ANNEX I
PHOSPHORUS LOADING SPREADSHEET MODEL RESULTS FOR LAKE OKEECHOBEE STORAGE SECTION 203 STUDY ALTERNATIVES 1, 2, and 3

EXECUTIVE SUMMARY

The major goal of the Lake Okeechobee Storage Reservoir Section 203 Study (LOCAR, Project, or Section 203 Study) is to improve the quantity, timing, and distribution of water entering Lake Okeechobee. The Project will improve management of lake water levels, reduce excessive releases of water to the St. Lucie and Caloosahatchee Estuaries, and increase operational flexibility. These goals will be achieved through the aboveground storage of approximately 200,000 acre-feet (ac-ft) of water in a reservoir northwest of Lake Okeechobee.

This Project is not expected to significantly influence the phosphorus (P) load to Lake Okeechobee. To evaluate any effects, the phosphorus loading spreadsheet model (PLSM) was used to estimate P loads to Lake Okeechobee from proposed Project features relative to the Future Without Project (FWO) simulation. In this effort, PLSM is being used to evaluate three alternatives: Alternatives 1, 2, and 3. All alternatives include aboveground reservoirs that are able to accept water from and return water to the lake.

PLSM used the daily Regional Simulation Model Basin flow estimates to calculate P loads for the FWO and Alternatives 1, 2, and 3. These scenarios were compared to evaluate P load changes for the alternatives. PLSM uses conservative estimates to account for uncertainty in reservoir and watershed conditions and to maximize the probability that any differences are captured.

To estimate P loads, a constant concentration was used. Because a single value has not been determined for the FWO condition, a range was used in a sensitivity analysis that encompasses the likely flow-weighted concentration. These values range from 40 micrograms of P per liter (µg P/l^{-}), which is based on the Lake Okeechobee Total Maximum Daily Load of 105 metric tons per year divided by the average annual flows to Lake Okeechobee from water years 1974 to 2016 (2.1 million ac-ft or 2.6 billion cubic meters) to 100 µg P/l, which is the current Upper Kissimmee Sub-watershed flow-weighted mean concentration.

Loads are summed by year and then averaged over the 52-year simulation period (1965 to 2016) to obtain an average annual P load. The average loads for Alternatives 1, 2, and 3 compared to the FWO condition were all less than 1 percent lower. This small decrease is predominantly attributed to the settling of particulate matter from the lake water while in the reservoir, prior to it being recycled back to Lake Okeechobee. These results indicate that the LOCAR Project will not affect P loads to the lake.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I INTRODUCTION

The Lake Okeechobee Storage Reservoir Section 203 Study (LOCAR or Project) will be part of the Comprehensive Everglades Restoration Plan (CERP) once it is authorized by the U.S. Congress under the Water Resources Development Act (WRDA). The goals of LOCAR are to improve the quantity, timing, and distribution of water entering Lake Okeechobee. The Project will assist the management of Lake Okeechobee water levels, reduce excessive releases of water to the St. Lucie and Caloosahatchee Estuaries, and increase operational flexibility. The LOCAR alternatives evaluated in this report are Alternatives 1, 2, and 3 (**Figure I-1**). Each alternative involves the construction of one or two aboveground reservoirs that will provide approximately 200,000 acre-foot (ac-ft) of storage, which can be accepted from and returned to Lake Okeechobee.

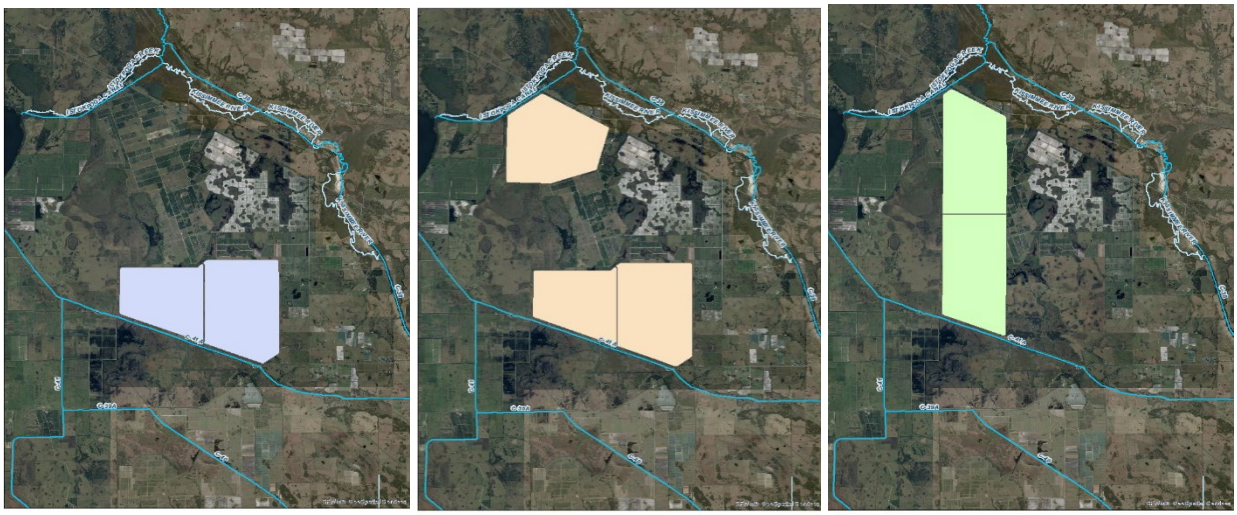


Figure I-1. Project maps of reservoirs for each scenario.

To evaluate the effect of these LOCAR alternatives on phosphorus (P) loads to Lake Okeechobee, a simple P loading spreadsheet model (PLSM; James 2018) was used to quickly estimate the potential P loads from the alternatives. PLSM uses daily simulated flows from alternative scenarios generated by the Regional Simulation Model for Basins tool (RSM-BN; SFWMD 2005a, 2005b) to estimate P loads and evaluate the effect of sub-watershed and features (e.g., reservoirs) on these P loads to the lake. This report evaluates the effect of three alternatives, Alternatives 1, 2, and 3, in comparison to the Future Without Project (FWO).

I.1 Methods

The methods used in this effort followed those documented in James (2018). Proposed reservoirs receive recharge water from the lake and discharge water to the lake. In short, daily flow estimates from the RSM-BN model were used to estimate P loads for three major categories: sub-watersheds, reservoir inflows, and reservoir outflows. The flows and loads of subwatersheds and reservoir outflows to the lake were summed and are reported separately. All categories, with the exception of the reservoir outflows, multiply flow values by a constant P concentration. The daily reservoir P content is defined by the sum of inflows,

outflows, and a daily removal rate defined by a constant settling rate (i.e., 1 meter per year, 0.0027 meter per day) divided by the average water depth. The removal rate is multiplied by the daily storage to develop daily settling of P. The constant for the sub-watersheds are based on a baseline P concentration used for all inflows to features and discharges from sub-watersheds to determine P loads. The FWO scenario and FWO P loads are based on the baseline P concentration.

I.1.1 Features and Scenario P Concentrations

To estimate P loads, a baseline P concentration value was used. Because a single value has not been determined for the FWO condition, a range was used in a sensitivity analysis that encompasses the likely flow-weighted P concentration that will occur. These values range from 40 micrograms of P per liter (μg P/l^{-1}), which is based on the Lake Okeechobee Total Maximum Daily Load (TMDL) of 105 metric tons per year (FDEP 2001) divided by the average annual flows to Lake Okeechobee from water years 1974 to 2016 (i.e., 2.1 million ac-ft or 2.6 billion cubic meters; Sharfstein and Zhang 2017) to 100 μg P/l^{-1}, which is the Upper Kissimmee Sub-watershed flow-weighted mean concentration (Sharfstein and Zhang 2017). Two intermediate values of 60 and 80 μg P/l^{-1} were also included. These values were applied to all net watershed discharges to the lake.

I.1.2 Annual Average P Loads

For each alternative and baseline, daily net P loads and flows were summed by year, and the 52-year average was determined. These were compared to the average annual FWO scenario for the same baseline. Flow-weighted mean P concentration of the alternatives were used as a check for calculation errors and comparison against the FWO scenario estimates. Only the Indian Prairie/Istokpoga and Kissimmee Sub-watersheds were included in this analysis.

I.2 Results

The estimated FWO average annual flow and P load for the assessed sub-watersheds was 1.6 million ac-ft per year and 78.9 metric tons per year, respectively, assuming a P concentration of 40 μg P/l^{-1} (**Table I-1** and **Table I-2**). Using this baseline concentration, the total flows and loads for the reservoirs were 1.59 million ac-ft per year and 78.5 tons per year (Alternative 1); 1.59 million ac-ft per year and 78.3 tons per year (Alternative 2); and 1.59 million ac-ft per year and 78.5 tons per year (Alternative 3).

The changes in flows represented by the three alternatives are shown in **Figure I-2**, and predict a moderate reduction of flow to Lake Okeechobee by 9,000 to 13,000 ac-ft, or 0.5 to 0.8 percent (**Table I-1**).

Table I-1. Average Annual Flow Volume (1965–2016) for the FWO and Alternatives 1, 2, and 3.

Alternative	Flow from Watershed Independent of Project (1,000 ac-ft) [1]	Recycled Reservoir Input (1,000 ac-ft) [2]	Percent Difference from FWO
FWO	1,600	-	-
Alternative 1	1,591	46.90	-0.5%
Alternative 2	1,587	55.94	-0.8%
Alternative 3	1,590	56.79	-0.6%

[1/] Includes Indian Prairie/Istokpoga and Kissimmee River Sub-watersheds.
[2/] Recycled water is already included in Lake flow calculations and is therefore not an additional flow to the lake.
ac-ft–acre-foot; FWO–Future Without Project

Table I-2. Average Annual (1965–2016) P Load Estimates for the FWO and Alternatives 1, 2, and 3.

Alternative	Load from Watershed Independent of Project[1] (metric tons)	Recycled Reservoir Input (metric tons)[2]	Percent Difference from FWO
FWO	78.9		
Alternative 1	78.5	2.2	-0.5%
Alternative 2	78.3	2.8	-0.8%
Alternative 3	78.5	2.5	-0.6%

Note: Assumes a baseline concentration of 40 micrograms phosphorous per liter.
1/ Includes Indian Prairie/Istokpoga and Kissimmee River Sub-watersheds.
2/ Recycled water is already included in Lake P load calculations and is therefore not an additional load to the lake.
FWO–Future Without Project; P–phosphorous

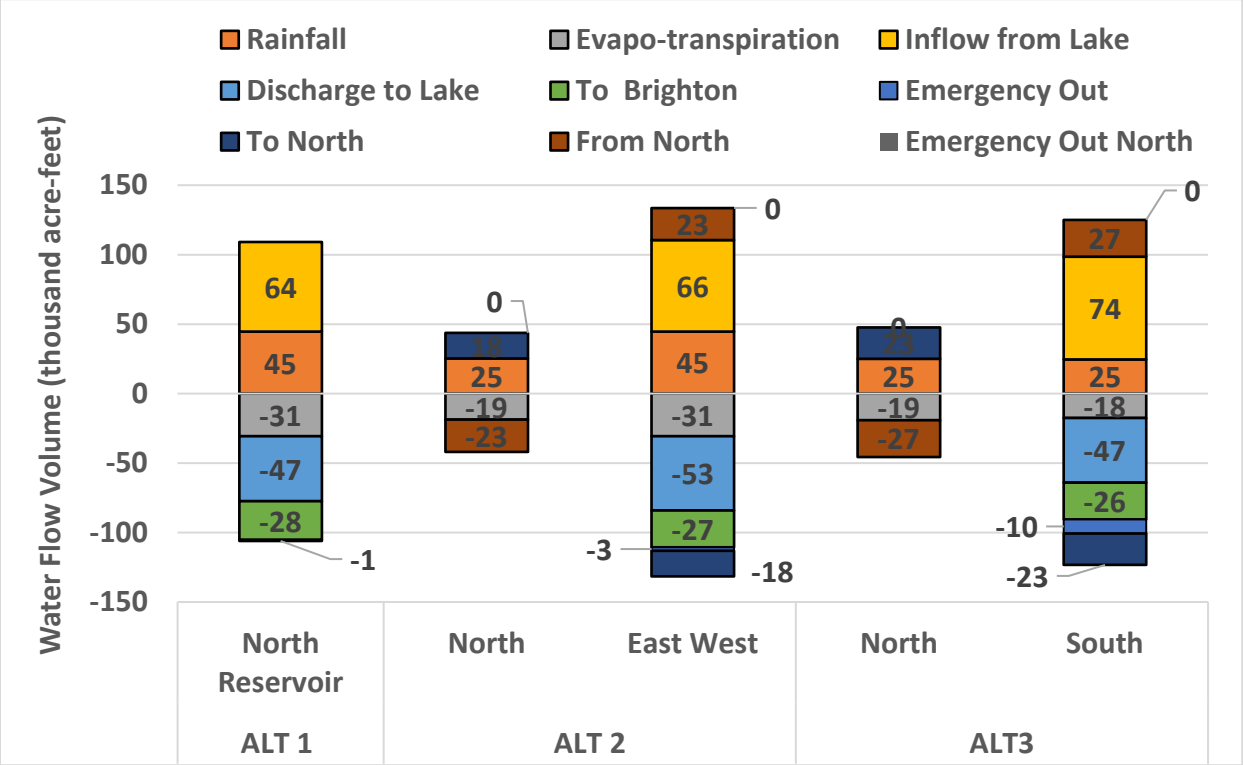


Figure I-2. Average annual volume flows of the Alternative (ALT) 1, 2, and 3 reservoirs.

Given the baseline concentration of 40 µg P/l^{-1}, Alternatives 1, 2, and 3 result in small reduction of loads between 0.4 and 0.6 metric tons per year, compared to the FWO scenario (**Table I-2; Figure I-3**). This is a 0.5 to 0.8 percent decrease and is predominantly attributed to the settling of particulate matter in the reservoir of water recycled from Lake Okeechobee.

Increasing the baseline P concentration from 40, 60, and 80, to 100 µg P/l^{-1} results in increased loads (**Figure I-4**), but the percent change in the loads for each alternative compared to the FWO remains similar. The differences are very small (i.e., less than 1 percent; **Figure I-5**).

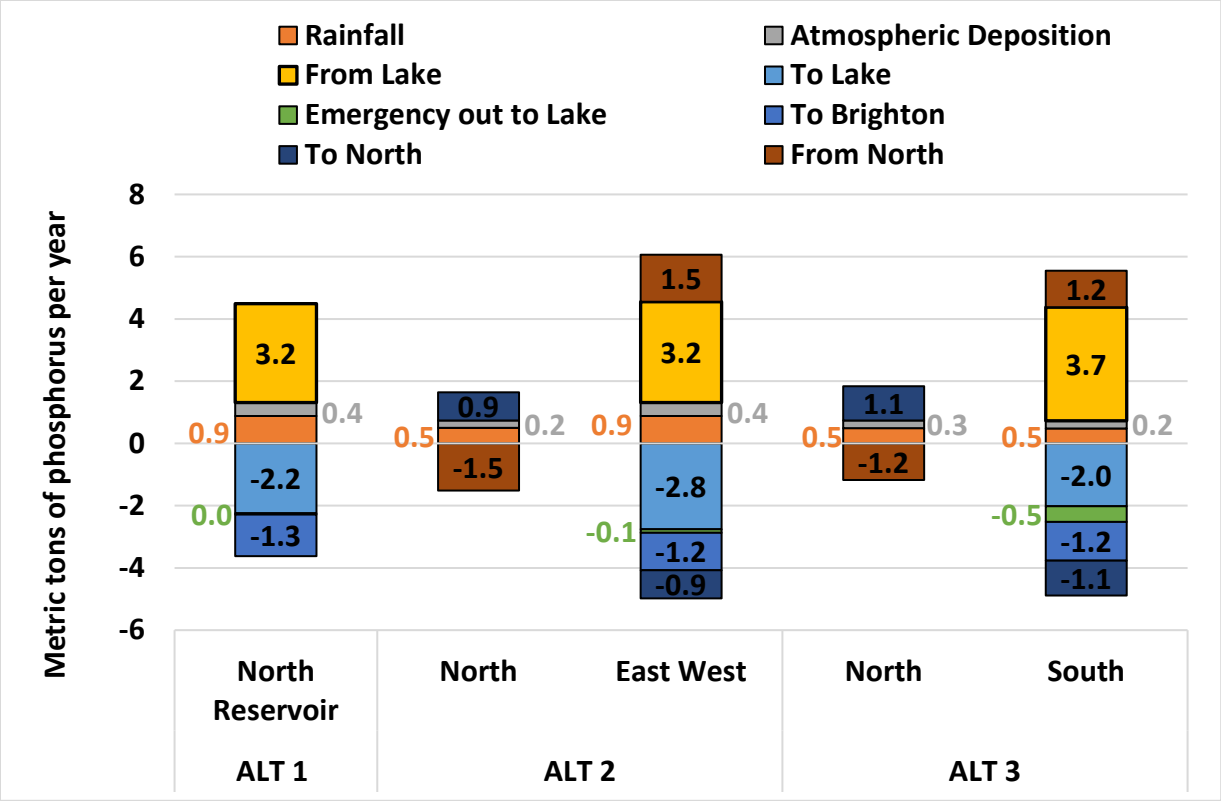
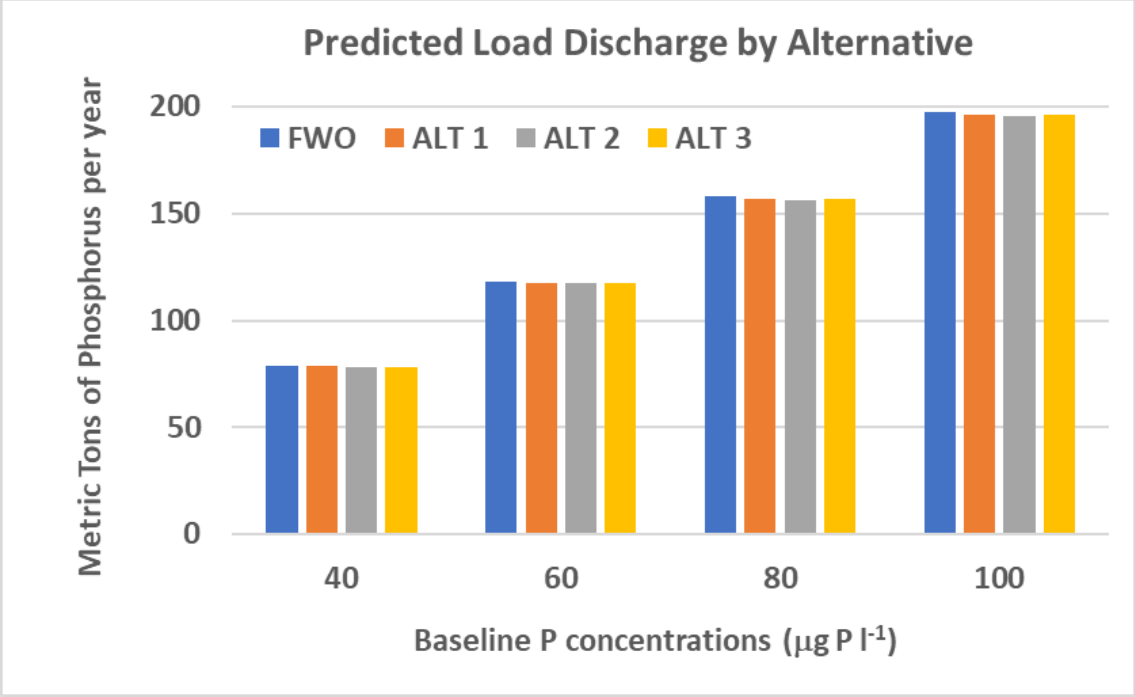
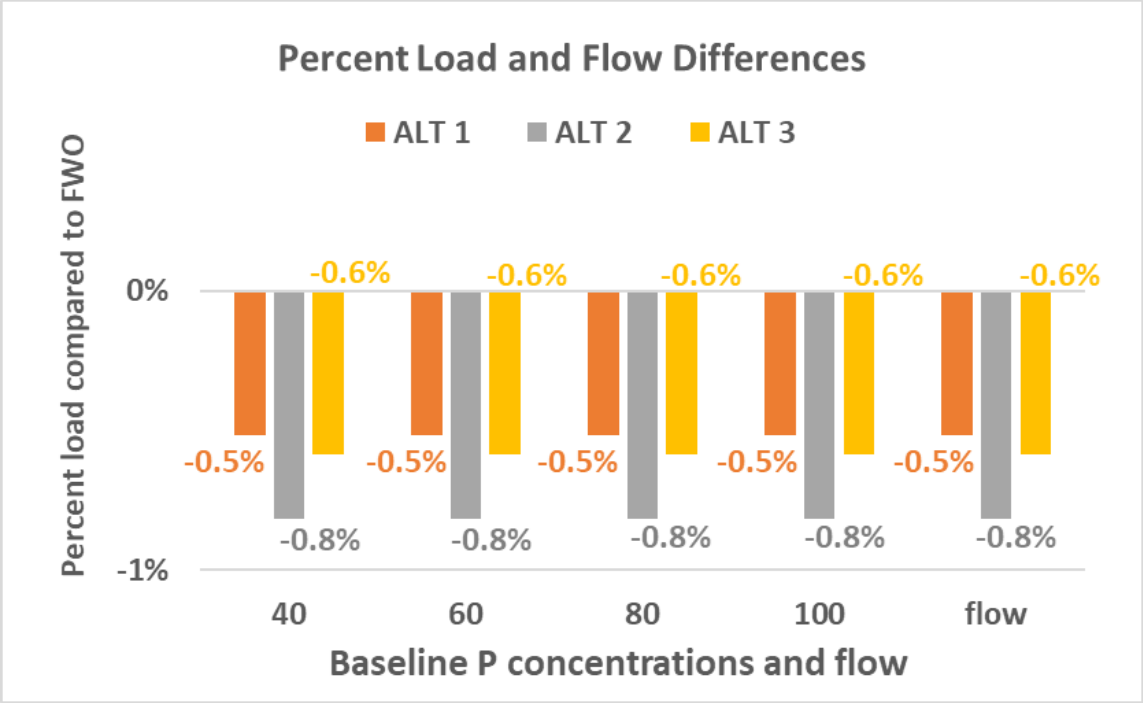


Figure I-3. Average annual phosphorus loads to and from reservoirs in Alternatives (ALT) 1, 2, and 3.



Note: Includes Indian Prairie/Istokpoga and Kissimmee River Sub-watersheds.

Figure I-4. Estimated phosphorous loads resulting from LOCAR alternatives.



Note: Includes Indian Prairie/Istokpoga and Kissimmee River Sub-watersheds.

Figure I-5. Estimated percent phosphorous load change resulting from Alternatives (ALT) 1, 2, and 3 compared to the FWO condition.

I.3 Discussion

Given the conservative assumptions of PLSM, the three alternatives will not affect TP load to Lake Okeechobee, as compared to the FWO condition. Water is being recirculated from the lake to the reservoir and back to the lake, and therefore any reduction in flows and loads are predicted to be small.

I.4 Conclusions

The PLSM indicates P loads will decrease slightly with all alternatives. It is important to note that the reduction in P load is predominantly attributed to the settling of particulates being drawn from Lake Okeechobee downstream of S65E to be stored in the reservoir. Water will be returned to the Lake during dry times or when water is needed in the system. Water quality will therefore be influenced by residence time and water levels within the reservoir, as well as antecedent filling or discharge profiles. Despite the possibility of short-term fluctuations in phosphorus concentrations, conservative estimates over the long-term predict a smallP load reduction and suggest LOCAR will not negatively affect P Load to the lake. Additionally, the PLSM indicated all the alternatives provide water supply benefits.

I.5 References

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