Peer Review of Stormwater Management Criteria in Evaluation of Alternative Stormwater Regulations for Southwest Florida

For the Florida Department of Environmental Protection

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Section 1
BACKGROUND

The purpose of this document is to provide an independent peer review for the Florida Department of Environmental Protection (FDEP) of the "Evaluation of Alternative Stormwater Regulations for Southwest Florida" (EASRSF) prepared by Environmental Research and Design, Inc. (ERD) for the Water Enhancement and Restoration Coalition, Inc. (WERC).

The EASRSF report included the following sections:

- Section 1 – Introduction
- Section 2 – Estimation of Pre- and Post-Development Loadings
  - 2.1 – Calculation of Runoff Volumes
  - 2.2 – Evaluation of Runoff Characteristics
  - 2.3 – Estimation of Pre- and Post-Development Loadings
- Section 3 – Stormwater Treatment Options
  - 3.1 – Evaluation of Potential Treatment Options
  - 3.2 – Performance Efficiencies of Selected Treatment Options
  - 3.3 – Selection of Treatment Options
  - 3.4 – Evaluation of Pond Stratification Potential
  - 3.5 – Estimation of Loadings from Wetland Systems
- Section 4 – Design Examples
- Section 5 – References

This peer review focuses on the following issues:

1. Review the information presented in the EASRSF report relevant to pre-development and post-development loading (Section 2);

2. Document other available data or information on BMP efficiencies and "irreducible" (limiting) concentrations for dry retention and wet detention;

3. Develop Storage, Treatment, Overflow, Runoff Model (STORM) curves for three land use impervious conditions for comparison with the EASRSF report tables for southwest Florida based on recommended "live-pool" drawdown rates by the EASRSF report;

4. Review criteria for lake depth, potential stratification, potential anaerobic conditions and chemical reduction (versus oxidation), operation and maintenance issued based on wet detention permanent pool criteria in the EASRSF report; and

5. Review wetland event mean concentration data.

This peer review presents comments and recommendations for these topics, including the need for further data or research where appropriate.

Section 2
PEER REVIEW COMMENTS

The EASRSF report was reviewed by CDM personnel, including a wetlands expert and several senior water resource engineers and scientists. Each member of the CDM peer review team has knowledge of the standard practices and common principles of water resources engineering and their applicability to the laws and regulations of the State of Florida and the United States (US). In addition, each peer review member has project specific experience in southwest Florida with the South Florida Water Management District (SFWMD) and United States Army Corps of Engineers (USACE), including SFWMD environmental resource permits (ERPs) and USACE Section 404 permits for retrofits and new development. The comments generated by CDM's peer review team have been compiled in this peer review report.

2.1 ESTIMATION OF PRE- AND POST-DEVELOPMENT LOADINGS

This section of the peer review addresses the EASRSF estimation of pre- and post-development loading using the concentration-based method.

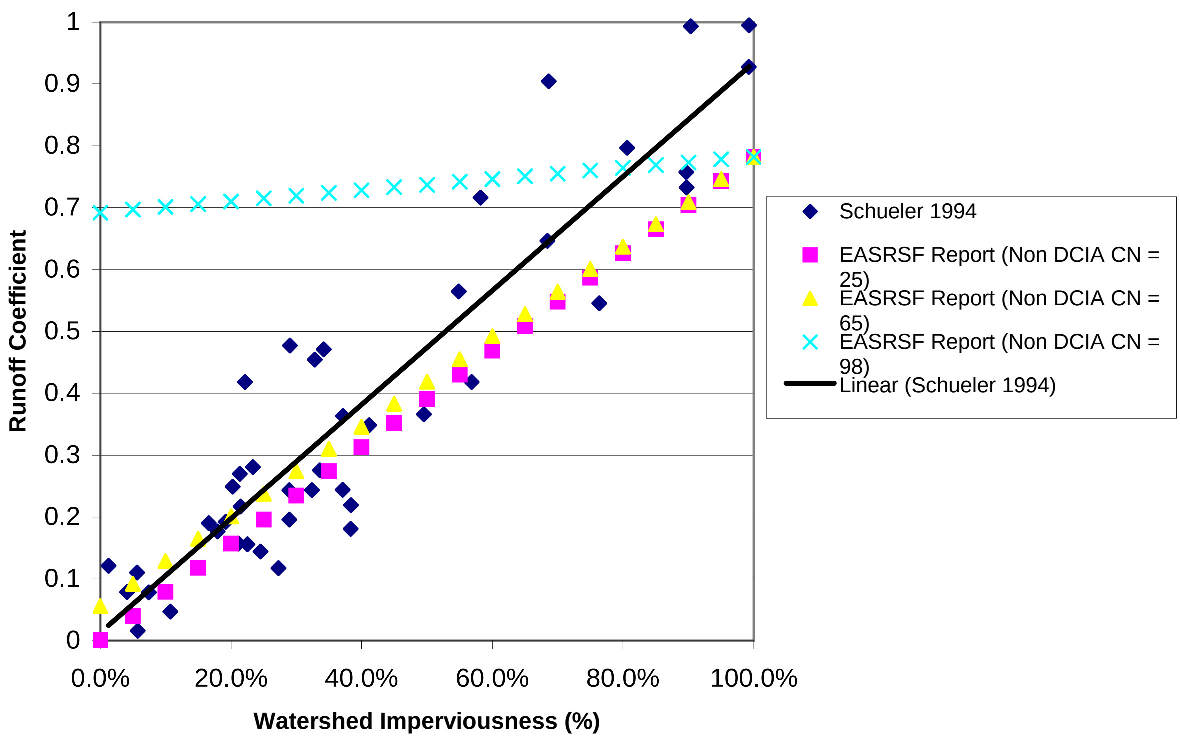
2.1.1 Calculation of Runoff Volumes

The EASRSF report proposes an alternative method to evaluate annual runoff volume to be used in pre- and post-development comparisons. After initial review, it appeared that the methodology for estimating pre- and post-development runoff may underestimate runoff volume for higher impervious area applications. For instance, consider Table 4 in the EASRSF report for a case of 100 percent directly connected impervious area (DCIA). The annual runoff coefficient based on the methodology presented would be 0.782. This value is lower than typically observed and estimated values of 0.9 to 0.95. By definition, DCIA produces instantaneous runoff after initial evaporation, and the evaporation term is generally 10 percent or less for DCIA. The disparity among the EASRSF report suggested runoff C coefficients and typical values based on percent imperviousness is further supported by **Figure 2-1** below, which compares the EASRSF approach to values published by Schueler (Schueler 1994).

However, after further review and calculations performed in Section 2.3, it appears that evaporation effects for Southwest Florida may be in the range of 20 percent and the EASRSF report runoff coefficient includes consideration of evaporation. We recommend that this should be further clarified in the report.

The C values should be refined for different rain gage locations in the State for potential future applications.

Figure 2-1
Comparison of Schueler Data and EASRSF's Methodology of Approximating the Runoff Coefficient



2.1.2 Pre- and Post-Development Nonpoint Source Pollutant Loadings

In general, the nonpoint source pollutant loading values presented in the EASRSF report (Table 7) seem reasonable and are within ranges typically used in Florida. The EMC values published in the EASRSF report are based on a summary of published studies conducted in central and south Florida. The individual studies are summarized is a series of tables in Appendix A (i.e., Table A-2) of the EASRSF report based on land use.

It appears that the EMCs published in the EASRSF report (Table 7) were estimated by taking a straight average of the values presented in the Appendix A tables. We recommend that the number of samples per site be considered in the weighting of the EMCs as a refinement to Tables 7 and A-2. This refinement is not expected to appreciably change the values.

2.2 OTHER AVAILABLE DATA AND INFORMATION REGARDING BMPs

The EASRSF report recommends the selection of either dry retention or wet detention to meet the goal of “no net increase in loadings under post-development conditions”. The recommendation is based on the premise that these two systems are the only common stormwater management systems capable of achieving pollutant removal efficiencies in excess of 60 percent and potentially up to 95 percent depending on the pollutant of concern. These ranges of removal are higher than normally observed, and most literature references do not support the higher wet detention nutrient removal efficiencies predicted by the EASRSF report.

It is also important to note the difference between stormwater retrofit projects and new development projects with respect to the application of the EASRSF criteria. Stormwater retrofits, by definition, are designed to reduce pollutant loads from land uses and drainage systems that were built before stormwater treatment regulations were implemented. New development projects increase pollutant loadings, and therefore, will need to meet a higher treatment level (e.g., larger BMPs) to achieve the no net increase in pollutant loading goal. As a specific example, a new development may need, and possibly desire, a larger wet detention lake and permanent pool (with longer residence times). The longer residence times in the EASRSF criteria for wet detention ponds have significant capital cost implications for municipalities implementing retrofit stormwater improvements (e.g. 1000 percent excavation cost increase for a potential 50 percent TP removal increase). This section will compare some of the EASRSF report predicted removal efficiencies for wet detention and dry retention versus some of the more widely accepted and documented data sources. Recommendations for refinements and clarifications are made.

2.2.1 Wet Detention Removal Efficiencies

The EASRSF report presents expected nutrient removal efficiencies (EASRSF report Figures 3 and 4) for residence times in excess of 100 days that are significantly greater than average efficiencies reported in national databases:

- Total Nitrogen (TN): For residence times of 100 to 300 days, EASRSF report Figure 3 shows 5 data points with efficiencies of 80 to 85 percent and a regression curve with maximum efficiencies of 65 to 75 percent. National databases such as Center for Watershed Protection (2000) and ASCE (2001) typically report average TN removal efficiencies on the order of 30 to 45 percent for wet detention ponds. However, these sources also have limited Florida-specific data, and removal efficiencies in Florida could be higher. Studies in Florida (Harper, 1998; Yousef and Wanielista, 1993) have also demonstrated that wet detention systems built to meet the state's presumptive design criteria typically get 30 to 40 percent removal of TN loadings.

- Total Phosphorus (TP): For residence times of 100 to 300 days, EASRSF report Figure 4 shows 5 data points with 90 percent efficiency and a regression curve with maximum efficiencies of 80 to 90 percent. National databases (Center for Watershed Protection, 2000 and ASCE 2001) typically report average TP removal efficiencies on the order of 50 to 70 percent for wet detention ponds. Again, these sources have limited Florida-specific data. Studies in Florida (Harper, 1998; Yousef and Wanielista, 1993) have also demonstrated that wet detention systems built to meet the state's presumptive design criteria typically get 60 to 70 percent removal of TP loadings.

Since the EASRSF report relies upon BMP removal efficiency estimates which are significantly greater than those reported elsewhere in Florida and the United States for statistically significant data sets, it would be helpful if the report could document the following information:

1. The source data reported in EASRSF report Figures 3 and 4 (along with site descriptions);

2. The monitoring approach used to measure average removal efficiencies in those ponds with very long residence times (parameters, methods, frequency, durations of monitoring to residence time, etc.); and

3. Whether the average removal efficiencies were based upon ratios of "event" concentrations or cumulative mass loads (inflow/outflow). Efficiency calculations based on mean concentrations are subject to greater variation and error and are generally not recommended (ASCE/EPA, 2002). Cumulative mass balance monitoring for flow and loads in and out of the pond system is desirable over a statistically significant time period.

Walker Method Comparison

The efficiencies reported in design example #1 (Section 4.1 of the EASRSF report) were compared with projections from the empirical model developed by Walker (1985, 1986). The Walker model is based on empirical data for over 295 lakes and reservoirs, of which 5 are in Florida and Georgia. It is used to predict expected removal efficiencies for TN and TP based on residence time of a wet detention facility and the inflow concentrations in terms of ratios of nutrient species for the land use and water quality conditions as the EASRSF report example. The results of this comparison are summarized in **Table 2-1** below. This comparison shows that the EASRSF report results predict higher removal efficiencies as compared to the Walker results. The Walker methodology for analyzing the EASRSF report design example #1 is included in **Appendix A.**

Table 2-1
EASRSF Report Design Example #1
Wet Detention Predicted Removal Efficiencies for TN and TP
Comparison with Walker Model and Irreducible Concentrations

Method	Predicted % TP Removal	Predicted % TN Removal
EASRSF Report	90%	74%
Walker Model	76%	53%
Irreducible Concentration Method	40% to 55%	13% to 27%

Notes:

1. The EASRSF report Design Example #1 stipulated that a 100 acre, medium density residential area would require a wet detention pond with a 269 day residence time and expected the TN inflow would be 2.18 mg/l and the TP inflow would be 0.335 mg/l
2. The Walker Model requires as input, the residence time and ratios of ortho-P/TP and inorganic-N to TN. The ortho-P/TP ratio was estimated to be 0.33 and the inorganic-N to TN ratio was estimated to be 0.45 based on typical values for the design example.
3. For the irreducible concentrations method, wet detention discharge concentrations range from 1.6 mg/L to 1.9 mg/L for TN and 0.15 mg/L to 0.20 mg/L for TP (ASCE/EPA 2002).

Irreducible Concentration Method Comparison

In addition, there is significant research available that suggests a wet detention facility may only have the ability to remove pollutants to limiting levels, termed "irreducible concentrations". The ASCE/EPA report "Urban Stormwater BMP Performance Monitoring" (April 2002) describes irreducible concentrations for urban BMP discharges. The irreducible concentrations represent the lowest discharge concentration which can be achieved by urban BMPs based upon published BMP studies and databases from around the United States. Again, it is understood that limited Florida-specific data are in this database.

It is recognized that experimental stormwater treatment areas (STAs) in the SFWMD achieve lower concentrations, but these are a special case of 1,000- to 6,000-acre wetlands with relatively steady flow. The irreducible concentrations reported in the ASCE/EPA report are 1.6 to 1.9 mg/L for TN and 0.15 to 0.2 mg/L for TP. While it is recognized that Nitrogen-limiting conditions in some Florida water bodies may result in greater nitrogen uptake (wetlands, benthic algae, phytoplankton) and lower irreducible concentrations, the BMP discharge concentrations resulting from the EASRSF report methodology and BMP efficiency curves (EASRSF report Figures 3 and 4) are still considerably lower than the irreducible concentrations of 0.3 to 0.7 mg/L for TN (75 percent removal efficiency) and 0.018 to 0.05 mg/L for TP (90 percent removal efficiency).

The EASRSF report acknowledges that the BOD removal efficiencies (EASRSF report Figure 6) should be limited to values that do not result in discharge concentrations less than 1 to 2 mg/L which reflect "background conditions" (p. 3-14) or essentially an irreducible concentration. It is recommended that a similar approach be taken to establish provisional upper bound removal efficiencies for TN and TP. Use of the Walker or irreducible concentrations methods would establish the upper bound removal efficiency at 20 to 50 percent for TN and at 45 to 75 percent for TP, which would be more in line with published national and Florida BMP effectiveness data. These lower maximum removal efficiencies would also result in residence times less than 30 days which would avoid the potential "pond stratification" problems discussed in the EASRSF report. Further data to document and verify these efficiencies are presented in the following sections.

2.2.2 Establishing Removal Efficiencies for Wet Detention Facilities

The removal efficiency curves presented in the EASRSF report Figure 3 (TN), Figure 4 (TP) and Figure 5 (TSS) are based on studies within the State of Florida. These data were then compiled and used to formulate regressions to predict expected removal efficiencies based on residence time. The EASRSF report takes this analysis a step further by suggesting that these regressions should be used as a basis of sizing facilities. There are several important items that should be considered that do not support the use of these regressions for sizing larger permanent pools for wet detention facilities (e.g., great than approximately 50 days) without further supporting data.

First, the higher residence time removal values (greater than 100 days) appear to be based on only 5 data points which essentially “level out” or reach an asymptote at about 50 days. Second, a review of how the removal efficiencies were established for the data presented in the EASRSF report is necessary to verify the monitoring programs were adequate to be included in the analysis. This is especially important when considering facilities with residence times in excess of 30 to 50 days.

A more involved monitoring program is required to collect reliable monitoring data (inflow vs. outflow) for ponds with residence times greater than 30 days. This is because inflow and outflow must be continuously monitored over a very long period to account for the long residence times (e.g., monitor for about 12 months continuously to measure the outflow from about 12 storms with an average residence time of 30 days). If a storm is missed, particularly at the outflow station, the mass balance used to calculate the BMP removal efficiency can exhibit significant error. For this reason, longer term mass balances are needed to account for flow and pollutant mass. Because the duration of the inflow storm "event" (averages 2 to 2.5 hours for Southwest Florida) is usually much shorter than the outflow duration due to storage routing, peak shaving and bleed-down requirements (release of the first 0.5 inch of runoff over 24 hours), it is more difficult to fully monitor the pond discharges at the outflow station.

If at least 10 to 15 storm events were monitored at the pond sites presented in EASRSF report Figures 3 and 4 for statistical validation (ASCE/EPA, 2002), the minimum required duration (continuous monitoring) of the BMP monitoring program is 3 to 4 years for a 100-day residence time (approximately 3.65 full inflow-outflow events per year with 10 to 15 total events yields 2.7 to 4 years of monitoring) and 8 to 12 years for a 300-day residence time. If the BMP efficiency data in EASRSF report Figures 3 and 4 were not based on continuous monitoring for these durations, the reported data points may not be representative. Likewise, if the reported data points are based on only a few storm events over a fairly short duration (say 6 to 12 months), it is possible that the pollutant removal statistics overestimate the inflow loadings and underestimate the outflow loadings, since the two stations may monitor entirely different storm events. That is, in a pond with a residence time of 100 to 300 days, the inflow storms do not necessarily correspond to the outflow discharges if the monitoring program is limited to a 6 to12 month period.

2.2.3 Dry Retention Removal Efficiencies

Dry retention is a reliable BMP with good performance in areas with SCS Hydrologic Group A or B soils and a depth to wet season water table greater than 2 feet below the basin invert. The EASRSF report estimates a 100 percent removal efficiency for all stormwater pollutants which are captured in the dry retention storage facility, assuming that "stormwater pollutants are trapped in the upper 4 inches of soil" underlying the retention basin (EASRSF report pages 3-4 and 3-6). While the estimate of 100 percent removal may be appropriate for TP, TSS, BOD, and most metals which are removed by trapping of the particulate fraction and/or adsorption, it may not be as accurate for nitrites and nitrates, which are soluble and may not be significantly adsorbed onto the underlying soil particles and may pass relatively untreated into interflow/baseflow which may flow into streams and lakes downstream of the retention facility. This could be especially true for certain permeable strata in Southwest Florida.

Denitrification of nitrate-N forms under anoxic subsurface flow conditions is likely to be the primary mechanism for nitrogen removal; however, only about one-third of the TN in urban runoff is typically in the nitrate-N form and some of the nitrate-N releases may not be subject to anoxic conditions. Therefore, the estimate of 100 percent removal of TN by dry retention facilities may be higher than what would be measured under field conditions. Further documentation or data are recommended to verify the estimated dissolved nitrogen removal efficiencies in dry retention basins.

2.3 STORAGE TREATMENT OVERFLOW RUNOFF MODEL (NetSTORM) COMPARISON TO EASRSF REPORT RESULTS

The EASRSF report publishes a series of tables in Appendix B detailing the expected removal efficiencies for dry retention systems based on the amount of treatment volume provided, the runoff coefficients based on the EASRSF report's recommended methodology, and design criteria (Table 8 EASRSF report). In order to check the EASRSF report's average annual rainfall and runoff volume efficiencies (and associated expected removal efficiencies), CDM developed a NetSTORM model using 43 years of rainfall for the Ft. Myers National Climatic Data Center (NCDC) gage for 3 land use imperviousness conditions.

NetSTORM is a hydrologic model designed for flow rate characterization in combined sewer systems, wastewater treatment plants, and stormwater detention and treatment systems. Its methodology is based upon the original STORM developed by CDM for the USACE Hydrologic Engineering Center (HEC) in the 1970s. It uses the Rational Method to compute runoff, and it computes event and annual capture and overflow volumes for a specified storage volume and treatment (discharge) rate.

The three land use imperviousness conditions selected for the NetSTORM analysis were for runoff coefficients of 1.0, 0.60, and 0.20 for the treatment volume discharge rate recommended in the EASRSF report (entire treatment volume/40 hrs) and for the current SFWMD treatment discharge rate (0.5 inch/24 hours). The results of this analysis, including comparisons to the EASRSF report data, are summarized in **Figure 2-2, Figure 2-3** and **Figure 2-4** of this peer review. The comparison between NetSTORM and EASRSF report results indicate minor differences in expected amounts of average annual rainfall volume capture. It should be noted that evaporation is a major component of the water budget for DCIA (approximately 20 percent) for the Ft. Myers rain gage where a large percentage of rainfall volume is represented by rainfall events less than 0.1 inch. Therefore, the runoff coefficients in the EASRSF report appear to be appropriate for Southwest Florida, but should be verified for other areas. It is recommended that the slightly faster EASRSF drawdown requirement of the total volume infiltrated over 40 hours be implemented (slightly greater safety factor for the infiltration of retained runoff).

2.4 WET DETENTION POND DEPTHS

The methodology for sizing wet detention facilities presented in the EASRSF report states that these facilities may require permanent pool depths up to 30 feet to achieve residence times in the range of 300 to 350 days. This section of the Peer Review discusses potential issues for pond depths greater than typically accepted standards of practice and data review and monitoring recommendations.

2.4.1 Pond Stratification Potential

The EASRSF report includes a new procedure for evaluating vertical stratification in the large wet ponds which will result from the recommended methodology and BMP efficiency

Figure 2-2
Dry Retention Average Annual Volume Capture 100% DCIA
Comparison of EASRSF Report and NetSTORM Runs
Ft. Myers Airport Rainfall Data (1960 to 2002)

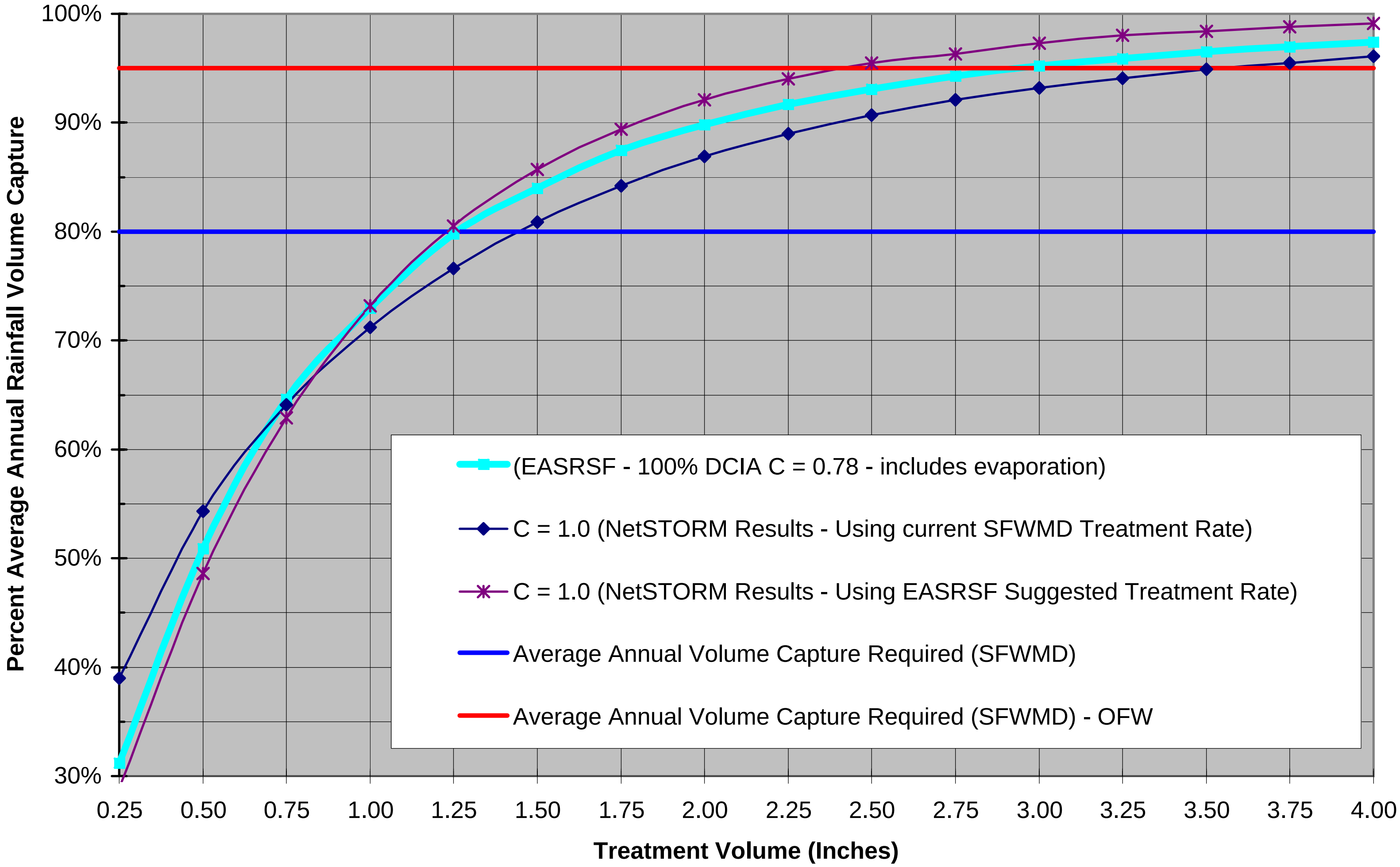


Figure 2-3
Dry Retention Average Annual Volume Capture for C = 0.60
Comparison of EASRSF Report and NetSTORM Runs
Ft. Myers Airport Rainfall Data (1960 to 2002)

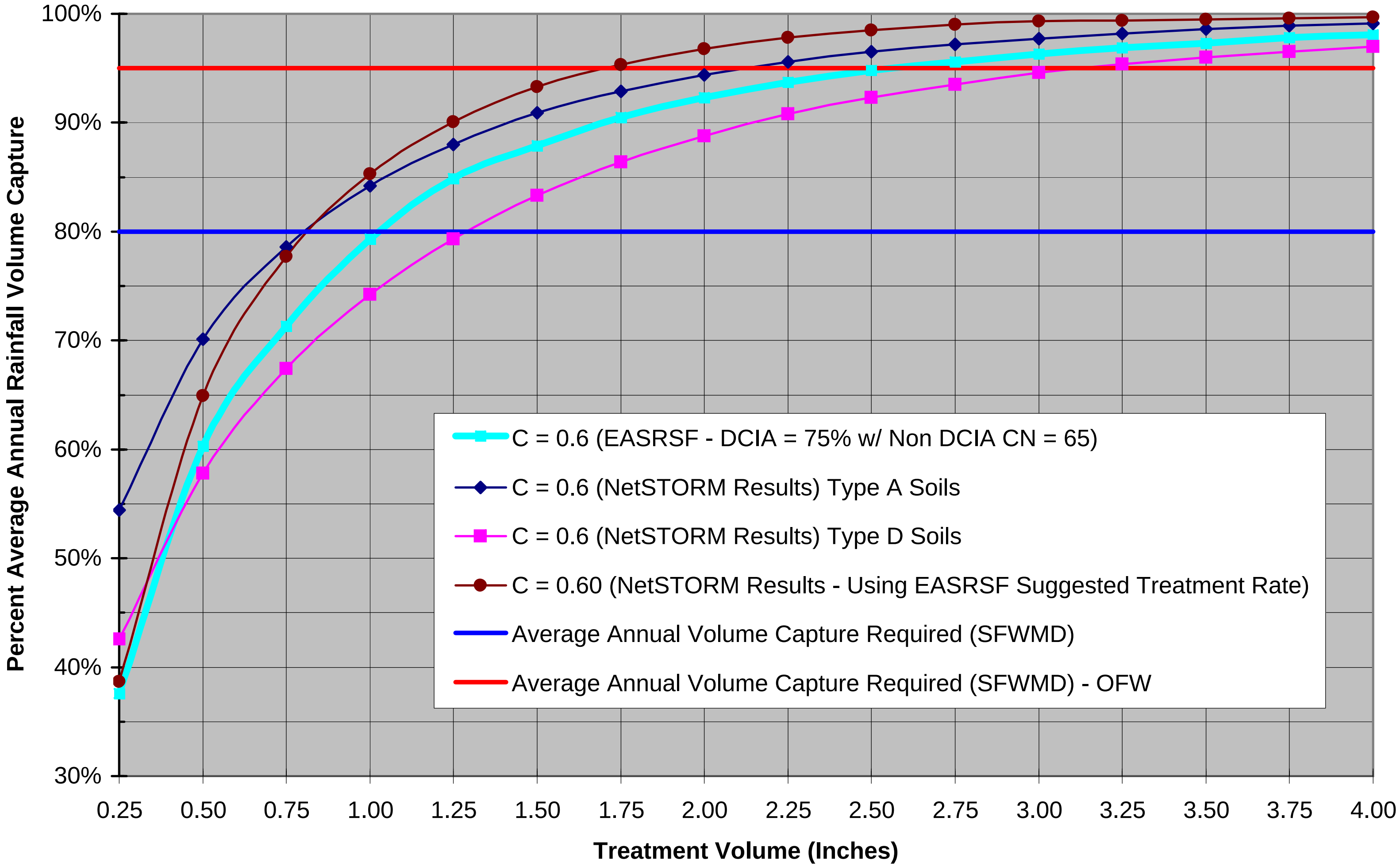
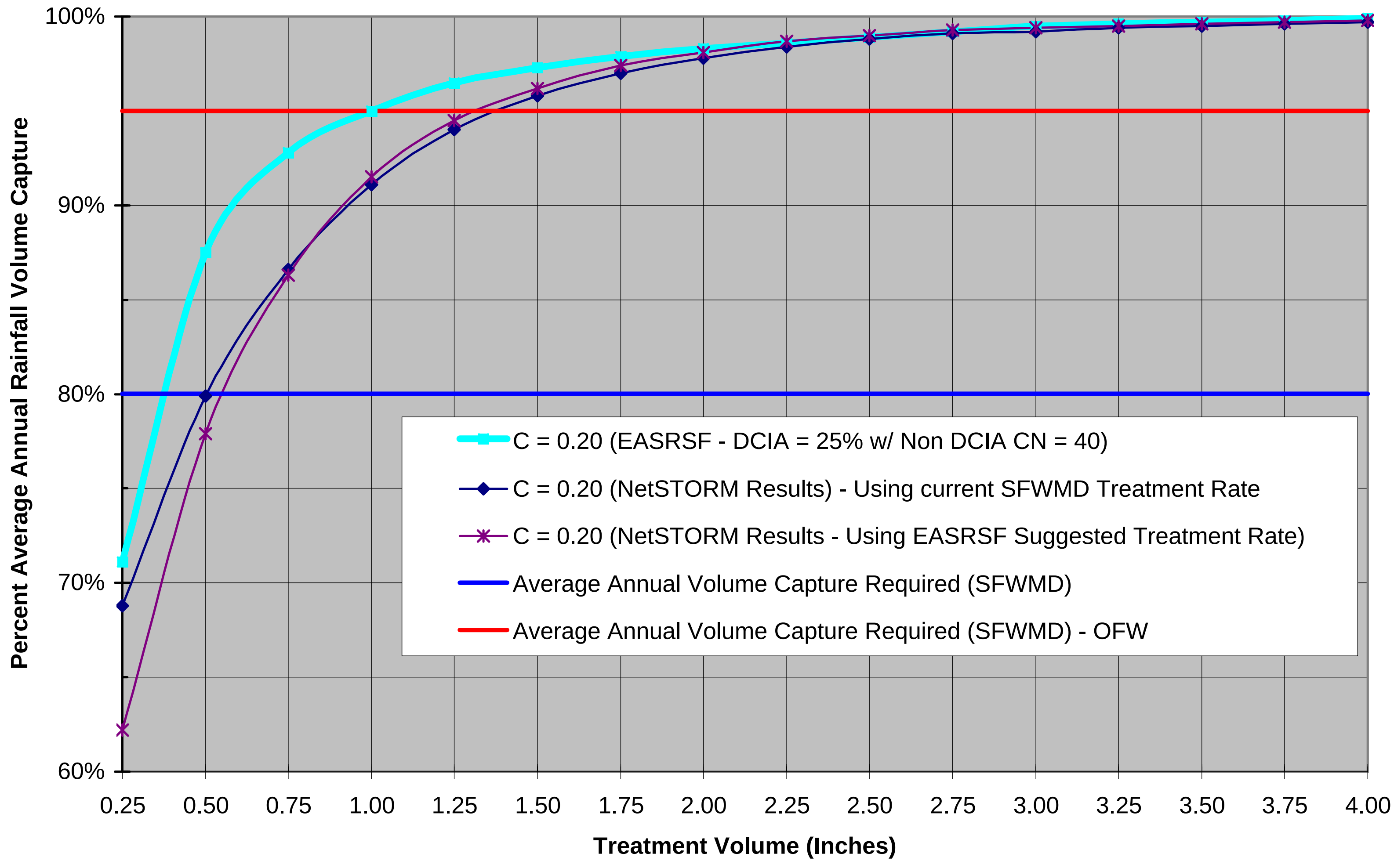


Figure 2-4
Dry Retention Average Annual Volume Capture for C = 0.20
Comparison of EASRSF Report and NetSTORM Runs
Ft. Myers Airport Rainfall Data (1960 to 2002)



curves (e.g., 269-day residence time for the wet pond BMP covered by Design Example #1). These evaluations of pond stratification potential are required because of the depths necessary to achieve the very high residence times for 90 percent TP removal efficiency (with a reasonable surface area). The report indicates that the depths of the permanent pool will range from 6 feet to 30 feet (p. 3-7). Other Florida (FDEP 1988) and national BMP guidelines (e.g., WEF/ASCE, 1998) recommend a maximum depth of 10 to 14 feet to minimize the risk of thermal stratification which can result in the discharge of poor quality waters from the anaerobic lower zone during storm, wind, or seasonal events that destratify the pond. Predicting stratification and anoxic depth as a function of chlorophyll-a, Secchi depth, and total phosphorous appears to be an appropriate provisional method that should be refined to consider water color, groundwater flow, and depth greater than 7.1 meters (up to 30 ft in EASRSF report).

The following paragraphs present other references on this topic.

Other References on Pond Depth and Stratification

Stratification in detention ponds is caused by water density difference that is a non-linear function of temperature. The intensity of sunlight decreases exponentially with water depth. Water absorbs about 30 percent of the energy in sunlight as heat. As surface water absorbs this energy, it becomes warmer and less dense than the water beneath. The result is warmer, less dense layers of water that float over the top of cooler, denser layers of water. The degree of stratification in a pond can be calculated by determining the difference of water temperatures between depth increments (Hargreaves, 2003). This yields to a rate of temperature change with depth. The literature mentions other ways to measure stratification, such as dissolved oxygen and electrical conductivity (EPA, 2000, page 15).

The literature includes models for predicting Chlorophyll-a concentration as a function of Secchi Disk depth. This empirical method applies when chlorophyll-a is the dominant attenuation factor and the homogenous, equivalent conditions have been satisfied. Chlorophyll-a is only one attenuation substance of a group that includes dissolved solids, humic acids, and algae of different age, size and species. Therefore, this regression model varies considerably in both the slope and the intercept, emphasizing that the relationship between Secchi depth transparency and trophic state variables such as chlorophyll can be highly variable for a number of reasons (Carlson and Simpson, 1986). Further investigations are required to reach conclusions that strongly support predicting stratification and anoxic depth as a function of trophic state variables.

It should also be noted that groundwater flow interaction can significantly affect stratification, and there is significant groundwater interaction with lakes in Southwest Florida. More groundwater interaction would generally be favorable for more well-mixed conditions at the pond bottom, but it would not necessarily add oxygen.

2.4.2 Determination of Maximum Pond Depth

As discussed in the EASRSF report, selecting the maximum depth of the pond and controlling water quality parameters are critical factors in attempting to limit stratification.

This section provides comparisons and references on publications defining the maximum depth of a pond for potential consideration to refine the EASRSF method.

In a study comparing a 2.7-meter (8 ft) pond with a 1.1-meter (4 ft) pond in Florida (adjacent stormwater ponds constructed for the study), Cunningham (1993) found that the deeper 2.7-meter pond stratified frequently during warm and cold weather periods, while the shallower 1.1-meter pond only stratified during extended periods of hot weather.

According to Hartigan (1989), a mean depth of 1 to 3 meters (3 to 10 ft) should be maintained in the permanent pool of a wet pond, shallow enough to minimize the risk of thermal stratification (no greater than 4 meters [13 feet] to 6 meters [20 feet]), but deep enough to discourage algal blooms and to minimize sediment re-suspension.

These previous studies on the maximum pond depth, as well as other design criteria (residence time and length-width ratio), are summarized in **Table 2-2** and the Florida Development Manual presents further documentation on wet detention criteria.

For the ambient water quality conditions expected in the large permanent pools resulting from the EASRSF report (e.g., 0.034 to 0.05 mg/L TP assuming a 90 percent removal requirement), the maximum depth to the top of the anoxic zone (hypolimnion) is approximately 10 to 14 feet based on the regression equation reported on EASRSF report p. 3-22. Therefore, if residence times on the order of 100 to 300 days will be required for wet detention ponds, it is recommended that the design criteria specify a maximum permanent pool depth of 10 to 14 feet for residential and high intensity commercial land use (not 30 feet as suggested on p. 3-7). By setting the maximum depth at a level which is above the expected anoxic zone, the regulatory agency will not have to consider options such as mechanical aeration systems which will add maintenance costs/risks while potentially reducing the reliability of the BMP pond. For ponds which exclusively serve low intensity commercial land use (i.e., has a much lower TP loading factor [0.18 mg/L] than other land uses), a maximum pool depth greater than 14 feet may be acceptable. It should be noted that a larger lake area would be required to achieve a given residence time than for a shallower lake.

The EASRSF report implies that the pond stratification evaluation should be based upon the mean depth of the permanent pool. The Peer Review team recommends also comparing the calculated anoxic zone depth with the maximum depth of the permanent pool, since it is the deeper layers which may become anoxic during the year. Setting the maximum depth at an appropriate level and then calculating the resulting mean depth is a suggested refinement that would reduce stratification potential.

It is recommended that further data be collected and evaluated on wet detention lake stratification which considers groundwater interaction, color, DO, depth, Secchi dish depth, temperature, pH, turbidity, and other parameters as appropriate. The FDEP is partnering with the Bonita Bay Group to monitor shallow and deep ponds at the Brooks development to refine the EASRSF methodology for lake depth.

Interim wet detention lake depths are recommended in Section 3.0

Table 2-2 Detention Pond Design Criteria from a Variety of Sources Reviewed

Design Criteria	Value	Comment	Source
Pond Depth	Permanent Pool = 8 - 10 feet		Florida Development Manual (FDEP 1988)
	Permanent Pool = 1- 2.7 meter (3.33 - 9 feet)	Frequent stratification at 2.7 m (9 feet)	Cunningham, 1993
	Permanent Pool = 3 - 8 feet		Minnesota Pollution Control Agency, 2000, Chap. 5, p 46
	Permanent Pool = 1 - 3 meter (3 - 10 feet)		Hartigan, 1989
Length-Width Ratio	No less than 3:1		Florida Development Manual (FDEP 1988)
	1 - 3	Increase of removal efficiency	Wu and Yu, 1995
	1 - 4.4		Ellis, 1989; Hartigan, 1989
	3 - 7		Yousef and Wanielista, 1993
Hydraulic Residence Time	14 Days		Florida Development Manual (FDEP 1988)
	72 hours		Hvitved-Jacobsen et al., 1989
	Minimum 2 weeks		Hartigan, 1989
Wet Pond Area/Watershed Area	5%		Florida Development Manual (FDEP 1988)
	3%	Recommended for optimal removal	Athanas, 1988
Detention Basin Volume / Median of the Storm Runoff Volumes	4 - 6		Yousef and Wanielista, 1993

2.5 WETLAND EVENT MEAN CONCENTRATIONS

The EMCs recommended in the EASRSF report for wetlands (Table 5) seem reasonable based on the variability of the EMCs for the 19 wetland sites and compared to the irreducible concentrations reported by ASCE/EPA (2002). Additionally, the irreducible background concentration from wetlands is on the order of 1.50 mg/L for TN and 0.02 mg/L for TP (Kadlec and Knight, 1995).

It is important to note that wetlands are protected in Florida under the ERP program, as well as the USACE Section 404 dredge and fill permitting program and mitigation is required for adverse impacts on wetlands if they cannot be avoided. Additionally, Florida is unique in having statutory authority to incorporate certain wetlands into wastewater and stormwater treatment "trains". The FDEP (62-25.042, FAC) and several of the water management districts (e.g., SJRWMD chapter 40C-42.0265, FAC), but not the SFWMD, have adopted specific design criteria for the incorporation of wetlands into a stormwater management system. Therefore, avoidance and minimization of impacts should always be considered as the first option, with mitigation used if wetlands are impacted.

Section 3
CONCLUSIONS AND RECOMMENDATIONS

The basis for recommending alternative stormwater regulations, as stated in the EASRSF report, is guided by the goal of "no net increase in pollution" for necessary stormwater constituents under post-development conditions. It is important to note that this goal applies only to new development, since retrofit of stormwater systems can generally provide moderate to significant load reduction.

The peer review concurs that the approaches presented in the EASRSF report would provide higher removal efficiencies when compared to the stormwater treatment criteria under the existing regulations, especially for dry retention. Further clarifications, documentation, and data are necessary to confirm that the alternative criteria will meet the "no net increase in pollution" goals, particularly for nutrients.

The peer review of the EASRSF report has identified the following main issues requiring further clarification, documentation, analysis and review of specific data, or refinements of the EASRSF report recommended approaches. These issues, including recommendations, are summarized below:

1. The larger permanent pool volumes for wet detention should apply to new development. Retrofit should be addressed on a case-by-case basis as a demonstration of "no load increase" (and reduction).

2. The predicted removal efficiencies for wet detention presented in the EASRSF report are higher than published values and model predictions such as the Walker or irreducible concentrations methods, especially for nutrients. The recommended

efficiencies are based upon a limited number of data points for extremely long residence times and a more detailed review of the monitoring data is necessary to verify that the monitoring program established to generate such data is adequate. As stated previously, the suggested minimum required duration (continuous monitoring) of the BMP monitoring program is 3 to 4 years for a 100-day residence time and 8 to 12 years for a 300-day residence time. In the interim, without the existence of supportive data to confirm the EASRSF report predicted removal efficiencies, the Peer Review team recommends that:

- Either the Walker model or irreducible concentrations be used to predict expected TN and TP removal efficiencies as provisional calculation methods; and

- Additional monitoring data be collected and evaluated from existing and new systems to enhance the statistical significance of the supporting data and to evaluate the effectiveness of the systems. This is already being planned by FDEP.

3. The pond depth range recommended by the EASRSF report of up to 30 feet may be too deep for all systems pending further consideration or supporting data. The Peer Review team recommends that:

    - The design criteria specify a provisional maximum permanent pool depth of 10 to 14 feet to minimize the risk of reduced removal efficiencies due to vertical stratification unless site-specific data are presented to document that stratification will not occur or will not diminish treatment effectiveness;

    - An interim criterion for permanent pool volumes is proposed:

        - The first 14 to 21 days of residence time should be in the first 10 to 14 feet of pond depth below normal water level, and

        - Permanent pool residence time from 14/21 days through 50 days should be provided in the zone from 12 to 14 feet up to 20 feet deep.

    - Additional data be collected and evaluated from existing and new systems to refine statistical significance of the supporting data to enhance the estimation methodologies in the report based on EASRSF nutrient loading, water color and clarity, depth, solar radiation, water temperature, groundwater flow effects, and DO. In particular, the consideration of water color and depths greater than 20 feet in the monitoring is recommended. This is already being planned by FDEP.

4. Wetlands regulations should be referenced and the design example should be clarified to state that the wetlands should be protected unless permitted to be used for development or stormwater treatment in conjunction with a mitigation program consistent with the ERP and Section 404 permitting programs.

5. Further data verification is recommended for dry retention basin dissolved nitrogen removal, the EASRSF drawdown requirement of infiltration of the total treated volume over 40 hours should be implemented, the invert of the dry retention should be at least 2 feet above the wet season water table, and 4:1 slopes are recommended unless site-specific data are presented to support an alternative design.

6. Wet detention criteria should also include:

   - The normal water level (NWL) at or above the wet season water table; and

   - Consideration of 6:1 slopes for the littoral shelf.

7. Effective runoff coefficients should be refined for other locations across the state with clarification on the amount of evaporation.

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APPENDIX A

Wet Detention
Walker Method Comparison

Walker Removal Efficiency Section

This method was developed by Dr. William W. Walker. It is an empirical approach to nutrients removal in impoundments. It is the result of a research project which was based on a database describing morphometry, hydrology and water quality conditions in 299 Corps of Engineers reservoirs.

William W. Walker Jr.
Empirical Methods for predicting Eutrophication in Impoundments
Chief of Engineers, U.S. Army Washington
Tech.Report E-81-5 Environ. Lab
Waterways Exp. Sta. Vicksburg, MS, 1985

Terms for Both	(User inputs values in **blue**)			
PPV (acre-ft)	**90.60**			
Avg. Pond Depth (feet)	**15.10**			
Qs	6.24 m/yr			
Residence Time	**269** days			
T	0.7370 Years			
Phosphorus		**Nitrogen**		
TP inflow	0.335 mg/l	TN inflow	2.18 mg/l	
Pi	335 mg/m3	Ni	2,180 mg/m3	
F_{OT}	**0.33** (unitless)	F_{IN}	**0.45** (unitless)	
K2	0.054 m3/mg*yr	K2	0.0015 m3/mg*yr	
P	80 mg/m3	N	1,026 mg/m3	
% Removal of P	**76%**	**% Removal of TN**	**53%**	

Walker Method

Phosphorus Removal

$$P = \frac{\left(-1 + \left(1 + 4 \cdot K2 \cdot P_I \cdot T\right)^{0.5}\right)}{2 \cdot K2 \cdot T}$$ (Equation 2-5)

$$K2 = \frac{0.056 \cdot Q_S \cdot F_{OT}^{-1}}{Q_S + 13.3}$$ (Equation 2-6)

Where:
Pi = Inflow total phosphorus (mg/m3)
P = Total phosphorus released by the impoundment
Qs=Surface overflow rate (m/yr)
Fot = Tributary ortho-P/Total P (unitless)
T = Hydraulic residence time (years)
K2 = Second order decay rate function (m3/mg-yr)

Qs = (V/T)/(V/Z) = Z/T , where:

V = permanent pool volume (in cu. meters)
Z = mean depth (in meters) = V/A
T = avg hydraulic residence time (in years)

Nitrogen Removal

$$N = \frac{\left(-1 + \left(1 + 4 \cdot K2 \cdot N_I \cdot T\right)^{0.5}\right)}{2 \cdot K2 \cdot T}$$ (Equation 2-7)

(Equation 2-8)

$$K2 = \frac{0.0035 \cdot Q_S \cdot F_{IN}^{-0.59}}{Q_S + 17.3}$$

Where:
Ni = Inflow total nitrogen (mg/m3)
N = Total nitrogen released by the impoundment
Qs=Surface overflow rate (m/yr)
Fin = Tributary inorganic N/Total N (unitless)
T = Hydraulic residence time (years)
K2 = Second order decay rate function (m3/mg-yr)

Note: Tributary nutrient ratios are based on typical Southwest Florida data

Appendix B
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