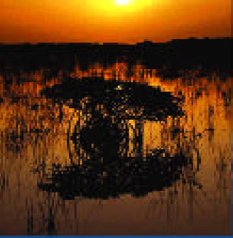
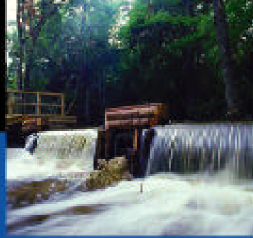


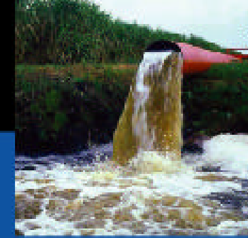

SFWMD

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

FINAL

EVALUATION OF STORMWATER TREATMENT POTENTIAL OF THE WESTERN C-11 IMPOUNDMENT

WORK ORDER NO. C-15982-W006-05

TASK 4: ALTERNATIVES EVALUATION REPORT

MARCH 2004
PROJECT NO. 6308-03-0032

PREPARED BY

MACTEC

MACTEC ENGINEERING AND CONSULTING, INC
KENNESAW, GEORGIA AND WEST PALM BEACH, FLORIDA

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MARCH 2004

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ATT	Advanced Treatment Technologies
C&SF	Central and South Florida
CERP	Comprehensive Everglades Restoration Plan
cfs	cubic feet per second
CPM	Critical Path Method
DMSTA	Dynamic Model for Stormwater Treatment Areas
ECP	Everglades Construction Project
EFA	Everglades Forever Act
EPA	Everglades Protection Area
ESP	Everglades Stormwater Program
F.A.C.	Florida Administrative Code
MACTEC	MACTEC Engineering and Consulting, Inc.
NURP	Nationwide Urban Runoff Program
O&M	Operations and Maintenance
ppb	parts per billion
SFWMD	South Florida Water Management District
STA	Stormwater Treatment Areas
USEPA	U.S. Environmental Protection Agency
WCA	Water Conservation Area
WRDA	Water Resources Development Act

EXECUTIVE SUMMARY

The South Florida Water Management District (SFWMD) has initiated a comprehensive Everglades program to protect and restore the Florida Everglades. The Everglades Forever Act requires that urban and agricultural runoff discharged to the Everglades Protection Area (EPA) must achieve and maintain state water quality standards including the phosphorus criterion established in Rule 62-302.540, Florida Administrative Code (F.A.C). The SFWMD has contracted with MACTEC Engineering and Consulting, Inc. (MACTEC) to perform an alternatives evaluation for using the Western C-11 Impoundment as a treatment area for elevated levels of total phosphorus generated within the C-11 West Basin. These alternatives were selected to minimize the impact to flood protection and water supply which are the main purposes of the impoundment.

Review of the phosphorus removal performance of each alternative using three design storms indicates little difference in the removal efficiency of each alternative. For the design storms the flow weighted average removal was relatively low (3.4 to 5.2 percent). However, during low flow events, removal is estimated to be as high as 52.8 percent. This indicates that for low flow conditions the use of an internal levee may substantially increase phosphorus removal. Sub-areas were used in the model to better approximate the geometry created by the addition of the levees, using sub-areas, phosphorus removal increased over the single area simulations by an average of 0.7 percent for the flow weighted average conditions and by as much as 36.9 percent during low flow conditions. These results indicate that the addition of the levees would increase the phosphorus removal potential of the impoundment.

Review of the potential environmental impacts of each alternative indicated little difference between the two designs and no significant additional impacts over the construction of the impoundment. The main differences noted were an increase in shallow water habitat from the longer levee design for Alternative 1 and the loss of approximately one acre of wetland along the C-502A canal for Alternative 2.

The major difference between Alternative 1 and 2 was presented in the opinion of costs. Alternative 1 was estimated at \$9.23 million and Alternative 2 was estimated to be \$8.15 million. The differences in costs were due to the longer levee length for Alternative 1.

Based on the information presented, Alternative 2 may be more cost effective of the two alternatives and could provide significant phosphorus removal under low flow conditions.

1.0 INTRODUCTION

1.1 BACKGROUND

During the settlement of southern Florida, the Everglades were changed when the region was drained for agriculture and development. Growth in the region continued through the 20th century, resulting in a loss of nearly half of the Everglades. The multi-purpose Central and South Florida (C&SF) project provides flood control, water supply for municipal, industrial, and agricultural purposes, prevention of saltwater intrusion, water supply for Everglades National Park, and protection of fish and wildlife resources. As an extension of the C&SF Project, the Comprehensive Everglades Restoration Plan (CERP) was authorized by the Water Resources Development Act (WRDA) of 2000 and approved as a framework and guide for modifications to the C&SF project needed to restore the south Florida ecosystem and to provide for the other water-related needs of the region (Brown and Caldwell, 2002). The CERP designates areas of concern and establishes projects to meet water quality and restoration goals.

In addition to CERP, Florida's 1994 Everglades Forever Act (EFA) established long-term water quality goals designed to restore and protect the Everglades Protection Area (EPA). To meet the EFA goals, the Florida Department of Environmental Protection and the South Florida Water Management District (SFWMD) initiated a comprehensive and consistent set of strategies, known as the Everglades Program. A major component of the Everglades Program is the Everglades Stormwater Program (ESP). In accordance with the requirements of the EFA, the "Non-ECP (Everglades Construction Project) Permit" was issued to the SFWMD so the SFWMD could operate and maintain water control structures which discharge into, within, or from the EPA, and which are not part of the ECP. Upon issuance of the Non-ECP permit, the SFWMD initiated the implementation of the permit conditions through the creation of the ESP, which includes eight urban and tributary basins.

The long-term goal of the Everglades restoration effort is to implement the optimal combination of source controls, Stormwater Treatment Areas (STAs), Advanced Treatment Technologies (ATTs), and/or regulatory programs to ensure that all waters discharged into the EPA meet the numeric phosphorus criterion of 10 parts per billion (ppb) and other applicable state water quality standards (Brown and Caldwell, 2002). Although progress has been made towards reducing phosphorus levels discharged to the EPA, additional phosphorus control measures are needed to achieve compliance with the requirements of the EFA.

1.2 PROJECT BACKGROUND

To meet the phosphorus requirements designated in the EFA, the SFWMD and other stakeholders developed the Long-Term Plan for Achieving Water Quality Goals, which addresses both the ECP and ESP Basins. In order to evaluate the feasibility of additional water quality improvement measures to meet long-term water quality goals in the C-11 West Basin (an ESP Basin), the SFWMD requested that MACTEC Engineering and Consulting, Inc. (MACTEC) formulate two alternative modifications to the internal design of the Western C-11 Impoundment that would maximize the travel time of excess stormwater inflows into the impoundment and would thus maximize the potential for reduction of pollutants within the impoundment.

The C-11 West Basin is located in south central Broward County and covers an area of about 72 square miles. The excess water from the basin, which is comprised of stormwater runoff and ground water seepage from the EPA, is pumped from the C-11 Canal via the S-9 pump station into Water Conservation Area (WCA) 3A (Figure 1.1). WCA 3A is defined in the EFA as part of the EPA. The SFWMD has initiated projects and programs in the basin, some of which are discussed below, to protect the EPA and meet EFA requirements.

The C-11 West Basin Critical Project is an ongoing project sponsored by the SFWMD and is intended to isolate WCA 3A seepage from C-11 West Basin runoff. A divide structure (S-381) contains seepage west of this new structure while a set of smaller pumps (S-9A) returns seepage back to the WCA 3A. It is expected that total phosphorus levels going into WCA 3A will be reduced by the recycling of seepage water. In addition, the smaller S-9A pumps will not only minimize the amount of stormwater pumped from the C-11 West Basin by the S-9 pumps, but will also reduce the frequency of bottom scour and drawdown caused by the larger (S-9) pumps.

The Western C-11 Impoundment and Diversion Canal project, a planned CERP project, consists of a 1,600-acre stormwater impoundment and approximately 8-miles of canal to divert flood waters to other storage areas (i.e., C-9 Impoundment). Urban runoff from the C-11 West Basin will be captured in these two impoundments, thus diverting stormwater away from WCA 3A. However, the initial CERP projects will not result in the elimination of all stormwater discharges to WCA 3A. As per CERP design, inflows not directly accommodated by the Western C-11 and C-9 Impoundments will bypass untreated to the S-9 pump station and WCA-3A. The potential for routing through the impoundment all excess stormwater as a means to achieving additional water quality improvements needs to be investigated and evaluated. Once routed through the impoundment, the excess inflows would then be returned to the C-11 West Canal at a point downstream (west) of the S-381 structure.

MACTEC has reviewed two potential alternatives to the Western C-11 Impoundment internal design as documented in the *Final Evaluation of Stormwater Treatment Potential of the Western C-11 Impoundment*, Task 2: Alternatives Formulation Report (MACTEC, 2003). These alternative designs consisted of constructing internal levees within the Western C-11 Impoundment that would maximize the travel time of excess stormwater inflows through the impoundment while minimizing the reduction in overall storage volume. By increasing the travel time through the impoundment, the potential for reduction of pollutants (by sedimentation of sediment entrained in the stormwater) within the impoundment prior to being returned to the C-11 West Canal downstream (west) of the S-381 structure is increased. As part of the Alternative 2 configuration, a different location for the outlet structure was reviewed.

The two alternatives formulated for evaluation consisted of constructing internal levees within the impoundment to route stormwater and prevent short-circuiting to the outfall. Alternative 1 consisted of a levee placed in a north-south orientation with an extension of this levee placed at the northern end directed eastward. One additional levees were also placed in the western portion of the impoundment to reduce the overall fetch length; thereby, reducing the potential for erosion from wave action. The influent and effluent structures for Alternative 1 are placed in the southeast and southwest corners of the impoundment, respectively. Alternative 2 consisted of a single levee directed to the northeast from below the midpoint of the western wall of the impoundment. At a distance of approximately two-thirds of the maximum width of the impoundment, the levee bends to the east. This configuration provides fetch reduction throughout the impoundment. For Alternative 2, the influent structure will remain in the southeast corner of the impoundment and the effluent structure will be moved to the north of the internal levee along the western wall. Figures presenting the two alternatives from the Alternatives Formulation Report are provided in Appendix A.

Internal levees will be constructed similar to the external levees that make the exterior sidewalls of the Western C-11 Impoundment. However, the internal levees may be designed with a 1:2 side slope. Top of levee elevations will be similar to the elevation of adjacent external levees. The width of the top of the levee will be approximately 12 feet and the bottom width will be approximately 52 feet. The two alternatives to the internal design of the Western C-11 Impoundment are similar in function. However, Alternative 1 consists of 12,200 feet of internal levee and Alternative 2 consists of 8,100 feet of internal levee.

1.3 MODIFICATIONS TO THE ORIGINAL INTERNAL LEVEE CONCEPTUAL DESIGN

Since the finalization of the Alternatives Formulation Report, additional internal modifications to the Western C-11 Impoundment have been added. These modifications include the addition of a sump near the outfall to provide a sediment trap. For Alternative 1, the sump is located approximately 800 feet north of the outfall structure (Appendix A) and is 2,500 feet in width (east/west) and 500 feet long (north/south) and extends from the western wall to the central internal levee. The sump will be 4 feet below the bottom grade of the impoundment (2 feet mean sea level [msl]) and have 3 to 1 side slopes to allow for vehicles to enter the sump for maintenance. For Alternative 2, modifications include a sump located approximately 3,200 feet north of the Alternative 2 outfall structure. This sump has a latitudinal centerline of 500 feet (east/west width) and a longitudinal length of 500 feet (north/south). Similar to Alternative 1 the sump will be 4 feet below the bottom grade of the impoundment and have 3 to 1 side slopes. Also, for Alternative 2, the fish refuge area located along the southern external levee will be reduced by approximately 11.5 acres. An additional fish refuge (approximately 11.5 acres) will be provided north of the internal levee adjacent to the outfall to provide refuge for fish in this area. These modifications have been added to the Alternatives Formulation Report figures presented in Appendix A. A figure with a conceptual cross section of the sump area has been included as Figure 1.2.

1.4 PROJECT OBJECTIVES

The objectives of this report are:

- Present an evaluation of the phosphorus removal performance of the two alternatives presented above using a phosphorus removal model. The two scenarios will look at a low flow and a high flow event and an additional high flow event to verify model performance. These scenarios will provide information of the potential long-term effectiveness of using the Western C-11 Impoundment for water quality treatment.
- Present a preliminary evaluation of the environmental impact of each alternative.
- Present a preliminary present worth cost estimate for each proposed alternative including capital costs and annual operation and maintenance (O&M) costs.
- Present preliminary implementation schedules, covering design, construction, start-up, and stabilization of the water quality treatment alternatives.

1.5 REPORT ORGANIZATION

This report is organized as follows:

- Section 1.0 describes the background of the project and describes the project objective;
- Section 2.0 presents an evaluation of the alternatives and estimates the phosphorus removal efficiency;
- Section 3.0 presents a preliminary assessment of the potential environmental impact for each alternative;
- Section 4.0 presents a preliminary cost comparison between the two alternatives, including capital costs and O&M costs;
- Section 5.0 presents a preliminary implementation schedule;
- Section 6.0 provides a summary of the alternative evaluations and conclusions; and
- Section 7.0 provides a list of references.

Tables and figures and appendices follow immediately after Section 7.0.

2.0 PERFOMANCE EVALUATION OF THE ALTERNATIVES

2.1 MODELING OBJECTIVES

To assess the feasibility of implementing an alternative design for the Western C-11 Impoundment, modeling of the potential removal for phosphorus was employed. The model used in this evaluation was selected based upon a review of the literature, discussions with the SFWMD, and discussions with Dr. William W. Walker, Jr. (wetland modeling consultant for SFWMD). This model used an empirical second order equation for predicting phosphorus retention in urban lakes and detention ponds. This model was developed by the U.S. Army Corps of Engineers and verified using U.S. Environmental Protection Agency (USEPA) Nationwide Urban Runoff Program (NURP) data (Walker, 1987). This modeling approach is presented in Phosphorus Removal by Urban Detention Basins by W.W. Walker, Jr. (Appendix B).

2.2 REMOVAL PERFORMANCE OF THE WESTERN C-11 IMPOUNDMENT

2.2.1 Model Description

The empirical model used in this evaluation relates phosphorus removal (through sedimentation) to a second order decay rate, K_2 and considers the overflow rate and settling velocity of sediment particles entering the system. Explanation of the model equations and parameters are presented below.

Mean surface overflow rate (Q_s) during storm periods equals:

$$Q_s = Q_m / A$$

where:

Q_m – mean pond outflow (cm^3/hr)

A – mean pond surface area (cm^2)

This ratio estimates the potential removal during storm events for particles of a given settling velocity. Under ideal conditions, particles with settling velocities greater than the surface overflow rate would be removed. The particles with settling velocities less than the surface overflow rate would pass though or remained suspended at the end of the event (Walker, 1987).

The following table presents the frequency distribution for particle settling velocities in typical urban runoff:

Percentile	10	30	50	70	90
Velocity (cm/hr)	0.9	9	46	210	2000

This estimates the potential performance of the impoundment in removing sediment.

For impoundments with volumes large enough to store runoff between events and with relatively long periods between storm events, other mechanisms in addition to settling (biological phosphorus uptake and adsorption) would also contribute to phosphorus removal. Under these conditions the performance of the impoundment would be related to the dimensionless storage ratio that estimates the impoundments potential to store and subsequently remove materials during quiescent periods between storm events:

$$V_p / V_m$$

where:

V_p – permanent pool volume (m^3)

V_m – mean storm volume (m^3)

Another estimate of the performance of the impoundment based on average storm conditions is related to the area ratio between the impoundment and the watershed. For a typical storm of approximately 1 centimeter and 4 hour duration, the impoundment area divided by the area of the watershed would need to exceed 0.001 to remove particles with settling velocities greater than the median. For finer particles (10 percentile) an impoundment area to watershed area ratio would have to exceed 0.12.

These performance estimates are based on sediment removal only. However, research has shown that the majority of the total phosphorus adsorbs to the finer particles. Walker (1987) modeled phosphorus removal using a second order reaction. For NURP detention basins in the northeast U.S. total phosphorus removal ranged from 0 to 96 percent with an average removal efficiency of approximately 48 percent. Removal rates are based on basin characteristics (area, impervious surface), precipitation characteristics (average rainfall, average storm duration, frequency, seasonal characteristics), and impoundment characteristics (area, volume, outflow rate). Equations used in the model are summarized below:

The second order decay rate (K_2 [m^3/mg·yr]) used can be calculated by the following equation:

$$K_2 = 0.056\left(Q_s F_o^{-1}\right)/(Q_s + 13.3)$$

where:

Q_s = mean surface overflow rate (cm/year)

F_o = Inflow orthophosphorus concentration over total phosphorus concentration

K_2 is incorporated into a dimensionless reaction rate (N_r):

$$N_r = K_2 P_i T$$

where:

P_i = inflow total phosphorus concentration (mg/m^3)

= total phosphorus loading/mean outflow rate

T = mean hydraulic residence time (years)

= mean pool volume/mean outflow rate

The phosphorus retention coefficient (R_p) is then calculated using:

$$R_p = 1 + \left[1 - \left(1 + 4N_r\right)^{0.5}\right]/2N_r$$

Conclusions for the model indicate that this model appears to be useful in predicting average phosphorus removal efficiencies in impoundments.

For the evaluation of the removal potential of the Western C-11 Impoundment, site specific information on the two design alternatives and hydrograph data and phosphorus concentrations from the SFWMD will be used. Additional information required for the model will be collected from the literature and various reports of the C-11 West Basin as appropriate.

2.2.2 Model Application/Input Parameters

Simulations using data from October 1967, July 1985, and November 1984 storm events (Table 2.1) were used to estimate the removal efficiency. This data (provided by the SFWMD) consisted of average daily inflow values in cubic feet per second (cfs) and the corresponding daily inflow total phosphorus concentration in parts per billion (ppb) measured during the storm events. For the modeling it was assumed that the impoundment was full (average depth 4 feet) and that the inflow and outflow were equal.

Additionally the empirical second order model required the use of an orthophosphate to total phosphate ratio (F_o). Long-term monitoring data for the C-11 West Basin was used to calculate the orthophosphate/total phosphate ratio of 0.3. Data used to calculate this ratio are presented in Appendix C.

Microsoft Excel spreadsheets were used to setup and run the model. For both designs, output for the performance of Alternative 1 and Alternative 2 was calculated for each day in the data set. Also, since the maximum flow for the impoundment is 2,500 cfs and the average total phosphorus input is 22 ppb, a separate column in the spreadsheets was assigned to calculate the estimated removal efficiency for this case.

The following input parameters (listed below) were entered for each day during the storm events:

1. Watershed area (m^2)
2. Impoundment (pond) Inflow, Q_i (cfs)
3. Impoundment (pond) outflow, Q_o (m^3/year) (Assumed equal to the impoundment inflow).
4. Impoundment (pond) surface area (m^2)
5. Mean pond depth, Z (m)
6. Inflow Total phosphorus, Pi (mg/m^3)
7. Ratio of inflow orthophosphorus/total phosphorous, F_o

2.2.3 Improving Model Application

The second order phosphorus removal empirical model does not take into account impoundment geometry. Initially, the empirical second order model was applied to the impoundment as a single area representing the impoundment with no levee addition. To take into account the routing of flows provided by the internal levee design alternatives, the impoundment was subdivided into 5 sub-areas. This subdivision was expected to approximate the geometry created by the internal levees. The division of the impoundment was influenced by the internal levee configuration in the proposed designs (Alternatives 1 and 2).

Removal performance was estimated for each sub-area using the following criteria.

- The inflow total phosphorus Pi (mg/m^3) coming to the first sub-area in the impoundment is equal to the average daily value (Pi) reported in the data set
- The calculated output phosphorus concentration from each sub-area is the input phosphorus (Pi) for the following sub-area.
- The impoundment inflow Q_i (cfs) is the same for each sub-area.

- The ratio of inflow orthophosphorus/total phosphorous (F_o = 0.3) is constant for each sub-area.

Prior to the sump addition, the effect of further subdivision of the impoundment was examined using the 1967 data and the Alternative 1 design. For the 1967 data, the number of sub-areas for Alternative 1 was increased to 10 and 20 sub-areas. The performance results of the model using 10 and 20 sub-areas showed a slight increase in model performance (Figure 2.3). However, the majority of the increase in model performance was noted using 5 subdivisions. Therefore, subdividing the impoundment into 5 sub-areas was selected to evaluate the removal performance for each alternative design (the number of sub-areas was later expanded to include the sump area). Additionally, the phosphorus removal performance was graphed for each day to assess the performance of using sub-areas at different flow rates. Figure 2.4 presents this information and shows that at lower flow rates subdividing the impoundment into sub-areas has a greater effect on removal performance than at higher flow rates.

2.2.4 Adding the Sump to Sub-Area 5

A sump was added to sub-area 5 for the final conceptual design to provide an area to trap debris and sediment prior to reaching the discharge structure. The sump dimensions were 500 feet parallel and 2,500 feet perpendicular to the flow direction and 8 feet deep. The sump was added to the design of both alternatives and included in the analysis of the phosphorus removal performance of the impoundment. To simulate the addition of the sump, sub-area 5 was divided into three (3) additional areas: sub-area 5A, sump area, and sub-area 5B (Figures 2.1 and 2.2). Subdividing Area 5 resulted in the use of 7 sub-areas in the modeling.

The phosphorus removal performance results obtained with the sump in sub-area 5 did not reveal significant difference in the flow weighted mean output concentrations to the results obtained without the sump addition.

2.2.5 Wetlands Mitigation Area

The north part of the Western C-11 (a wetlands mitigation area) was not included in the analysis of the impoundment in this study. This area will not normally be utilized for stormwater storage. If this area is incorporated during high flow events, the phosphorus removal performance of the impoundment would increase.

2.2.6 Model Results

There was little difference in model performance for Alternatives 1 and 2. However, there was a difference between using one overall area (no internal levee) as compared to 7 sub-areas (with internal levee providing routing). Flow weighted average removal performance for Alternative 1 and 2 are similar for each design alternative and the performance results with no subdivision are presented in Table 2.2. Model results using the 7 sub-area approach are presented in Table 2.3.

Results showed that for Alternative 1 with 7 sub-areas, removal performance is estimated to be 5.1 percent (1967), 3.5 percent (1985), and 3.4 percent (1994) and for Alternative 2 with 7 sub-areas, removal performance is estimated to be 5.2 percent (1967), 3.5 percent (1985), and 3.4 percent (1994).

Results also showed that the maximum removal efficiencies for each alternative range from 17.6 percent for 1967 Day 9 to 45.6 percent for 1994 Day 9. This indicates that at low flow conditions the impoundment is capable of removing significant percentages of total phosphorus from stormwater.

2.2.7 Model Sensitivity

Estimation of the retention coefficient (R_p) was found to be sensitive to the impoundment (pond) surface area (A), the mean impoundment depth (Z), the mean hydraulic residence time (T), and the impoundment outflow (Q_o). Except for outflow, the retention coefficient, R_p, increased as the other parameters increased. As outflow increased the retention in the impoundment decreased.

2.2.8 Model Uncertainty

The model used in this study was tested by developers on 60 Corps of Engineers reservoirs (Walker, 1985b) and was tested against independent reservoir data, additional tests were made against urban lake/detention pond data. As summarized by Walker (Walker, 1985), the observed and predicted (simulated) removals generally agree to within 15 percent (15%). The model error, as measured by mean squared errors was 0.017 for the 60 Corps of Engineers Reservoirs, and 0.034 for the 20 independent reservoirs and shallow lakes program.

2.2.9 Model Applicability

The use of the model presented in this report has limited application. Since the model does not account for changes in geometry, flow paths, biological phosphorus uptake, and removal mechanisms other than sedimentation, its use as a design tool is limited. However, it is useful as a screening tool in this application to assess the differences between alternatives.

2.3 POTENTIAL FOR SHORT-CIRCUITING

In the basic conceptual design of the Western C-11 Impoundment, without the proposed levee, the close proximity of the influent structure (S-503) and the discharge structure (S-504) may encourage a preferred (short-circuiting) flow path between the two structures. This situation is likely given the relatively short distance between the influent and the discharge structures (approximately 4,000 feet) compared to the length of the impoundment (more than 10,000 feet). A shorter flow path will reduce the active surface area within the impoundment. The impact of a reduction in the active surface area would result in a proportional decrease in the phosphorous removal performance of the impoundment. The construction of the levees will guarantee a longer flow path between the influent structure and the discharge structure (approximately 20,000 feet); therefore, maximizing the active surface area should increase the removal efficiency of the impoundment.

3.0 PRELIMINARY ASSESSMENT OF THE POTENTIAL ENVIRONMENTAL IMPACT FOR EACH ALTERNATIVE

3.1 GENERAL PROJECT BENEFITS

The Draft Integrated Feasibility Report and Supplemental Environmental Impact Statement (October 2001) contains a detailed environmental effects discussion that assesses the beneficial and adverse effects of the proposed project. These effects are due to pond construction and are independent of the proposed internal levee configurations. Both alternative configurations will have similar beneficial and adverse effects as the impoundment. This section describes only those apparent differences between the alternative internal levee configurations and does not go into detail to describe the environmental effects of the proposed Western C-11 impoundment project in its entirety. Section 7 of the Draft WPA Feasibility Study Report and Supplemental Environmental Impact Statement (USACE and SFWMD, 2001) can be referenced if additional detail is required on the effects of the proposed project.

The primary purposes of the Western C-11 Impoundment are to provide flood protection and water supply, with the additional purpose of treating elevated levels of total phosphorus generated within the C-11 West Basin. Both of the alternatives will provide the same general benefits to the local environment, including creation of desirable wildlife and fisheries habitat, flood control, and improved water quality (removal of dissolved nutrients, metals, and suspended solids). The two alternatives will have no significant impact to soils, geology, air quality, noise, land use, recreation, aesthetics, or cultural resources in the project vicinity beyond what is expected by the construction of the impoundment.

Both alternatives will require some disturbances to the local environment during construction. These disturbances might include displacement of local fauna utilizing the previous habitat, temporary increases in noise and air pollution from construction vehicles, vegetation removal, increases in turbidity from erosion, and conversion of agricultural and wetland habitat to open water. These potentially negative factors will be offset by the long-term benefits of the proposed project.

3.2 WILDLIFE AND FISHERIES HABITAT

Wetland mitigation areas on the north side of the impoundment provide approximately 215 additional acres of habitat for species that prefer wetland vegetation for foraging or nesting. Alternative 2 will require approximately 0.9 acres of additional wetland area to widen the C-502A canal to provide adequate drainage capacity. The canal widening is a result of moving the proposed discharge upstream along the existing canal. The canal will be widened by approximately 30 feet to accommodate the required 2,500 cfs flow rate, impacting existing wetland areas adjacent to the canal. This additional wetland impact is negligible when compared to the net benefit of the overall project of 215 constructed wetland acres. Both alternatives will provide beneficial wetland habitat to the area.

Alternative 1 has approximately 4,100 linear feet more internal levees than Alternative 2. The additional levee distance provides additional shallow water habitat and foraging area for a variety of fauna, including wading birds. Shallow water areas between two and three feet deep provide suitable habitat for small fish, tadpoles, and a variety of aquatic insects that serve as food for many species. This additional habitat is desirable for wildlife.

The additional levee distance also creates more areas of wind-protected and slack water than Alternative 2. These slack areas may be utilized by species that are less tolerant of wave action or flowing water. Slack areas may also be subject to warmer water temperatures, lower dissolved oxygen, and faster algal growth.

Both alternatives provide fish refuge areas near the inlet and outlet of the pond, providing aquatic species the ability to remain within the pond during periods of low water. Though there are slight differences between the two alternatives, there is no significant difference between the overall impact to wildlife and fisheries habitats from each alternative.

3.3 EXOTIC VEGETATION

Alternative 1 has approximately 4,100 linear feet more internal levees than Alternative 2. The additional levee distance provides additional shallow water habitat for the establishment of native or exotic vegetation. Exotic vegetation is not desirable and should be carefully controlled to avoid spreading.

4.0 PRELIMINARY COST COMPARISONS

Feasibility level opinions of costs were prepared for each of the internal levee alternative designs. Capital and annual O&M costs for the two stormwater treatment alternatives are presented on Tables 4.1 and 4.2. The major components of construction that were included in the costs for both alternatives were: the internal levees; the sump; and the S-502C Gated Culvert (2,500 cfs capacity). Also, for Alternative 2, increasing the capacity of the C-502A canal north from the planned location of the S-504 discharge structure (southeast corner of the impoundment) to the new location of the discharge structure north of the internal levee was included in the cost analysis. Unit prices for levee construction were primarily obtained from the publication "Heavy Construction Cost Data 2004", by RS Means Company, Inc. and the Basin Specific Feasibility Study (Brown and Caldwell, et al., 2002). Prices for the gated culvert were based on pricing provided in Appendix E, Cost Engineering Appendix, of the October, 2001, report published by U.S. Army Corps of Engineers, "Draft Integrated Feasibility Report and Supplemental Environmental Impact Statement" (USACE, 2001), unit prices from the RS Means publication, and manufacturer information (for slide gates). Backup construction cost tables are included as Tables 4.3 and 4.4. Backup calculations for annual operation and maintenance costs are included as Tables 4.5 and 4.6.

MACTEC evaluated the need for, and related impact of, additional construction or redesign of hydraulic structures for the two alternatives. As presented in the December 2003 report by MACTEC, Evaluation of Stormwater Treatment Potential of the Western C-11 Impoundment: Alternatives Formulation Report (MACTEC, 2003), the S-502C structure will have to be redesigned to increase its capacity from 300 cfs to 2,500 cfs for both alternatives. No other structures (including impoundment influent and effluent structures) will require redesign. Since Alternative 2 includes relocation of the impoundment discharge, a section of the C-502A canal (approximate length of 2000 feet) will need to be widened to increase the capacity from 1500 cfs to 2500 cfs. Costs were presented in Tables 4.3 and 4.4 for construction of the higher capacity S-502C Gated Culvert (2,500 cfs), compared with the cost for construction of the lower capacity S-502C (300 cfs) Gated Culvert, and the difference in cost was factored into the total capital costs. Costs were also included in Table 4.4 for widening of the C-502A canal based on standard unit cost presented in Appendix A of the Final Report, Basin Specific Feasibility Studies, Everglades Stormwater Program Basins (Brown and Caldwell, 2002).

Construction of internal levees will provide effective windbreaks within the impoundment (MACTEC, 2003). The two windbreaks, included as part of the original Western C-11 Impoundment design in Section

B.7.2.6.2 in Appendix B of the USACE Report (USACE, 2001), would not be required for either alternative. The cost for windbreak construction has been subtracted from the total costs (refer to Tables 4.1, 4.2, 4.3 and 4.4). The source of information on assumed quantity of fill material for the windbreaks is presented in Tables 4.3 and 4.4.

Quantities for costing of levee construction were estimated based on information presented in the December 2003 report by MACTEC. Structural and geotechnical design criteria for the internal levees were based on information related to the C-11 impoundment levee construction provided in Appendix B, Engineering Design, of the USACE report (USACE, 2001). Assumptions and backup quantity calculations used for development of the opinions of costs are presented in Appendix E.

Capital costs and annual O&M costs were based on 2004 dollars. Estimates of the 50-year present worth were based on 2004 dollars and are included in Tables 4.1 and 4.2. The present worth of capital and annual O&M costs was calculated to be $9.23 million for Alternative 1 and $8.15 million for Alternative 2.

5.0 PRELIMINARY IMPLEMENTATION SCHEDULE

A preliminary, feasibility level, implementation schedule has been developed for the design, construction, start-up and stabilization phases that make up the two internal levee design configurations for the Western C-11 Impoundment. A Critical Path Method (CPM) approach was applied in conjunction with the existing parameters of the Western C-11 impoundment perimeter levee construction to ensure that the internal levee construction would be concurrent and consistent. In addition to the CPM approach, time estimates were evaluated for probabilistic distribution. Anticipated start dates are based on interfaces with the perimeter levee construction and could be revised to accommodate the integration of the two work efforts on the Western C-11 impoundment.

The implementation schedule is divided into three phases, Design, Construction, and Project Management/Oversight. The Design Phase contains those elements required to submit the preliminary opinion of cost estimate followed by decision points for moving forward with the Conceptual Design and the selection of the appropriate alternative. The preliminary opinion of cost estimate presented in this report is considered to be the typical 35% completion point of a conceptual design; following the selection of the appropriate alternative are the balance of the tasks that form a full conceptual design.

Following the Design Phase is the Construction Phase which contains bid solicitation tasks if the current hauling contractor awarded the perimeter levee construction does not have capacity to support the additional internal levee construction activities that are required to be performed concurrent with the perimeter levee. A work plan will be generated to address the internal levee construction. The start of the internal levee activities has been delayed so that the perimeter levee construction could progress past the point of the tie-ins of the internal levee to the perimeter levee. The Construction Phase contains seven elements: haul road, foundation and sump excavation, internal levee construction, internal levee revetment, canal excavation (for Alternative 2), and gated culvert installation. The schedule has been compressed by overlapping the foundation and sump excavation and levee construction and the levee construction and revetment placement.

The Project Management/Oversight Phase contains those tasks associated with the administration and surveillance of the internal levee construction contract, if required. This phase also contains those activities for managing the project schedule and close-out of the project files after the completion of the internal levee construction.

For the purposes of this preliminary schedule it has been assumed that:

- The construction period for the Western C-11 Impoundment has been estimated to be nine (9) months.
- The commencement of the overall construction phase of the Western C-11 Impoundment would be January 2006.
- The perimeter levee construction would commence at the southwest corner of the Western C-11 Impoundment, working north and east to facilitate the internal levee construction.
- Clearing and grub of the Western C-11 Impoundment would be completed by others and complete to the point of allowing the commencement of construction of the haul road.
- There is no equipment or chemical treatment associated with either alternative, therefore startup has not been considered.
- In regards to stabilization, grass seeding is considered as part of this effort but will be performed during construction.
- Levee and revetment repairs have been considered within the 50 year O&M estimate.

Although the schedule shows dates for completion of specific activities, changes to the CERP schedule may impact the schedule presented. However, the time frame (number of days) for completion of construction activities should remain relatively constant.

6.0 SUMMARY AND CONCLUSIONS

Total phosphorus removal performance for each internal levee configuration alternative for the Western C-11 Impoundment was estimated using an empirical second order model developed by the USACE. This model estimated removal in detention basins and impoundments by estimating the sedimentation rate of sediment entering a system through stormwater runoff. The phosphorus removal model does not account for geometry of the impoundments. To improve model application and to better approximate the impoundment geometry, the Western C-11 Impoundment was subdivided into 7 sub-areas for both Alternative 1 and Alternative 2. Results from the model indicate that there is little difference in the phosphorus removal efficiencies of the two designs and flow weighted average performance ranged from 3.4 percent to 5.2 percent. Maximum removal performance occurred during low flow events at the tail end of the storms modeled. Removal during the low flow events with the internal levees ranged from 18.5 percent (76.9 cfs) to 52.8 percent (3.1 cfs). These results indicate that during low flow events, the Western C-11 Impoundment with the addition of an internal levee may be capable of removing sufficient phosphorus to reach the target total phosphorus concentration of 10 ppb. During average storm conditions, the model indicates that the addition of the internal levees will not remove significant quantities of phosphorus to reach target total phosphorus concentrations. However, the model does not take into account other phosphorus removal mechanisms such as biological uptake that may aid in phosphorus removal.

The preliminary environmental impact for the two alternative configurations also indicates relatively little difference. Also, there is expected to be no significant additional impacts from the addition of an internal levee over the construction of the impoundment. The differences noted between the two alternatives were that the additional length of the levee provided in Alternative 1 will provide additional shallow water habitat for aquatic vegetation and wading waterfowl. For Alternative 2, approximately one acre of wetland area along the C-502A would be utilized for needed widening to accommodate the 2,500 cfs flow rate from the location of the proposed outfall to the C-11 canal.

The most significant difference between Alternative 1 and Alternative 2 is in the estimated opinion of costs. The total cost for Alternative 1 is estimated to be $9.23 million and for Alternative 2 the cost is estimated to be $8.15 million. This difference is attributed to the additional length of the internal levee for Alternative 1 (12,100 feet) as compared to the length of Alternative 2 (8,700 feet). Also, for Alternative 2, the C-502A canal would need to be enlarged from a capacity of 1,500 cfs to 2,500 cfs from the location of the Alternative 2 outfall structure to the location of the original proposed location in the southeast corner of the impoundment. For both Alternative 1 and 2, the S-502C culvert would have to be redesigned to handle the additional flow of 2,500 cfs. Review of the removal performance and total costs indicate that Alternative 2 may be the more cost effective of the two alternatives proposed.

7.0 REFERENCES

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TABLES

Table 2.1
Representative Storm Events and Influent Phosphorus Concentrations
South Florida Water Management District
Western C-11 Impoundment
Alternatives Evaluation

Date	Flow Rate Q (cfs)	Influent P (mg/m^3)	Date	Flow Rate Q (cfs)	Influent P (mg/m^3)	Date	Flow Rate Q (cfs)	Influent P (mg/m^3)
10/5/1967	564.9	18.4	7/23/1985	1555.6	27.8	11/16/1994	2126.8	33.2
10/6/1967	769.7	20.3	7/24/1985	1305.5	25.4	11/17/1994	966.2	22.2
10/7/1967	747.5	20.1	7/25/1985	1512.7	27.4	11/18/1994	1142.0	23.8
10/8/1967	489.6	17.7	7/26/1985	429.0	17.1	11/19/1994	338.8	16.2
10/9/1967	547.6	18.2	7/27/1985	257.6	15.4	11/20/1994	201.9	14.9
10/10/1967	374.9	16.6	7/28/1985	158.4	14.5	11/21/1994	128.1	14.2
10/11/1967	253.0	15.4	7/29/1985	148.6	14.4	11/22/1994	74.8	13.7
10/12/1967	152.5	14.4	7/30/1985	75.0	13.7	11/23/1994	34.1	13.3
10/13/1967	76.9	13.7	7/31/1985	26.5	13.3	11/24/1994	3.1	13
Flow Weighted Average Total Phosphorus Concentration		18.4	Flow Weighted Average Total Phosphorus Concentration		24.7	Flow Weighted Average Total Phosphorus Concentration		26.1

Data obtained from the SFWMD

Prepared By: MET 1/15/2004
Checked By: AG 1/16/2004
Revised By: AG 2/19/2004
Checked By: MET 2/23/2004

Table 2.2
Summary of the Percent Removal of Influent Phosphorus
No Subdivision
South Florida Water Management District
Western C-11 Impoundment
Alternatives Evaluation

	Alternative 1				Alternative 2			
Date	Flow Rate Q (cfs)	Influent P (mg/m^3)	Effluent P (mg/m^3)	Estimated Removal	Flow Rate Q (cfs)	Influent P (mg/m^3)	Effluent P (mg/m^3)	Estimated Removal
10/5/1967	564.9	18.4	17.66	4.0%	564.9	18.4	17.66	4.0%
10/6/1967	769.7	20.3	19.61	3.4%	769.7	20.3	19.61	3.4%
10/7/1967	747.5	20.1	19.40	3.5%	747.5	20.1	19.40	3.5%
10/8/1967	489.6	17.7	16.93	4.3%	489.6	17.7	16.93	4.3%
10/9/1967	547.6	18.2	17.46	4.1%	547.6	18.2	17.46	4.1%
10/10/1967	374.9	16.6	15.77	5.0%	374.9	16.6	15.77	5.0%
10/11/1967	253.0	15.4	14.46	6.1%	253.0	15.4	14.45	6.1%
10/12/1967	152.5	14.4	13.27	7.8%	152.5	14.4	13.27	7.8%
10/13/1967	76.9	13.7	12.30	10.2%	76.9	13.7	12.30	10.2%
Flow Weighted Averages		18.4	17.6	4.2%		18.4	17.6	4.2%
7/23/1985	1555.6	27.8	27.11	2.5%	1555.6	27.8	27.11	2.5%
7/24/1985	1305.5	25.4	24.72	2.7%	1305.5	25.4	24.72	2.7%
7/25/1985	1512.7	27.4	26.71	2.5%	1512.7	27.4	26.71	2.5%
7/26/1985	429.0	17.1	16.31	4.6%	429.0	17.1	16.30	4.7%
7/27/1985	257.6	15.4	14.47	6.1%	257.6	15.4	14.47	6.1%
7/28/1985	158.4	14.5	13.38	7.7%	158.4	14.5	13.38	7.7%
7/29/1985	148.6	14.4	13.26	7.9%	148.6	14.4	13.26	7.9%
7/30/1985	75.0	13.7	12.29	10.3%	75.0	13.7	12.28	10.3%
7/31/1985	26.5	13.3	11.54	13.3%	26.5	13.3	11.54	13.3%
Flow Weighted Averages		24.7	23.9	3.0%		24.7	23.9	3.0%
11/16/1994	2126.8	33.2	32.46	2.2%	2126.8	33.2	32.46	2.2%
11/17/1994	966.2	22.2	21.52	3.1%	966.2	22.2	21.52	3.1%
11/18/1994	1142.0	23.8	23.13	2.8%	1142.0	23.8	23.13	2.8%
11/19/1994	338.8	16.2	15.35	5.3%	338.8	16.2	15.35	5.3%
11/20/1994	201.9	14.9	13.88	6.9%	201.9	14.9	13.88	6.9%
11/21/1994	128.1	14.2	13.00	8.4%	128.1	14.2	13.00	8.5%
11/22/1994	74.8	13.7	12.28	10.3%	74.8	13.7	12.28	10.3%
11/23/1994	34.1	13.3	11.62	12.6%	34.1	13.3	11.62	12.6%
11/24/1994	3.1	13	11.00	15.4%	3.1	13	11.00	15.4%
Flow Weighted Averages		26.1	25.4	2.9%		26.1	25.4	2.9%

Prepared By: MET 1/15/2004
Checked By: AG 1/16/2004
Revised By: AG 2/19/2004
Checked By: MET 2/23/2004

Table 2.3
Summary of the Percent Removal of Influent Phosphorus
Subdivision - 7 Sub-Areas*
South Florida Water Management District
Western C-11 Impoundment
Alternatives Evaluation

Date	Alternative 1				Alternative 2			
	Flow Rate Q (cfs)	Influent P (mg/m^3)	Effluent P (mg/m^3)	Estimated Removal	Flow Rate Q (cfs)	Influent P (mg/m^3)	Effluent P (mg/m^3)	Estimated Removal
10/5/1967	564.9	18.4	17.53	4.7%	564.9	18.4	17.52	4.8%
10/6/1967	769.7	20.3	19.51	3.9%	769.7	20.3	19.50	3.9%
10/7/1967	747.5	20.1	19.30	4.0%	747.5	20.1	19.30	4.0%
10/8/1967	489.6	17.7	16.78	5.2%	489.6	17.7	16.77	5.2%
10/9/1967	547.6	18.2	17.32	4.8%	547.6	18.2	17.32	4.9%
10/10/1967	374.9	16.6	15.57	6.2%	374.9	16.6	15.56	6.3%
10/11/1967	253.0	15.4	14.14	8.2%	253.0	15.4	14.13	8.2%
10/12/1967	152.5	14.4	12.72	11.7%	152.5	14.4	12.71	11.8%
10/13/1967	76.9	13.7	11.19	18.3%	76.9	13.7	11.16	18.5%
Flow Weighted Averages		18.4	17.4	5.2%		18.4	17.4	5.2%
7/23/1985	1555.6	27.8	27.04	2.7%	1555.6	27.8	27.04	2.7%
7/24/1985	1305.5	25.4	24.65	2.9%	1305.5	25.4	24.65	3.0%
7/25/1985	1512.7	27.4	26.65	2.8%	1512.7	27.4	26.64	2.8%
7/26/1985	429.0	17.1	16.13	5.7%	429.0	17.1	16.12	5.7%
7/27/1985	257.6	15.4	14.16	8.1%	257.6	15.4	14.15	8.1%
7/28/1985	158.4	14.5	12.85	11.4%	158.4	14.5	12.83	11.5%
7/29/1985	148.6	14.4	12.69	11.9%	148.6	14.4	12.67	12.0%
7/30/1985	75.0	13.7	11.15	18.6%	75.0	13.7	11.12	18.8%
7/31/1985	26.5	13.3	9.09	31.7%	26.5	13.3	9.01	32.3%
Flow Weighted Averages		24.7	23.8	3.6%		24.7	23.8	3.6%
11/16/1994	2126.8	33.2	32.41	2.4%	2126.8	33.2	32.40	2.4%
11/17/1994	966.2	22.2	21.44	3.4%	966.2	22.2	21.43	3.5%
11/18/1994	1142.0	23.8	23.05	3.1%	1142.0	23.8	23.05	3.2%
11/19/1994	338.8	16.2	15.12	6.7%	338.8	16.2	15.11	6.7%
11/20/1994	201.9	14.9	13.47	9.6%	201.9	14.9	13.46	9.7%
11/21/1994	128.1	14.2	12.33	13.2%	128.1	14.2	12.31	13.3%
11/22/1994	74.8	13.7	11.15	18.6%	74.8	13.7	11.11	18.9%
11/23/1994	34.1	13.3	9.53	28.3%	34.1	13.3	9.47	28.8%
11/24/1994	3.1	13	6.20	52.3%	3.1	13	6.14	52.8%
Flow Weighted Averages		26.1	25.2	3.4%		26.1	25.2	3.5%

Notes
*Sub-area 5 was sudivided into three areas (5A, 5B, and the Sump Area) to accommodate the addition of the sump

Prepared By: MET 1/15/2004
Checked By: AG 1/16/2004
Revised By: AG 2/19/2004
Checked By: MET 2/26/2004

Table 4.1
Opinion of Costs for Stormwater Treatment Alternative 1
Alternatives Evaluation Report
Evaluation of Stormwater Treatment Potential of the Western C-11 Impoundment
South Florida Water Management District

Cost Component	Estimated Cost, millions of dollars
Capital Costs	
Construction Costs	
Haul Road Construction	0.40
Foundation Excavation	0.26
Levee Construction	1.24
Revetment Construction	0.10
Sump Construction	1.31
Seeding and Mulching (Internal Levees)	0.13
S-502C Gated Box Culverts (2500 cfs capacity)	2.76
Subtract Cost of S-502C Gated Culverts (300 cfs capacity)	(1.60)
Subtract Cost of Windbreaks	(0.32)
Subtotal	**4.28**
Planning, engineering and design (10%)	0.43
Program and Construction management (10%)	0.43
Subtotal	**5.14**
Contingency (30%)	1.54
Total, construction costs	**6.68**
Total, Capital Costs	***6.68***
Average Annual O & M Costs	
Maintenance of Levees	0.04
Maintenance of Sumps	0.08
Maintenance of Gated Culverts	0.01
Subtotal	0.13
Contingency (30%)	0.04
Total, Annual O & M Costs	***0.17***
50-year Present Worth	
Capital costs	6.68
O & M Costs [$170,000 (P/A, 6-3/8 %, 50) = $170,000 (14.973)]	2.55
Total, 50-year Present Worth	**9.23**

Table 4.2
Opinion of Costs for Stormwater Treatment Alternative 2
Alternatives Evaluation Report
Evaluation of Stormwater Treatment Potential of the Western C-11 Impoundment
South Florida Water Management District

Cost Component	Estimated Cost, millions of dollars
Capital Costs	
Construction Costs	
Haul Road Construction Foundation Excavation Levee Construction Revetment Construction Sump Construction Seeding and Mulching (Internal Levees) C-502A Canal Widening S-502C Gated Box Culverts (2500 cfs capacity)	0.30 0.17 0.82 0.07 1.31 0.09 0.08 2.76
Subtract Cost of S-502C Gated Culverts (300 cfs capacity)	(1.60)
Subtract Cost of Windbreaks	(0.32)
Subtotal	**3.68**
Planning, engineering and design (10%) Program and Construction management (10%)	0.37 0.37
Subtotal	**4.42**
Contingency (30%)	1.33
Total, construction costs	**5.75**
Total, Capital Costs	***5.75***
Average Annual O & M Costs	
Maintenance of Levees Maintenance of Sumps Maintenance of Gated Culverts	0.03 0.08 0.01
Subtotal	0.12
Contingency (30%)	0.04
Total, Annual O & M Costs	***0.16***
50-year Present Worth	
Capital costs	5.75
O & M Costs [$160,000 (P/A, 6-3/8 %, 50) = $160,000 (14.973)]	2.40
Total, 50-year Present Worth	**8.15**

TABLE 4.3
BACKUP FOR OPINION OF CONSTRUCTION COSTS - ALTERNATIVE 1
Alternatives Evaluation Report
Evaluation of Stormwater Treatment Potential of the Western C-11 Impoundment
South Florida Water Management District

Item No.	Description	Estimated Quantity	Units	Unit Cost	Subtotal Costs	Cost source[1,2]	Total Item Cost
1.	**Haul Road Construction (assume 2 mile length, 20' width)**						$398,250
	1a. Stabilization Fabric	23,500	S.Y.	$3.50	$82,250	Estimate from Supplier + 25% markup	
	1b. Aggregate Surfacing (12-inch depth)	7,900	C.Y.	$40	$316,000	Means, 01550-700-0100	
2.	**Foundation Excavation**						$257,600
	2a. Excavate	35,300	C.Y.	$4.00	$141,200	Means, 02315-432-5400	
	2b. Spread Excavated Material on Ground Surface	38,800	C.Y.	$3.00	$116,400	Means, 02315-520-0190	
3.	**Levee Construction**						$1,236,600
	3a. Haul Material (3 mile round trip with 20 C.Y. haul vehicle)	172,000	C.Y.	$3.60	$619,200	Means, 02315-490-1220	
	3b. Place Embankment Fill	172,000	C.Y.	$3.00	$516,000	Means, 02315-520-0190	
	3c. Compact Embankment Fill (12-inch lifts)	172,000	C.Y.	$0.50	$86,000	Means, 02315-310-5100	
	3d. Grade and Shape Embankment	77,000	S.Y.	$0.20	$15,400	Means, 02310-100-3310	
4.	**Revetment Construction**						$101,120
	4a. Load Bedding Material for Transport from On-Site Source	2,100	C.Y.	$0.60	$1,260	Means, 02315-210-5070 (not incl. material cost)	
	4b. Haul Bedding Material (3 mile round trip)	2,100	C.Y.	$3.60	$7,560	Means, 02315-490-1220	
	4c. Place Bedding Material	2,100	C.Y.	$3.00	$6,300	Means, 02315-520-0190	
	4d. Furnish and Place Rip Rap	4,300	C.Y.	$20	$86,000	Means, 02370-450-0100 (not incl. material cost)	
5.	**Sump Construction**						$1,314,000
	5a. Excavate	180,000	C.Y.	$4.00	$720,000	Means, 02315-432-5400	
	5b. Spread Excavated Material on Ground Surface	198,000	C.Y.	$3.00	$594,000	Means, 02315-520-0190	
6.	**Seeding and Mulching (Internal Levees)**						$134,000
	6a. Erosion Control Matting (levee slopes only)	53,000	S.Y.	$2.00	$106,000	Estimate from Supplier + 25% markup	
	6b. Seeding (hydroseed, mulch and fertilizer)	14.0	Acres	$2,000	$28,000	Means, 02920-320-4600	

TABLE 4.3
BACKUP FOR OPINION OF CONSTRUCTION COSTS - ALTERNATIVE 1
Alternatives Evaluation Report
Evaluation of Stormwater Treatment Potential of the Western C-11 Impoundment
South Florida Water Management District

Item No.	Description	Estimated Quantity	Units	Unit Cost	Subtotal Costs	Cost source[1,2]	Total Item Cost
7.	**S-502C Gated Culverts, 2500 cfs capacity (3 - 12' x 8' precast reinforced concrete box culverts)**						$2,755,760
	7a. Cofferdam and Dewatering	1	L.S.	$762,000	$762,000	From App. E of USACE Report, item 01/01/15/004/08 (incl. contingency)	
	7b. Excavate (with hydraulic backhoe)	7,280	C.Y.	$2.50	$18,200	Means, 02315-424-0300	
	7c. Foundation Bedding Stone Layer	550	C.Y.	$7.20	$3,960	Unit costs for Items 4a, 4b and 4c	
	7d. Reinforced Concrete Box Culverts (furnish & install)	540	L.F.	$650	$351,000	Means, 02530-730-0450	
	7e. Place and Compact Backfill	4,480	C.Y.	$2.50	$11,200	02315-120-2200 and 02315-310-7600	
	7f. Permanent SSP Wingwalls	1	L.S.	$125,000	$125,000	From App. E of USACE Report, item 01/01/15/004/11 (incl. contingency)	
	7g. Gate Monolith	1	L.S.	$952,000	$952,000	From App. E of USACE Report, item 01/01/15/004/18 (incl. contingency) + 100%	
	7h. Discharge Wall	1	L.S.	$52,000	$52,000	From App. E of USACE Report, item 01/01/15/004/19 (incl. contingency) + 100%	
	7i. Walkway, Handrails, Stilling Wells, Staff Gauge	1	L.S.	$26,000	$26,000	From App. E of USACE Report, items 01/01/15/004/13,14,16 (incl. contingency) + 100%	
	7j. Furnish Slide Gates (stainless steel, self-contained with electric motor operator)	3	Each	$85,000	$255,000	Estimate from Waterman Industries + 25% markup	
	7k. Install Slide Gates	3	Each	$51,000	$153,000	Estimate Labor & Equip. Cost to be 60% of Material Price based on Means, 11285-600-0190	
	7l. Control Building and Electrical	1	L.S.	$40,000	$40,000	From App. E of USACE Report, items 01/01/15/004/17,23 (incl. contingency)	
	7m. Riprap	320	C.Y.	$20	$6,400	Means, 02370-450-0100 (not incl. material cost)	
DELETED CONSTRUCTION ITEMS (from original design)							
1.	**S-502C 2 Barrel Gated Culvert, 300 cfs capacity**	1	L.S.			From App. E of USACE Report, page E-40, item 01/01/15 total (incl. contingency)	$1,600,000
2.	**Windbreaks[3]**						$318,600
	2a. Haul Material (1 mile round trip from local stockpile)	59,000	C.Y.	$2.40	$141,600	Means, 02315-490-1150	
	2b. Place Embankment Fill	59,000	C.Y.	$3.00	$177,000	Means, 02315-520-0190	

Notes:

[1] Source of unit costs (unless otherwise noted): "Heavy Construction Cost Data 2004", by RS Means Company, Inc.

[2] Referenced USACE Report is the "Central and Southern Florida Project Water Preserve Areas Feasibility Study, Draft Integated Feasibility Report and Supplemental Environmental Impact Statement", October 2001

[3] Quantity of fill material for windbreak construction was obtained from Table B.7.6 in Appendix B of the USACE Report

TABLE 4.4
BACKUP FOR OPINION OF CONSTRUCTION COSTS - ALTERNATIVE 2

Alternatives Evaluation Report
Evaluation of Stormwater Treatment Potential of the Western C-11 Impoundment
South Florida Water Management District

Item No.	Description	Estimated Quantity	Units	Unit Cost	Subtotal Costs	Cost source[1,2]	Total Item Cost
1.	**Haul Road Construction (assume 1.5 mile length, 20' width)**						$297,600
	1a. Stabilization Fabric	17,600	S.Y.	$3.50	$61,600	Estimate from Supplier + 25% markup	
	1b. Aggregate Surfacing (12-inch depth)	5,900	C.Y.	$40	$236,000	Means, 01550-700-0100	
2.	**Foundation Excavation**						$171,000
	2a. Excavate	23,400	C.Y.	$4.00	$93,600	Means, 02315-432-5400	
	2b. Spread Excavated Material on Ground Surface	25,800	C.Y.	$3.00	$77,400	Means, 02315-520-0190	
3.	**Levee Construction**						$817,460
	3a. Haul Material (3 mile round trip with 20 C.Y. haul vehicle)	114,000	C.Y.	$3.60	$410,400	Means, 02315-490-1220	
	3b. Place Embankment Fill	114,000	C.Y.	$3.00	$342,000	Means, 02315-520-0190	
	3c. Compact Embankment Fill (12-inch lifts)	114,000	C.Y.	$0.50	$57,000	Means, 02315-310-5100	
	3d. Grade and Shape Embankment	40,300	S.Y.	$0.20	$8,060	Means, 02310-100-3310	
4.	**Revetment Construction**						$68,080
	4a. Load Bedding Material for Transport from On-Site Source	1,400	C.Y.	$0.60	$840	Means, 02315-210-5070 (not incl. material cost)	
	4b. Haul Bedding Material to Site (3 mile round trip)	1,400	C.Y.	$3.60	$5,040	Means, 02315-490-1220	
	4c. Place Bedding Material	1,400	C.Y.	$3.00	$4,200	Means, 02315-520-0190	
	4d. Furnish and Place Rip Rap	2,900	C.Y.	$20	$58,000	Means, 02370-450-0100 (not incl. material cost)	
5.	**Sump Construction**						$1,314,000
	5a. Excavate	180,000	C.Y.	$4.00	$720,000	Means, 02315-432-5400	
	5b. Spread Excavated Material on Ground Surface	198,000	C.Y.	$3.00	$594,000	Means, 02315-520-0190	
6.	**Seeding and Mulching (Internal Levees)**						$89,000
	6a. Erosion Control Matting (levee slopes only)	35,000	S.Y.	2.00	$70,000	Estimate from Supplier + 25% markup	
	6b. Seeding (hydroseed, mulch and fertilizer)	9.5	Acres	$2,000	$19,000	Means, 02920-320-4600	
7.	**C-502A Canal Widening[3]**						$81,200
	7a. Excavate and Sidecast Material	23,200	C.Y.	$3.50	$81,200	BSFS Report[4], Appendix A, item 1.7.1.1	

TABLE 4.4
BACKUP FOR OPINION OF CONSTRUCTION COSTS - ALTERNATIVE 2
Alternatives Evaluation Report
Evaluation of Stormwater Treatment Potential of the Western C-11 Impoundment
South Florida Water Management District

Item No.	Description	Estimated Quantity	Units	Unit Cost	Subtotal Costs	Cost source[1,2]	Total Item Cost
8.	**S-502C Gated Culverts, 2500 cfs capacity (3 - 12' x 8' precast reinforced concrete box culverts)**						$2,755,760
	8a. Cofferdam and Dewatering	1	L.S.	$762,000	$762,000	From App. E of USACE Report, item 01/01/15/004/08 (incl. contingency)	
	8b. Excavate (with hydraulic backhoe)	7,280	C.Y.	$2.50	$18,200	Means, 02315-424-0300	
	8c. Foundation Bedding Stone Layer	550	C.Y.	$7.20	$3,960	Unit costs for Items 4a, 4b and 4c	
	8d. Reinforced Concrete Box Culverts (furnish & install)	540	L.F.	$650	$351,000	Means, 02530-730-0450	
	8e. Place and Compact Backfill	4,480	C.Y.	$2.50	$11,200	02315-120-2200 and 02315-310-7600	
	8f. Permanent SSP Wingwalls	1	L.S.	$125,000	$125,000	From App. E of USACE Report, item 01/01/15/004/11 (incl. contingency)	
	8g. Gate Monolith	1	L.S.	$952,000	$952,000	From App. E of USACE Report, item 01/01/15/004/18 (incl. contingency) + 100%	
	8h. Discharge Wall	1	L.S.	$52,000	$52,000	From App. E of USACE Report, item 01/01/15/004/19 (incl. contingency) + 100%	
	8i. Walkway, Handrails, Stilling Wells, Staff Gauge	1	L.S.	$26,000	$26,000	From App. E of USACE Report, items 01/01/15/004/13,14,16 (incl. contingency) + 100%	
	8j. Furnish Slide Gates (stainless steel, self-contained with electric motor operator)	3	Each	$85,000	$255,000	Estimate from Waterman Industries + 25% markup	
	8k. Install Slide Gates	3	Each	$51,000	$153,000	Estimate Labor & Equip. Cost to be 60% of Material Price based on Means, 11285-600-0190	
	8l. Control Building and Electrical	1	L.S.	$40,000	$40,000	From App. E of USACE Report, items 01/01/15/004/17,23 (incl. contingency)	
	8m. Riprap	320	C.Y.	$20	$6,400	Means, 02370-450-0100 (not incl. material cost)	
DELETED CONSTRUCTION ITEMS (from original design)							
1.	**S-502C 2 Barrel Gated Culvert, 300 cfs capacity**	1	L.S.			From App. E of USACE Report, page E-40, item 01/01/15 total (incl. contingency)	$1,600,000
2.	**Windbreaks[5]**						$318,600
	2a. Haul Material (1 mile round trip from local stockpile)	59,000	C.Y.	$2.40	$141,600	Means, 02315-490-1150	
	2b. Place Embankment Fill	59,000	C.Y.	$3.00	$177,000	Means, 02315-520-0190	

Notes:

1 Source of unit costs (unless otherwise noted): "Heavy Construction Cost Data 2004", by RS Means Company, Inc.

2 Referenced USACE Report is the "Central and Southern Florida Project Water Preserve Areas Feasibility Study, Draft Integated Feasibility Report and Supplemental Environmental Impact Statement", October 2001

3 Canal widening to increase capacity of the portion of the C-502A canal between the proposed relocated C-11 Impoundment Discharge Structure (S-504) and the existing design location for S-504. Excavation quantity based on: canal length of 2000 L.F.; assumed depth of excavation of 15.6 ft.; and bottom width increased from 100 ft. to 120 ft. (from information provided in Section B.5.2.6.1 of the USACE Report)

4 Unit cost from "Final Report, Basin Specific Feasibility Studies, Everglades Stormwater Program Basins", October 2002. Cost for deep canal excavation with no blasting.

5 Quantity of fill material for windbreak construction was obtained from Table B.7.6 in Appendix B of the USACE Report

TABLE 4.5
BACKUP FOR ESTIMATED ANNUAL O & M COSTS - ALTERNATIVE 1

Alternatives Evaluation Report
Evaluation of Stormwater Treatment Potential of the Western C-11 Impoundment
South Florida Water Management District

Item No.	Description	Estimated Quantity	Units	Unit Cost	Annual Costs	Cost source
1.	**Maintenance of Levees**					
	1a. General Maintenance of Levees	2.3	Miles	$1,530	$35,190	BSFS Report[1], Appendix A, item 2.2.4
	1b. Vegetation Control (assume 5 mowings per year)	10.8	Acres	$60	$648	Means[2], 02935-300-4200
2.	**Maintenance of Sumps**					
	2a. Removal of Sediment (using barge mounted dragline or clamshell, hopper dumped, and pumped to disposal area outside impoundment levees)[3]				$84,000	See Note 4
3.	**Maintenance of Gated Culverts (S-502C Structure)**					
	3a. General Maintenance	1	Each	$6,000	$6,000	BSFS Report, Appendix A, item 2.2
TOTAL ANNUAL COST					**$125,838**	**(Round to $130,000)**

Notes:

[1] Costs from "Final Report, Basin Specific Feasibility Studies, Everglades Stormwater Program Basins", October 2002

[2] Costs from "Heavy Construction Cost Data 2004", by RS Means Company, Inc.

[3] Assumes 45,000 C.Y. (25% of sump volume) of sediment removed every 25 years

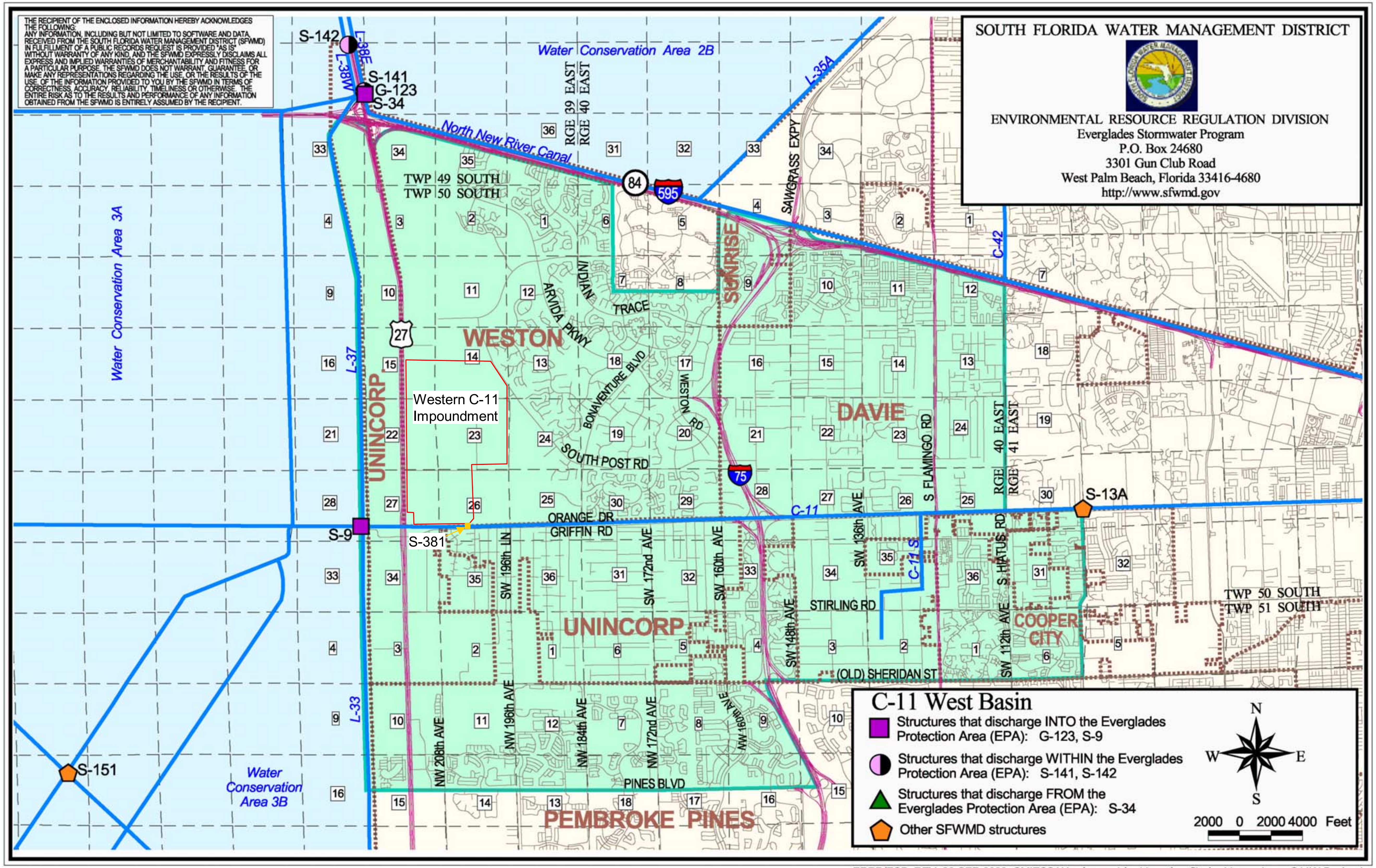
[4] Cost for sediment removal represents an annualized amount for sediment removal every 25 years at a cost of $12 per cubic yard (in 2004 dollars) and an estimated mob. and demob. cost of $30,000 (in 2004 dollars), using a discount rate of 6-3/8%

TABLE 4.6
BACKUP FOR ESTIMATED ANNUAL O & M COSTS - ALTERNATIVE 2
Alternatives Evaluation Report
Evaluation of Stormwater Treatment Potential of the Western C-11 Impoundment
South Florida Water Management District

Item No.	Description	Estimated Quantity	Units	Unit Cost	Annual Costs	Cost source
1.	**Maintenance of Levees**					
	1a. General Maintenance of Levees	1.6	Miles	$1,530	$24,480	BSFS Report[1], Appendix A, item 2.2.4
	1b. Vegetation Control (assume 5 mowings per year)	7.2	Acres	$60	$432	Means[2], 02935-300-4200
2.	**Maintenance of Sumps**					
	2a. Removal of Sediment (using barge mounted dragline or clamshell, hopper dumped, and pumped to disposal area outside impoundment levees)[3]				$84,000	See Note 4
3.	**Maintenance of Gated Culverts (S-502C Structure)**					
	3a. General Maintenance	1	Each	$6,000	$6,000	BSFS Report, Appendix A, item 2.2
TOTAL ANNUAL COST					**$114,912**	**(Round to $120,000)**

Notes:
[1] Costs from "Final Report, Basin Specific Feasibility Studies, Everglades Stormwater Program Basins", October 2002
[2] Costs from "Heavy Construction Cost Data 2004", by RS Means Company, Inc.
[3] Assumes 45,000 C.Y. (25% of sump volume) of sediment removed every 25 years
[4] Cost for sediment removal represents an annualized amount for sediment removal every 25 years at a cost of $12 per cubic yard (in 2004 dollars) and an estimated mob. and demob. cost of $30,000 (in 2004 dollars), using a discount rate of 6-3/8%

FIGURES



sfwmd.gov

SOURCE: http://www.sfwmd.gov/org/reg/esp/pdfs/map_c11w_121800.pdf

FIGURE 1.1

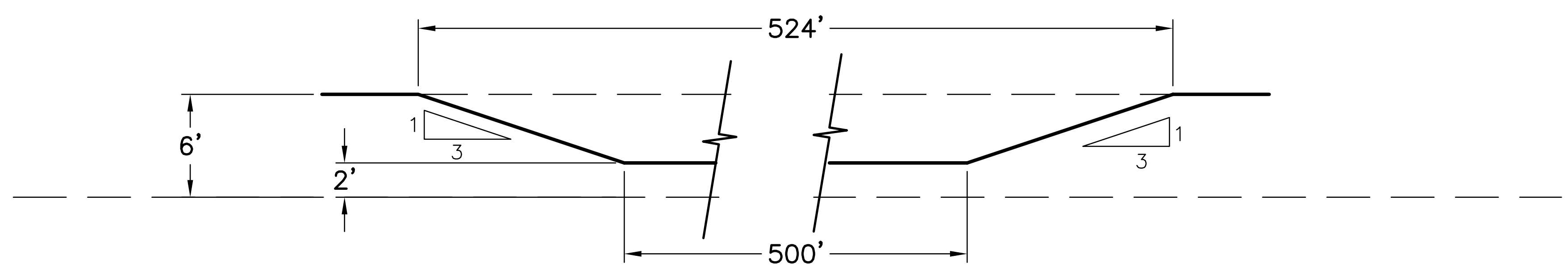
C-11 WEST STORMWATER MANAGEMENT BASIN

MACTEC PROJECT NUMBER: 6308-03-0032

MACTEC

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WEST PALM BEACH, FLORIDA

ALTERNATIVES EVALUATION REPORT
WESTERN C-11 IMPOUNDMENT



SCALE N.T.S.

SOUTH FLORIDA
WATER MANAGEMENT DISTRICT
WEST PALM BEACH, FLORIDA

MACTEC
Engineering and Consulting, Inc.
3200 TOWN POINT DRIVE, SUITE 100
KENNESAW, GEORGIA 30144 (770) 421-3400

ALTERNATIVES EVALUATION REPORT

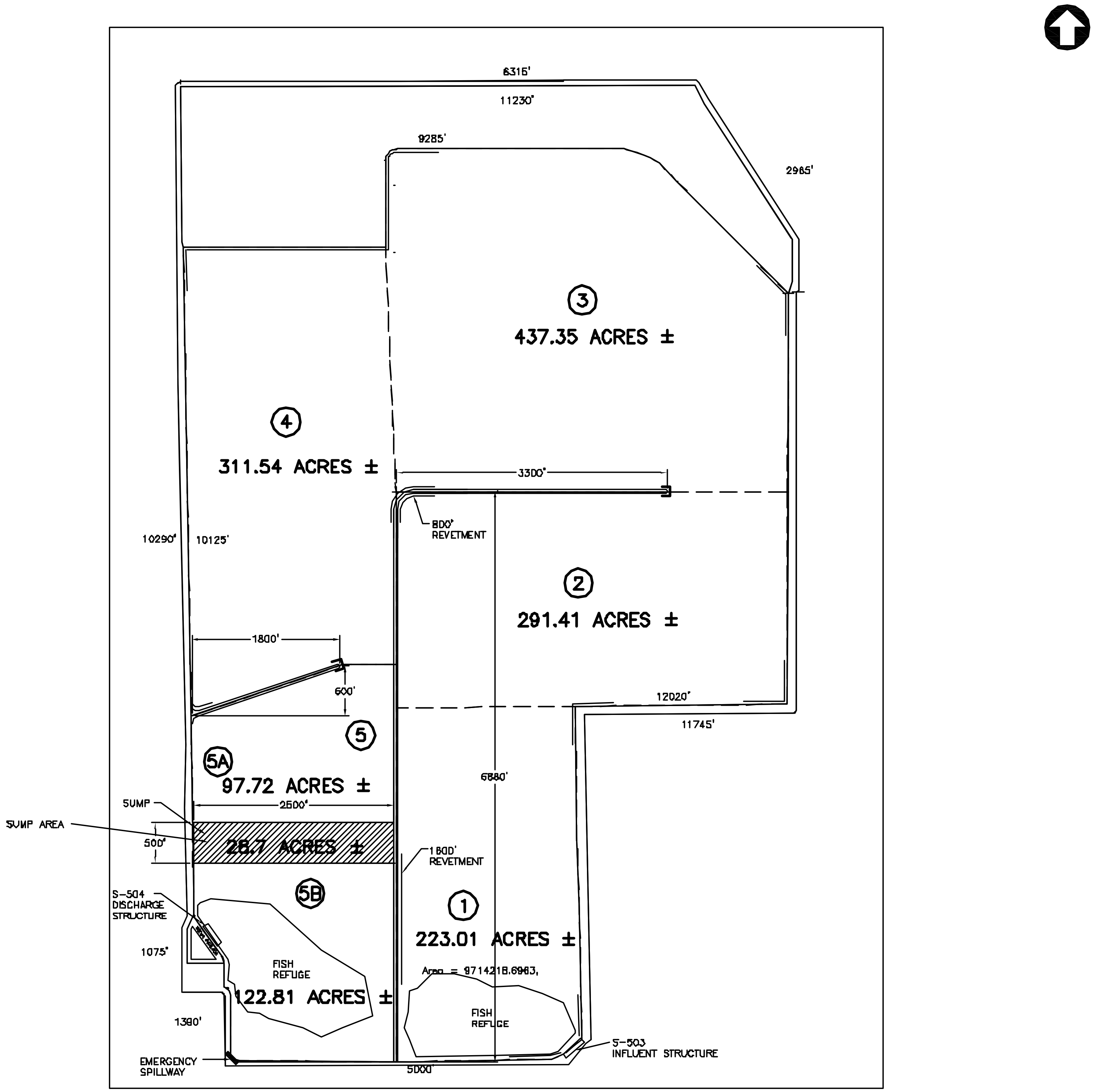
CONCEPTUAL SUMP
CROSS SECTION
WESTERN C-11 IMPOUNDMENT

JOB NO. 6308-03-0032

FIGURE 1.2

PREPARED BY/DATE

CHECKED BY/DATE



SCALE IN FEET
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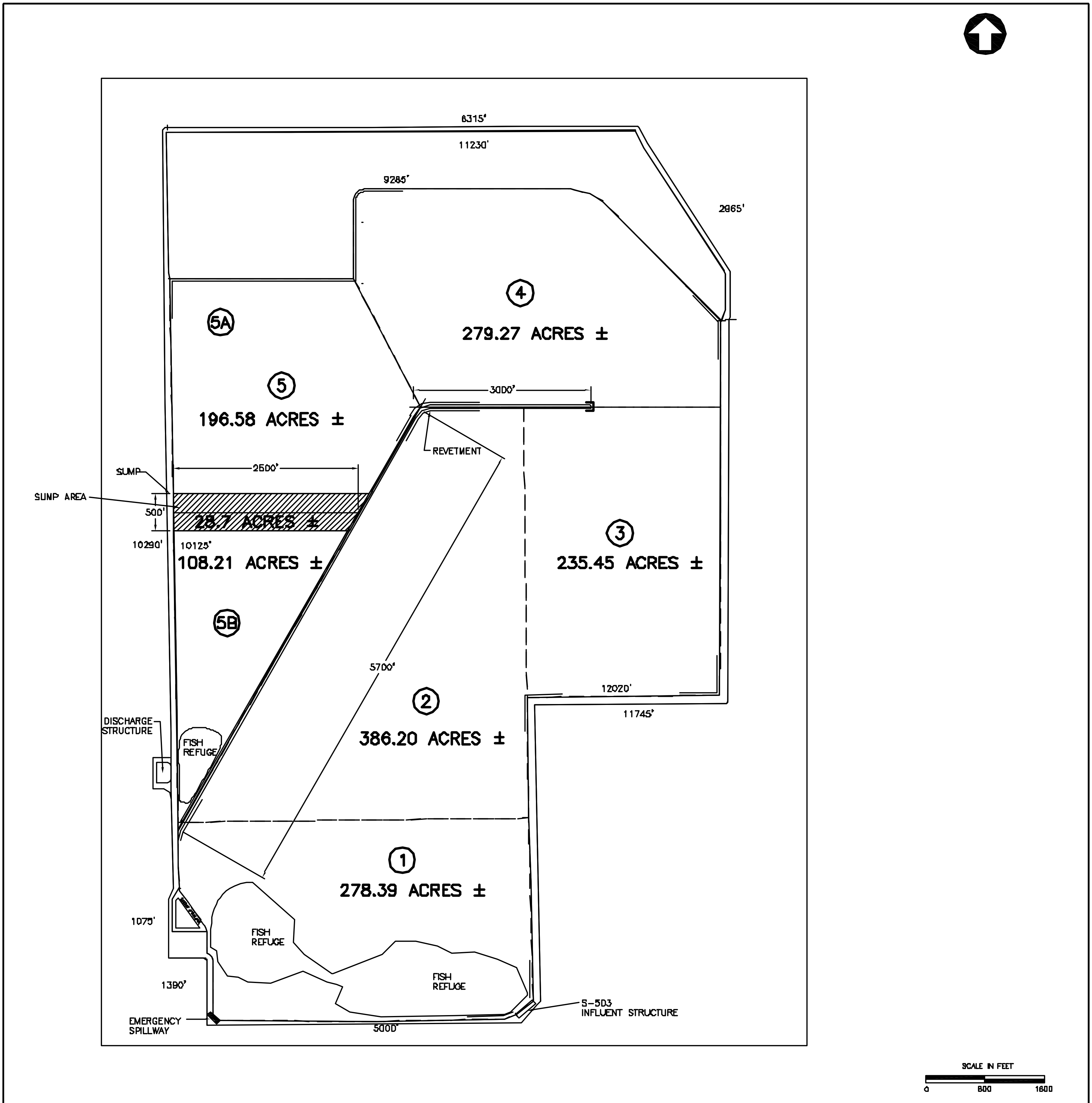
DESIGNED M. TANNER DRAWN T. GLADSTONE CHECKED M. TANNER IN CHARGE DATE 10/23/03	SOUTH FLORIDA WATER MANAGEMENT DISTRICT WEST PALM BEACH, FLORIDA MACTEC Engineering and Consulting, Inc. 3200 TOWN POINT DRIVE, SUITE 100 KENNESAW, GEORGIA 30144 (770) 421-3400	ALTERNATIVES EVALUATION REPORT ALTERNATIVE 1 CONCEPTUAL SUB-AREA DIVISION WESTERN C-11 IMPOUNDMENT	SCALE AS SHOWN CONTRACT 6308-03-0032 DWG. NO. 2.1 REV PAGE NO



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DRAWN: T. GLADSTONE	MACTEC Engineering and Consulting, Inc. 3200 TOWN POINT DRIVE, SUITE 100 KENNESAW, GEORGIA 30144 (770) 421-3400	ALTERNATIVE 2 CONCEPTUAL SUB-AREA DIVISION WESTERN C-11 IMPOUNDMENT	CONTRACT: 6308-03-0032
CHECKED: M. TANNER			DWG. NO.: 2.2
IN CHARGE:			REV:
DATE: 10/23/03			PAGE NO:

Figure 2.3
Number of Sub-Areas vs. Removal Efficiency
for Alternative 1 using Flow Weighted Averages for 1967
South Florida Water Management District
Western C-11 Impoundment
Alternatives Evaluation

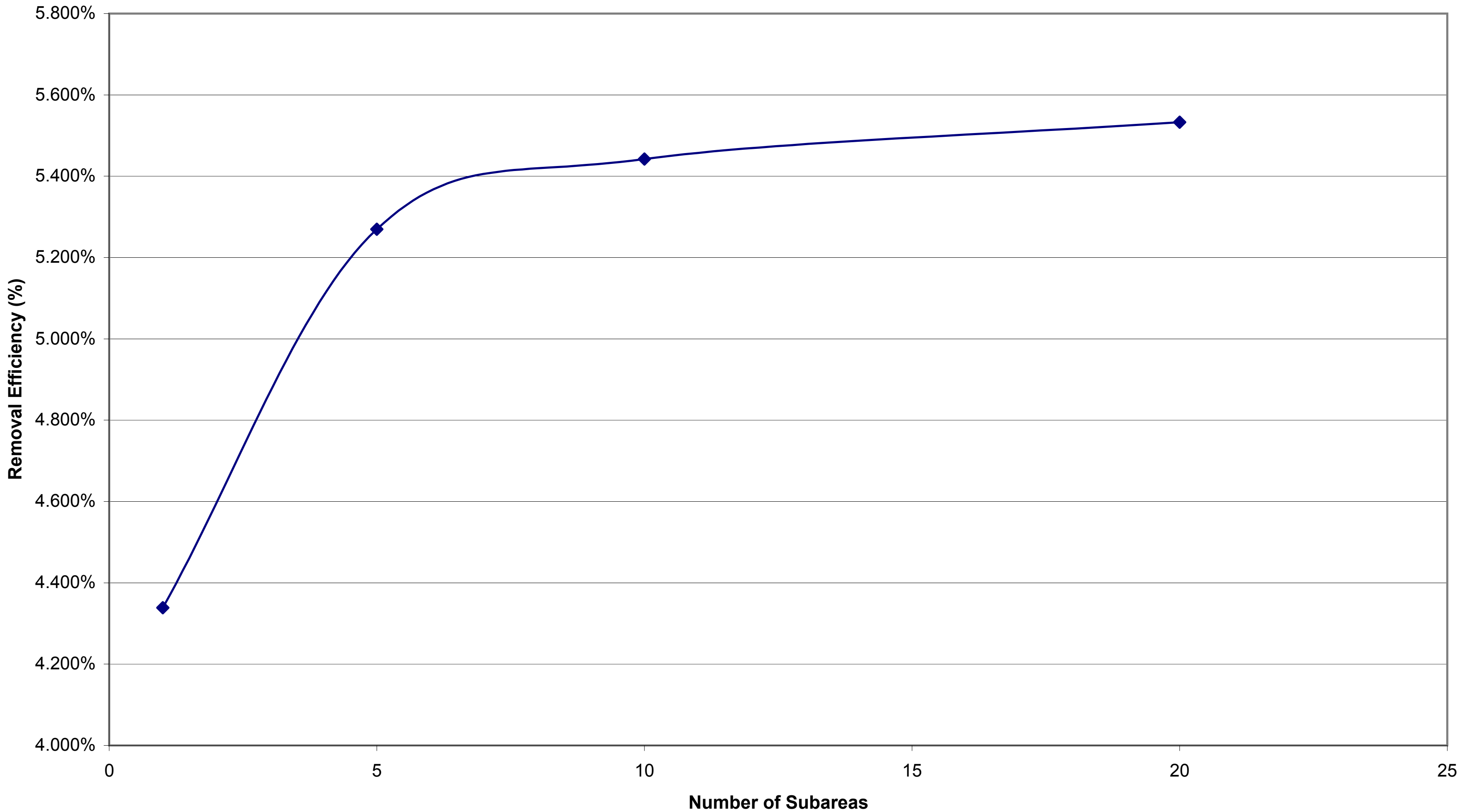
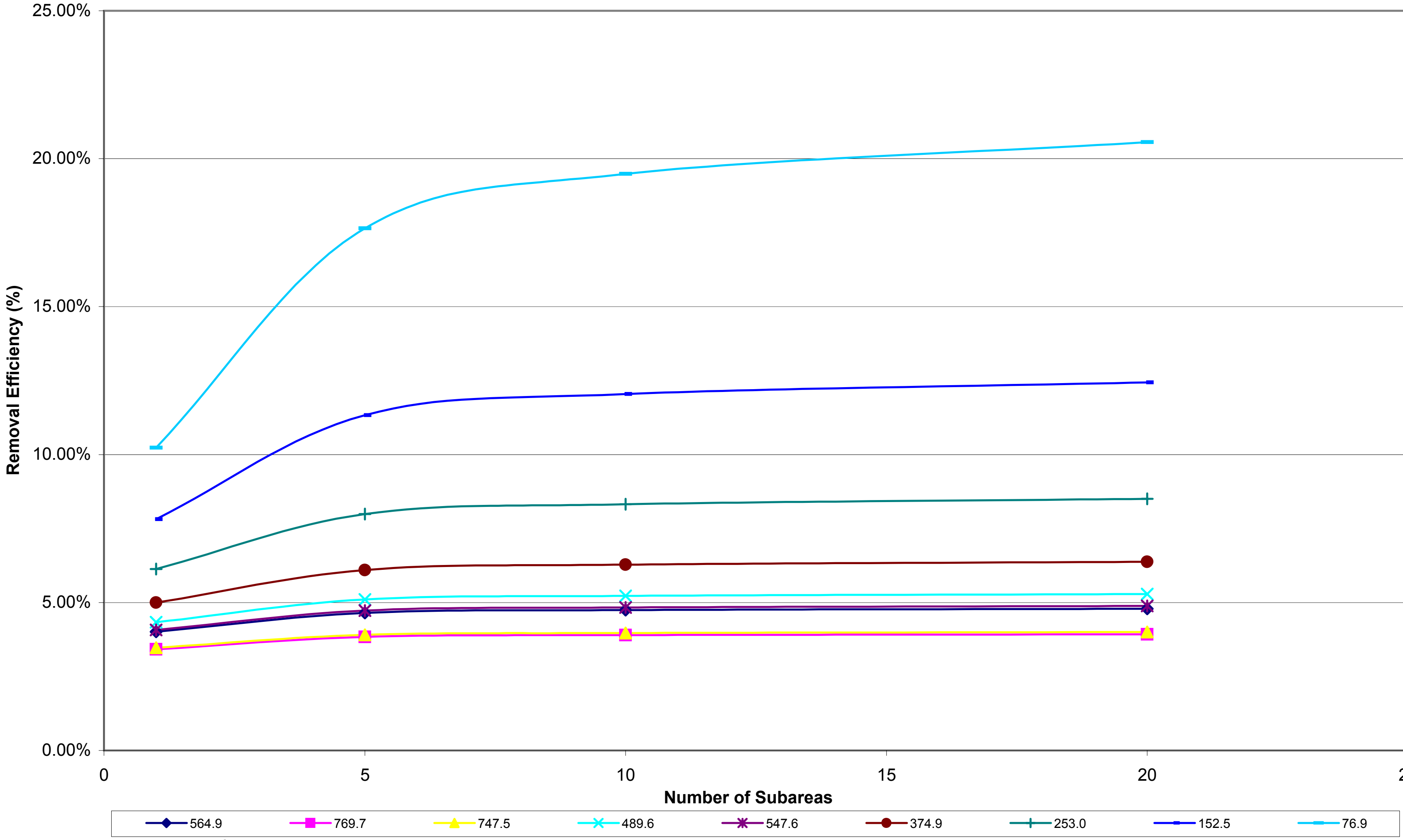
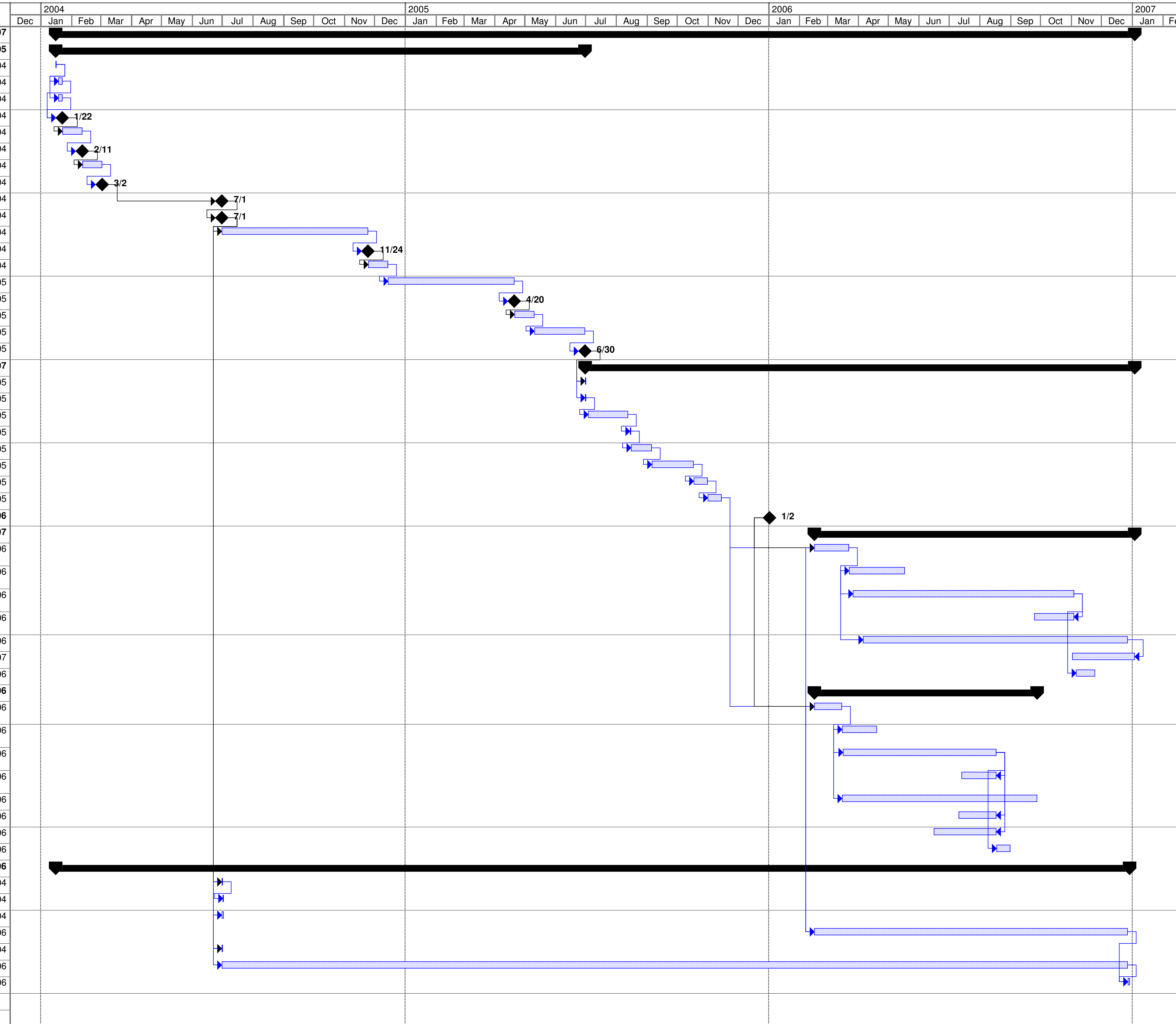


Figure 2.4
Number of Sub-Areas vs. Removal Efficiency for Alternative 1 using Daily Flowrates for 1967
South Florida Water Management District
Western C-11 Impoundment
Alternatives Evaluation



Flowrates in cubic feet per second

ID	Task Name	Duration	Start	Finish
1	**FEASIBILITY LEVEL EVALUATION OF ALTERNATIVES (See NOTE 1)**	**774 days**	**1/16/04**	**1/3/07**
2	**DESIGN PHASE**	**380 days**	**1/16/04**	**6/30/05**
3	Review Feasibility Studies, Conceptual Plans, 2001 Consolidated Rep	1 day	1/16/04	1/16/04
4	Prepare Preliminary Cost Estimate (Alternative 1)	4 days	1/19/04	1/22/04
5	Prepare Preliminary Cost Estimate (Alternative 2)	4 days	1/19/04	1/22/04
6	Submit Preliminary Cost Estimates for Alternatives 1 & 2	0 days	1/22/04	1/22/04
7	District Review	14 days	1/23/04	2/11/04
8	District Comments Received	0 days	2/11/04	2/11/04
9	Response to District Comments	14 days	2/12/04	3/2/04
10	Submit Revised Report	0 days	3/2/04	3/2/04
11	District Decision Point for Conceptual Design of Internal Levee	0 days	7/1/04	7/1/04
12	Alternative Selected by District	0 days	7/1/04	7/1/04
13	Mid-Point Design (65%)	105 days	7/1/04	11/24/04
14	Submit Mid-Point Design to SFWMD	0 days	11/24/04	11/24/04
15	SFWMD Review	14 days	11/25/04	12/14/04
16	Pre-Final Design (95%)	91 days	12/15/04	4/20/05
17	Submit Pre-Final Design to SFWMD	0 days	4/20/05	4/20/05
18	SFWMD Review	14 days	4/21/05	5/10/05
19	Final Design (100%)	37 days	5/11/05	6/30/05
20	Submit Final Design of Internal Levee to SFWMD	0 days	6/30/05	6/30/05
21	**CONSTRUCTION PHASE**	**394 days**	**7/1/05**	**1/3/07**
22	Receive Approval to Solicit	1 day	7/1/05	7/1/05
23	Receive Approval to Award	1 day	7/1/05	7/1/05
24	Advertise for Contract	30 days	7/4/05	8/12/05
25	Open bids	1 day	8/15/05	8/15/05
26	Review Bids	15 days	8/16/05	9/5/05
27	Award Contract	30 days	9/6/05	10/17/05
28	Prepare Field Work Plans	10 days	10/18/05	10/31/05
29	Review/Approve Field Work Plans	10 days	11/1/05	11/14/05
30	**Commence C-11 Impoundment Construction**	**0 days**	**1/2/06**	**1/2/06**
31	**Internal Levee Construction - Alternative 1 (12,200 feet)**	**230 days**	**2/16/06**	**1/3/07**
32	Haul Road	25 days	2/16/06	3/22/06
33	Foundation Excavation	40 days	3/23/06	5/17/06
34	Levees	160 days	3/27/06	11/3/06
35	Revetment	30 days	9/25/06	11/3/06
36	Sump Construction	190 days	4/6/06	12/27/06
37	S-502C Gated Culverts	45 days	11/2/06	1/3/07
38	Seeding & Mulching	15 days	11/6/06	11/24/06
39	**Internal Levee Construction - Alternative 2 (8,100 feet)**	**160 days**	**2/16/06**	**9/27/06**
40	Haul Road	20 days	2/16/06	3/15/06
41	Foundation Excavation	25 days	3/16/06	4/19/06
42	Levees	110 days	3/17/06	8/17/06
43	Revetment	25 days	7/14/06	8/17/06
44	Sump Construction	140 days	3/16/06	9/27/06
45	C-502A Canal Widening	28 days	7/11/06	8/17/06
46	S-502C Gated Culverts	45 days	6/16/06	8/17/06
47	Seeding & Mulching	10 days	8/18/06	8/31/06
48	**PROJECT MANAGEMENT/OVERSIGHT**	**771 days**	**1/16/04**	**12/29/06**
49	Determine Project Milestones w/ SFWMD	1 day	7/1/04	7/1/04
50	Determine Review Frequency w/ SFWMD	1 day	7/2/04	7/2/04
51	Finalize FS Team Structure	2 days	7/1/04	7/2/04
52	Administer/Surveillance of Internal Levee Construction Contract	225 days	2/16/06	12/27/06
53	Distribute Prelim Project Schedule	1 day	7/1/04	7/1/04
54	Manage Project Schedule	650 days	7/1/04	12/27/06
55	Close Project Folders	2 days	12/28/06	12/29/06
56				
57	**NOTE 1: Schedule Drift may occur due to changes in the CERP schedule.**			



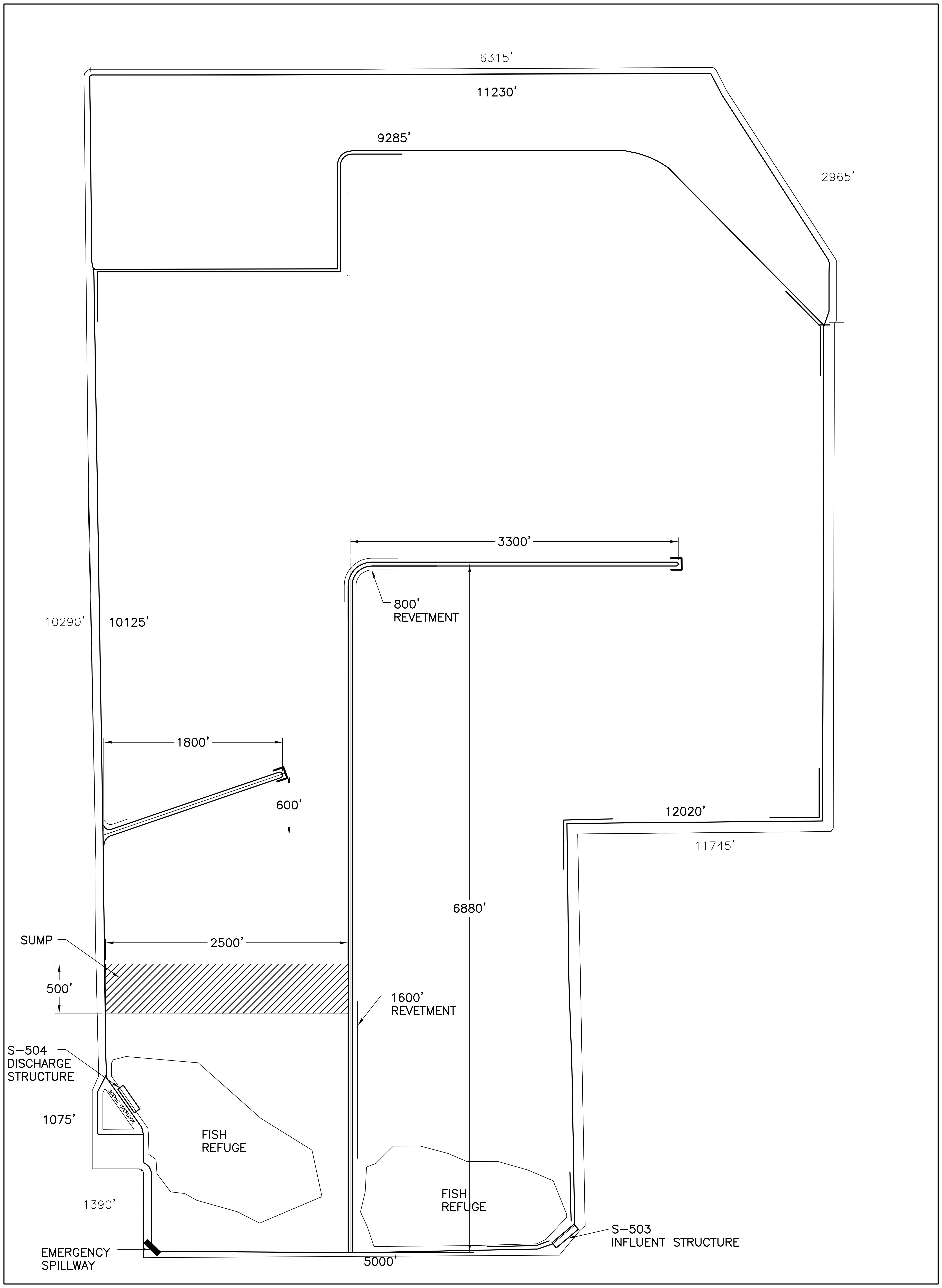
Project: Preliminary Implementation Schedule
Date: 2/23/04

Task		Progress		Summary		External Tasks	
Split		Milestone		Project Summary		External Milestone	

Deadline

Figure 5.1

APPENDIX A
ALTERNATIVES 1 AND 2 CONCEPTUAL LEVEE CONFIGURATION



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DESIGNED M. TANNER DRAWN T. GLADSTONE CHECKED M. TANNER IN CHARGE DATE 10/23/03	SOUTH FLORIDA WATER MANAGEMENT DISTRICT WEST PALM BEACH, FLORIDA MACTEC Engineering and Consulting, Inc. 3200 TOWN POINT DRIVE, SUITE 100 KENNESAW, GEORGIA 30144 (770) 421-3400	ALTERNATIVES FORMULATION REPORT ALTERNATIVE 1 CONCEPTUAL INTERNAL LEVEE CONFIGURATION WESTERN C-11 IMPOUNDMENT	SCALE AS SHOWN CONTRACT 6308-03-0032 DWG. NO. 3 REV PAGE NO

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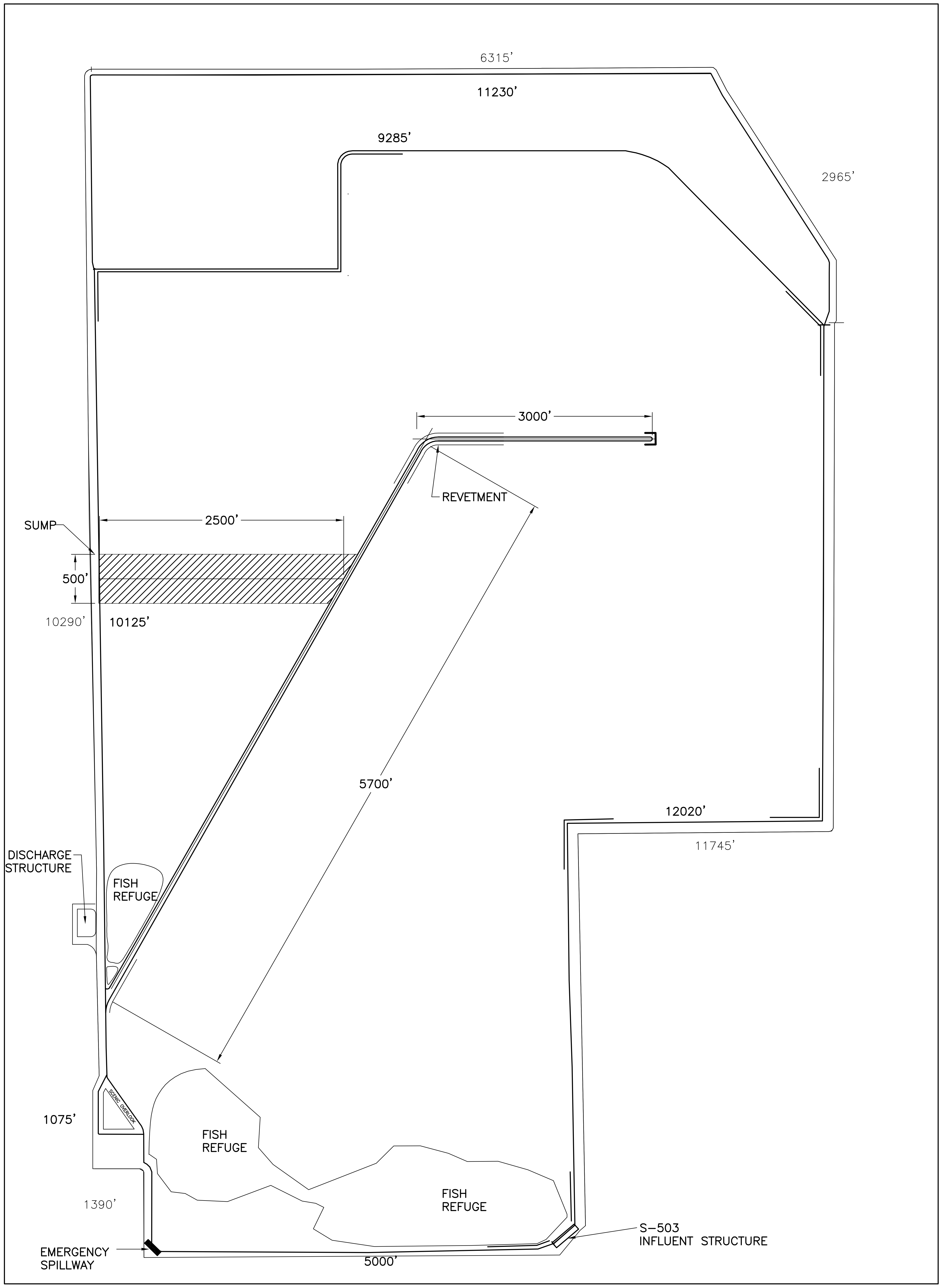

SCALE IN FEET
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DESIGNED M. TANNER DRAWN T. GLADSTONE CHECKED M. TANNER IN CHARGE DATE 10/23/03	SOUTH FLORIDA WATER MANAGEMENT DISTRICT WEST PALM BEACH, FLORIDA MACTEC Engineering and Consulting, Inc. 3200 TOWN POINT DRIVE, SUITE 100 KENNESAW, GEORGIA 30144 (770) 421-3400	ALTERNATIVES FORMULATION REPORT ALTERNATIVE 2 CONCEPTUAL INTERNAL LEVEE CONFIGURATION WESTERN C-11 IMPOUNDMENT	SCALE AS SHOWN CONTRACT 6308-03-0032 DWG. NO. 4 REV PAGE NO

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APPENDIX B

PHOSPHORUS REMOVAL BY URBAN RUNOFF DETENTION BASINS: W.W. WALKER

PHOSPHORUS REMOVAL BY URBAN RUNOFF DETENTION BASINS

William W. Walker, Jr.
Environmental Engineer
Concord, Massachusetts

ABSTRACT

An empirical model previously developed for predicting phosphorus retention in reservoirs is tested against the urban lake/detention pond data set. Detention pond design criteria developed under the EPA's Nationwide Urban Runoff Program (NURP) are evaluated using the model. For summer precipitation and runoff quality typical of St. Paul, Minnesota, a basin designed according to NURP criteria is estimated to have a long-term-average phosphorus removal efficiency of 47-68 percent. For a given loading regime, phosphorus removal is shown to be more sensitive to pond depth than to surface area. Specific design features for enhancing phosphorus removal (deepening, promoting infiltration, promoting plug flow, and chemical treatment) are discussed. The methodology can be used to evaluate wet detention pond design criteria in other regions, with substitution of appropriate precipitation and runoff quality characteristics.

INTRODUCTION

Cause–effect relationships linking urban watershed development to lake and reservoir eutrophication are well established. Urban watersheds typically export 5 to 20 times as much phosphorus per unit area per year, as compared with undeveloped watersheds in a given region (Reckhow et al. 1980; Athayde et al. 1983; Dennis, 1985). Summaries of urban runoff data collected under the EPA's Nationwide Urban Runoff Program (NURP) indicate mean concentrations of 420 ppb total phosphorus and 150 ppb dissolved phosphorus (Athayde et al. 1983). In contrast, lakes with total phosphorus concentrations exceeding 20–30 ppb may experience nuisance algal growths (Vollenweider, 1976). NURP concluded that "lakes for which the contributions of urban runoff are significant in relation to other nonpoint sources (even in the absence of point source discharges) are indicated to be highly susceptible to eutrophication and that urban runoff controls may be warranted in such situations" (Athayde et al. 1983).

A relationship between urban land use and phosphorus export for watersheds in the Minneapolis/St. Paul area is shown in Figure 1 (Walker, 1985a). Increases in phosphorus export associated with urban watershed development primarily reflect increases in impervious area and surface runoff. Runoff tends to have much higher concentrations of total and dissolved phosphorus compared with base flows that are filtered through the soil column before reaching stream channels or lakes. Specific urban sources (lawn fertilizers, leaf fall, pets) and streambank erosion resulting from higher peak flows also contribute to urban phosphorus loadings.

Physical, economic, and institutional constraints make control of nonpoint phosphorus export from urban watersheds a difficult problem. While the concept of "source control" is attractive, the sources are generally too diverse to permit control of a major fraction of the total loading by targeting one or more specific components. Devices and management practices such as catch basins and street sweeping are generally ineffective at controlling the export of fine particulates and soluble nutrients which have the greatest potential for stimulating lake eutrophication. Performance monitoring conducted under NURP (Athayde et al. 1983; U.S. Environ. Prot. Agency, 1986) has shown that detention ponds, which intercept, store, and treat runoff before releasing it to receiving streams or lakes, can be designed to provide significant removals of many urban runoff pollutants, including phosphorus.

This paper compiles and analyzes data on phosphorus removal by runoff detention basins and urban lakes reported in the literature. It describes the basin design criteria for suspended solids removal developed under NURP. An empirical model for predicting phosphorus removal efficiency as a function of watershed characteristics, basin morphometry, and climatologic factors is described and tested. The model is employed to evaluate the NURP design criteria from a phosphorus removal perspective under Minnesota climatologic conditions. Specific design features which may enhance phosphorus removal are discussed.

NURP DESIGN CRITERIA FOR SUSPENDED SOLIDS REMOVAL

Athayde et al. (1983) concluded that wet detention basins, in which permanent water pools are maintained, are potentially effective for reducing loadings of suspended solids, heavy metals, and nutrients

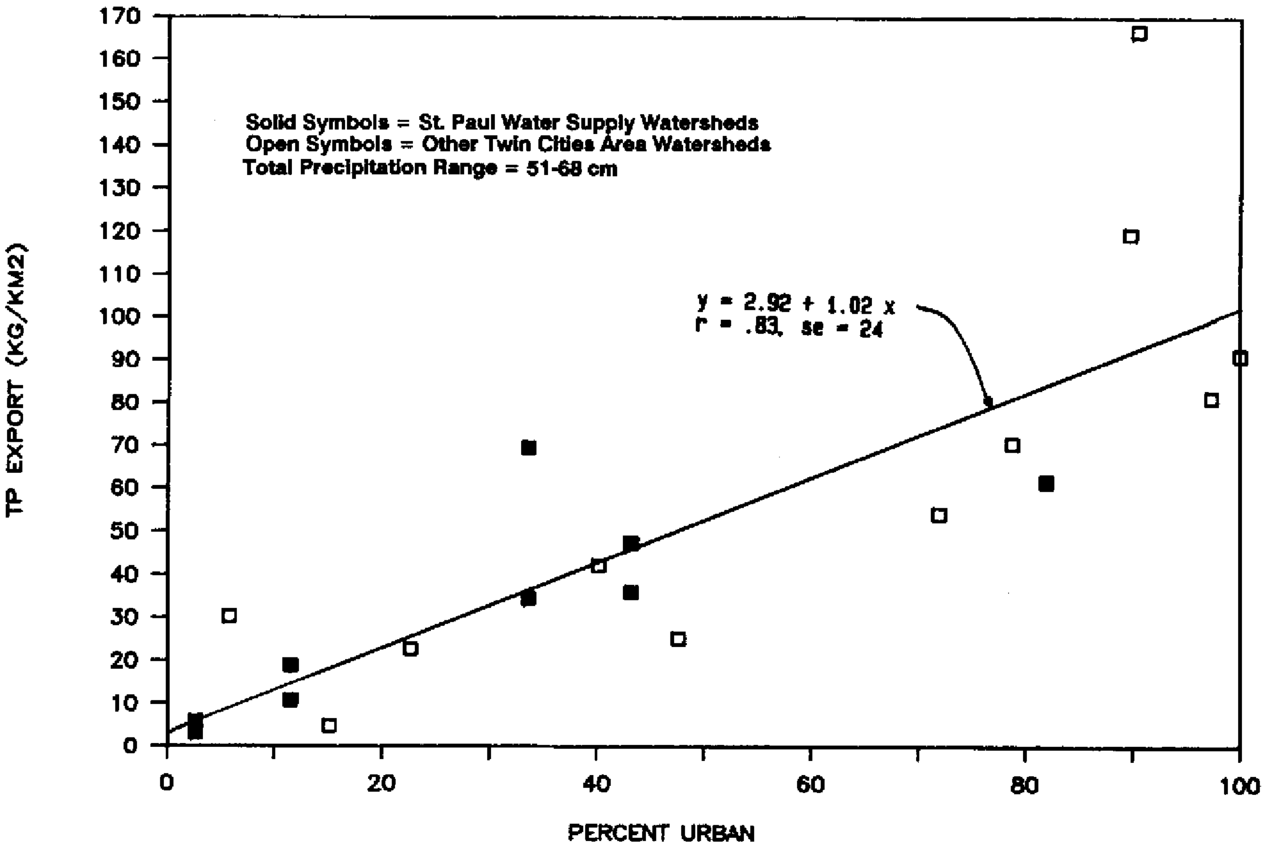

Figure 1.–Phosphorus export vs. urban land use for twin cities watersheds. Reference: Walker, 1985a.

from urban watersheds. Dry detention basins, which are used to control peak runoff but empty completely between storm events, have pollutant removal performance which ranges "from insignificant to quite poor". The presence of a permanent pool is important because it (1) permits "treatment" (sedimentation, adsorption, biological uptake) to occur during the relatively long times between storm events; (2) increases sedimentation efficiency and reduces bottom scouring potential by dissipating runoff energy; and (3) provides a habitat for algae and aquatic plants which can assist in the removal of soluble pollutants.

While some success with extended detention dry ponds (flood detention areas fitted with outlet control devices designed to store runoff for a day or so following events) has been reported for suspended solids and heavy metals, removals of soluble and total nutrients in such basins have been quite low (Randall,1982; Athayde et al. 1983).

Based upon analysis of data from wet detention basins monitored under NURP (Table 1), Driscoll (1983) has shown that average removal efficiency for suspended solids depends upon the following hydraulic and variables:

Q_m/A = mean surface overflow rate during storm periods (cm/hr)
= pond outflow / surface area

V_p/V_m = permanent pool volume / mean storm volume (dimensionless)

The first ratio determines potential removal during storm events for particles of a given settling velocity. Under ideal conditions for sedimentation, particles having settling velocities greater than Q_m/A would be removed; the remaining would either pass through the pond or remain suspended in the pond at the end of the event. The second ratio determines the pond's potential to store and subsequently remove materials during quiescent periods between storm events.

Using data from several NURP projects, Driscoll (1983) constructed a frequency distribution for particle settling velocities in typical urban runoff:

Percentile :	10	30	50	70	90
Velocity (cm/hr) :	.9	9	46	210	2000

Table 1.—Hydraulic characteristics and treatment effectiveness of NURP wet detention basins.

LOCATION	BASIN	BASIN/ WATERSHED AREA	MEAN DEPTH M	Q_m/A	V_p/V_m	PERCENT REMOVAL SS	TP	DP
Lansing, MI	Grace No.	.0001	0.8	270	.045	0	0	0
Lansing, MI	Grace So.	.0004	0.8	72	.17	32	12	23
Ann Arbor, MI	Pitt	.0009	1.5	57	.52	32	18	0
Ann Arbor, MI	Traver	.0031	1.3	9.1	1.16	5	34	56
Ann Arbor, MI	Swift Run	.0115	0.5	6.0	1.02	85	3	29
Long Island, NY	Unqua	.0184	1.0	2.4	3.07	60	45	
Washington, DC	Westleigh	.0285	0.6	1.5	5.31	81	54	71
Lansing, MI	Waverly Hills	.0171	1.4	2.7	7.57	91	79	70
Glen Ellyn, IL	Lake Ellyn	.0176	1.6	3.0	10.7	84	34	

Hydraulic Characteristics Relative to Mean Monitored Storm:

Q_m/A = Mean Surface Overflow Rate During Storm (cm/hr)
V_p/V_m = Basin Permanent Pool Volume/Mean Runoff Volume

SS = Total Suspended Solids
TP = Total Phosphorus
DP = Total Dissolved Phosphorus

Data Source: Driscoll (1983)

For a typical urban watershed in northern U.S. climate (runoff coefficient = .2, mean storm size = 1 cm, mean storm duration = 4 hours), the ratio of pond area to watershed area would have to exceed .001 to remove particles with settling velocities above the median value (46 cm/hr) during an average storm. To remove fine particles (say, 10th percentile or settling velocity = .9 cm/hr) during an average storm, the ratio of pond area to watershed area would have to exceed .12; the maximum ratio for basins listed in Table 1 is .029. Especially since storms with above average intensities have major influences on long-term average performance, it is unlikely that a typical basin design would remove significant quantities of fine particles during storm events.

Several investigators have shown that phosphorus tends to be concentrated in the fine particulate fractions of street dirt and urban runoff suspended solids (Sartor et al. 1974; Pitt, 1979; Ahern et al. 1980). To achieve significant removals of fine sediments and phosphorus, quiescent settling must be involved, i.e., the pond must be large enough to store runoff for treatment during the relatively long periods between storm events. With sufficient storage, mechanisms other than settling (biological uptake, adsorption) can also contribute to phosphorus removal. Under these conditions, overall performance would be more sensitive to volume ratio (V_pV_m) than to the overflow rate (Q_m/A).

For a given climatologic regime, the above hydraulic parameters and average removal efficiency can be related directly to basic design features such as mean depth and ratio of basin area to watershed area, as illustrated in Figure 2 (Athayde et al. 1983). The performance curves are based upon simulations which account for regional storm event distributions, settling under dynamic and quiescent conditions, and the distribution of particle settling velocities in urban runoff (Driscoll, 1983; U.S. Environ. Prot. Agency, 1986). Based upon NURP data and model predictions, effective control of suspended solids and associated pollutants can be achieved in basins with a mean depth of at least 1 meter and surface area greater than or equal to one percent of the watershed area, for a typical urban watershed with a runoff coefficient of 0.2.

Table 2 evaluates the hydraulic parameters of a detention basin designed according to NURP criteria and operating in the Minneapolis/St. Paul climate. The "relative volume" (V_{rel} = ratio of pond volume to impervious watershed area (cm)) is a useful summary statistic which normalizes pond size against the contributing watershed. As shown in Table 2, the pond performance indicators Q_m/A, V_p/V_m, and T, can be calculated from V_{rel} and regional precipitation characteristics. The mean hydraulic residence time (T, years) is defined as pool volume divided by the mean seasonal outflow. This hydraulic variable has been used in empirical models for predicting average sediment retention in reservoirs (Brune, 1953) and phosphorus retention in lakes and reservoirs (Vollenweider,1976; Canfield and Bachman,1981). A NURP pond operating in the Twin Cities summer climate would have a relative volume of 5 cm, a mean storm overflow rate of 4.5 cm/hr, a pond/mean-storm volume ratio of 5.3, and a mean hydraulic residence time of 16.4 days. Summer precipitation statistics have been used for the

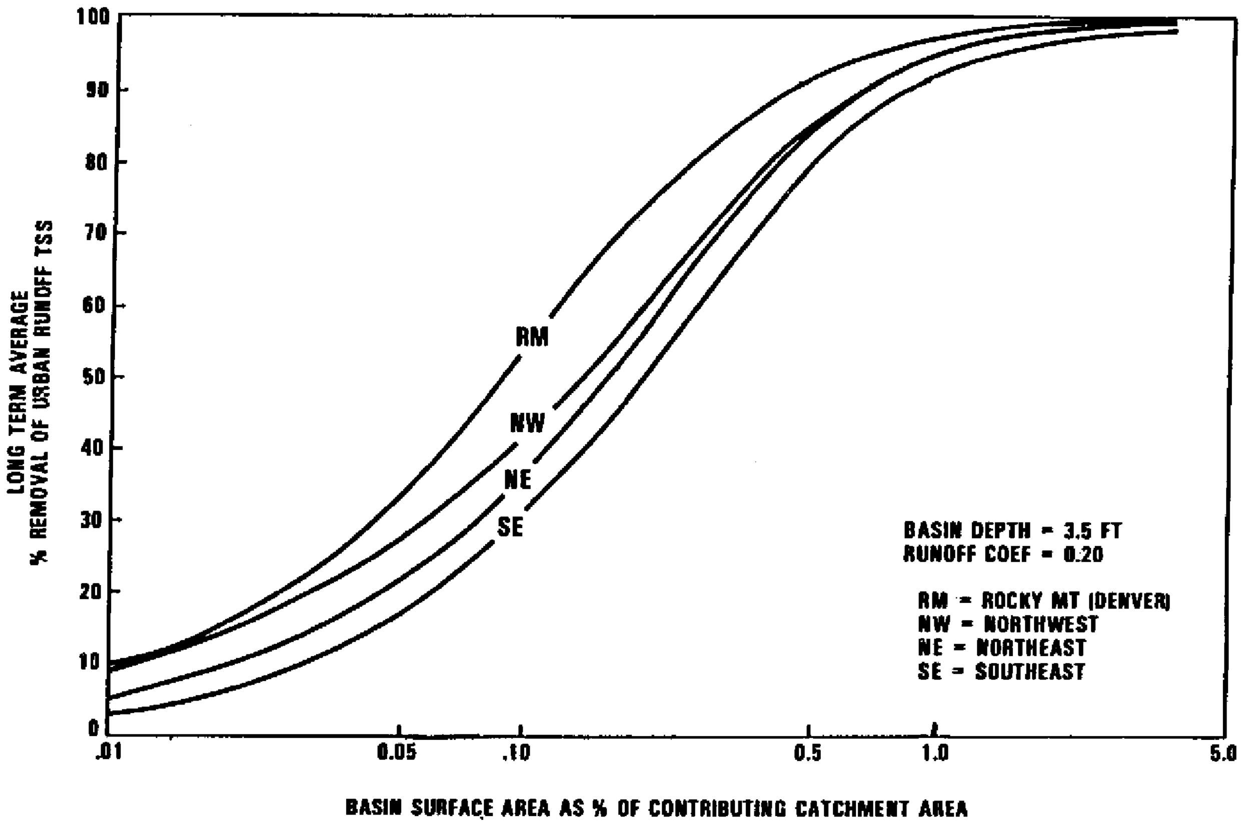

Figure 2.—Detention basin performance for suspended solids removal.
Reference: Athayde et al., 1983.

evaluation because they incorporate the peak rainfall month for this region (June) and because monitoring data indicate that differences between urban and nonurban watersheds with respect to runoff and phosphorus export are most apparent during the summer months. Analogous statistics can be calculated for other regions, with appropriate adjustments in the precipitation statistics.

Driscoll (1983) predicted total phosphorus removal efficiency as a function of suspended solids removal efficiency and the fraction of inflow phosphorus in particulate form. This approach is deficient, however, in that it assumes that the dissolved fraction is inert and that particulate phosphorus is distributed uniformly among size fractions. Removal efficiency for dissolved phosphorus equals or exceeds that for total phosphorus in five out of the seven basins (with complete data in Table 1). The removal of dissolved phosphorus is especially important for controlling eutrophication because dissolved forms are the most readily available for algal uptake in downstream lakes. It is apparent that mechanisms other than particle settling (adsorption, precipitation, biological uptake) are partially responsible for phosphorus transformations and removal in these basins. It would be difficult to model all of these mechanisms explicitly.

With a pond volume exceeding five times the mean storm runoff volume, fluctuations in pond fine-particle concentrations associated with average events would tend to be relatively small. For the purposes of predicting long-term average removals of fine particles and phosphorus in a typical wet detention pond, it may not be necessary to consider temporal variability associated with individual storm events. A simpler, empirical approach that deals with annual or seasonal phosphorus loadings and mean hydraulic residence times is possible.

DATA BASE DEVELOPMENT

Pond performance and related data compiled from the literature are summarized in Table 3. The data set includes nine natural and artificial wet detention basins monitored under NURP (Driscoll, 1983). Data from urban lakes in Minnesota, Illinois, Washington, D.C., and Missouri are also included. Wetlands with permanent pools are represented in Minnesota and Florida. These consist of artificial detention ponds and wetlands in series. Hydraulic residence times

Table 2.—Detention pond design and performance variables.

POND AND WATERSHED CHARACTERISTICS:		NURP POND DESIGN CRITERIA
A_w	= watershed area (ha)	
r_c	= watershed runoff coefficient	= .2
A	= pond area (ha)	$\geq .01\ A_w$
Z	= pond mean depth (m)	≥ 1
PRECIPITATION CHARACTERISTICS:		**VALUES FOR MINNEAPOLIS/ST. PAUL JUNE—AUGUST**
P_m	= mean storm size (cm)	= .95
T_e	= mean time between event midpoints (hrs)	= 75
T_d	= mean storm duration (hrs)	= 4.2
P_t	= total seasonal precipitation (cm)	= 27.7
T_t	= length of season (years)	= .25
WATERSHED RUNOFF:		
V_m	= mean storm runoff volume (ha × cm)	$= A_w r_c P_m$
V_t	= total seasonal runoff volume (ha × cm)	$= A_w r_c P_t$
POND PERFORMANCE INDICATORS:		**VALUES FOR NURP POND IN TWIN CITIES CLIMATE**
V_{rel}	= pond relative volume (cm)	
	$= 100\ AZ/(A_w r_c)$	= 5.0 cm
Q_m/A	= surface overflow rate during mean storm (cm/hr)	
	$= V_m/(T_d A) = P_m Z/(V_{rel} T_d)$	= 4.5 cm/hr
V_p/V_m	= pond volume/mean runoff volume	
	$= 100\ AZ/(A_w r_c P_m) = V_{rel}/P_m$	= 5.3
T	= mean hydraulic residence time (years)	
	$= 100\ AZ/(V_t/T_t) = V_{rel} T_t/P_t$	= .045 years = 16.4 days

and removal efficiencies have been calculated from permanent pool volumes and total outflow over the entire monitoring period for each impoundment.

The data set represents a diverse collection of systems from different areas of the country. Common factors include the presence of a permanent pool and domination of inflows by urban (or, in two cases, agricultural) runoff. The data set is limited in the sense that different sampling intensities, durations, seasons, and data reduction techniques were employed by the various investigators.

In every case except two (Ann Arbor/Traver and Washington/Burke), the reported removal of suspended solids exceeds that of total phosphorus. This is consistent with the tendency for phosphorus to concentrate in the fine particulate fractions which are less readily removed via sedimentation. Some fraction of the total phosphorus in urban runoff is in a dissolved form (12 to 68 percent for systems in Table 3) and may be removed or transformed at rates which are slower than direct sedimentation. Driscoll (1983) attributed the low suspended solids removal efficiency at Traver (suspended solids removal 5 percent, total phosphorus removal 34 percent) to bank erosion at the outlet structure.

MODEL TESTING

A variety of empirical models have been developed for predicting phosphorus retention in lakes and reservoirs (Vollenweider,1976; Canfield and Bachman,1981). The model considered here (Table 4) is based upon data from 60 Corps of Engineer reservoirs (Walker,1985b) and has been tested against independent reservoir and lake data (Clasen and Bernhardt,1980). The sedimentation of phosphorus is represented as a second-order reaction, i.e., the rate of phosphorus removal per unit volume per unit time is proportional to the square of concentration. With a fixed second-order decay rate, K_2, of 0.1 m^3/mg-yr, the model explains 80 percent of the variance in Corps reservoir outflow concentrations. When the decay rate is related to surface overflow rate and inflow ortho-phosphorus/total phosphorus ratio using the empirically-derived equation in Table 4, the explained variance increases to 89 percent.

Table 3.—Summary of detention pond, wetland, and urban lake characteristics.

LOCATION	BASIN	BASIN/ WATERSHED AREA RATIO	MEAN DEPTH M	HYDRAULIC RESID. TIME YRS	INFLOW		(C) REMOVALS (%)			PLOT SYMBOL	MONITORED STORMS
					TP PPB	DP TP	TP	DP	SS		
USEPA NURP Detention Basins (USEPA, 1982; Driscoll, 1983) (a)											
Lansing, MI	Grace No.	.0001	0.8	0.001	395	.12	0	0	0	o	18
Lansing, MI	Grace So.	.0004	0.8	0.003	435	.14	12	23	32	o	18
Ann Arbor, MI	Pitt	.0009	1.5	0.006	200	.20	18	0	32	o	6
Ann Arbor, MI	Traver	.0031	1.3	0.031	91	.36	34	56	5	o	5
Ann Arbor, MI	Swift Run	.0115	0.5	0.017	134	.29	3	29	85	o	5
Long Island, NY	Unqua	.0184	1.0	0.094	229		45		60	o	8
Washington, DC	Westleigh	.0285	0.6	0.091	398	.56	54	71	81	o	32
Lansing, MI	Waverly Hills	.0171	1.4	0.263	198	.22	79	70	91	o	29
Glen Ellyn, IL	Lake Ellyn	.0176	1.6	0.119	506	.19	34		84	o	23
Minnesota Wetlands (Brown, 1985) (b)											
Twin Cities, MN	Fish	.0221	1.2	0.100	307	.59	44	32	92	x	5
Twin Cities, MN	Spring	.0007	1.3	0.002	293	.68	0	0	0	x	5
Minnesota Wetland (Weidenbacher and Willenbring, 1984; Wilson, 1986)											
Roseville, MN	Josephine	0.619	1.2	0.124	416	.67	62	69	79	j	
Minnesota Urban Lakes (Erdmann et al., 1983)											
Minneapolis, MN	Harriet	.3080	8.8	23.529	1232		96			m	
Minneapolis, MN	Calhoun	.1326	9.8	7.407	700		89			m	
Minneapolis, MN	Isles	.1554	2.4	1.321	685		87			m	
Minneapolis, MN	Cedar	.1062	6.0	3.096	439		88			m	
Minneapolis, MN	Brownie	.0228	4.9	0.193	181		66			m	
Florida Detention Pond/Wetland (Martin and Smoot, 1986)											
Orlando, FL	Pond	.0047	1.9	0.020	181	.34	35	57	58	f	13
Orlando, FL	Wetland	.0177	0.2	0.007	118	.23	13	0	53	f	13
Orlando, FL	Pond + Wetl.	.0224	0.6	0.027	181	.34	43	52	80	f	13
Illinois Urban Lake (Hey, 1982)											
Glen Ellyn, IL	Lake Ellyn	.0161	1.6	0.076	441	.31	60	72	87	*	14
Washington Urban Runoff Detention Pond (Randall, 1982)											
Washington, DC	Burke	.1150	2.6	0.106	398	.51	59	56	37	b	29
Missouri Agricultural Flood Detention Reservoir (Schreiber et al., 1980)											
Columbia, MO	Callahan	.0056	2.0	0.029	1409	.07	74	43	88	+	3 yrs
Missouri Urban Lake (Oliver and Grigoropoulos, 1981)											
Rolla, MO	Frisco	.0512	1.0	0.077	309		65		88	z	25

(a) Mean Residence Times for NURP Detention Basins Calculated from Mean Storm Overflow Rates Reported by Driscoll (1983), Assuming Mean Storm Duration/Total Time Between Storms = .05.
(b) Mass Balances on Minnesota Wetlands Reported for March–Mid May Only
(c) TP = Total Phosphorus, DP = Dissolved Phosphorus, SS = Total Suspended Solids

This formulation has been shown to be useful for predicting reservoir-to-reservoir variations in average pool and outflow phosphorus concentrations and for predicting spatial variations within reservoirs (Walker,1985b).

The empirical retention model is tested against the urban lake/detention pond data set in Figure 3. Data set ranges and performance statistics are summarized in Table 5. To permit inclusion of seven impoundments with missing data, inflow dissolved phosphorus is assumed to be 38 percent of inflow total phosphorus, based upon summaries of urban runoff data by Athayde et al.(1983), Driscoll (1983) and Ahern et al. (1980). To satisfy data requirements of the retention model (Table 4), inflow ortho phosphorus is assumed to be 79 percent of inflow total dissolved phosphorus in each case (Ahern et al. 1980; Bowman et al. 1979).

As shown in Figure 3, observed and predicted removals generally agree to within 15 percent, with one exception. Lake Ellyn, an Illinois urban lake monitored under NURP, occurs twice in the data set, once from the summary of NURP data reported by Driscoll (1983) (observed removal = 35 percent, predicted removal = 74 percent) and once from a report by Hey (1982), the project investigator (observed removal = 60 percent, predicted removal = 63 percent). Differences in data reduction procedures and/or averaging periods may account for the discrepancies between these two sources.

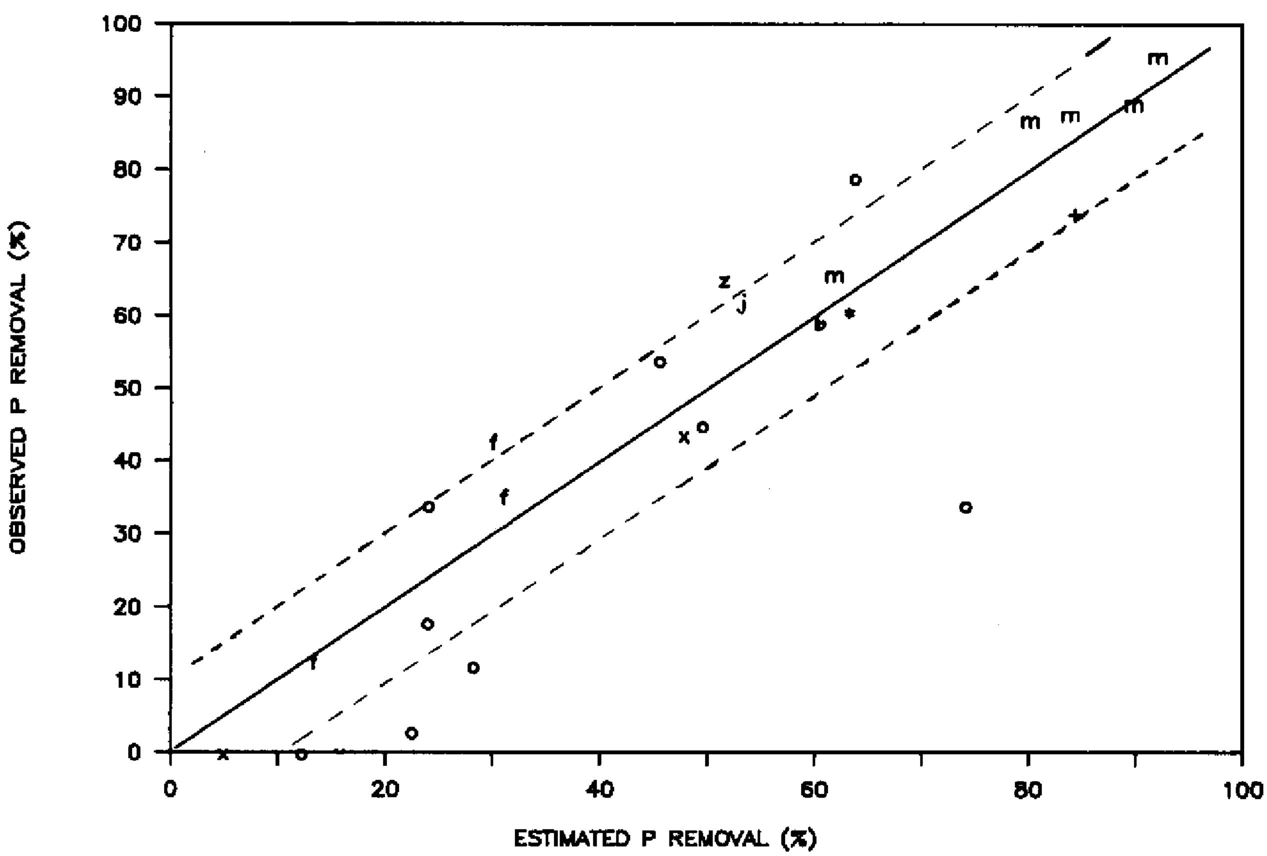

Figure 3.—Observed and predicted phosphorus removal efficiencies symbols defined in Table 3. Dashed lines indicate 10 percent error bounds.

Table 4.—Phosphorus retention model developed for Corps of Engineer reservoirs.

Symbol Definitions:	
F_o	= inflow ortho P/total P ratio
T	= mean hydraulic residence time (years)
	= mean pool volume/mean outflow rate
Q_s	= mean surface overflow rate (m/yr)
	= mean outflow rate/mean surface area
P_i	= inflow total phosphorus concentration (mg/m^3)
	= total phosphorus loading/mean outflow rate
Second Order Decay Rate (m^3/mg-yr):	
K_2	$= .056\ Q_sF_o^{-1}/(Q_s + 13.3)$
Dimensionless Reaction Rate:	
N_r	$= K_2P_iT$
Retention Coefficient (Mixed System):	
R_p	$= 1 + [1 - (1 + 4N_r)^{.5}]/(2N_r)$

With the exception of the Minneapolis lakes, the mean depths and hydraulic residence times of the impoundments in this data set tend to be lower than those represented in the model development and testing data sets (Table 5). Model errors, as measured by mean squared errors in the logarithms of predicted outflow concentrations, are of similar magnitude (.017 for Corps Reservoirs, .034 for OECD Reservoirs and Shallow Lakes, .018 for the entire detention pond data set, and .012 for the detention pond data set excluding the outlier discussed above). Despite the heterogeneity of the detention pond data set, the empirical model derived from much larger and more consistent data bases appears to be useful for predicting average phosphorus removal efficiencies without detailed simulation of individual storm events.

MODEL APPLICATIONS

The empirical model tested above can be used to examine the relationship between basin morphometric features (area, depth) and phosphorus removal efficiency for a given watershed and climate. Such an application is demonstrated below for precipitation rates and urban runoff concentrations typical of the St. Paul area. The approach can be applied to other areas with substitution of appropriate regional parameters.

Model implementation requires specification of mean hydraulic residence time, surface overflow rate, inflow total phosphorus concentration, and inflow orthophosphorus/total phosphorus ratio. As shown in Table 2, relative volume is directly propor-

Table 5.—Data set and model performance statistics.

	MODEL DEVELOPMENT	MODEL TESTING	THIS STUDY
Data Set	a	b	c
Impoundments	60	20	24
Data Set Characteristics			
Mean Depth (m)	1.5–58	5–20	.2–8.8
Residence Time (years)	.013–1.91	.3–1.6	.001–23.5
Inflow Total P (ppb)	14–1047	5–1000	91–1232
Inflow Ortho P/Total P	.06–.95	.13–.8	.06–.54
Model Performance Statistics*			
Predicted Variable: Annual Outflow Total Phosphorus Concentration			
N	60	20	24 (23)**
R^2	.887	.886	.780 (.850)
Mean Squared Error	.017	.034	.018 (.012)
Predicted Variable: Mean, Growing-Season, Mixed-Layer P Concentration			
N	40	19	
R^2	.923	.934	
Mean Squared Error	.013	.019	

*Model Performance Statistics Calculated on Log_{10} scales
**Excluding One Outliers (Lake Ellyn/Driscoll (1983))
Data Sets:
a U.S. Army Corps of Engineer Reservoirs, Walker (1985a)
b OECD Reservoir and Shallow Lakes Program (Clasen and Bernhardt, 1980)
c Urban Lakes and Detention Ponds, This Study, Table 3

tional to mean hydraulic residence time for a given season length and total precipitation. Mean surface overflow rate (mean depth/mean hydraulic residence time) can be calculated for a given relative volume and pond depth. Based upon review of regional urban runoff data, an inflow total phosphorus concentration of 650 ppb and inflow orthophosphorus/total phosphorus ratio of 0.3 have been assumed for the purposes of the following evaluations.

Using the above parameters, predicted total phosphorus removal percentages are plotted as a function of relative volume and mean depth in Figure 4. A basin designed according to NURP criteria (V_{rel} = 5 cm, Z = 1 m, Table 2) is estimated to have a phosphorus removal efficiency of 59 percent. The predicted performance is very sensitive to V_{rel} at values below 3 to 5 cm. At values above 5 cm, however, performance is relatively insensitive to volume and increasingly sensitive to mean depth.

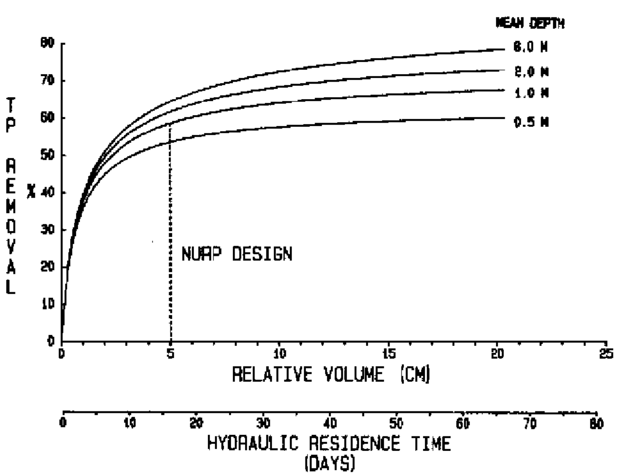

Figure 4.—Predicted phosphorus removal efficiency vs. relative volume (X axis = pond volume/(watershed area x runoff coefficient).

An alternative way of expressing the performance curves is to plot percent removal against basin relative area (pond area/(watershed area X runoff coefficient)) for various mean depths (Fig. 5). This isolates effects of pond area and depth. Generally, depth sensitivity is maintained over a wide range of relative areas. In contrast, performance is relatively insensitive to area for relative areas above 3 percent. This suggests that deepening a pond is generally preferable to increasing its surface area for improving phosphorus retention.

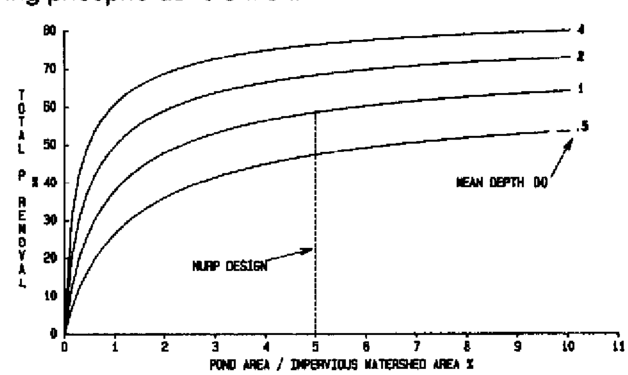

Figure 5.—Predicted phosphorus removal efficiency vs. Relative area (X axis = 100 percent x pond area/(watershed area x runoff coefficient).

The flatness of the performance curves suggests that the NURP design is relatively robust and cost-effective for phosphorus removal. When land values are not considered, pond volume is the best predictor of capital cost (Schueler, 1986). When land values are considered, however, costs may be more directly related to area, depending upon local conditions. In order to increase removal efficiency from 59 to 75 percent, (a 40 percent reduction in the residual loading) the pond volume would have to be increased by a factor of 4 (from V_{rel} = 5 to 20 cm). This could be achieved, for example, by increasing the mean depth from 1 to 3 meters and increasing the relative area from 5 to 6.6 percent.

Figure 6 illustrates the sensitivity of model predictions to twofold variations in each input parameter for a basin designed according to NURP criteria. Removal rates are most sensitive to inflow phosphorus concentration, inflow ortho phosphorus/total phosphorus ratio, and the effective second-order decay coefficient (predicted removal range = 47 to 68 percent). A first-order error analysis indicates that the effects of model error can be approximately represented by twofold variations in the effective decay coefficient for estimation of 90 percent confidence ranges (Walker, 1985b). Thus, when potential model error is considered, the predicted performance of a NURP basin would range from 47 to 68 percent. Compilation and analysis of regional runoff data can help to reduce uncertainty associated with estimates of P_i and F_o.

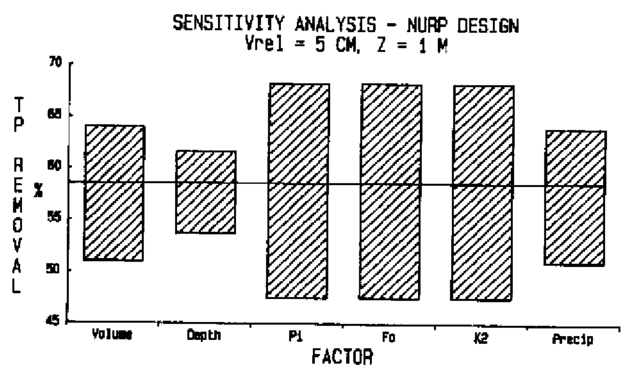

Figure 6.—Sensitivity of model predictions to input factors effects of 2-fold variations in each input factor on predicted phosphorus removal efficiency are shown. Base values are 5 cm for relative volume, 1 m for depth, 650 ppb for pi, .3 for Fo, and 27 cm for precipitation. For example, the depth bar shows the predicted performance range for a depth range of 0.5 to 2 meters with other input factors held fixed.

Sensitivities to volume and precipitation rate range from 51 to 64 percent. The responses to twofold variations in precipitation approximately reflect the expected performance range under different seasonal hydrologic conditions. Based upon analysis of 20 years of precipitation data from the Minneapolis/St. Paul airport, seasonal (in this example, June–August) precipitation averages 28 cm and ranges from 13 to 43 cm. The relative insensitivity of performance to variations in precipitation rate and mean hydraulic residence time reflects that fact that the NURP design criterion occurs on a relatively flat portion of the volume performance curves in Figure 4.

DESIGN FEATURES TO IMPROVE PHOSPHORUS REMOVAL EFFICIENCY

Model applications indicate that the NURP design criterion corresponds to a 47 to 68 percent removal efficiency for total phosphorus under the average seasonal climatic conditions considered. As discussed above, urban watershed development typically results in a 5 to 20-fold increase in phosphorus export (Fig. 1). If a "zero-impact" situation is called for, removals 80 to 95 percent would be required. While the NURP design is apparently robust and cost-effective, it may not be sufficient to satisfy water quality management objectives in some watersheds.

Possibilities for modifying detention basin designs to promote phosphorus removal beyond the levels predicted above include

1. Deepening ponds beyond 1 meter
2. Designing to promote infiltration
3. Using ponds in series to promote plug flow
4. Applying chemicals to precipitate orthophosphorus

Performance sensitivity to these options is illustrated in Figure 7. Depending upon site-specific conditions, some or all of these options may be applicable.

The first option is to increase mean depth and relative volume. As discussed above, cost-effectiveness (mass of phosphorus removed per unit volume) decreases as the relative volume increases beyond 5 cm. Increases in volume may be accomplished via excavation, dredging, and/or increasing normal pool elevation. Generally, the latter would be most economical, but it may interfere with adjacent land uses or flood control objectives. As illustrated in Figure 7, increasing the mean depth from 1 to 4 meters (at a fixed relative area of 5 percent) increases the removal efficiency from 59 to 76 percent. An additional doubling of depth to 8 meters increases efficiency by another 6 percent. Increasing depth to the point where thermal stratification would develop is not recommended because of the potential development of anaerobic conditions and subsequent release of dissolved phosphorus from bottom sediments.

The performance calculations assume that a water balance is maintained in the pond and that all

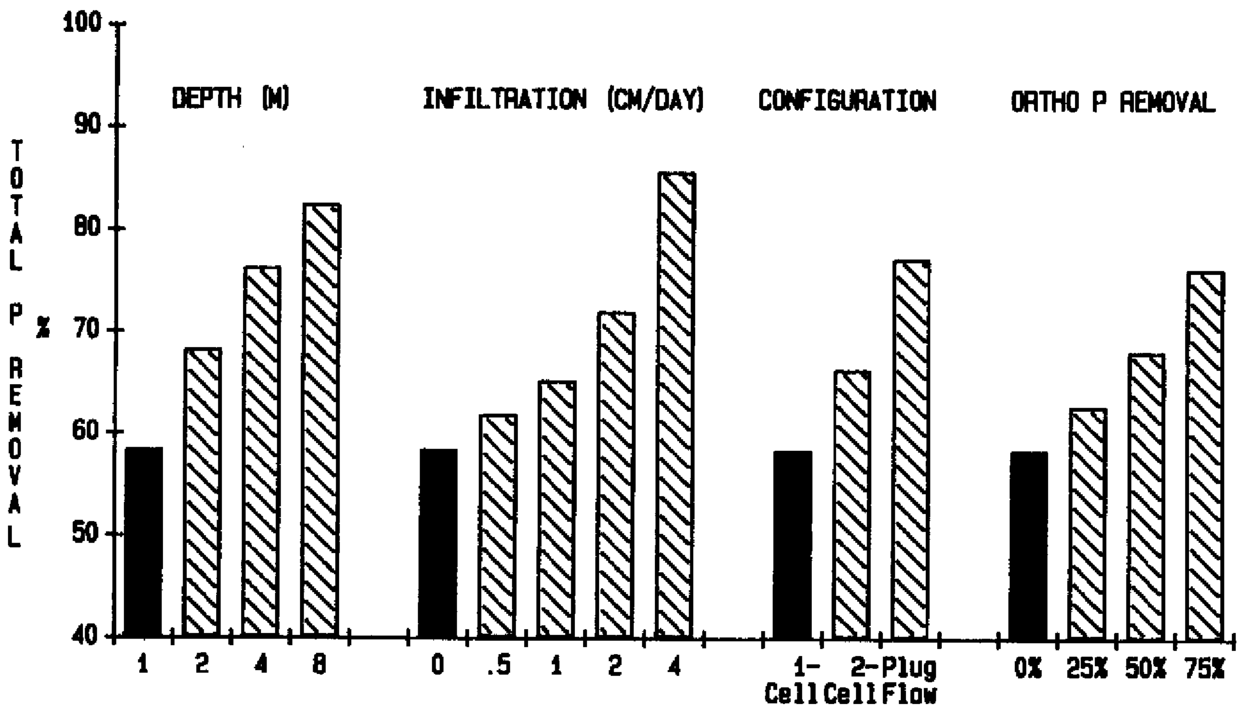

Figure 7.—Alternative methods for increasing phosphorus removal efficiency (solid bar = predicted performance of NURP basin design; hatched bar = predicted performance of modified design).

discharge is through a surface outlet. Overall phosphorus removal may be enhanced by promoting infiltration to groundwaters, which would tend to remove significant quantities of dissolved and suspended phosphorus via adsorption and filtration. Feasibility depends strongly upon soil characteristics and groundwater regimes. Self-sealing of pond bottoms with organic material and clays may limit long-term performance. During extended dry periods, loss of permanent pool volume may pose aesthetic problems. Design of outlets and topography to promote overflow of the pond onto adjacent pervious soils during storm events and subsequent infiltration may be feasible and effective in some situations.

Approximate perspectives on the potential effects of infiltration on removal efficiency are shown in Figure 7. The magnitude of the pond overflow rate in relation to the infiltration rate through the pond bottom determines potential benefits. Effects on removal efficiency have been estimated according to the following equation derived from a mass balance:

$$1\text{-}R_{pi} = (1\text{-}R_p)\,(1 - i/q_s) \qquad (1)$$

where,

R_{pi} = retention coefficient, adjusted for infiltration

R_p = retention coefficient without infiltration

q_s = pond surface overflow rate (cm/day)

i = infiltration rate (cm/day)

This assumes that percolated water no longer contributes to downstream loading. McGauhey (1968) reports "equilibrium infiltration rates" (after extended periods of permanent flooding) for sands and loams in the range of 1.5 to 37 cm/day. The NURP design in this climate corresponds to a surface overflow rate of 22 m/yr or 6 cm/day. As illustrated in Figure 7, increasing the infiltration rate from 0 to 4 cm/day increases removal efficiency from 59 to 86 percent. Promoting infiltration may be a viable option in areas with permeable soils.

The solution to the phosphorus retention model (Table 4) assumes completely mixed conditions. Separation of the detention pond into two or more distinct cells would promote plug-flow conditions and increase removal efficiency for suspended solids and phosphorus. The importance of designing sedimentation basins to promote plug-flow behavior is well established in the sanitary engineering field (Fair et al. 1968). Oberts (1983) has suggested that staged designs for runoff treatment (sedimentation basins followed by natural or artificial wetland basins) may be beneficial in providing a range of conditions and habitats for various removal mechanisms to operate and in protecting wetlands from sediment accumulation. Two-cell configurations have also been suggested to facilitate pond maintenance (Driscoll, 1986). Urban trash, coarse and medium suspended solids (representing most of the sediment mass) would tend to be deposited in the first pond. Dredging or other maintenance practices could be implemented in the first pond without disturbing established biological communities in the second. The second pond would also provide a buffer against water quality disturbances associated with maintenance of the first pond.

The model can be used to evaluate the potential benefits of multicell designs with respect to phosphorus removal. The second-order sedimentation model has been shown to apply to simulations of spatial variations in several lakes and reservoirs, when advection and dispersion processes are represented (Walker, 1985b). The solution for the retention coefficient under plug-flow conditions is given by:

$$R_p = N_r/(1 + N_r) \qquad (2)$$

where N_r is defined in Table 4. Figure 6 compares the predicted performance of a NURP basin in each of three configurations (completely mixed, two-cell, plug flow). The two-cell case is based upon simulation of two, completely-mixed basins in series, each with a relative volume of 2.5 cm. Generally, some elevation drop would be required between the first and second cells to prevent back-mixing. Performance of the basin increases from 59 to 83 percent as the configuration changes from mixed to plug-flow conditions. The potential increase in performance is substantial enough to seriously consider two-cell or multicell designs.

The addition of chemicals to promote precipitation of orthophosphorus is another method to improve performance. Ahern et al. (1980) used laboratory settling column tests to estimate the annual phosphorus removal efficiency of a sedimentation basin in an urban Wisconsin watershed. It was projected that seasonal addition of alum would increase annual removal efficiency from 62 to 76 percent. Applying ferric chloride or alum to the inflows of drinking water reservoirs in Europe has been shown to be effective at reducing reservoir algal growths (Bernhardt, 1980; Bannink et al. 1978; Hayes et al. 1984). The feasibility of applying this technique to onsite and regional detention ponds in the watersheds of the St. Paul water supply lakes is currently under investigation (Walker, 1986). While chemical addition would involve additional cost and more intensive operation, the expense and effort may be justified in some situations, depending upon runoff chemistry, watershed conditions, and lake/reservoir management objectives.

Effects of chemical treatment to remove orthophosphorus can be estimated by adjusting the inflow orthophosphorus/total phosphorus ratio used to calculate the effective sedimentation rate (Table 4). As illustrated in Figure 6, chemical treatment to remove between 0 and 75 percent of the inflow orthophosphorus (without influencing inflow total phosphorus) would increase removal efficiency from 59 to 76 percent. Model projections are similar to those obtained by Ahern et al. (1980).

Other possibilities for improving performance include (1) promoting growth of specific types of aquatic vegetation which are adapted to phosphorus removal from the water column (versus bottom sediments) and (2) hydraulic design of outlet structures to provide temporary storage on top of the permanent pool (slow draining flood pool). The latter may increase detention time and removal efficiency for larger events, depending upon the extent of flood storage volume available, outlet design, hydrograph characteristics, and flood elevation constraints. It is not possible to evaluate these alternatives with a model of the type described above, however.

MAINTENANCE CONSIDERATIONS

The design criteria evaluated above refer to permanent pool volume and depth during the period of operation. Removal of sediment would be required at periodic intervals in order to maintain performance. Since dredging costs are typically three to five times dry excavation costs per unit volume (Schueler, 1986), it may make sense to oversize a pond initially to insure performance over a specified design period. Experience with detention ponds in the Washington, D.C. area and in Canada indicates volume losses on the order of .5–1 percent per year (Scheuler, 1986; Chambers and Tottle, 1980). Monitoring data on suspended solids export from stabilized urban watersheds can be used to project sediment accumulation rates for detention ponds in a particular region. Since potential sedimentation rates during construction periods are much greater and more difficult to predict, the initial pond volume criteria should apply to pond conditions at the end of the construction period when watershed vegetation has been re-established. The sizing of ponds is only one design aspect; other practical considerations regarding design and operation are discussed in a publication by the Washington Area Council Governments (1986).

Multiple-use potentials of detention ponds should be considered in their design and maintenance. Based upon a survey of 360 Maryland residents, the public considers wet detention ponds to be important resources with respect to wildlife attraction, landscaping, aesthetics, recreation, and property values (Metropolitan Washington Council Governments, 1983). These values, combined with potential pollutant removal effectiveness, suggest that urban ponds have important places in lake and watershed management.

CONCLUSIONS

1. An empirical model originally developed for predicting phosphorus retention in reservoirs has been shown to be useful for predicting phosphorus retention in urban lakes and wet detention basins.

2. Detention pond sizing criteria for suspended solids removal developed under the EPA's Nationwide Urban Runoff Program can be most effectively expressed in terms of relative volume (pond volume/impervious watershed area > 5 cm) and mean depth (> 1 meter). For a given climate, relative volume is directly linked to important predictors of pond performance, including mean hydraulic residence time and pond/mean storm volume ratio.

3. For conditions typical of the St. Paul area, ponds designed according to NURP criteria are estimated to have mean hydraulic residence times of 16 days and total phosphorus removal efficiencies of 47 to 68 percent. The design appears to be reasonably robust (insensitive to key design parameters). With appropriate adjustments in precipitation statistics and runoff water quality conditions, the methodology can be applied to predict pond performance in other regions.

4. Possibilities for improving performance include: (1) increasing mean depth; (2) promoting infiltration; (3) promoting plug flow conditions; (4) chemical treatment to remove orthophosphorus; (5) encouraging growth of certain types of aquatic plants; and (6) design of outlet structure to provide extended detention of large runoff events. These may be useful and appropriate, depending upon the desired level of control and other site-specific conditions.

5. Allocating additional pool volume to allow for sediment accumulation over a design lifetime is suggested as a means of improving treatment longevity and reducing long-term maintenance requirements.

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APPENDIX C

ORTHOPHOSPHORUS VS. TOTAL PHOSPHORUS DATA

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South Florida Water Management District
Western C-11 Impoundment
Alternatives Evaluation

Date	OPO4 mg/L	TPO4 mg/L	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio
1/24/1990	0.008	0.031	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
2/20/1990	0.002	0.037	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
3/19/1990	0.002	0.032	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
4/2/1990	0.002	0.018	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
4/16/1990	0.002	0.016	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
6/11/1990	0.007	0.018	0.389	0.389	0.389	0.389	0.389	0.389	0.389	0.389	0.389	0.389	0.389
6/27/1990	0.002	0.021	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
7/9/1990	0.008	0.017	0.471	0.471	0.471	0.471	0.471	0.471	0.471	0.471	0.471	0.471	0.471
7/23/1990	0.006	0.023	0.261	0.261	0.261	0.261	0.261	0.261	0.261	0.261	0.261	0.261	0.261
8/6/1990	0.002	0.011	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182
8/20/1990	0.002	0.005	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
9/4/1990	0.002	0.009	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
9/17/1990	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
10/1/1990	0.002	0.010	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
10/15/1990	0.002	0.014	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143
10/29/1990	0.002	0.017	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118
11/13/1990	0.011	0.041	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268
12/12/1990	0.007	0.017	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412
1/23/1991	0.002	0.014	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2/4/1991	0.010	0.019	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526
3/6/1991	0.006	0.017	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
3/18/1991	0.015	0.012	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250
4/29/1991	0.002	0.016	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
5/28/1991	0.006	0.019	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316
6/10/1991	0.005	0.008	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625
6/24/1991	0.002	0.009	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
7/8/1991	0.006	0.012	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
7/22/1991	0.007	0.020	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350
8/5/1991	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
8/20/1991	0.002	0.013	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
9/3/1991	0.002	0.014	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143
9/16/1991	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
9/30/1991	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
10/14/1991	0.002	0.014	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143
10/28/1991	0.002	0.013	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
11/12/1991	0.002	0.013	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
12/9/1991	0.002	0.018	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
1/21/1992	0.002	0.013	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
2/11/1992	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
3/10/1992	0.014	0.035	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
3/24/1992	0.009	0.014	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643	0.643
4/27/1992	0.002	0.021	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
5/28/1992	0.002	0.044	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045

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Date	OPO4 mg/L	TPO4 mg/L	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio
7/6/1992	0.002	0.021	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
7/21/1992	0.002	0.009	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
8/3/1992	0.007	0.012	0.583	0.583	0.583	0.583	0.583	0.583	0.583	0.583	0.583	0.583	0.583
8/19/1992	0.006	0.002	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
9/28/1992	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
10/26/1992	0.008	0.011	0.727	0.727	0.727	0.727	0.727	0.727	0.727	0.727	0.727	0.727	0.727
11/9/1992	0.010	0.012	0.833	0.833	0.833	0.833	0.833	0.833	0.833	0.833	0.833	0.833	0.833
11/19/1992	0.010	0.013	0.769	0.769	0.769	0.769	0.769	0.769	0.769	0.769	0.769	0.769	0.769
12/21/1992	0.004	0.014	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286
1/4/1993	0.009	0.010	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900
2/18/1993	0.005	0.014	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357
3/1/1993	0.006	0.015	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
3/17/1993	0.004	0.019	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
4/12/1993	0.008	0.015	0.533	0.533	0.533	0.533	0.533	0.533	0.533	0.533	0.533	0.533	0.533
4/28/1993	0.002	0.013	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
5/10/1993	0.007	0.019	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368
6/7/1993	0.011	0.013	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846
7/21/1993	0.002	0.011	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182
9/15/1993	0.002	0.015	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133
10/13/1993	0.002	0.009	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
11/8/1993	0.002	0.011	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182
12/6/1993	0.006	0.013	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462
1/10/1994	0.004	0.018	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
2/7/1994	0.005	0.006	0.833	0.833	0.833	0.833	0.833	0.833	0.833	0.833	0.833	0.833	0.833
3/7/1994	0.004	0.011	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364
4/4/1994	0.002	0.005	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
5/11/1994	0.005	0.013	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
6/22/1994	0.002	0.020	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
7/11/1994	0.029	0.021	1.381	1.381	1.381	1.381	1.381	1.381	1.381	1.381	1.381	1.381	1.381
8/9/1994	0.002	0.002	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9/29/1994	0.002	0.014	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143
10/3/1994	0.004	0.012	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333
11/8/1994	0.002	0.009	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
12/12/1994	0.002	0.009	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
1/18/1995	0.002	0.011	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182
2/21/1995	0.002	0.008	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
3/14/1995	0.002	0.018	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
4/17/1995	0.002	0.010	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
4/25/1995	0.002	0.007	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286
5/15/1995	0.002	0.006	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333
6/5/1995	0.002	0.007	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286
6/19/1995	0.002	0.015	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133
7/3/1995	0.002	0.011	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182

APPENDIX C
ORTHOPHOSPHATE vs. TOTAL PHOSPHORUS DATA
South Florida Water Management District
Western C-11 Impoundment
Alternatives Evaluation

Date	OPO4 mg/L	TPO4 mg/L	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio
7/18/1995	0.002	0.011	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182
8/7/1995	0.002	0.020	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
9/11/1995	0.007	0.010	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700
10/10/1995	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
10/24/1995	0.002	0.010	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
11/14/1995	0.002	0.009	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
12/12/1995	0.002	0.005	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
1/2/1996	0.005	0.010	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
1/16/1996	0.004	0.007	0.571	0.571	0.571	0.571	0.571	0.571	0.571	0.571	0.571	0.571	0.571
2/12/1996	0.002	0.010	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
3/4/1996	0.004	0.014	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286
3/26/1996	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
4/8/1996	0.002	0.026	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077
5/20/1996	0.002	0.015	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133
7/2/1996	0.002	0.009	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
7/16/1996	0.002	0.009	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
8/26/1996	0.005	0.015	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333
9/17/1996	0.002	0.013	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
10/1/1996	0.002	0.007	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286
10/21/1996	0.002	0.016	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
10/29/1996	0.002	0.005	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
11/18/1996	0.002	0.011	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182
12/10/1996	0.002	0.017	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118
1/14/1997	0.002	0.017	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118
1/27/1997	0.002	0.004	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
5/13/1997	0.002	0.013	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
6/17/1997	0.002	0.031	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
7/15/1997	0.002	0.008	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
8/12/1997	0.002	0.011	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182
12/16/1997	0.004	0.018	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
7/14/1998	0.004	0.019	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
8/11/1998	0.002	0.014	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143
9/29/1998	0.005	0.013	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
10/6/1998	0.002	0.011	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182
10/20/1998	0.005	0.010	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
11/10/1998	0.006	0.014	0.429	0.429	0.429	0.429	0.429	0.429	0.429	0.429	0.429	0.429	0.429
11/24/1998	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
12/15/1998	0.002	0.008	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
12/29/1998	0.004	0.010	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
1/12/1999	0.007	0.011	0.636	0.636	0.636	0.636	0.636	0.636	0.636	0.636	0.636	0.636	0.636
2/9/1999	0.005	0.013	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
2/23/1999	0.005	0.010	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
3/23/1999	0.008	0.013	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615

APPENDIX C
ORTHOPHOSPHATE vs. TOTAL PHOSPHORUS DATA
South Florida Water Management District
Western C-11 Impoundment
Alternatives Evaluation

Date	OPO4 mg/L	TPO4 mg/L	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio
4/20/1999	0.006	0.013	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462
5/18/1999	0.005	0.017	0.294	0.294	0.294	0.294	0.294	0.294	0.294	0.294	0.294	0.294	0.294
6/1/1999	0.005	0.016	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313
6/15/1999	0.007	0.018	0.389	0.389	0.389	0.389	0.389	0.389	0.389	0.389	0.389	0.389	0.389
6/29/1999	0.007	0.017	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412
7/13/1999	0.002	0.015	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133
7/27/1999	0.007	0.011	0.636	0.636	0.636	0.636	0.636	0.636	0.636	0.636	0.636	0.636	0.636
8/10/1999	0.006	0.016	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375
8/24/1999	0.006	0.017	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
9/7/1999	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
9/22/1999	0.006	0.019	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316
10/5/1999	0.005	0.017	0.294	0.294	0.294	0.294	0.294	0.294	0.294	0.294	0.294	0.294	0.294
10/19/1999	0.047	0.074	0.635	0.635	0.635	0.635	0.635	0.635	0.635	0.635	0.635	0.635	0.635
11/2/1999	0.007	0.017	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412
11/16/1999	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
12/14/1999	0.002	0.010	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1/25/2000	0.005	0.012	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417
2/8/2000	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
3/7/2000	0.002	0.015	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133
3/21/2000	0.004	0.015	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
4/18/2000	0.002	0.015	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133
5/30/2000	0.005	0.010	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
6/13/2000	0.002	0.016	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
6/27/2000	0.002	0.017	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118
7/11/2000	0.002	0.014	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143
7/25/2000	0.005	0.019	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263
8/8/2000	0.002	0.015	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133
8/22/2000	0.002	0.016	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
9/5/2000	0.004	0.014	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286
9/19/2000	0.004	0.013	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308
10/3/2000	0.006	0.020	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
11/28/2000	0.004	0.012	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333
1/23/2001	0.002	0.012	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
2/20/2001	0.004	0.014	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286
3/20/2001	0.004	0.020	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
4/17/2001	0.014	0.022	0.636	0.636	0.636	0.636	0.636	0.636	0.636	0.636	0.636	0.636	0.636
5/29/2001	0.004	0.017	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235
6/12/2001	0.004	0.018	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
6/26/2001	0.005	0.022	0.227	0.227	0.227	0.227	0.227	0.227	0.227	0.227	0.227	0.227	0.227
7/10/2001	0.002	0.018	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
7/24/2001	0.005	0.021	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238
8/7/2001	0.005	0.024	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
8/21/2001	0.004	0.017	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235

APPENDIX C
ORTHOPHOSPHATE vs. TOTAL PHOSPHORUS DATA
South Florida Water Management District
Western C-11 Impoundment
Alternatives Evaluation

Date	OPO4 mg/L	TPO4 mg/L	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio
9/4/2001	0.002	0.013	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
9/18/2001	0.002	0.013	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
10/2/2001	0.005	0.019	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263
10/16/2001	0.004	0.010	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
10/30/2001	0.002	0.019	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
11/13/2001	0.007	0.012	0.583	0.583	0.583	0.583	0.583	0.583	0.583	0.583	0.583	0.583	0.583
12/26/2001	0.004	0.012	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333
1/22/2002	0.004	0.010	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
2/5/2002	0.002	0.019	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
3/19/2002	0.007	0.017	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412
4/2/2002	0.019	0.029	0.655	0.655	0.655	0.655	0.655	0.655	0.655	0.655	0.655	0.655	0.655
5/28/2002	0.005	0.037	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135
6/11/2002	0.005	0.019	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263
6/25/2002	0.004	0.021	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190
7/9/2002	0.005	0.021	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238
7/23/2002	0.005	0.018	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278
8/6/2002	0.004	0.018	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
8/20/2002	0.004	0.018	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
9/17/2002	0.007	0.022	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318	0.318
10/1/2002	0.004	0.016	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
10/15/2002	0.002	0.020	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
11/26/2002	0.005	0.017	0.294	0.294	0.294	0.294	0.294	0.294	0.294	0.294	0.294	0.294	0.294
12/10/2002	0.004	0.024	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
1/21/2003	0.011	0.028	0.393	0.393	0.393	0.393	0.393	0.393	0.393	0.393	0.393	0.393	0.393
3/18/2003	0.006	0.021	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286
4/29/2003	0.002	0.016	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
5/27/2003	0.005	0.025	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
6/10/2003	0.009	0.022	0.409	0.409	0.409	0.409	0.409	0.409	0.409	0.409	0.409	0.409	0.409
7/22/2003	0.002	0.016	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
8/5/2003	0.004	0.014	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286
8/19/2003	0.004	0.022	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182
9/2/2003	0.002	0.014	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143
10/28/2003	0.002	0.011	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182
11/12/2003	0.002	0.011	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182
		Avg Ratio	0.308	0.228	0.250	0.256	0.250	0.284	0.285	0.280	0.275	0.272	0.288
		Period	1990-2003	2003.000	2002-2003	2001-2003	2000-2003	1999-2003	1998-2003	1997-2003	1996-2003	1995-2003	1994-2003

APPENDIX D

MODEL OUTPUT SPREADSHEET PAGES

Alternative 1 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09
Surface Area	A (m^2)	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06
Mean Surface Overflow	Q_s (m/yr)	82.819	112.845	109.590	71.780	80.283	54.964	37.092	22.358	11.274	366.521
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
Mean Pond Volume	V_m (m^3)	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mean Hydraulic Residence Time	T (yr)	0.015	0.011	0.011	0.017	0.015	0.022	0.033	0.055	0.108	0.003
Inflow Total P	P_i (mg/m^3)	18.4	20.3	20.1	17.7	18.2	16.6	15.4	14.4	13.7	22.0
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08
Basin/Watershed Area		0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Decay rate	K_2 =	0.161	0.167	0.166	0.157	0.160	0.150	0.137	0.117	0.086	0.180
Reaction rate	Nr =	0.044	0.037	0.037	0.047	0.044	0.055	0.070	0.092	0.127	0.013
Retention Coefficient	Rp =	0.040	0.034	0.035	0.043	0.041	0.050	0.061	0.078	0.102	0.013
Output concentration		17.66	19.61	19.40	16.93	17.46	15.77	14.46	13.27	12.30	21.72
Percent P Retained in Impoundment		**4.0%**	**3.4%**	**3.5%**	**4.3%**	**4.1%**	**5.0%**	**6.1%**	**7.8%**	**10.2%**	**1.3%**
Influent Mass Flowrate	[(mg/s)/(cfs/m3)]	10394.2	15624.9	15024.8	8665.9	9966.3	6223.3	3896.2	2196.0	1053.5	
Effluent Mass Flowrate	[(mg/s)/(cfs/m3)]	9976.7	15090.8	14503.3	8290.2	9560.2	5912.3	3657.3	2024.4	945.7	

Flow Weighted Average Initial Concentration	(mg/m^3)	**18.4**
Flow Weighted Average Final Concentration	(mg/m^3)	**17.6**
Average Removal	**(%)**	**4.2%**

Alternative 2 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09
Surface Area	A (m^2)	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06
Mean Surface Overflow	Q_s (m/yr)	82.677	112.652	109.402	71.657	80.146	54.870	37.029	22.320	11.255	365.894
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
Mean Pond Volume	V_m (m^3)	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mean Hydraulic Residence Time	T (yr)	0.015	0.011	0.011	0.017	0.015	0.022	0.033	0.055	0.108	0.003
Inflow Total P	P_i (mg/m^3)	18.4	20.3	20.1	17.7	18.2	16.6	15.4	14.4	13.7	22.0
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08
Basin/Watershed Area		0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Decay rate	K_2 =	0.161	0.167	0.166	0.157	0.160	0.150	0.137	0.117	0.086	0.180
Reaction rate	Nr =	0.044	0.037	0.037	0.047	0.044	0.055	0.070	0.092	0.127	0.013
Retention Coefficient	Rp =	0.040	0.034	0.035	0.043	0.041	0.050	0.061	0.078	0.102	0.013
Output concentration		17.66	19.61	19.40	16.93	17.46	15.77	14.45	13.27	12.30	21.72
Percent P Retained in Impoundment		**4.0%**	**3.4%**	**3.5%**	**4.3%**	**4.1%**	**5.0%**	**6.1%**	**7.8%**	**10.2%**	**1.3%**
Influent Mass Flowrate	[(mg/s)/(cfs/m3)]	10394.2	15624.9	15024.8	8665.9	9966.3	6223.3	3896.2	2196.0	1053.5	
Effluent Mass Flowrate	[(mg/s)/(cfs/m3)]	9976.1	15090.0	14502.5	8289.7	9559.6	5911.9	3657.0	2024.2	945.7	

Flow Weighted Average Initial Concentration	(mg/m^3)	**18.4**
Flow Weighted Average Final Concentration	(mg/m^3)	**17.6**
Average Removal	**(%)**	**4.2%**

Alternative 1 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09
Surface Area	A (m^2)	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06
Mean Surface Overflow	Q_s (m/yr)	228.064	191.398	221.775	62.895	37.766	23.223	21.786	10.996	3.885	366.521
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
Mean Pond Volume	V_m (m^3)	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mean Hydraulic Residence Time	T (yr)	0.005	0.006	0.006	0.019	0.032	0.053	0.056	0.111	0.314	0.003
Inflow Total P	P_i (mg/m^3)	27.8	25.4	27.4	17.1	15.4	14.5	14.4	13.7	13.3	22.0
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08
Basin/Watershed Area		0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Decay rate	K_2 =	0.176	0.175	0.176	0.154	0.138	0.119	0.116	0.084	0.042	0.180
Reaction rate	Nr =	0.026	0.028	0.027	0.051	0.069	0.090	0.093	0.128	0.176	0.013
Retention Coefficient	Rp =	0.025	0.027	0.025	0.046	0.061	0.077	0.079	0.103	0.133	0.013
Output concentration		27.11	24.72	26.71	16.31	14.47	13.38	13.26	12.29	11.54	21.72
Percent P Retained in Impoundment		**2.5%**	**2.7%**	**2.5%**	**4.6%**	**6.1%**	**7.7%**	**7.9%**	**10.3%**	**13.3%**	**1.3%**
Influent Mass Flowrate	[(mg/s)/(cfs/m3)]	43245.7	33159.7	41448.0	7335.9	3967.0	2296.8	2139.8	1027.5	352.5	
Effluent Mass Flowrate	[(mg/s)/(cfs/m3)]	42167.2	32272.1	40402.6	6995.0	3726.6	2119.9	1970.3	921.4	305.7	

Flow Weighted Average Initial Concentration	(mg/m^3)	**24.7**
Flow Weighted Average Final Concentration	(mg/m^3)	**23.9**
Average Removal	**(%)**	**3.0%**

Alternative 2 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09
Surface Area	A (m^2)	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06
Mean Surface Overflow	Q_s (m/yr)	227.674	191.070	221.395	62.787	37.702	23.183	21.749	10.977	3.878	365.894
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
Mean Pond Volume	V_m (m^3)	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mean Hydraulic Residence Time	T (yr)	0.005	0.006	0.006	0.019	0.032	0.053	0.056	0.111	0.315	0.003
Inflow Total P	P_i (mg/m^3)	27.8	25.4	27.4	17.1	15.4	14.5	14.4	13.7	13.3	22.0
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08
Basin/Watershed Area		0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Decay rate	K_2 =	0.176	0.175	0.176	0.154	0.138	0.119	0.116	0.084	0.042	0.180
Reaction rate	Nr =	0.026	0.028	0.027	0.051	0.069	0.091	0.094	0.129	0.176	0.013
Retention Coefficient	Rp =	0.025	0.027	0.025	0.047	0.061	0.077	0.079	0.103	0.133	0.013
Output concentration		27.11	24.72	26.71	16.30	14.47	13.38	13.26	12.28	11.54	21.72
Percent P Retained in Impoundment		**2.5%**	**2.7%**	**2.5%**	**4.7%**	**6.1%**	**7.7%**	**7.9%**	**10.3%**	**13.3%**	**1.3%**
Influent Mass Flowrate	[(mg/s)/(cfs/m3)]	43245.7	33159.7	41448.0	7335.9	3967.0	2296.8	2139.8	1027.5	352.5	
Effluent Mass Flowrate	[(mg/s)/(cfs/m3)]	42165.6	32270.8	40401.0	6994.6	3726.3	2119.7	1970.1	921.3	305.7	

Flow Weighted Average Initial Concentration	(mg/m^3)	**24.7**
Flow Weighted Average Final Concentration	(mg/m^3)	**23.9**
Average Removal	**(%)**	**3.0%**

Alternative 1 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09
Surface Area	A (m^2)	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06	6.09E+06
Mean Surface Overflow	Q_s (m/yr)	311.807	141.653	167.427	49.671	29.600	18.781	10.966	4.999	0.454	366.521
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
Mean Pond Volume	V_m (m^3)	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06	7.43E+06
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mean Hydraulic Residence Time	T (yr)	0.004	0.009	0.007	0.025	0.041	0.065	0.111	0.244	2.684	0.003
Inflow Total P	P_i (mg/m^3)	33.2	22.2	23.8	16.2	14.9	14.2	13.7	13.3	13.0	22.0
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08
Basin/Watershed Area		0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Decay rate	K_2 =	0.179	0.171	0.173	0.147	0.129	0.109	0.084	0.051	0.006	0.180
Reaction rate	Nr =	0.023	0.033	0.030	0.059	0.079	0.101	0.129	0.166	0.215	0.013
Retention Coefficient	Rp =	0.022	0.031	0.028	0.053	0.069	0.084	0.103	0.126	0.154	0.013
Output concentration		32.46	21.52	23.13	15.35	13.88	13.00	12.28	11.62	11.00	21.72
Percent P Retained in Impoundment		**2.2%**	**3.1%**	**2.8%**	**5.3%**	**6.9%**	**8.4%**	**10.3%**	**12.6%**	**15.4%**	**1.3%**
Influent Mass Flowrate	[(mg/s)/(cfs/m3)]	70609.8	21449.6	27179.6	5488.6	3008.3	1819.0	1024.8	453.5	40.3	
Effluent Mass Flowrate	[(mg/s)/(cfs/m3)]	69039.9	20792.1	26410.0	5199.9	2801.9	1665.3	918.8	396.2	34.1	

Flow Weighted Average Initial Concentration	(mg/m^3)	**26.1**
Flow Weighted Average Final Concentration	(mg/m^3)	**25.4**
Average Removal	**(%)**	**2.9%**

Alternative 2 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09
Surface Area	A (m^2)	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06	6.10E+06
Mean Surface Overflow	Q_s (m/yr)	311.274	141.411	167.141	49.586	29.550	18.748	10.948	4.991	0.454	365.894
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
Mean Pond Volume	V_m (m^3)	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06	7.44E+06
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mean Hydraulic Residence Time	T (yr)	0.004	0.009	0.007	0.025	0.041	0.065	0.111	0.244	2.689	0.003
Inflow Total P	P_i (mg/m^3)	33.2	22.2	23.8	16.2	14.9	14.2	13.7	13.3	13.0	22.0
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08
Basin/Watershed Area		0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Decay rate	K_2 =	0.179	0.171	0.173	0.147	0.129	0.109	0.084	0.051	0.006	0.180
Reaction rate	Nr =	0.023	0.033	0.030	0.059	0.079	0.101	0.129	0.166	0.215	0.013
Retention Coefficient	Rp =	0.022	0.031	0.028	0.053	0.069	0.085	0.103	0.126	0.154	0.013
Output concentration		32.46	21.52	23.13	15.35	13.88	13.00	12.28	11.62	11.00	21.72
Percent P Retained in Impoundment		**2.2%**	**3.1%**	**2.8%**	**5.3%**	**6.9%**	**8.5%**	**10.3%**	**12.6%**	**15.4%**	**1.3%**
Influent Mass Flowrate	[(mg/s)/(cfs/m3)]	70609.8	21449.6	27179.6	5488.6	3008.3	1819.0	1024.8	453.5	40.3	
Effluent Mass Flowrate	[(mg/s)/(cfs/m3)]	69037.4	20791.1	26408.8	5199.6	2801.7	1665.2	918.8	396.2	34.1	

Flow Weighted Average Initial Concentration	(mg/m^3)	**26.1**
Flow Weighted Average Final Concentration	(mg/m^3)	**25.4**
Average Removal	(%)	**2.9%**

Alternative 1 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	**subarea 1**
Mean Surface Overflow	Q_s (m/yr)	558.958	761.604	739.637	484.450	541.840	370.956	250.339	150.896	76.091	2473.703	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.002	0.002	0.002	0.003	0.002	0.003	0.005	0.008	0.016	0.000	
Inflow Total P	P_i (mg/m^3)	18.4	20.3	20.1	17.7	18.2	16.6	15.4	14.4	13.7	22.0	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
Decay rate	K_2 =	0.182	0.183	0.183	0.182	0.182	0.180	0.177	0.172	0.159	0.186	
Reaction rate	Nr =	0.007	0.006	0.006	0.008	0.007	0.010	0.013	0.020	0.035	0.002	
Retention Coefficient	Rp =	0.007	0.006	0.006	0.008	0.007	0.010	0.013	0.019	0.033	0.002	
Output concentration		18.27	20.18	19.98	17.56	18.07	16.44	15.20	14.12	13.25	21.96	

Alternative 1 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500.0	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	**subarea 2**
Mean Surface Overflow	Q_s (m/yr)	427.758	582.839	566.028	370.739	414.658	283.885	191.579	115.477	58.231	1893.071	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.003	0.002	0.002	0.003	0.003	0.004	0.006	0.011	0.021	0.001	
Inflow Total P	P_i (mg/m^3)	18.27	20.18	19.98	17.56	18.07	16.44	15.20	14.12	13.25	21.96	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	
Decay rate	K_2 =	0.181	0.183	0.182	0.180	0.181	0.178	0.175	0.167	0.152	0.185	
Reaction rate	Nr =	0.009	0.008	0.008	0.010	0.010	0.013	0.017	0.025	0.042	0.003	
Retention Coefficient	Rp =	0.009	0.008	0.008	0.010	0.009	0.012	0.016	0.024	0.039	0.003	
Output concentration		18.10	20.03	19.82	17.38	17.90	16.24	14.95	13.79	12.74	21.90	

Alternative 1 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	**subarea 3**
Mean Surface Overflow	Q_s (m/yr)	285.019	388.350	377.149	247.027	276.290	189.155	127.651	76.944	38.800	1261.369	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.004	0.003	0.003	0.005	0.004	0.006	0.010	0.016	0.031	0.001	
Inflow Total P	P_i (mg/m^3)	18.10	20.03	19.82	17.38	17.90	16.24	14.95	13.79	12.74	21.90	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	
Decay rate	K_2 =	0.178	0.180	0.180	0.177	0.178	0.174	0.169	0.159	0.139	0.185	
Reaction rate	Nr =	0.014	0.011	0.012	0.015	0.014	0.018	0.024	0.035	0.056	0.004	
Retention Coefficient	Rp =	0.013	0.011	0.011	0.015	0.014	0.018	0.023	0.033	0.050	0.004	
Output concentration		17.85	19.80	19.60	17.12	17.65	15.95	14.61	13.34	12.10	21.81	

Alternative 1 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	**subarea 4**
Mean Surface Overflow	Q_s (m/yr)	400.119	545.179	529.455	346.784	387.865	265.542	179.200	108.016	54.468	1770.751	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.003	0.002	0.002	0.004	0.003	0.005	0.007	0.011	0.022	0.001	
Inflow Total P	P_i (mg/m^3)	17.85	19.80	19.60	17.12	17.65	15.95	14.61	13.34	12.10	21.81	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	
Decay rate	K_2 =	0.181	0.182	0.182	0.180	0.180	0.178	0.174	0.166	0.150	0.185	
Reaction rate	Nr =	0.010	0.008	0.008	0.011	0.010	0.013	0.017	0.025	0.041	0.003	
Retention Coefficient	Rp =	0.010	0.008	0.008	0.011	0.010	0.013	0.017	0.024	0.038	0.003	
Output concentration		17.68	19.65	19.44	16.94	17.48	15.75	14.36	13.02	11.64	21.75	

Alternative 1 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	**subarea 5a**
Mean Surface Overflow	Q_s (m/yr)	1275.589	1738.043	1687.914	1105.555	1236.524	846.554	571.294	344.357	173.646	5645.196	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.007	0.000	
Inflow Total P	P_i (mg/m^3)	17.68	19.65	19.44	16.94	17.48	15.75	14.36	13.02	11.64	21.75	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
Decay rate	K_2 =	0.185	0.185	0.185	0.184	0.185	0.184	0.182	0.180	0.173	0.186	
Reaction rate	Nr =	0.003	0.003	0.003	0.003	0.003	0.004	0.006	0.008	0.014	0.001	
Retention Coefficient	Rp =	0.003	0.003	0.003	0.003	0.003	0.004	0.006	0.008	0.014	0.001	
Output concentration		17.63	19.60	19.39	16.88	17.42	15.68	14.28	12.91	11.48	21.73	

Alternative 1 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	**Sump subarea**
Mean Surface Overflow	Q_s (m/yr)	4343.880	5918.719	5748.009	3764.850	4210.849	2882.847	1945.480	1172.671	591.334	19224.110	
Mean Pond Depth	Z (m)	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	
Mean Pond Volume	V_m (m^3)	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.002	0.004	0.000	
Inflow Total P	P_i (mg/m^3)	17.63	19.60	19.39	16.88	17.42	15.68	14.28	12.91	11.48	21.73	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		6.24E-04	6.24E-04	6.24E-04	6.24E-04	6.24E-04	6.24E-04	6.24E-04	6.24E-04	6.24E-04	6.24E-04	
Decay rate	K_2 =	0.186	0.186	0.186	0.186	0.186	0.186	0.185	0.185	0.183	0.187	
Reaction rate	Nr =	1.84E-03	1.50E-03	1.53E-03	2.04E-03	1.88E-03	2.47E-03	3.32E-03	4.96E-03	8.65E-03	5.15E-04	
Retention Coefficient	Rp =	1.84E-03	1.50E-03	1.53E-03	2.03E-03	1.87E-03	2.45E-03	3.30E-03	4.91E-03	8.50E-03	5.14E-04	
Output concentration		17.60	19.57	19.36	16.85	17.39	15.65	14.24	12.85	11.38	21.72	

Alternative 1 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	**subarea 5b**
Mean Surface Overflow	Q_s (m/yr)	1014.993	1382.970	1343.082	879.696	983.909	673.607	454.582	274.007	138.171	4491.913	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.009	0.000	
Inflow Total P	P_i (mg/m^3)	17.60	19.57	19.36	16.85	17.39	15.65	14.24	12.85	11.38	21.72	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	
Decay rate	K_2 =	0.184	0.185	0.185	0.184	0.184	0.183	0.181	0.178	0.170	0.186	
Reaction rate	Nr =	0.004	0.003	0.003	0.004	0.004	0.005	0.007	0.010	0.017	0.001	
Retention Coefficient	Rp =	0.004	0.003	0.003	0.004	0.004	0.005	0.007	0.010	0.017	0.001	
Output concentration		17.53	19.51	19.30	16.78	17.32	15.57	14.14	12.72	11.19	21.70	
Percent P Retained in Impoundment		**4.7%**	**3.9%**	**4.0%**	**5.2%**	**4.8%**	**6.2%**	**8.2%**	**11.7%**	**18.3%**	**1.4%**	
Influent Mass Flowrate	[(mg/s)/(cfs/m3)]	10394.2	15624.9	15024.8	8665.9	9966.3	6223.3	3896.2	2196.0	1053.5		
Effluent Mass Flowrate	[(mg/s)/(cfs/m3)]	9901.1	15013.7	14426.4	8214.4	9484.9	5835.3	3577.2	1940.1	860.9		
Flow Weighted Average Initial Concentration	(mg/m^3)	**18.4**										
Flow Weighted Average Final Concentration	(mg/m^3)	**17.4**										
Average Removal	**(%)**	**5.2%**										

Alternative 2 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	**subarea 1**
Mean Surface Overflow	Q_s (m/yr)	447.764	610.097	592.501	388.078	434.051	297.162	200.539	120.878	60.954	1981.608	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.003	0.002	0.002	0.003	0.003	0.004	0.006	0.010	0.020	0.001	
Inflow Total P	P_i (mg/m^3)	18.4	20.3	20.1	17.7	18.2	16.6	15.4	14.4	13.7	22.0	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	
Decay rate	K_2 =	0.181	0.183	0.183	0.180	0.181	0.179	0.175	0.168	0.153	0.185	
Reaction rate	Nr =	0.009	0.007	0.008	0.010	0.009	0.012	0.016	0.024	0.042	0.003	
Retention Coefficient	Rp =	0.009	0.007	0.007	0.010	0.009	0.012	0.016	0.023	0.039	0.002	
Output concentration		18.24	20.15	19.95	17.53	18.03	16.40	15.16	14.06	13.17	21.95	

Alternative 2 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	**subarea 2**
Mean Surface Overflow	Q_s (m/yr)	322.768	439.785	427.101	279.744	312.883	214.207	144.557	87.134	43.939	1428.430	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.004	0.003	0.003	0.004	0.004	0.006	0.008	0.014	0.028	0.001	
Inflow Total P	P_i (mg/m^3)	18.24	20.15	19.95	17.53	18.03	16.40	15.16	14.06	13.17	21.95	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	
Decay rate	K_2 =	0.179	0.181	0.181	0.178	0.179	0.176	0.171	0.162	0.143	0.185	
Reaction rate	Nr =	0.012	0.010	0.010	0.014	0.013	0.016	0.022	0.032	0.052	0.003	
Retention Coefficient	Rp =	0.012	0.010	0.010	0.013	0.012	0.016	0.021	0.030	0.048	0.003	
Output concentration		18.02	19.95	19.75	17.29	17.81	16.14	14.84	13.64	12.54	21.87	

Alternative 2 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	**subarea 3**
Mean Surface Overflow	Q_s (m/yr)	529.425	721.364	700.558	458.854	513.211	351.357	237.112	142.923	72.071	2343.002	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.002	0.002	0.002	0.003	0.002	0.003	0.005	0.009	0.017	0.001	
Inflow Total P	P_i (mg/m^3)	18.02	19.95	19.75	17.29	17.81	16.14	14.84	13.64	12.54	21.87	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
Decay rate	K_2 =	0.182	0.183	0.183	0.181	0.182	0.180	0.177	0.171	0.158	0.186	
Reaction rate	Nr =	0.008	0.006	0.006	0.008	0.008	0.010	0.013	0.020	0.033	0.002	
Retention Coefficient	Rp =	0.007	0.006	0.006	0.008	0.008	0.010	0.013	0.019	0.031	0.002	
Output concentration		17.88	19.83	19.63	17.15	17.68	15.98	14.64	13.38	12.15	21.82	

Alternative 2 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	**subarea 4**
Mean Surface Overflow	Q_s (m/yr)	446.353	608.175	590.634	386.855	432.684	296.226	199.907	120.497	60.762	1975.364	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.003	0.002	0.002	0.003	0.003	0.004	0.006	0.010	0.020	0.001	
Inflow Total P	P_i (mg/m^3)	17.88	19.83	19.63	17.15	17.68	15.98	14.64	13.38	12.15	21.82	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	
Decay rate	K_2 =	0.181	0.183	0.183	0.180	0.181	0.179	0.175	0.168	0.153	0.185	
Reaction rate	Nr =	0.009	0.007	0.007	0.010	0.009	0.012	0.016	0.023	0.037	0.002	
Retention Coefficient	Rp =	0.009	0.007	0.007	0.010	0.009	0.011	0.015	0.022	0.035	0.002	
Output concentration		17.73	19.69	19.48	16.99	17.52	15.80	14.42	13.09	11.73	21.77	

Alternative 2 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	**subarea 5a**
Mean Surface Overflow	Q_s (m/yr)	634.109	864.000	839.080	549.583	614.689	420.831	283.996	171.183	86.321	2806.287	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.002	0.001	0.001	0.002	0.002	0.003	0.004	0.007	0.014	0.000	
Inflow Total P	P_i (mg/m^3)	17.73	19.69	19.48	16.99	17.52	15.80	14.42	13.09	11.73	21.77	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	
Decay rate	K_2 =	0.183	0.184	0.184	0.182	0.183	0.181	0.178	0.173	0.162	0.186	
Reaction rate	Nr =	0.006	0.005	0.005	0.007	0.006	0.008	0.011	0.016	0.027	0.002	
Retention Coefficient	Rp =	0.006	0.005	0.005	0.007	0.006	0.008	0.011	0.016	0.025	0.002	
Output concentration		17.62	19.59	19.38	16.87	17.41	15.67	14.26	12.88	11.43	21.73	

Alternative 2 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	**Sump subarea**
Mean Surface Overflow	Q_s (m/yr)	4157.874	5665.278	5501.878	3603.638	4030.540	2759.403	1862.174	1122.457	566.013	18400.930	
Mean Pond Depth	Z (m)	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	
Mean Pond Volume	V_m (m^3)	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.002	0.004	0.000	
Inflow Total P	P_i (mg/m^3)	17.62	19.59	19.38	16.87	17.41	15.67	14.26	12.88	11.43	21.73	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Decay rate	K_2 =	0.186	0.186	0.186	0.186	0.186	0.186	0.185	0.184	0.182	0.187	
Reaction rate	Nr =	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.005	0.009	0.001	
Retention Coefficient	Rp =	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.005	0.009	0.001	
Output concentration		17.58	19.56	19.35	16.84	17.38	15.63	14.22	12.82	11.33	21.72	

Alternative 2 - 1967 Data

Date		10/5/1967	10/6/1967	10/7/1967	10/8/1967	10/9/1967	10/10/1967	10/11/1967	10/12/1967	10/13/1967	Max Q (cfs)	
Basin inflow	Q (cfs)	564.9	769.7	747.5	489.6	547.6	374.9	253.0	152.5	76.9	2500	
Outflow	Q (m^3/yr)	5.04E+08	6.87E+08	6.68E+08	4.37E+08	4.89E+08	3.35E+08	2.26E+08	1.36E+08	6.87E+07	2.23E+09	
Surface Area	A (m^2)	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	**subarea 5b**
Mean Surface Overflow	Q_s (m/yr)	1151.934	1569.558	1524.288	998.383	1116.656	764.489	515.913	310.975	156.813	5097.955	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.008	0.000	
Inflow Total P	P_i (mg/m^3)	17.58	19.56	19.35	16.84	17.38	15.63	14.22	12.82	11.33	21.72	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
Decay rate	K_2 =	0.185	0.185	0.185	0.184	0.184	0.183	0.182	0.179	0.172	0.186	
Reaction rate	Nr =	0.003	0.003	0.003	0.004	0.004	0.005	0.006	0.009	0.015	0.001	
Retention Coefficient	Rp =	0.003	0.003	0.003	0.004	0.003	0.005	0.006	0.009	0.015	0.001	
Output concentration		17.52	19.50	19.30	16.77	17.32	15.56	14.13	12.71	11.16	21.70	
Percent P Retained in Impoundment		**4.8%**	**3.9%**	**4.0%**	**5.2%**	**4.9%**	**6.3%**	**8.2%**	**11.8%**	**18.5%**	**1.4%**	
Influent Mass Flowrate	[(mg/s)/(cfs/m3)]	10394.2	15624.9	15024.8	8665.9	9966.3	6223.3	3896.2	2196.0	1053.5		
Effluent Mass Flowrate	[(mg/s)/(cfs/m3)]	9898.8	15011.2	14423.9	8212.1	9482.6	5833.0	3574.8	1937.6	858.2		
Flow Weighted Average Initial Concentration	(mg/m^3)	**18.4**										
Flow Weighted Average Final Concentration	(mg/m^3)	**17.4**										
Average Removal	**(%)**	**5.2%**										

Alternative 1 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	**subarea 1**
Mean Surface Overflow	Q_s (m/yr)	1539.237	1291.768	1496.788	424.487	254.890	156.734	147.037	74.211	26.221	2473.703	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.003	0.005	0.008	0.008	0.016	0.047	0.000	
Inflow Total P	P_i (mg/m^3)	27.8	25.4	27.4	17.1	15.4	14.5	14.4	13.7	13.3	22.0	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
Decay rate	K_2 =	0.185	0.185	0.185	0.181	0.177	0.172	0.171	0.158	0.124	0.186	
Reaction rate	Nr =	0.004	0.004	0.004	0.009	0.013	0.019	0.020	0.036	0.077	0.002	
Retention Coefficient	Rp =	0.004	0.004	0.004	0.009	0.013	0.019	0.020	0.033	0.067	0.002	
Output concentration		27.69	25.29	27.29	16.95	15.20	14.23	14.12	13.24	12.41	21.96	

Alternative 1 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	**subarea 2**
Mean Surface Overflow	Q_s (m/yr)	1177.945	988.562	1145.459	324.851	195.062	119.945	112.524	56.792	20.067	1893.071	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.004	0.006	0.010	0.011	0.021	0.061	0.001	
Inflow Total P	P_i (mg/m^3)	27.69	25.29	27.29	16.95	15.20	14.23	14.12	13.24	12.41	21.96	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	
Decay rate	K_2 =	0.185	0.184	0.185	0.179	0.175	0.168	0.167	0.151	0.112	0.185	
Reaction rate	Nr =	0.005	0.006	0.005	0.011	0.017	0.024	0.026	0.043	0.085	0.003	
Retention Coefficient	Rp =	0.005	0.006	0.005	0.011	0.016	0.023	0.024	0.040	0.073	0.003	
Output concentration		27.54	25.14	27.14	16.76	14.96	13.90	13.77	12.72	11.51	21.90	

Alternative 1 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	**subarea 3**
Mean Surface Overflow	Q_s (m/yr)	784.874	658.687	763.229	216.451	129.971	79.920	74.976	37.841	13.371	1261.369	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.002	0.002	0.002	0.006	0.009	0.015	0.016	0.032	0.091	0.001	
Inflow Total P	P_i (mg/m^3)	27.54	25.14	27.14	16.76	14.96	13.90	13.77	12.72	11.51	21.90	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	
Decay rate	K_2 =	0.184	0.183	0.183	0.176	0.169	0.160	0.159	0.138	0.094	0.185	
Reaction rate	Nr =	0.008	0.009	0.008	0.017	0.024	0.034	0.036	0.057	0.098	0.004	
Retention Coefficient	Rp =	0.008	0.008	0.008	0.016	0.023	0.032	0.033	0.051	0.083	0.004	
Output concentration		27.33	24.93	26.93	16.49	14.62	13.46	13.32	12.07	10.56	21.81	

Alternative 1 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	**subarea 4**
Mean Surface Overflow	Q_s (m/yr)	1101.832	924.686	1071.446	303.861	182.458	112.195	105.253	53.123	18.770	1770.751	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.004	0.007	0.011	0.012	0.023	0.065	0.001	
Inflow Total P	P_i (mg/m^3)	27.33	24.93	26.93	16.49	14.62	13.46	13.32	12.07	10.56	21.81	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	
Decay rate	K_2 =	0.184	0.184	0.184	0.179	0.174	0.167	0.166	0.149	0.109	0.185	
Reaction rate	Nr =	0.006	0.006	0.006	0.012	0.017	0.024	0.026	0.041	0.075	0.003	
Retention Coefficient	Rp =	0.006	0.006	0.006	0.012	0.016	0.023	0.024	0.038	0.065	0.003	
Output concentration		27.18	24.78	26.78	16.30	14.38	13.14	12.99	11.61	9.87	21.75	

Alternative 1 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	**subarea 5a**
Mean Surface Overflow	Q_s (m/yr)	3512.667	2947.921	3415.795	968.716	581.681	357.680	335.550	169.356	59.839	5645.196	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.007	0.020	0.000	
Inflow Total P	P_i (mg/m^3)	27.18	24.78	26.78	16.30	14.38	13.14	12.99	11.61	9.87	21.75	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
Decay rate	K_2 =	0.186	0.186	0.186	0.184	0.182	0.180	0.180	0.173	0.153	0.186	
Reaction rate	Nr =	0.002	0.002	0.002	0.004	0.006	0.008	0.008	0.014	0.031	0.001	
Retention Coefficient	Rp =	0.002	0.002	0.002	0.004	0.005	0.008	0.008	0.014	0.029	0.001	
Output concentration		27.13	24.74	26.73	16.24	14.30	13.04	12.88	11.44	9.58	21.73	

Alternative 1 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	**Sump subarea**
Mean Surface Overflow	Q_s (m/yr)	11962.010	10038.830	11632.124	3298.857	1980.852	1218.040	1142.681	576.723	203.776	19224.110	
Mean Pond Depth	Z (m)	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	
Mean Pond Volume	V_m (m^3)	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.004	0.012	0.000	
Inflow Total P	P_i (mg/m^3)	27.13	24.74	26.73	16.24	14.30	13.04	12.88	11.44	9.58	21.73	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Decay rate	K_2 =	0.186	0.186	0.186	0.186	0.185	0.185	0.185	0.182	0.175	0.187	
Reaction rate	Nr =	0.001	0.001	0.001	0.002	0.003	0.005	0.005	0.009	0.020	0.001	
Retention Coefficient	Rp =	0.001	0.001	0.001	0.002	0.003	0.005	0.005	0.009	0.019	0.001	
Output concentration		27.10	24.71	26.70	16.20	14.25	12.98	12.82	11.34	9.39	21.72	

Alternative 1 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	**subarea 5b**
Mean Surface Overflow	Q_s (m/yr)	2795.048	2345.677	2717.967	770.812	462.847	284.608	266.999	134.757	47.614	4491.913	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.000	0.001	0.000	0.002	0.003	0.004	0.005	0.009	0.026	0.000	
Inflow Total P	P_i (mg/m^3)	27.10	24.71	26.70	16.20	14.25	12.98	12.82	11.34	9.39	21.72	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	
Decay rate	K_2 =	0.186	0.186	0.186	0.184	0.181	0.178	0.178	0.170	0.146	0.186	
Reaction rate	Nr =	0.002	0.002	0.002	0.005	0.007	0.010	0.010	0.017	0.035	0.001	
Retention Coefficient	Rp =	0.002	0.002	0.002	0.005	0.007	0.010	0.010	0.017	0.033	0.001	
Output concentration		27.04	24.65	26.65	16.13	14.16	12.85	12.69	11.15	9.09	21.70	
Percent P Retained in Impoundment		**2.7%**	**2.9%**	**2.8%**	**5.7%**	**8.1%**	**11.4%**	**11.9%**	**18.6%**	**31.7%**	**1.4%**	
Influent Mass Flowrate	[(mg/s)/(cfs/m3)]	43245.7	33159.7	41448.0	7335.9	3967.0	2296.8	2139.8	1027.5	352.5		
Effluent Mass Flowrate	[(mg/s)/(cfs/m3)]	42069.3	32182.5	40306.1	6919.0	3647.2	2035.4	1885.4	836.5	240.8		
Flow Weighted Average Initial Concentration	(mg/m^3)	**24.7**										
Flow Weighted Average Final Concentration	(mg/m^3)	**23.8**										
Average Removal	**(%)**	**3.6%**										

Alternative 2 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	**subarea 1**
Mean Surface Overflow	Q_s (m/yr)	1233.036	1034.796	1199.031	340.044	204.185	125.555	117.787	59.448	21.005	1981.608	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.004	0.006	0.010	0.010	0.021	0.058	0.001	
Inflow Total P	P_i (mg/m^3)	27.8	25.4	27.4	17.1	15.4	14.5	14.4	13.7	13.3	22.0	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	
Decay rate	K_2 =	0.185	0.184	0.185	0.180	0.175	0.169	0.168	0.153	0.114	0.185	
Reaction rate	Nr =	0.005	0.006	0.005	0.011	0.016	0.024	0.025	0.043	0.088	0.003	
Retention Coefficient	Rp =	0.005	0.005	0.005	0.011	0.016	0.023	0.024	0.040	0.075	0.002	
Output concentration		27.66	25.26	27.26	16.92	15.16	14.17	14.06	13.16	12.30	21.95	

Alternative 2 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	**subarea 2**
Mean Surface Overflow	Q_s (m/yr)	888.827	745.926	864.315	245.119	147.185	90.505	84.906	42.853	15.141	1428.430	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.002	0.001	0.005	0.008	0.013	0.014	0.028	0.081	0.001	
Inflow Total P	P_i (mg/m^3)	27.66	25.26	27.26	16.92	15.16	14.17	14.06	13.16	12.30	21.95	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	
Decay rate	K_2 =	0.184	0.183	0.184	0.177	0.171	0.163	0.161	0.142	0.099	0.185	
Reaction rate	Nr =	0.007	0.008	0.007	0.015	0.022	0.031	0.033	0.053	0.098	0.003	
Retention Coefficient	Rp =	0.007	0.007	0.007	0.014	0.021	0.029	0.031	0.048	0.083	0.003	
Output concentration		27.47	25.07	27.07	16.67	14.85	13.76	13.63	12.52	11.28	21.87	

Alternative 2 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	**subarea 3**
Mean Surface Overflow	Q_s (m/yr)	1457.910	1223.516	1417.704	402.059	241.423	148.453	139.268	70.290	24.836	2343.002	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.003	0.005	0.008	0.009	0.017	0.049	0.001	
Inflow Total P	P_i (mg/m^3)	27.47	25.07	27.07	16.67	14.85	13.76	13.63	12.52	11.28	21.87	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
Decay rate	K_2 =	0.185	0.185	0.185	0.181	0.177	0.171	0.170	0.157	0.122	0.186	
Reaction rate	Nr =	0.004	0.005	0.004	0.009	0.013	0.019	0.020	0.034	0.067	0.002	
Retention Coefficient	Rp =	0.004	0.005	0.004	0.009	0.013	0.019	0.020	0.032	0.060	0.002	
Output concentration		27.35	24.96	26.95	16.52	14.65	13.50	13.36	12.12	10.61	21.82	

Alternative 2 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	**subarea 4**
Mean Surface Overflow	Q_s (m/yr)	1229.150	1031.535	1195.253	338.972	203.541	125.159	117.416	59.261	20.939	1975.364	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.004	0.006	0.010	0.010	0.021	0.058	0.001	
Inflow Total P	P_i (mg/m^3)	27.35	24.96	26.95	16.52	14.65	13.50	13.36	12.12	10.61	21.82	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	
Decay rate	K_2 =	0.185	0.184	0.185	0.180	0.175	0.169	0.168	0.152	0.114	0.185	
Reaction rate	Nr =	0.005	0.005	0.005	0.011	0.015	0.022	0.023	0.038	0.071	0.002	
Retention Coefficient	Rp =	0.005	0.005	0.005	0.010	0.015	0.021	0.022	0.035	0.062	0.002	
Output concentration		27.22	24.82	26.82	16.35	14.44	13.21	13.06	11.69	9.95	21.77	

Alternative 2 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	**subarea 5a**
Mean Surface Overflow	Q_s (m/yr)	1746.184	1465.443	1698.028	481.559	289.160	177.806	166.806	84.189	29.747	2806.287	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.003	0.004	0.007	0.007	0.014	0.041	0.000	
Inflow Total P	P_i (mg/m^3)	27.22	24.82	26.82	16.35	14.44	13.21	13.06	11.69	9.95	21.77	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	
Decay rate	K_2 =	0.185	0.185	0.185	0.182	0.178	0.174	0.173	0.161	0.129	0.186	
Reaction rate	Nr =	0.004	0.004	0.004	0.008	0.011	0.016	0.017	0.027	0.053	0.002	
Retention Coefficient	Rp =	0.003	0.004	0.004	0.007	0.011	0.015	0.016	0.026	0.048	0.002	
Output concentration		27.12	24.73	26.72	16.23	14.28	13.01	12.85	11.39	9.47	21.73	

Alternative 2 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	**Sump subarea**
Mean Surface Overflow	Q_s (m/yr)	11449.794	9608.965	11134.034	3157.600	1896.032	1165.883	1093.751	552.028	195.050	18400.930	
Mean Pond Depth	Z (m)	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	
Mean Pond Volume	V_m (m^3)	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.004	0.013	0.000	
Inflow Total P	P_i (mg/m^3)	27.12	24.73	26.72	16.23	14.28	13.01	12.85	11.39	9.47	21.73	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Decay rate	K_2 =	0.186	0.186	0.186	0.186	0.185	0.185	0.184	0.182	0.175	0.187	
Reaction rate	Nr =	0.001	0.001	0.001	0.002	0.003	0.005	0.005	0.009	0.021	0.001	
Retention Coefficient	Rp =	0.001	0.001	0.001	0.002	0.003	0.005	0.005	0.009	0.020	0.001	
Output concentration		27.09	24.70	26.69	16.19	14.23	12.95	12.79	11.29	9.28	21.72	

Alternative 2 - 1985 Data

Date		7/23/1985	7/24/1985	7/25/1985	7/26/1985	7/27/1985	7/28/1985	7/29/1985	7/30/1985	7/31/1985	Max Q (cfs)	
Basin inflow	Q (cfs)	1555.6	1305.5	1512.7	429.0	257.6	158.4	148.6	75.0	26.5	2500	
Outflow	Q (m^3/yr)	1.39E+09	1.17E+09	1.35E+09	3.83E+08	2.30E+08	1.41E+08	1.33E+08	6.70E+07	2.37E+07	2.23E+09	
Surface Area	A (m^2)	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	**subarea 5b**
Mean Surface Overflow	Q_s (m/yr)	3172.151	2662.152	3084.670	874.809	525.293	323.006	303.022	152.939	54.038	5097.955	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.000	0.000	0.000	0.001	0.002	0.004	0.004	0.008	0.023	0.000	
Inflow Total P	P_i (mg/m^3)	27.09	24.70	26.69	16.19	14.23	12.95	12.79	11.29	9.28	21.72	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
Decay rate	K_2 =	0.186	0.186	0.186	0.184	0.182	0.179	0.179	0.172	0.150	0.186	
Reaction rate	Nr =	0.002	0.002	0.002	0.004	0.006	0.009	0.009	0.015	0.031	0.001	
Retention Coefficient	Rp =	0.002	0.002	0.002	0.004	0.006	0.009	0.009	0.015	0.030	0.001	
Output concentration		27.04	24.65	26.64	16.12	14.15	12.83	12.67	11.12	9.01	21.70	
Percent P Retained in Impoundment		**2.7%**	**3.0%**	**2.8%**	**5.7%**	**8.1%**	**11.5%**	**12.0%**	**18.8%**	**32.3%**	**1.4%**	
Influent Mass Flowrate	[(mg/s)/(cfs/m3)]	43245.7	33159.7	41448.0	7335.9	3967.0	2296.8	2139.8	1027.5	352.5		
Effluent Mass Flowrate	[(mg/s)/(cfs/m3)]	42065.7	32179.3	40302.5	6916.7	3644.8	2032.9	1882.9	833.8	238.8		

Flow Weighted Average Initial Concentration	(mg/m^3)	**24.7**
Flow Weighted Average Final Concentration	(mg/m^3)	**23.8**
Average Removal	**(%)**	**3.6%**

Alternative 1 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	9.02E+05	**subarea 1**
Mean Surface Overflow	Q_s (m/yr)	2104.428	956.037	1129.987	335.236	199.776	126.753	74.013	33.741	3.067	2473.703	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	1.10E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.004	0.006	0.010	0.016	0.036	0.398	0.000	
Inflow Total P	P_i (mg/m^3)	33.2	22.2	23.8	16.2	14.9	14.2	13.7	13.3	13.0	22.0	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
Decay rate	K_2 =	0.185	0.184	0.184	0.180	0.175	0.169	0.158	0.134	0.035	0.186	
Reaction rate	Nr =	0.004	0.005	0.005	0.011	0.016	0.023	0.036	0.064	0.181	0.002	
Retention Coefficient	Rp =	0.004	0.005	0.005	0.010	0.015	0.022	0.033	0.057	0.135	0.002	
Output concentration		33.08	22.09	23.69	16.03	14.67	13.89	13.24	12.54	11.24	21.96	

Alternative 1 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	1.18E+06	**subarea 2**
Mean Surface Overflow	Q_s (m/yr)	1610.473	731.634	864.755	256.549	152.884	97.001	56.641	25.821	2.347	1893.071	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	1.44E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.002	0.001	0.005	0.008	0.013	0.022	0.047	0.520	0.001	
Inflow Total P	P_i (mg/m^3)	33.08	22.09	23.69	16.03	14.67	13.89	13.24	12.54	11.24	21.96	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	
Decay rate	K_2 =	0.185	0.183	0.184	0.177	0.172	0.164	0.151	0.123	0.028	0.185	
Reaction rate	Nr =	0.005	0.007	0.006	0.014	0.020	0.029	0.043	0.073	0.164	0.003	
Retention Coefficient	Rp =	0.005	0.007	0.006	0.013	0.019	0.027	0.040	0.064	0.125	0.003	
Output concentration		32.93	21.94	23.54	15.82	14.39	13.51	12.72	11.74	9.83	21.90	

Alternative 1 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	1.77E+06	**subarea 3**
Mean Surface Overflow	Q_s (m/yr)	1073.072	487.494	576.193	170.941	101.868	64.633	37.740	17.205	1.564	1261.369	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	2.16E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.003	0.002	0.007	0.012	0.019	0.032	0.071	0.780	0.001	
Inflow Total P	P_i (mg/m^3)	32.93	21.94	23.54	15.82	14.39	13.51	12.72	11.74	9.83	21.90	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	
Decay rate	K_2 =	0.184	0.182	0.182	0.173	0.165	0.155	0.138	0.105	0.020	0.185	
Reaction rate	Nr =	0.007	0.010	0.009	0.020	0.028	0.039	0.057	0.088	0.151	0.004	
Retention Coefficient	Rp =	0.007	0.010	0.009	0.019	0.027	0.037	0.051	0.075	0.117	0.004	
Output concentration		32.71	21.72	23.33	15.52	14.00	13.01	12.07	10.86	8.68	21.81	

Alternative 1 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	1.26E+06	**subarea 4**
Mean Surface Overflow	Q_s (m/yr)	1506.414	684.360	808.879	239.972	143.006	90.733	52.981	24.153	2.196	1770.751	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	1.54E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.002	0.002	0.005	0.009	0.013	0.023	0.051	0.556	0.001	
Inflow Total P	P_i (mg/m^3)	32.71	21.72	23.33	15.52	14.00	13.01	12.07	10.86	8.68	21.81	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	
Decay rate	K_2 =	0.185	0.183	0.184	0.177	0.171	0.163	0.149	0.120	0.026	0.185	
Reaction rate	Nr =	0.005	0.007	0.006	0.014	0.020	0.028	0.041	0.066	0.128	0.003	
Retention Coefficient	Rp =	0.005	0.007	0.006	0.014	0.020	0.027	0.038	0.059	0.103	0.003	
Output concentration		32.55	21.57	23.19	15.31	13.72	12.66	11.60	10.22	7.79	21.75	

Alternative 1 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	3.95E+05	**subarea 5a**
Mean Surface Overflow	Q_s (m/yr)	4802.481	2181.755	2578.726	765.037	455.906	289.260	168.904	77.000	7.000	5645.196	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	4.82E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.000	0.001	0.000	0.002	0.003	0.004	0.007	0.016	0.174	0.000	
Inflow Total P	P_i (mg/m^3)	32.55	21.57	23.19	15.31	13.72	12.66	11.60	10.22	7.79	21.75	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
Decay rate	K_2 =	0.186	0.186	0.186	0.183	0.181	0.178	0.173	0.159	0.064	0.186	
Reaction rate	Nr =	0.002	0.002	0.002	0.004	0.007	0.010	0.015	0.026	0.087	0.001	
Retention Coefficient	Rp =	0.002	0.002	0.002	0.004	0.007	0.009	0.014	0.025	0.075	0.001	
Output concentration		32.50	21.52	23.14	15.24	13.63	12.55	11.44	9.97	7.21	21.73	

Alternative 1 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	1.16E+05	**Sump subarea**
Mean Surface Overflow	Q_s (m/yr)	16354.335	7429.734	8781.573	2605.251	1552.539	985.043	575.185	262.217	23.838	19224.110	
Mean Pond Depth	Z (m)	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	
Mean Pond Volume	V_m (m^3)	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	2.83E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.000	0.000	0.000	0.001	0.002	0.002	0.004	0.009	0.102	0.000	
Inflow Total P	P_i (mg/m^3)	32.50	21.52	23.14	15.24	13.63	12.55	11.44	9.97	7.21	21.73	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Decay rate	K_2 =	0.187	0.186	0.186	0.186	0.185	0.184	0.182	0.178	0.120	0.187	
Reaction rate	Nr =	0.001	0.001	0.001	0.003	0.004	0.006	0.009	0.016	0.088	0.001	
Retention Coefficient	Rp =	0.001	0.001	0.001	0.003	0.004	0.006	0.009	0.016	0.076	0.001	
Output concentration		32.47	21.50	23.11	15.20	13.58	12.47	11.34	9.81	6.66	21.72	

Alternative 1 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	4.97E+05	**subarea 5b**
Mean Surface Overflow	Q_s (m/yr)	3821.360	1736.035	2051.906	608.744	362.767	230.166	134.398	61.270	5.570	4491.913	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	6.06E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.000	0.001	0.001	0.002	0.003	0.005	0.009	0.020	0.219	0.000	
Inflow Total P	P_i (mg/m^3)	32.47	21.50	23.11	15.20	13.58	12.47	11.34	9.81	6.66	21.72	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	
Decay rate	K_2 =	0.186	0.185	0.185	0.183	0.180	0.176	0.170	0.153	0.055	0.186	
Reaction rate	Nr =	0.002	0.003	0.003	0.006	0.008	0.012	0.017	0.030	0.080	0.001	
Retention Coefficient	Rp =	0.002	0.003	0.003	0.006	0.008	0.011	0.017	0.028	0.070	0.001	
Output concentration		32.41	21.44	23.05	15.12	13.47	12.33	11.15	9.53	6.20	21.70	
Percent P Retained in Impoundment		**2.4%**	**3.4%**	**3.1%**	**6.7%**	**9.6%**	**13.2%**	**18.6%**	**28.3%**	**52.3%**	**1.4%**	
Influent Mass Flowrate	[(mg/s)/(cfs/m3)]	70609.8	21449.6	27179.6	5488.6	3008.3	1819.0	1024.8	453.5	40.3		
Effluent Mass Flowrate	[(mg/s)/(cfs/m3)]	68920.2	20711.1	26325.3	5122.7	2719.7	1579.7	833.9	325.1	19.2		
Flow Weighted Average Initial Concentration	(mg/m^3)	**26.1**										
Flow Weighted Average Final Concentration	(mg/m^3)	**25.2**										
Average Removal	**(%)**	**3.4%**										

Alternative 2 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	**subarea 1**
Mean Surface Overflow	Q_s (m/yr)	1685.794	765.852	905.199	268.548	160.035	101.538	59.290	27.029	2.457	1981.608	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	1.37E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.002	0.001	0.005	0.008	0.012	0.021	0.045	0.497	0.001	
Inflow Total P	P_i (mg/m^3)	33.2	22.2	23.8	16.2	14.9	14.2	13.7	13.3	13.0	22.0	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	
Decay rate	K_2 =	0.185	0.183	0.184	0.178	0.172	0.165	0.152	0.125	0.029	0.185	
Reaction rate	Nr =	0.004	0.006	0.006	0.013	0.020	0.028	0.043	0.075	0.188	0.003	
Retention Coefficient	Rp =	0.004	0.006	0.006	0.013	0.019	0.027	0.040	0.066	0.139	0.002	
Output concentration		33.05	22.06	23.66	15.99	14.62	13.82	13.16	12.43	11.19	21.95	

Alternative 2 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	1.56E+06	**subarea 2**
Mean Surface Overflow	Q_s (m/yr)	1215.194	552.060	652.507	193.581	115.360	73.193	42.739	19.484	1.771	1428.430	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	1.91E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.002	0.002	0.006	0.011	0.017	0.029	0.063	0.689	0.001	
Inflow Total P	P_i (mg/m^3)	33.05	22.06	23.66	15.99	14.62	13.82	13.16	12.43	11.19	21.95	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	
Decay rate	K_2 =	0.185	0.182	0.183	0.175	0.167	0.158	0.142	0.111	0.022	0.185	
Reaction rate	Nr =	0.006	0.009	0.008	0.018	0.026	0.036	0.053	0.086	0.169	0.003	
Retention Coefficient	Rp =	0.006	0.009	0.008	0.017	0.025	0.034	0.048	0.074	0.128	0.003	
Output concentration		32.85	21.87	23.47	15.72	14.26	13.35	12.52	11.51	9.75	21.87	

Alternative 2 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	9.53E+05	**subarea 3**
Mean Surface Overflow	Q_s (m/yr)	1993.239	905.523	1070.283	317.524	189.221	120.055	70.103	31.959	2.905	2343.002	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	1.16E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.004	0.006	0.010	0.017	0.038	0.420	0.001	
Inflow Total P	P_i (mg/m^3)	32.85	21.87	23.47	15.72	14.26	13.35	12.52	11.51	9.75	21.87	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
Decay rate	K_2 =	0.185	0.184	0.184	0.179	0.174	0.168	0.157	0.132	0.033	0.186	
Reaction rate	Nr =	0.004	0.005	0.005	0.011	0.016	0.023	0.034	0.058	0.137	0.002	
Retention Coefficient	Rp =	0.004	0.005	0.005	0.011	0.016	0.022	0.032	0.052	0.109	0.002	
Output concentration		32.73	21.75	23.36	15.55	14.04	13.06	12.12	10.91	8.69	21.82	

Alternative 2 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	1.13E+06	**subarea 4**
Mean Surface Overflow	Q_s (m/yr)	1680.482	763.439	902.346	267.701	159.530	101.218	59.103	26.944	2.449	1975.364	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	1.38E+06	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.002	0.001	0.005	0.008	0.012	0.021	0.045	0.498	0.001	
Inflow Total P	P_i (mg/m^3)	32.73	21.75	23.36	15.55	14.04	13.06	12.12	10.91	8.69	21.82	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	
Decay rate	K_2 =	0.185	0.183	0.184	0.178	0.172	0.165	0.152	0.125	0.029	0.185	
Reaction rate	Nr =	0.004	0.006	0.006	0.013	0.018	0.026	0.038	0.062	0.126	0.002	
Retention Coefficient	Rp =	0.004	0.006	0.006	0.012	0.018	0.025	0.035	0.055	0.101	0.002	
Output concentration		32.59	21.61	23.22	15.36	13.79	12.74	11.69	10.31	7.81	21.77	

Alternative 2 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	7.96E+05	**subarea 5a**
Mean Surface Overflow	Q_s (m/yr)	2387.364	1084.574	1281.912	380.308	226.636	143.794	83.964	38.278	3.480	2806.287	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	9.71E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.001	0.001	0.001	0.003	0.005	0.008	0.015	0.032	0.351	0.000	
Inflow Total P	P_i (mg/m^3)	32.59	21.61	23.22	15.36	13.79	12.74	11.69	10.31	7.81	21.77	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	
Decay rate	K_2 =	0.186	0.184	0.185	0.180	0.176	0.171	0.161	0.139	0.039	0.186	
Reaction rate	Nr =	0.003	0.004	0.004	0.009	0.013	0.018	0.027	0.046	0.106	0.002	
Retention Coefficient	Rp =	0.003	0.004	0.004	0.009	0.013	0.018	0.026	0.042	0.088	0.002	
Output concentration		32.49	21.52	23.13	15.23	13.61	12.51	11.39	9.88	7.12	21.73	

Alternative 2 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	1.21E+05	**Sump subarea**
Mean Surface Overflow	Q_s (m/yr)	15654.039	7111.591	8405.545	2493.694	1486.059	942.864	550.556	250.989	22.817	18400.930	
Mean Pond Depth	Z (m)	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	
Mean Pond Volume	V_m (m^3)	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	2.96E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.010	0.107	0.000	
Inflow Total P	P_i (mg/m^3)	32.49	21.52	23.13	15.23	13.61	12.51	11.39	9.88	7.12	21.73	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Decay rate	K_2 =	0.187	0.186	0.186	0.186	0.185	0.184	0.182	0.177	0.118	0.187	
Reaction rate	Nr =	0.001	0.001	0.001	0.003	0.004	0.006	0.009	0.017	0.090	0.001	
Retention Coefficient	Rp =	0.001	0.001	0.001	0.003	0.004	0.006	0.009	0.016	0.077	0.001	
Output concentration		32.46	21.49	23.10	15.19	13.56	12.44	11.28	9.71	6.58	21.72	

Alternative 2 - 1994 Data

Date		11/16/1994	11/17/1994	11/18/1994	11/19/1994	11/20/1994	11/21/1994	11/22/1994	11/23/1994	11/24/1994	Max Q (cfs)	
Basin inflow	Q (cfs)	2126.8	966.2	1142.0	338.8	201.9	128.1	74.8	34.1	3.1	2500	
Outflow	Q (m^3/yr)	1.90E+09	8.63E+08	1.02E+09	3.03E+08	1.80E+08	1.14E+08	6.68E+07	3.05E+07	2.77E+06	2.23E+09	
Surface Area	A (m^2)	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	4.38E+05	**subarea 5b**
Mean Surface Overflow	Q_s (m/yr)	4336.932	1970.257	2328.746	690.875	411.711	261.219	152.531	69.536	6.321	5097.955	
Mean Pond Depth	Z (m)	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	
Mean Pond Volume	V_m (m^3)	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	5.34E+05	
Inflow orth P / total P	F_o	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Mean Hydraulic Residence Time	T (yr)	0.000	0.001	0.001	0.002	0.003	0.005	0.008	0.018	0.193	0.000	
Inflow Total P	P_i (mg/m^3)	32.46	21.49	23.10	15.19	13.56	12.44	11.28	9.71	6.58	21.72	
Watershed Area	A_w (m^2)	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	1.86E+08	
Basin/Watershed Area		0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
Decay rate	K_2 =	0.186	0.185	0.186	0.183	0.181	0.178	0.172	0.157	0.060	0.186	
Reaction rate	Nr =	0.002	0.002	0.002	0.005	0.007	0.010	0.015	0.027	0.076	0.001	
Retention Coefficient	Rp =	0.002	0.002	0.002	0.005	0.007	0.010	0.015	0.025	0.067	0.001	
Output concentration		32.40	21.43	23.05	15.11	13.46	12.31	11.11	9.47	6.14	21.70	
Percent P Retained in Impoundment		**2.4%**	**3.5%**	**3.2%**	**6.7%**	**9.7%**	**13.3%**	**18.9%**	**28.8%**	**52.8%**	**1.4%**	
Influent Mass Flowrate	[(mg/s)/(cfs/m3)]	70609.8	21449.6	27179.6	5488.6	3008.3	1819.0	1024.8	453.5	40.3		
Effluent Mass Flowrate	[(mg/s)/(cfs/m3)]	68915.5	20708.4	26322.3	5120.4	2717.3	1577.1	831.3	322.9	19.0		
Flow Weighted Average Initial Concentration	(mg/m^3)	**26.1**										
Flow Weighted Average Final Concentration	(mg/m^3)	**25.2**										
Average Removal	**(%)**	**3.5%**										

APPENDIX E

COST BACKUP INFORMATION

Appendix E

Assumptions for Opinions of Cost for Construction of Internal Levees

Summary of Alternatives (shown on Drawings 2, 3 & 4 of the Dec. 2003 MACTEC Report)

Alternative 1:
Two Internal Levees: 12,200 feet total length
Levee Slope Protection: 4,100 feet total length of revetment (on one slope)

Alternative 2:
One Internal Levee: 8,100 feet total length
Levee Slope Protection: 2,700 feet total length of revetment (on one slope)

Structural and Geotechnical Design and Cost Criteria

Internal levee design criteria to be similar to that for the C-11 impoundment levees presented in Appendix B, Section B.11.6.5 of the USACE Report, as summarized below:

Materials of Construction for Levee Embankment:

- Sand and gravel overburden excavated from the adjacent C-502A canal or seepage canals
- Crushed and processed rock will not be used for internal levee construction (with exception of revetment)
- Revetment material will be as described below under "Slope Protection"
- Road surfacing will not be required at top of levees; area to be vegetated

Foundation Construction: Remove top 18 inches of overburden (existing soil) for full width and lengths of levees

Dewatering: Assume that depth to groundwater is greater than the required depth of excavation for foundation construction and that no dewatering will be required

Seepage Control: Toe drain not required

Slope Protection: Install revetment to protect one or both sides of the internal levees at locations indicated on the Drawings included in the Dec. 2003 MACTEC report. Revetment to consist of 12 inches bedding stone plus 18 inches of riprap from toe of slope to elevation 12 feet above mean sea level (msl). Remaining portions of slopes to be grassed.

Placement and Compaction of Embankment Material: Place soil in 12-inch lifts; compact to 98% of the material's maximum dry density as determined by standard proctor testing.

Excavation: Assume that no rock excavation is required for foundation construction. Use normal excavation equipment. Dispose of excavated material on-site.

Haul Tonnage and Volume Calculation Criteria:
Compaction Factor for Sandy Overburden: 0.85
Swell Factor for Sandy Overburden: 1.10
Unit Weight: 115 pcf

Additional Assumptions

Site Preparation: Assume that all site preparation (including tree clearing, demolition, and other related work) within the area required for construction of internal levees has already been included in the scope of work and costs for the Western C-11 Impoundment construction

Location of Suitable Material:

- Sand and gravel overburden for levee construction obtained from construction of the adjacent C-502A canal or seepage canals. Assumed average haul distance: 3 miles (round trip)
- Revetment material obtained from on-site

Dimensions of Internal Levees:

- Side Slope: 2 (horizontal) to 1 (vertical)
- Height: 10 feet above bottom of the impoundment (top elevation at 16 ft above msl)
- Top Width: 12 feet
- Cross-Sectional Area (not including foundation): 320 cubic feet