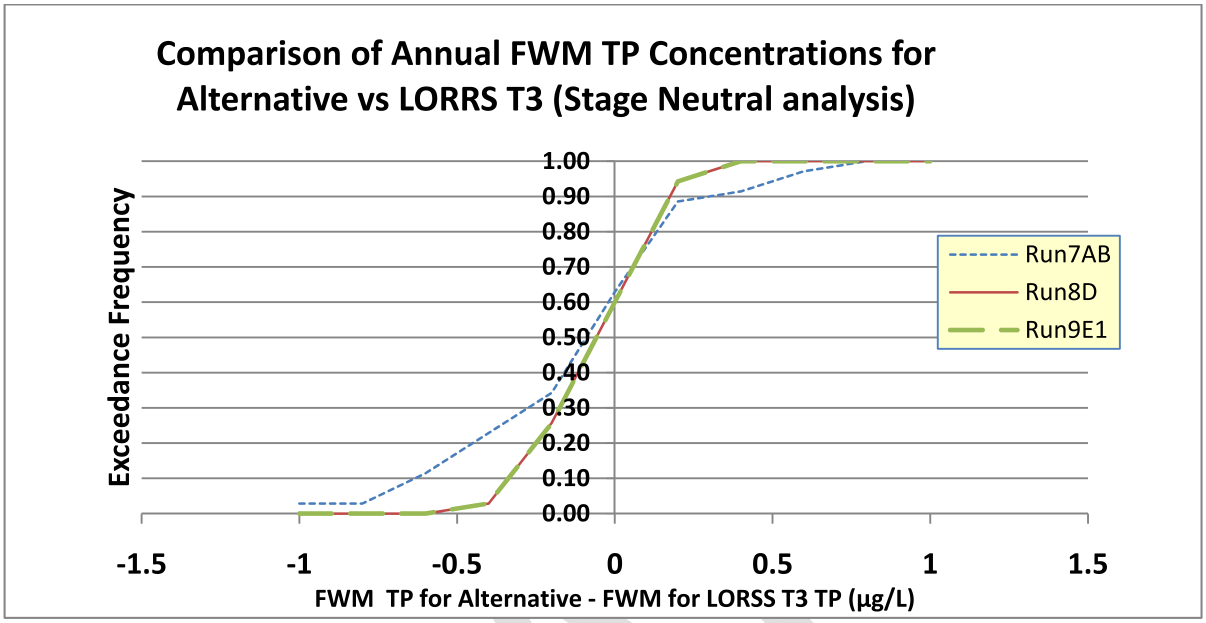


Figure 12. Exceedance Frequency Plot of Difference Between Annual Flow-Weighted Mean TP Concentrations and Long-Term Limit for Four Alternatives Computed Using Partial Stage Neutral Analysis.

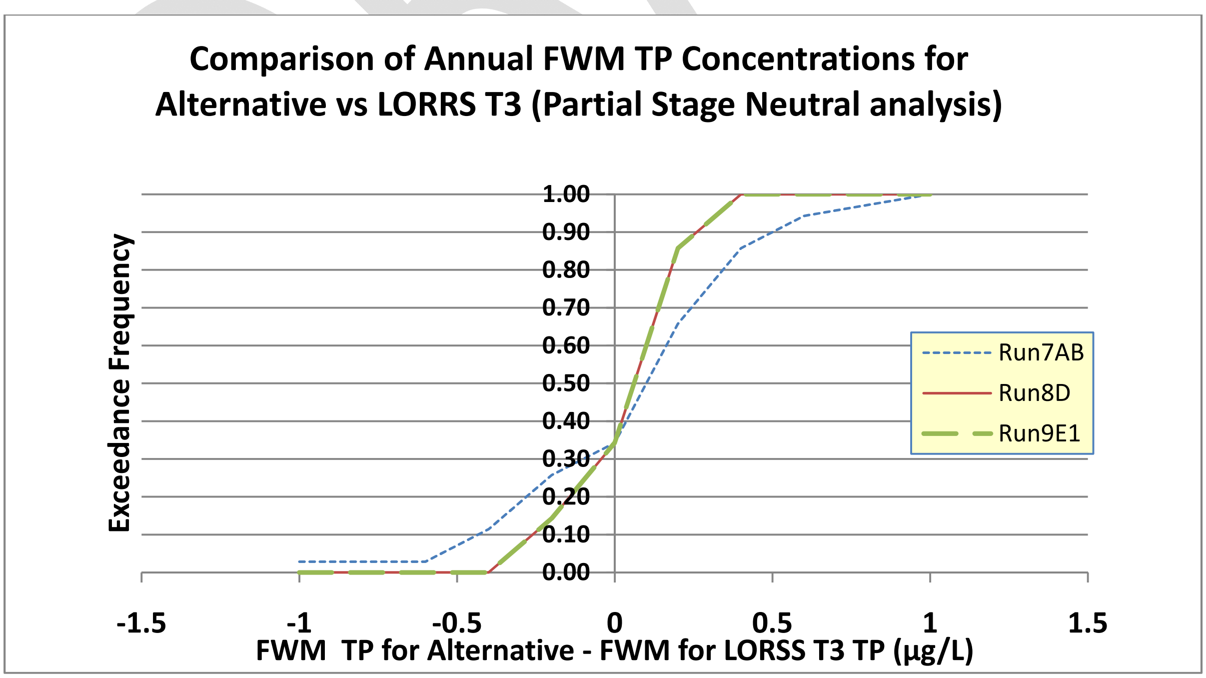


Figure 13. Exceedance Frequency Plot of Difference Between Annual Flow-Weighted Mean TP Concentrations and Long-Term Limit for Four Alternatives Computed Using FWM Structure Concentrations.

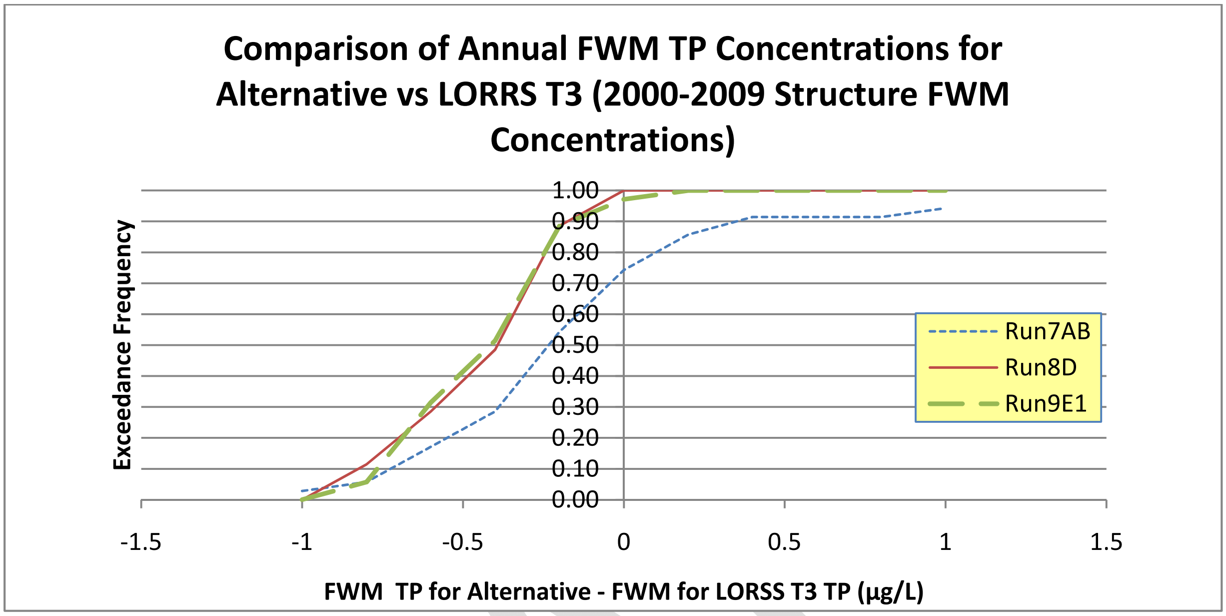
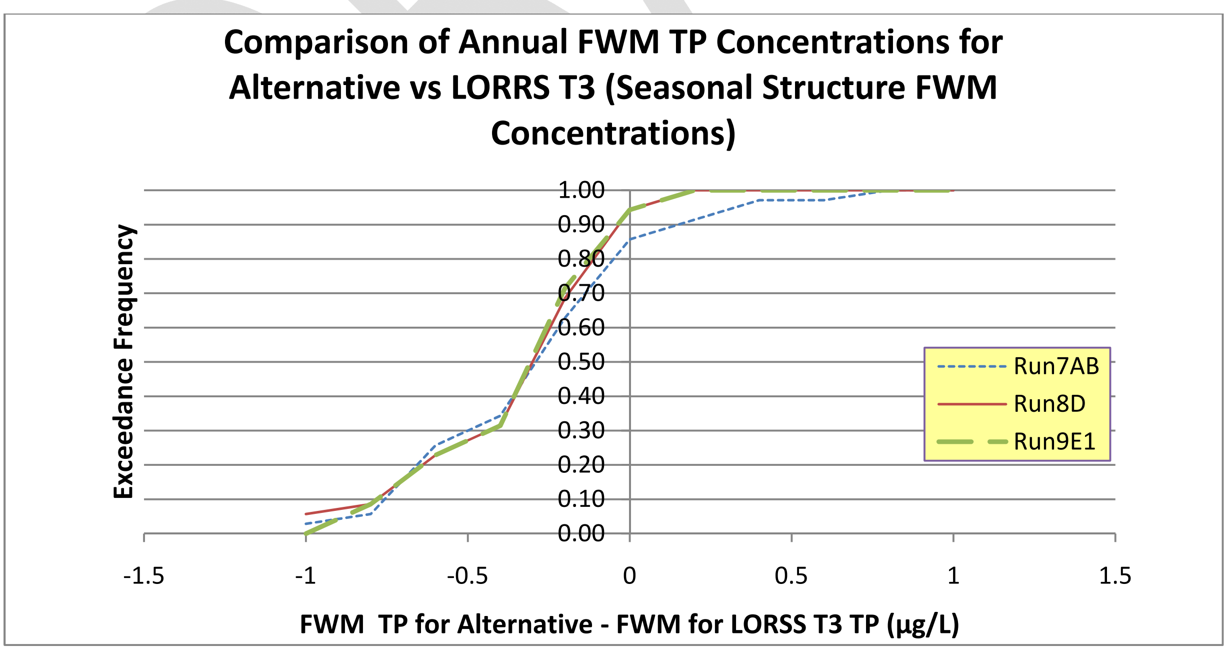


Figure 14. Exceedance Frequency Plot of Difference Between Annual Flow-Weighted Mean TP Concentrations and Long-Term Limit for Four Alternatives Computed Using Seasonal FWM Structure Concentrations.



APPENDIX A

VBA CODE FOR WALKER ERTP EQUATIONS

```
' MDS 9/22/2010  - COPIED WWW FORMULA MACRO VBA CODE TO ERTP ANALYSIS SPREADSHEET'
'WWW  9/21/2010 -  Handy formulas for Everglades Applications -  bill@wwwalker.net
'Ive checked these, but PLEASE if you apply them to anything important, PLEASE send application to me for review FIRST.
'Excel Macros (VBA code) for ERTP regressions  compliance equations for SRS inflow P limits
'Set up your spreadsheet for application:
' copy to VBA module in the spreadsheet and they will be directly accessible from spreadsheet.
' if you dont know what a VBA module is, here is how:
'   create any excel macro from the spreadsheet.  Menu: Tools/Macros/Create new macro;
'   edit the macro:  Menu: Tools/Macros - then select the name of the macro that you just created
'   the vba code screen will pop up
'   copy and past this code into the code page
'   save the project.
'an even simpler method would be to copy this whole excel file and give it a new name; then add your application...
'it will automatically contain the vba code for your application expressed as simple escel formulas
'Good Luck.  Bill   bill@wwwalker.net

'...............................................................................
'ERTP :  Daily SRS inflow concentrations vs. WCA-3A stage and Julian Date
'ref WWW May 2010 ERTP Report

'INPUTS: Stage = Daily WCA-3A Mean Stage ;  Rise in stage over previous 30-day period,  d = Excel date
'..............................................................
Function Julian(d)
'julian day from excel date
Dim yY
yY = Year(d)
Julian = d - DateSerial(yY - 1, 12, 31)
End Function

Function TP_S12(Stage, Rise, d)
'predicts FWM TP Conc for Combined S12 Inflows based upon Stage, and Stage Increase for 30-day Period
'd = excel date
Dim thetA As Double, r As Double
Const rmiN As Double = -0.86
Const rmaX As Double = 1.7
jul = Julian(d)
```

```
If Rise < rmiN Then
   r = rmiN
   ElseIf Rise > rmaX Then
   r = rmaX
   Else
   r = Rise
   End If
thetA = 2 * 3.14159 * jul / 365.25
TP_S12 = Exp(5.42214923047894 - 0.309488167769267 * Stage + 0.196900601885714 * r +
7.03568461147456E-03 * r ^ 2 + -7.81224725188258E-02 * Sin(thetA) + -0.136581153188268 * Cos(thetA))
End Function

Function TP_S333(Stage, Rise, d)
'predicts daily FWM TP Conc for S333 Inflows based upon Stage, and Stage Increase for 30-day Period
'd = excel date '........................................
Dim thetA As Double, r As Double
Const rmiN As Double = -0.86
Const rmaX As Double = 1.7
jul = Julian(d)
If Rise < rmiN Then
   r = rmiN
   ElseIf Rise > rmaX Then
   r = rmaX
   Else
   r = Rise
   End If

thetA = 2 * 3.14159 * jul / 365.25
TP_S333 = Exp(4.48670795168741 - 0.202801335672738 * Stage + 0.148859147432265 * r +
0.177922006680722 * r ^ 2 + -7.84260609792212E-02 * Sin(thetA) + -0.248972204377472 * Cos(thetA))
End Function

Function TP_S12_S333(Stage, Rise, d)
'predicts FWM TP Conc for Combined S12 +S333 Inflows based upon Stage, and Stage Increase for 30-day
Period
'd = excel date
Dim thetA As Double, r As Double
Const rmiN As Double = -0.86
Const rmaX As Double = 1.7
jul = Julian(d)
If Rise < rmiN Then
   r = rmiN
```

```
   ElseIf Rise > rmaX Then
   r = rmaX
   Else
   r = Rise
   End If
thetA = 2 * 3.14159 * jul / 365.25
TP_S12_S333 = Exp(5.7778422244209 - 0.339788838814727 * Stage + 0.178134437816834 * r +
9.33546988707403E-02 * r ^ 2 + -7.53375539462238E-02 * Sin(thetA) + -0.182273093872336 * Cos(thetA))
End Function
Function TP_S12_NESRS(Stage, Rise, d)
'predicts FWM TP Conc for Combined S12 Inflows  + Inflow to NESRS (S333-S334) based upon Stage, and
Stage Increase for 30-day Period
'd = excel date
Dim thetA As Double, r As Double
Const rmiN As Double = -0.86
Const rmaX As Double = 1.7
jul = Julian(d)
If Rise < rmiN Then
   r = rmiN
   ElseIf Rise > rmaX Then
   r = rmaX
   Else
   r = Rise
   End If
thetA = 2 * 3.14159 * jul / 365.25
TP_S12_NESRS = Exp(5.85839860983666 - 0.348582585832904 * Stage + 0.192492692388293 * r +
8.73560482211548E-02 * r ^ 2 + -7.49823667911143E-02 * Sin(thetA) + -0.173504391290261 * Cos(thetA))
End Function ..........................................................................................

'equations for Consent Decree P limits for Inflow TP concentration to Shark RIver SLough
'q = total wca3A basin outflow = S12x + S333  (DO NOT SUBTRACT S334)  kac-ft/yr
'..........................................................................................
Function ENP_LT_Target(q As Double) As Double
   Dim qQ As Double
   qQ = q
   If qQ > 1061 Then qQ = 1061
   ENP_LT_Target = 11.38 - 0.00538 * qQ
End Function

Function ENP_LT_Limit(q As Double) As Double
'rounded off
   Dim qQ As Double
```

```
   qQ = q
   If qQ > 1061 Then qQ = 1061
   ENP_LT_Limit = 11.38 - 0.00538 * qQ + 1.397 * (2.493 - 0.00231 * qQ + 0.0000017 * qQ ^ 2) ^ 0.5
   ENP_LT_Limit = Application.WorksheetFunction.Round(ENP_LT_Limit, 1)
End Function

Function ENP_LT_Limit2(q As Double) As Double   'not rounded
   Dim qQ As Double
   qQ = q
   If qQ > 1061 Then qQ = 1061
   ENP_LT_Limit2 = 11.38 - 0.00538 * qQ + 1.397 * (2.493 - 0.00231 * qQ + 0.0000017 * qQ ^ 2) ^ 0.5
   'ENP_LT_Limit = Application.WorksheetFunction.Round(ENP_LT_Limit, 1)
End Function

Function ENP_INT_Limit(q As Double) As Double
'rounded off
   Dim qQ As Double
   qQ = q
   If qQ > 1061 Then qQ = 1061
   ENP_INT_Limit = 11.16 - 0.00465 * qQ + 1.397 * (6.377 - 0.00591 * qQ + 0.00000436 * qQ ^ 2) ^ 0.5
   ENP_INT_Limit = Application.WorksheetFunction.Round(ENP_INT_Limit, 1)
End Function

Function ENP_INT_Target(q As Double) As Double
   Dim qQ As Double
   qQ = q
   If qQ > 1061 Then qQ = 1061
   ENP_INT_Target = 11.16 - 0.00465 * qQ
End Function

Function ENP_Freq_Target(q As Double) As Double
   Dim qQ As Double
   qQ = q
   If qQ > 1061 Then qQ = 1061
   ENP_Freq_Target = 48.41 - 0.02896 * qQ
End Function
Function ENP_Freq_Limit(q As Double) As Double
'rounded off
   Dim qQ As Double
   qQ = q
   If qQ > 1061 Then qQ = 1061
```

```
    ENP_Freq_Limit = 48.41 - 0.02896 * qQ + 1.397 * (330.1 - 0.3071 * qQ + 0.0002254 * qQ ^ 2) ^ 0.5
    ENP_Freq_Limit = Application.WorksheetFunction.Round(ENP_Freq_Limit, 1)
End Function
```