ANNEX E
RECOVER REPORTS

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E.0 REPORTS PROVIDED BY RECOVER TO SUPPORT THE PLAN

E.1 INTRODUCTION AND PURPOSE OF THE EVALUATION

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project Team has identified their final array of alternative plans and requested that Restoration Coordination and Verification (RECOVER) conduct a system-wide evaluation of the alternative plans being considered. The role of RECOVER is to organize and apply scientific and technical information in ways that are most effective in supporting the objectives of the Comprehensive Everglades Restoration Plan (CERP or Comprehensive Plan). One of the primary missions of RECOVER is to work with the project team to evaluate and maximize the contribution made by each project to the system-wide performance of the CERP. The RECOVER Evaluation Team (ET) is charged with the responsibility of conducting system-wide evaluations.

The ET is an interagency and interdisciplinary scientific and technical team charged with developing and using performance measures for evaluating alternative plans developed for project implementation reports (PIRs). The purposes of system-wide evaluations are to (1) inform the project team of the compatibility of proposed project alternative plans with regional CERP restoration goals and performance expectations; (2) determine the performance of each alternative plan toward meeting system-wide goals and objectives through the use of system-wide performance measures, project performance measures, and best professional judgment; (3) identify improvements for project performance that would improve its system-wide performance, and (4) provide decision-makers required information regarding system-wide performance expectations of specific projects.

The type of RECOVER evaluations may vary depending on the applied tools, new information that may have become available, the project's relationship to the Central and Southern Florida (C&SF) Project, or the project implementation schedule. In the case of hydrologically isolated projects, RECOVER may not be able to rely on regional modeling results for their evaluations. For these projects, the scope of RECOVER's evaluations may be limited to reviewing project-level model results and applying best professional judgment.

E.2 PROJECT BACKGROUND AND GENERAL DESCRIPTION OF ALTERNATIVE PLANS

E.2.1 Project Goals and Objectives

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project is part of the CERP as authorized by the Water Resources Development Act (WRDA) 2000 (U.S. Congress 2000). The goal of the Caloosahatchee River (C-43) West Basin

Storage Reservoir Project is to capture Caloosahatchee River (C-43) Basin runoff and releases from Lake Okeechobee. The project's primary purpose will be to provide environmental water supply deliveries to the Caloosahatchee Estuary and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. The objectives of this project, as identified in the Caloosahatchee River (C-43) West Basin Storage Reservoir Project Feasibility Scoping Meeting Documentation (USACE and SFWMD 2005) are as follows:

- Improve the quantity, timing, and distribution of freshwater flows to the Caloosahatchee Estuary by capturing runoff from the Caloosahatchee Basin and Lake Okeechobee releases.
- Improve water quality in the Caloosahatchee Estuary by reducing nutrient inflows from the Caloosahatchee Basin.
- Improve salinity balance in the Caloosahatchee Estuary for estuarine organisms. Reduce the spatial extent and duration of occurrences of extreme low and high salinities.
- Improve the spatial extent and functional quality of habitat for estuarine biota.
- Increase plant and animal diversity and abundance, particularly increasing the spatial extent of SAV.
- Conserve and protect water resources to ensure sustainability of economic and natural resources.
- Ensure availability of ground and surface water supplies for environmental resources while protecting existing legal sources of water for agricultural and urban uses.
- Maintain existing level of service for flood protection in the project area.
- Provide recreational, tourism, and environmental education opportunities.

E.2.2 Project Background

The overall purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project can best be understood in terms of its contribution and relationship to the overarching purpose of restoring the South Florida ecosystem. The Caloosahatchee River (C-43) West Basin Storage Reservoir Project will contribute to South Florida ecosystem restoration through features to increase the availability of water for the natural environment (i.e., the Caloosahatchee Estuary) to enable a more natural salinity regime for the estuary. By mitigating low flows to the estuary during the dry season (November-May) and extreme high flows during the wet season (June-October), natural salinity ranges suitable to improve habitat suitability and increase biological diversity will be established. Additional water made available by the project could supply urban and agricultural users.

The Caloosahatchee River (C-43) West Basin Storage Reservoir is intended to capture local basin runoff and Lake Okeechobee (LO) regulatory releases. The reservoirs will be used to attenuate flood conditions in the local basin, provide estuarine water deliveries, and potentially reduce nutrient impacts of runoff to the estuaries (USACE and SFWMD 1999). Through additional information development performed for the Initial CERP Update (ICU), it was determined that land-use and runoff calculations performed for the Caloosahatchee River (C-43) basin during the Restudy grossly overestimated the amount of runoff available in the local basin, while underestimating the urban and agricultural water demands. In addition to these updates, the low flow target to maintain acceptable salinities in the Caloosahatchee Estuary were updated from 300 cfs to 450 cfs, and deliveries from Lake Okeechobee were capped at Restudy-like levels. The combination of all these changes had the unintended consequence of requiring more environmental water deliveries from a system now producing less local runoff and shouldering increased agricultural and urban demand, while being unable to increase the amount of water supplied by Lake Okeechobee. Cost estimates for potential solutions to the above-listed problems were estimated to exceed the cost containment cap for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project. Consequently, the C-43 BSR Project was split into two separate PIRs. The first PIR, termed Caloosahatchee River (C-43) West Basin Storage Reservoir Project, consists of a separable western storage reservoir at the Berry Groves site to address the needs of the lower Caloosahatchee River (C-43) basin and the Caloosahatchee Estuary. This PIR will primarily address estuarine freshwater flows and will only incidentally address water quality effects regarding sedimentation during reservoir retention. A subsequent PIR, consists of the remaining reservoirs identified in the original project, primarily addressing the needs of the upper Caloosahatchee River (C-43) basin, including water quality issues within the basin. The Caloosahatchee River (C-43) West Basin Storage Reservoir project is on a compressed timescale to coordinate with SFWMD Accelerate Program activities prior to the projected beginning of construction in June 2007. It will include formulation, evaluation, and justification of the separable western storage reservoir while acknowledging that the project is a part of a more comprehensive plan for the Caloosahatchee River (C-43) Basin.

E.2.3 General Description of Alternative Plans

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project identified their final array of project alternative plans. Each alternative plan that is being considered includes a reservoir to store and release water to the estuary. The configurations and operational plans that make up the final suite of alternative plans are detailed in ***Table E-1***.

TABLE E-1: SUMMARY OF CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT ALTERNATIVE PLANS

Alternative Name	Reservoir			Pump Size (cfs)	Operating Scheme
	Size (acres)	Depth (ft)	Storage Capacity (ac-ft)		
Alt2	10,000	10	100,000	1500	PIR
Alt3a	10,000	17	170,000	1500	A8
Alt 3b	10,000	17	170,000	1500	PIR
Alt 3c	10,000	17	170,000	3800	PIR
Alt 4	10,000	22	220,000	3800	PIR

E.3 EVALUATION METHODOLOGY AND INFORMATION CONSIDERED

This section outlines the methodology used by RECOVER to conduct its system-wide evaluation of alternative plans. It also describes the modeling and technical information considered by RECOVER to evaluate the potential system-wide effects of the project. RECOVER's analyses of the information presented and implications to the system are presented in later sections of this report.

Because the Caloosahatchee River (C-43) West Basin Storage Reservoir Project is essentially outside the spatial resolution and domain of the South Florida Water Management Model (SFWMM), the MIKESHE model was developed and used to dynamically simulate the entire land phase of the hydrologic cycle within the Caloosahatchee River (C-43) basin. Because the MIKESHE model and the SFWMM are not dynamically linked, the two models operate separately. Essentially, the Caloosahatchee River (C-43) West Basin Storage Reservoir Project receives a set volume of water from the SFWMM boundary based on the planning assumptions modeled in the 2050RD condition. The MIKESHE model then uses these boundary conditions and models the individual alternative plans for the western reservoir. The MIKESHE daily output for the S-79 structure was used to evaluate the project's performance using the CERP system-wide performance measure NE-3: Caloosahatchee salinity envelope (http://www.evergladesplan.org/pm/recover/recover_docs/et/ne-03.pdf).

Because the SFWMM essentially provides a pass-off volume of water to the MIKESHE model to manage within the local basin, conditions within the rest of the system remained unchanged based on changes in alternative plans. For this reason, RECOVER focused its evaluation on the project's performance within the Caloosahatchee Estuary, and worked in conjunction with the project's environmental sub-team to apply the hydrologic performance measure and interpret habitat suitability indices (HSI) output developed by the project team. RECOVER conducted its evaluation based on the following SFWMM and MIKESHE scenarios:

- 2000 Existing Condition using revised deliveries to the Caloosahatchee basin (2000RD)
- 2050 Future without CERP Condition using revised deliveries to the Caloosahatchee basin (2050RD)
- 2050 Future without Project (FWO) Condition using the MIKESHE model (2050FWO)
- 2050 Future Condition with each alternative in place with the rest of CERP using the MIKESHE model (Alt2, Alt3a, Alt3b, Alt3c, and Alt 4)

RECOVER recognizes that the West Basin Storage Reservoir Project Team will likely perform additional model runs during refinement of their alternatives leading up to their alternative formulation briefing. When available, RECOVER will review these additional model results and provide modified and/or additional comments to the Project Team on alternative plan performance where appropriate.

E.4 CONSISTENCY WITH THE COMPREHENSIVE PLAN

The planning objectives developed for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project are generally consistent with the objectives of the Comprehensive Plan (USACE and SFWMD 1999). The planning goal of this project is to address the declining health of Caloosahatchee River and Estuary ecosystems by improving water deliveries to the estuary to reduce excessive high flows during wet season and increase the availability of water for the estuarine system during the dry season to provide a salinity range that is suitable for a healthy ecosystem that promotes estuarine habitat, increased fish and wildlife, and biological diversity. After estuarine system needs are met, any additional water could supply urban and agricultural needs. The twelve objectives developed for the Project presented in ***Table E-2*** directly correspond to specific CERP goal(s) contained in the Central and Southern Florida Project Comprehensive Review Study Final Integrated Feasibility Report and Programmatic Environmental Impact Statement (USACE and SFWMD 1999).

TABLE E-2: SUMMARY OF CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT OBJECTIVES AND CORRESPONDING CERP OBJECTIVES

CERP Goal: Restore ecologic values by increasing habitat and functional quality and improving native plant and animal species abundance and diversity
West Basin Storage Reservoir Project Objectives:
▪ Improve the quantity, timing, and distribution of freshwater flows to the Caloosahatchee Estuary by capturing runoff from the Caloosahatchee Basin and Lake Okeechobee releases.
▪ Improve water quality in the Caloosahatchee Estuary by reducing nutrient inflows from the Caloosahatchee Basin.
▪ Improve salinity balance in the Caloosahatchee Estuary for estuarine organisms. Reduce the spatial extent and duration of occurrences of extreme low and high salinities.
▪ Improve the spatial extent and functional quality of habitat for estuarine biota.
CERP Goal: Enhance economic values and social well being
West Basin Storage Reservoir Project Objectives:
▪ Conserve and protect water resources to ensure sustainability of economic and natural resources.
▪ Ensure availability of ground and surface water supplies for environmental resources while protecting existing legal sources of water for agricultural and urban uses.
▪ Maintain existing level of service for flood protection in the project area.
▪ Provide recreational, tourism, and environmental education opportunities

E.5 SYSTEM-WIDE PERFORMANCE OF ALTERNATIVE PLANS

The following sections summarize performance of the project alternatives using the methodology described in Section E.3 of this report.

E.5.1 Caloosahatchee Estuary

RECOVER's review of alternative plans focused on freshwater discharges from the Caloosahatchee River (C-43 canal) at the S-79 structure. Based on these analyses, the project will provide substantial benefits to the area.

The CERP system-wide Caloosahatchee Estuary salinity envelope performance measure, NE-3, targets a mean monthly inflow between 450 and 2800 cfs during all months, with a low flow target of no months during October to July when the mean monthly inflow from the Caloosahatchee watershed, as measured at S-79, falls below a low flow limit of 450 cfs and the high flow target is no months with mean monthly flow greater than 2800 cfs, as measured at the S-79, from Lake Okeechobee regulatory releases in combination with flows from the Caloosahatchee River (C-43) basin. These predictive performance targets are summarized in ***Table E-3***. A reduction in the number of low flow and high flow events and a reduction in the frequency and duration of high and low flow events is required to show improvement over the base conditions.

TABLE E-3: SUMMARY OF CERP SYSTEM-WIDE PERFORMANCE MEASURE NE-3 PREDICTIVE TARGETS

Performance Metric	Target
Low Flow Events	
Mean monthly flow at S-79 <450 cfs (July-October)	0
Number of consecutive months mean monthly flow at S-79 < 450cfs	Alternative with fewest consecutive months is best
Number of consecutive years with mean monthly flows at S-79 < 450 cfs	Alternative with fewest consecutive years is best
S-79 Flow Distribution	
Percent of mean monthly flows at S-79 450-800 cfs	75%
Percent of mean monthly flows at S-79 800-2800 cfs	25%
Moderate and Extreme High Flow Events	
Mean monthly flows at S-79 > 2800 cfs	0 (especially March-October)
Mean monthly flows at S-79 > 4500 cfs	0 (especially March-October)
Lake Okeechobee Regulatory Releases (measured at S-77RG)	
Number of days with LO regulatory releases	0
Daily volume of LO regulatory releases	0
Total volume of LO regulatory releases	0

E.5.1.1 Low Flow Events (<450 cfs)

The target of no flows less than 450 cfs especially between October and July has been found to be ecologically significant to valued ecosystem components (VECs) within the estuary, primarily for submerged aquatic vegetation (SAV) and the American oyster. The health of these VECs is crucial to maintaining the ecological structure and function of the estuary by providing food, living space, and foraging sites for other naturally occurring estuarine species (RECOVER 2006). Performance between October and July, corresponding to the dry season, is especially important to the health and stability of SAV communities within the estuary. An important upper estuarine feature is the freshwater-brackish submerged grass, *Vallisneria americana* (tape grass), which when present is located near the shoreline in the upper estuary to a depth of about 1.0 m (Hoffacker et al. 1994; Chamberlain and Doering 1998). *Vallisneria americana* is the dominant type of SAV in the upper Caloosahatchee Estuary and occurs in well-defined beds in shallow water. *Vallisneria americana* is thought to be an important habitat for a variety of freshwater and estuarine invertebrate and vertebrate species, including some commercially and recreationally important fishes (Bortone and Turpin 1999). Additionally, it can serve as a food source for the Florida manatee. *Vallisneria americana* is more sensitive to low freshwater flows and high salinities than the most common higher salinity grasses in the Caloosahatchee Estuary such as shoal grass (*Halodule wrightii*), turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*). During times of extended low flow conditions, when salinity is too high, *Vallisneria*

americana becomes very sparse and can disappear completely (Chamberlain et al. 1995; Doering et al. 2002; SFWMD 2000). By reducing or eliminating low flow events, high salinities are reduced supporting greater *Vallisneria americana* beds and their associated ecological function.

Volety et al. (2003) has demonstrated the importance of the American oyster (*Crassostrea virginica)* as a VEC in the Caloosahatchee Estuary. A greater abundance of decapods and fishes are associated with clusters of live oyster compared to dead-articulated clusters, while the structure provided by both living and dead oyster shells supports a greater abundance than no shells. Species richness and dominance are higher for samples with oyster clusters (dead or live) compared to controls with no oyster shell. While high flow events (i.e., low salinities) are more detrimental to oysters than low flow events (i.e., high salinities), extended low flows can negatively impact oysters by making them prone to disease and predation. Low flow events will increase salinities in areas normally associated with lower salinity, and result in the migration of marine predators and pests. Oyster spat that recruit to downstream areas will also be exposed to higher salinity and heavy predation pressure resulting in very little survival (Volety et al. 2003). Infection by the oyster pathogen, *Perkinsus marinus*, increases during higher salinity and temperature conditions. Field studies by Volety et al. (2003) determined that the prevalence of infection is high when salinities are high due to low flow. Reducing or eliminating low flow events with short pulses of freshwater inflow can greatly benefit oyster populations by killing predators, such as the southern oyster drill and the whelk and reducing *Perkinsus marinus* infection.

Each of the alternatives evaluated demonstrates a decrease in the number of months when flows through the S-79 structure are less than 450 cfs between October and July (***Figure E-1***). These decreases range from 8% of the period of record (POR) for Alt2 to 21% of the POR for Alt3c and Alt4 (***Table E-4***). With regard to the target for this metric, 0% of the POR, alternatives Alt3c and Alt4 perform best. When the monthly distribution of these events is evaluated, differences among the alternatives' performance is more easily observed. By focusing on the heart of the dry season, between March and June, the differences among alternatives becomes apparent. While the largest decreases in damaging low flow events during this time period occur under alternatives Alt3c and Alt4, alternatives Alt2 and Alt3a do not show substantial decreases over the FWO condition (***Figure E-2***).

TABLE E-4: MEAN MONTHLY FLOW EVENTS <450 CFS AT THE S-79 STRUCTURE OCTOBER TO JULY

	Number of Events	Percent POR
Target	0	0%
2050FWO	42	39%
Alt2	33	31%
Alt3a	32	30%
Alt3b	30	28%
Alt3c	19	18%
Alt4	19	18%

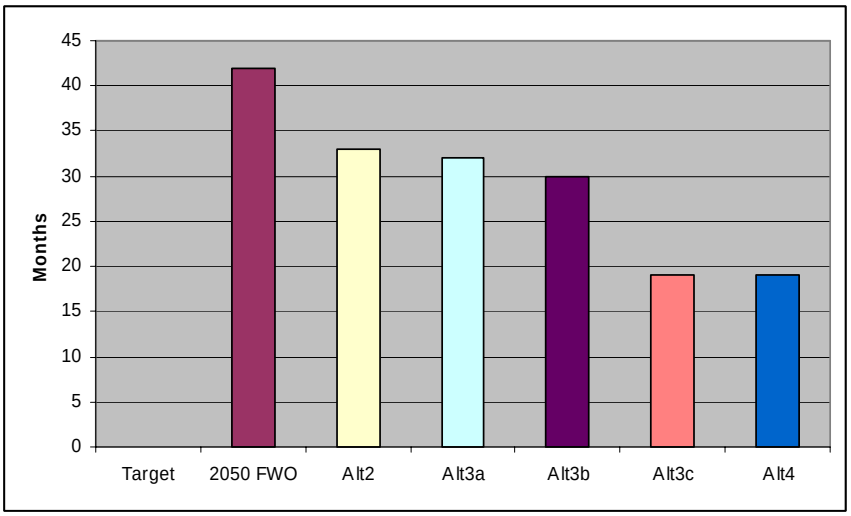

FIGURE E-1: NUMBER OF MEAN MONTHLY FLOW EVENTS LESS THAN 450 CFS OCTOBER TO JULY

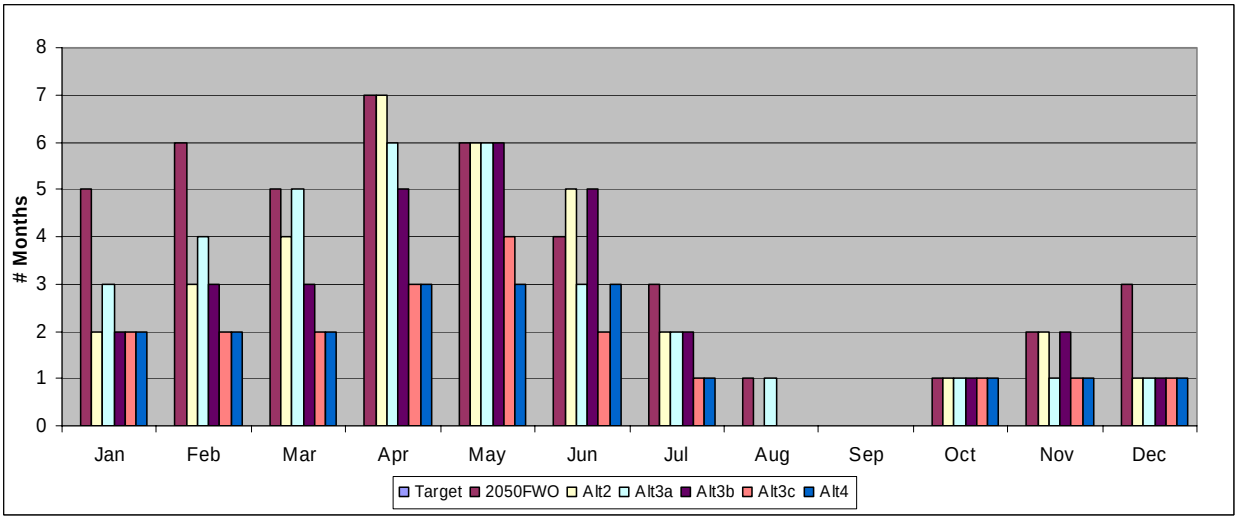

FIGURE E-2: DISTRIBUTION OF MEAN MONTHLY FLOWS LESS THAN 450CFS

E.5.1.2 Flow Distribution at S-79

The target of 75% of S-79 flows between 450-800 cfs and most of the remaining inflow between 800-2800 cfs is important for protecting and restoring estuarine resources while promoting species abundance and diversity (RECOVER 2006). Each of the alternatives increases the number of months where flow is within the desired envelope (***Table E-5*** and ***Figure E-3***). Alternatives Alt3c and Alt4 provide the greatest percentage of time within the desired flow envelope at 82% of the POR. RECOVER also evaluated the alternatives' performance based on mean weekly flows through the S-79 structure. Using this method, the ranking of alternative performance remained unchanged with alternatives. Alt3c and Alt4 again provide the best performance at 82% and 84% of the POR respectively ***Table E-6*** and ***Figure E-4.***

TABLE E-5: MEAN MONTHLY DISTRIBUTION OF FLOWS FROM S-79

	450-800 cfs	800-2800 cfs	%POR in Desired Envelope
Target	75.0%	25.0%	100.0%
2050FWO	25.0%	25.9%	50.9%
Alt2	42.6%	25.0%	67.6%
Alt3a	51.9%	15.7%	67.6%
Alt3b	45.4%	24.1%	69.4%
Alt3c	55.6%	26.9%	82.4%
Alt4	55.6%	26.9%	82.4%

TABLE E-6: MEAN WEEKLY DISTRIBUTION OF FLOWS FROM S-79

	450-800 cfs	800-2800 cfs	%POR in Desired Envelope
Target	75.0%	24.6%	99.6%
2050FWO	23.7%	21.8%	45.5%
Alt2	44.9%	23.1%	67.9%
Alt3a	47.9%	16.2%	64.1%
Alt3b	50.4%	24.4%	74.8%
Alt3c	59.4%	22.9%	82.3%
Alt4	60.7%	23.1%	83.8%

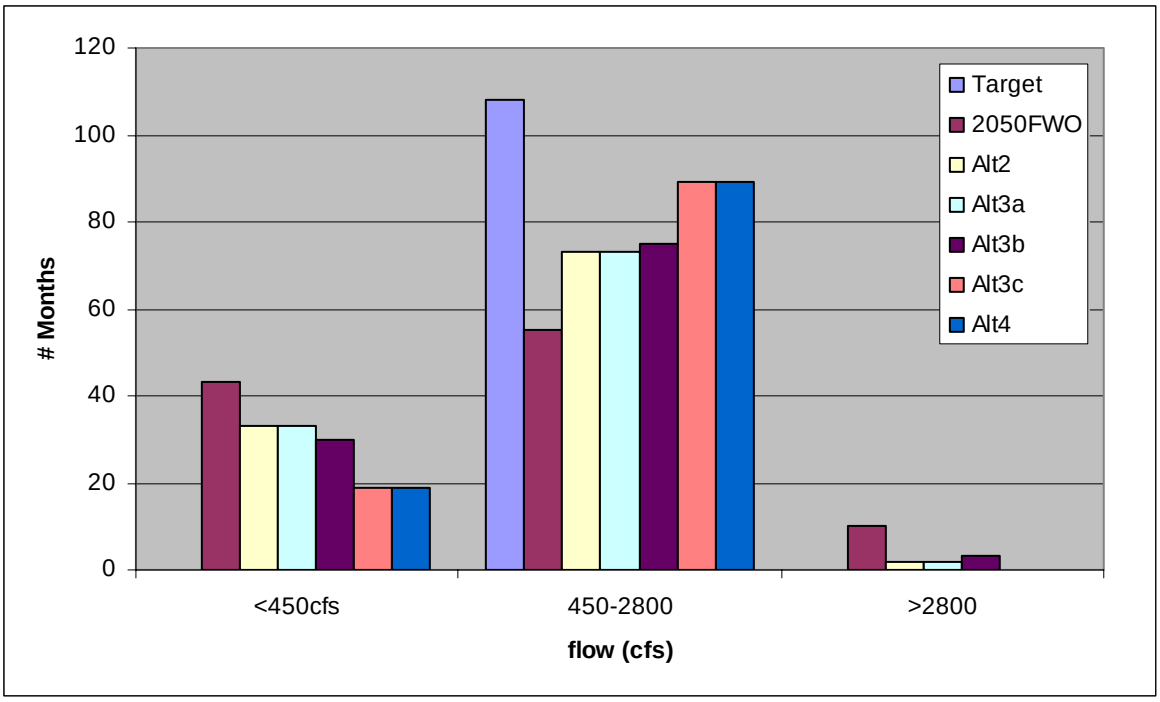

FIGURE E-3: MEAN MONTHLY FLOWS AT S-79 WITHIN THE DESIRABLE 450-2800 CFS FLOW RANGE

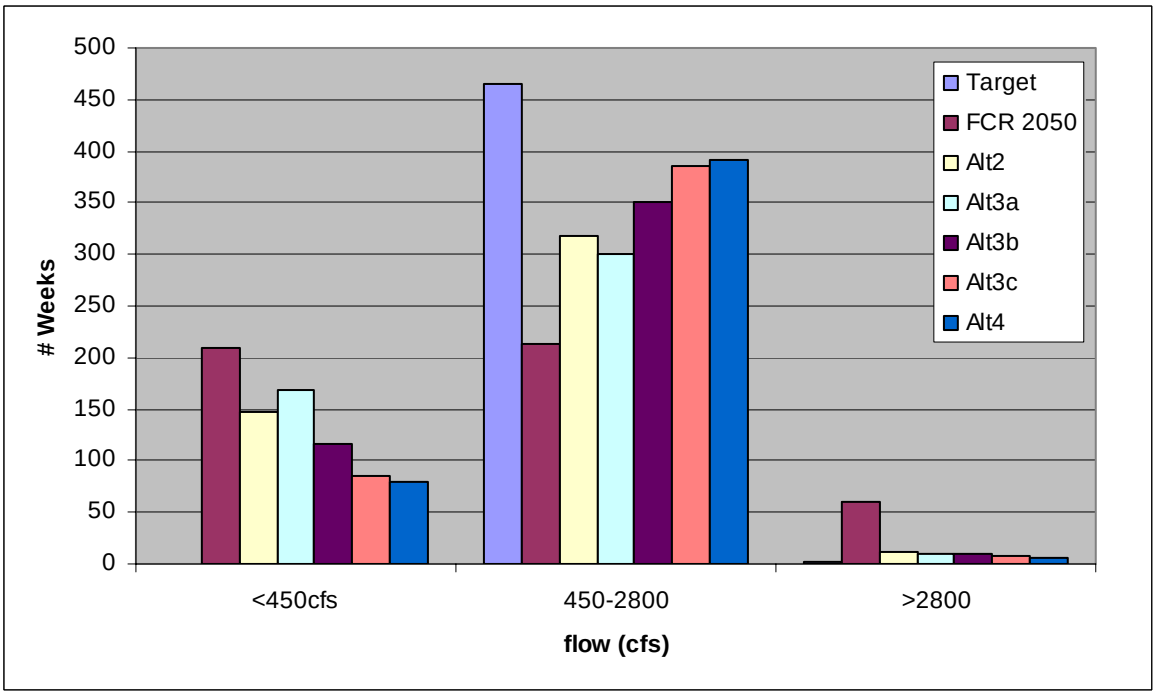

FIGURE E-4: MEAN WEEKLY FLOWS AT S-79 WITHIN THE DESIRABLE 450-2800 CFS FLOW RANGE

To understand any additional improvements in flow distributions, RECOVER evaluated the changes in seasonal flow distributions for mean monthly flows. The increases in the number of desirable flows that occur during the March-October period have been identified as most beneficial to indicator species communities in the Caloosahatchee Estuary with regard to SAV and juvenile oyster recruitment and survival. As with the previous analyses, Alt3c and Alt4 provide the largest increase in the number of months with flows within the desired envelope (***Figure E-5***).

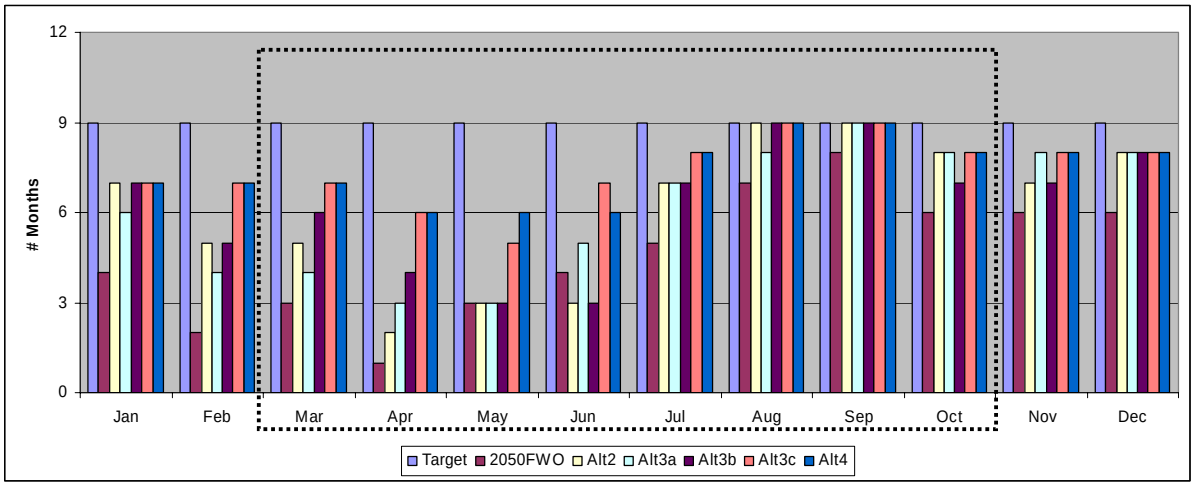

FIGURE E-5: SEASONAL MEAN MONTHLY FLOWS WITHIN THE DESIRABLE 450-2800 CFS FLOW RANGE

E.5.1.3 Moderate and Extreme High Flow Events

Moderate and extreme high flow events in the Caloosahatchee Estuary (>2800 cfs and >4500 cfs, respectively) directly impact estuarine salinities and ecosystem indicators such as the American oyster and SAV. Reduction in these high volume releases, especially during the period from March to October, may lead to decreases in mass mortality (salinity < 3 ppt) as well as poor spat production and excessive valve closure (salinity < 14ppt) in the oyster population (RECOVER 2006). Oysters are particularly susceptible to high flows that drastically lower salinity levels during the spawning season. One key component of spawning success is the requirement of salinities of approximately 7.5 ppt or greater (Sellers and Stanley 1984, Volety et al 2003). High flow events (flows > 2800 cfs, i.e., lower salinities) have a much greater impact on oysters than low flow events (i.e., higher salinities) as these inhibit reproduction and recruitment. This is exacerbated as oyster life spans are short and the effects of missed spawning opportunities prevent restoration of healthy populations. Optimum oyster ranges for physiological purposes, food abundance, and stenohaline predator avoidance is 10 to 20 ppt (Mazzoti et al. 2005). These salinities and flows have been corroborated by monitoring at S-79 structure where monthly flow volumes of 87.2 to 196 thousand ac-ft create salinities of less than 7.5 ppt. These flow volumes equate to mean monthly flows of 2800 cfs.

All alternatives measurably reduce the number of months and number of consecutive months where high flow events occurred. All alternatives substantially reduced the number of months with flows greater than 2800 cfs and completely eliminated flows greater than 4500 cfs, creating favorable conditions for the American oyster. Alternatives Alt3c and Alt4 provided the best performance and eliminated all flows greater than 2800 cfs (***Table E-7)***.

TABLE E-7: SUMMARY OF MODERATE AND EXTREME HIGH MEAN MONTHLY FLOWS

Alternative	Months 2800-4500 cfs	Percent Change	Months >4500 cfs	Percent Change
Target	0		0	
2050FWO	7		3	
Alt2	2	-71%	0	-100%
Alt3A	2	-71%	0	-100%
Alt3B	3	-57%	0	-100%
Alt3C	0	-100%	0	-100%
Alt4	0	-100%	0	-100%

Note: Percent change indicates difference between the modeled alternative and the 2050 FWO condition.

To demonstrate the additional differences among alternative plans in preventing moderate high flow events (2800 cfs – 4500 cfs) a 30-day moving average of S-79

structure flows was evaluated. In most cases there is little difference between alternatives, however if attention is directed at the June 1982 to March 1983 time frame, differences among the alternative plans are apparent. To provide more resolution, ***Figure E-6*** depicts these 30-day moving averages during this critical period. For those alternatives without additional pumping and reservoir capacity (i.e. alternatives Alt2 and Alt3B), daily flows frequently exceeded 3000 cfs and in some cases exceed 10,000 cfs. When these high daily flows are converted to 30-day moving average flows, differences among the alternative plans can be discerned. Note that the 30-day moving average for flows through the S-79 structure exceed 3000 cfs for alternatives Alt2 and Alt3B during June of 1982, October of 1983, and March of 1983. Flows that exceed the moderate high flow criteria do not occur for alternatives Alt3C and Alt4. The larger pumping capacity and increased reservoir depth for these alternatives effectively prevent high flows to the estuary from the S-79 structure. From an ecological perspective, these high flows occur during oyster spawning windows. This protracted period of low salinity would have interrupted the oyster spawning cycle, potentially killing adult oysters, as well as spat that had set earlier in the season. As daily flows exceed 8,000 cfs mortality to reefs of adult oysters would also be expected to occur. These high flows also occur during the growing season for the SAV *Halodule wrightii*, which would inhibit growth.

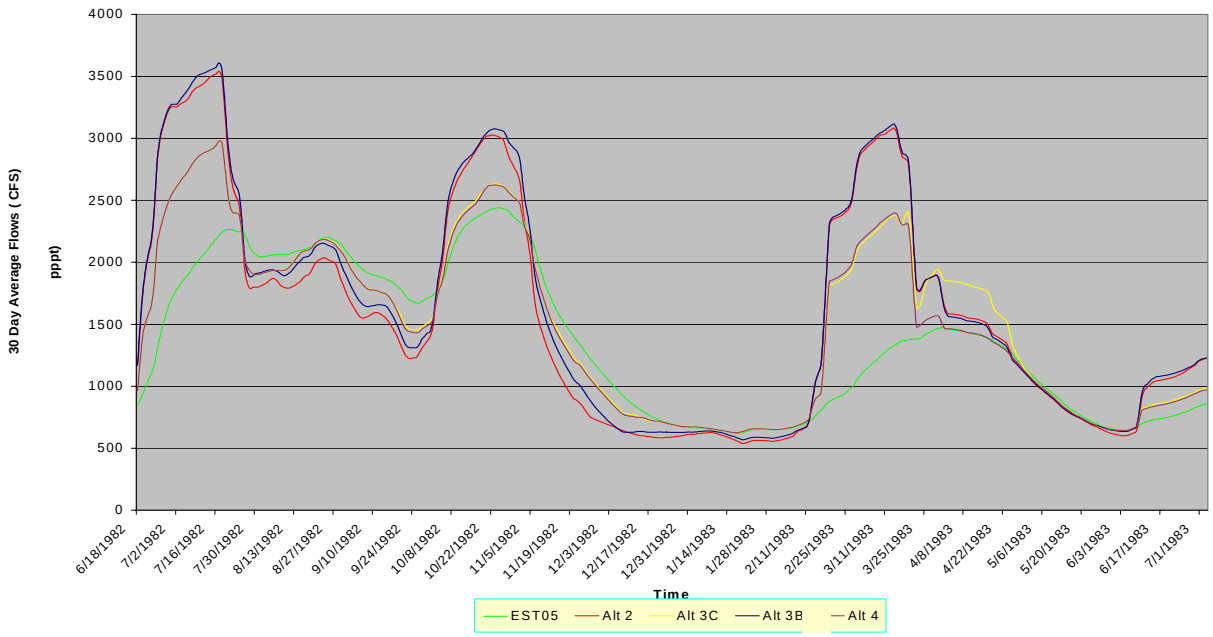

FIGURE E-6: 30-DAY MOVING AVERAGE S-79 FLOWS JUNE 1982 TO JUNE 1983

Periods of low salinity shorter than 30-days also impact oyster and *Halodule wrightii* health, therefore an analysis was conducted on a shorter time scale to

determine if more low salinity episodes were prevented through implementation of the alternative plans. For this analysis a two-week moving average was employed over the POR. Four events were identified when salinities were expected to drop below 3ppt based on flows greater than 2800 cfs: October 1979, July 1982, October 1982, and March 1983. These four episodes of low salinity did not occur for alternatives Alt3C and Alt4, but did occur for alternatives Alt2 and Alt3B. Impacts to estuarine oyster communities would have occurred in late 1979 thereby affecting the 1980 spawning season. After less than two years of recovery, three more episodes would occur in 1982 and early 1983. This would have compromised recovery of oysters in the Caloosahatchee Estuary system. If the MIKESHE period of record is representative of a longer time scale, then these episodic low salinity events could provide chronic and cyclic destruction of the oyster and *Halodule wrightii* communities. The additional pumping capacity and storage provided by alternatives Alt3C and Alt4 clearly improve ecological conditions within the estuary.

E.5.1.4 LO Regulatory Releases

Because the volumes of water provided by SFWMM boundary conditions into the MIKE-SHE model were fixed and did not vary based on the alternative plans, there was no change in the number or frequency of LO regulatory releases to the Caloosahatchee Estuary. The ability of the alternative plans to mitigate the LO regulatory releases that did occur is demonstrated through the substantial reduction or moderate high flow events (2800-4500 cfs) and the complete elimination of extreme high flow events (>4500 cfs).

E.5.1.5 Ecological Impact for the Caloosahatchee Estuary

The alternatives show a measurable reduction in low flow events due to the project and will provide significant benefit to the VECs tape grass (*Vallisneria americana)* and American oyster (*Crassostrea virginica).* A reduction in the low flow events eliminates high salinities, which has greatly reduced *Vallisneria americana* beds in the Caloosahatchee Estuary in the past (Chamberlain et al. 1995; Doering et al. 2002; SFWMD 2000). This reduction of high salinity conditions will lead to more extensive *Vallisneria americana* beds and greater ecological function in the Caloosahatchee Estuary. A reduction in low flow events eliminates high salinities that will benefit oyster populations by killing predators, such as the southern oyster drill and the whelk and reducing *Perkinsus marinus* infection (Volety et al. 2003). This reduction in high salinities not only decreases predation and disease, it also diminishes predation pressure on oyster spat, allowing greater recruitment.

In addition to the reduction in low flow events, the reduction of high flow events and the reduction in the duration of the high flow events due to the project will provide significant benefits to the area. When S-79 discharges exceed 4000 cfs,

salinities drop below 3 ppt upstream of Shell Point which can limit population survival and abundance of oysters in this region (Volety et al. 2003). A greater abundance of decapods and fishes are associated with clusters of live oyster compared to dead oyster clusters, while the structure provided by both living and dead oyster shells support a greater abundance than no shells (Volety et al. 2003). Therefore, the reduction of high flow events, which reduces low salinity events affecting oysters, will lead to increased diversity and abundance of estuarine fauna, one of CERP's primary goals.

E.5.2 Water Supply, Flood Damage Reduction, and Saltwater Intrusion

The severity and duration of water restrictions when drought levels exceed a 1-in-10 condition need to be reviewed to determine the full extent of predicted water supply impacts in the Caloosahatchee River (C-43) basin. To perform a review based on Supply-Side Management (SSM), raw or post-processed data that will allow the determination of monthly demand volume, number of days per month with cutbacks (demands not met), and volume of cutbacks (demand not met) per each month is required. Since this data is not readily available from MIKESHE output, annual average volumes (AAV) were evaluated. It is important to note that the average annual number will not allow for a determination of differences in alternative performance regarding water supply deliveries.

The results for agricultural and urban domestic self-supply in the Caloosahatchee River (C-43) basin indicate that "demands not met" dominate the model results and urban domestic self-supply for groundwater predicts over 90% of demand is not met. At this time, it is not possible for RECOVER to determine whether disparities between AAV demand and supply are a result of model assumptions/operations or accurately reflect the demands of urbanization within the basin. The following RECOVER evaluation presents performance based on the available model outputs and suggests additional areas of investigation for water supply analysis.

E.5.2.1 Caloosahatchee East Basin

A significant difference does not occur between the 2050FWO and the environmental target (EST05) for agricultural surface water and groundwater AAV demands (***Table E-8***). Only alternative Alt3a exhibits better performance for surface water AAV deliveries to agricultural users than the other alternatives and Alt3A matches the volume of surface water delivered in the 2000 base condition. All alternatives appear to slightly increase groundwater AAV agricultural demand over the 2050FWO without significant differences in performance. The agricultural groundwater AAV demand for all alternatives exceeds the AAV demands in the 2000 base condition.

All future planning conditions and alternatives are almost identical regarding surface water and groundwater AAV for urban self-supply (i.e., local irrigation-type wells). It appears the model presumes surface water will not be used for domestic supply in the future. The 2000 base condition does show a surface water demand of 800 ac-ft/year and a groundwater demand of 19,000 ac-ft/year for urban self-supply in the Caloosahatchee east basin.

TABLE E-8: EAST CALOOSAHATCHEE (S-78 BASIN) SUMMARY (1000 AC-FT)

	Irrigation and Domestic Self-supply AAV DEMAND				Irrigation AAV SUPPLY				AAV DEMAND NOT MET			
	Agriculture		Urban		Agriculture		Urban		Agriculture		Urban	
	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW
2000Base	142.4	1.7	0.8	18.6	130.7	1.0	0.8	0.6	11.7	0.7	0.0	18.0
2050FWO	146.7	17.9	0.0	51.9	134.8	8.8	0.0	1.8	12.0	9.1	0.0	50.1
EST05	146.8	18.0	0.0	52.0	133.4	8.9	0.0	1.8	13.4	9.0	0.0	50.1
Alt2	147.4	20.2	0.0	52.2	126.8	10.7	0.0	1.9	20.6	9.5	0.0	50.3
Alt3A	148.3	20.1	0.0	52.7	130.2	10.6	0.0	1.9	18.0	9.5	0.0	50.9
Alt3B	147.4	20.3	0.0	52.2	126.8	10.7	0.0	1.9	20.6	9.5	0.0	50.3
Alt3C	147.3	20.3	0.0	52.2	126.8	10.8	0.0	1.9	20.4	9.5	0.0	50.3
Alt 4	147.3	20.3	0.0	52.2	127.3	10.7	0.0	1.9	20.0	9.5	0.0	50.3

E.5.2.2 Caloosahatchee West Basin

Agricultural AAV provided via surface water is significantly different for 2050FWO and EST05, but groundwater is only slightly different (***Table E-9***). The target deliveries to the estuary appear to reduce the surface water available for agricultural supply in the western basin. Alternative Alt3A exhibits substantially better agricultural AAV deliveries and is the only alternative providing as much AAV delivered to agriculture as the 2050FWO. Alternatives Alt3C and Alt4 provide the next highest volume of agricultural AAV and Alt2 and Alt3B are both similar in AAV to EST05 and provide the lowest AAV deliveries to agricultural users. The alternatives do not differ significantly for groundwater AAV regarding demands not met for agricultural users. Alternative Alt3A has a slightly lower volume of groundwater AAV deliveries that is offset by higher surface water AAV deliveries in the basin. Alternative Alt3A resembles the 2050FWO and the other alternatives resemble the EST05.

Surface water and groundwater AAV demands for domestic self-supply do not differ significantly between 2050FWO and EST05. All of the alternatives show increased surface water AAV demand over the 2000 base condition and the 2050FWO. Alternative Alt3A has a slightly lower surface water AAV demand. All alternatives are practically identical regarding groundwater AAV demand for urban users. Adjusting for the predicted demands not met, the alternatives

provide approximately 10% more AAV than the 2050FWO and approximately 20% less AAV than the 2000 base condition.

TABLE E-9: WEST CALOOSAHATCHEE (S-79 BASIN) SUMMARY (1000 AC-FT)

	Irrigation and Domestic Self-supply AAV DEMAND				Irrigation AAV SUPPLY				AAV DEMAND NOT MET			
	Agriculture		Urban		Agriculture		Urban		Agriculture		Urban	
	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW
2000Base	87.7	61.2	1.1	42.4	65.7	17.9	0.8	13.4	22.0	43.3	0.3	29.0
2050FWO	61.3	54.0	6.2	118.3	52.5	18.9	2.9	9.8	8.8	35.2	3.3	108.6
EST05	56.5	58.9	6.2	118.5	34.8	20.0	2.9	9.8	21.6	38.9	3.3	108.7
Alt2	55.3	59.4	8.6	125.3	33.7	20.1	4.1	10.6	21.6	39.3	4.5	114.7
Alt3A	61.1	53.5	8.4	124.5	53.7	18.7	4.1	10.5	7.4	34.8	4.3	114.0
Alt3B	56.0	58.6	8.6	125.2	36.0	20.0	4.1	10.6	20.0	38.7	4.5	114.6
Alt3C	57.6	57.0	8.5	125.0	41.5	19.7	4.2	10.5	16.2	37.3	4.3	114.4
Alt 4	57.9	56.7	8.5	125.0	42.5	19.6	4.1	10.6	15.5	37.2	4.3	114.4

E.5.2.3 Suggestions for further investigation

The following section presents some insight and questions that might be considered during further investigation of water supply metrics within the Caloosahatchee River (C-43) basin:

- The data requested for a SSM-type water supply review might help determine discrepancies not apparent in AAV data.
- The 2050FWO, EST05, and alternative plans all exhibit increased groundwater demands over the 2000 base condition for urban users and appear to be the governing factor in increased demand not met.
- Why does the East Caloosahatchee 2000 base agricultural AAV provided seem to match the current understanding of the basin, while the West Caloosahatchee 2000 base AAV provided seems decreased from on the ground observations? What are the differences in how the two sub-basins are modeled?
- If the model results are predicting correctly, could the environmental deliveries require so much from the system that less water is available for consumptive use? The inconsistencies between the modeled 2000 base and on the ground conditions indicate issues with modeling assumptions/operations for groundwater in the basin.
- Why do the alternatives add 12,000 ac-ft/year to consumptive use demands above the amount predicted in the 2050 Bases? Most of this is added in the West Caloosahatchee Urban demands – but there are indications of smaller additions throughout.

E.5.3 Interaction with Other Projects

While each CERP project is considered as a stand-alone component, it is important to remember that the interactions among projects will ultimately determine CERP's restoration success for the South Florida ecosystem. With this in mind, RECOVER sought to understand how surrounding projects might interact with the Caloosahatchee River (C-43) West Basin Storage Reservoir project to maximize system benefits. The primary projects identified include Aquifer Storage and Recovery (ASR), Lake Okeechobee Watershed (LOW) Project, and the Lake Okeechobee Regulation Schedule (LORS). While the West Basin Storage Reservoir Project is able to capture and re-release many of the high flow events that result during the wet season in order to better mimic the natural salinity patterns of the estuary, the LOW Project and LORS will clearly impact the amount of water that travels to the estuary in the wet season. Coordination of these projects will be necessary to alleviate high lake stages to maintain littoral zone health while maximizing utilization of the reservoirs in the LOW Project and the Caloosahatchee River (C-43) West Basin Storage Reservoir project to mitigate high flows in the wet season and supplement low flows during the dry season. Additionally, the advent of ASR, or similar storage option, will help to store additional water to ensure that local water supply needs are met. The combined effect of these projects, LOW and LORS reducing the number of moderate and extreme high low events and the Caloosahatchee River (C-43) West Basin Storage Reservoir project providing water to the estuary during the dry season, are expected to meet estuary restoration goals.

E.5.4 Ability of Project Alternatives to Address Planning and Scientific Uncertainties (CERP Adaptive Management)

As with other ecosystem restoration projects throughout the nation, every potential restoration action carries with it an amount of uncertainty and risk. In the case of the Caloosahatchee River (C-43) West Basin Storage Reservoir project, this uncertainty has been identified and project alternatives have been formulated to address and alleviate those uncertainties. In general, uncertainties related to large-scale restoration can be categorized as scientific uncertainties and planning uncertainties.

E.5.4.1 Scientific Uncertainty

The environmental response corresponding to a specific action is uncertain; this is scientific uncertainty. With regard to the Caloosahatchee (C-43) West Basin Storage Reservoir project, there is little uncertainty that more natural salinity patterns in the estuary will improve habitat for desirable indicator species (SAV, oysters, and estuarine fishes) if the timing and distribution of flows meets seasonal targets. It is expected that obtaining more natural flow regimes will benefit target species populations directly by decreasing extreme salinity fluxes.

There is, however, uncertainty regarding the exact water quality benefits provided by the proposed project and the extent of secondary benefits to the broader estuarine community. The HSIs developed by the project team demonstrate the benefits to given species within the estuary over the FWO condition; however they do not demonstrate large differences among the alternative plans. The inability to reveal these differences may be an artifact of model sensitivity, or may indicate that the estuary ecology is benefited over the range of alternative plans evaluated. At this time, the scientific evidence is not available to support one of these theories over the other. Given the scientific uncertainties mentioned, it will be necessary for future scientific findings regarding the resiliency of species indicators and effects on total estuarine health to be incorporated in project operations. Additionally, in order for the project to quantify the total benefits resulting in the estuary post-implementation, activities will need to include associated monitoring and assessment activities at appropriate spatial and temporal scales to provide feedback to the predictive tools (i.e., HSIs) developed during the planning of this project.

E.5.4.2 Planning Uncertainties

The largest planning uncertainty facing the Caloosahatchee River (C-43) West Basin Storage Reservoir team is the project's affect on agricultural and urban water supply in the western Caloosahatchee River (C-43) basin. Initial modeling results indicate that additional investigation is warranted to determine the exact impacts to water supply in this region. A related issue is the cap on water deliveries from LO to the Caloosahatchee River (C-43) basin to Restudy-like levels. The CERP A Refinement currently being conducted by the System Planning and Operations Team (SPOT) is investigating the effects to LO if water deliveries are raised to 2000 levels. The results of this investigation will be presented to CERP decision-makers to determine whether revisions to the stated policy are warranted, and are outside the scope of the project team's planning effort.

E.6 OPPORTUNITIES FOR ALTERNATIVE PLAN IMPROVEMENTS AND OTHER CONSIDERATIONS

As part of the responsibilities given to RECOVER, this section presents suggested improvements to the alternative plans, which, where possible, are intended to improve the project's performance or enhance benefits to the natural system. These suggested improvements to the alternative plans should be considered by the project during the design of the final plan or reevaluation of alternative plans when appropriate.

Two primary opportunities to improve project performance have been identified. First, the project team should strive to optimize operations to coordinate with

other storage features such as ASR, the LOW Project, and the LORS in order to increase benefits to LO (i.e., fewer deviations from the LO stage envelope) and the Caloosahatchee Estuary (i.e., fewer regulatory releases, especially during sensitive periods for key indicator species). Second, the project team should further investigate water supply issues within the Caloosahatchee basin, with specific emphasis on urban groundwater demands within the western basin. RECOVER will remain available to participate in these investigations.

E.7 CONCLUSIONS

RECOVER's system-wide evaluation indicates that all of the project alternative plans improve estuary health over the FWO Project Condition by altering hydrology to achieve a more natural salinity pattern within the estuary. Alternative plans Alt3C and Alt4 provide the most benefits to the estuary by reducing the number of damaging high and low flows to the greatest extent at both the monthly and weekly scale. The project alternative plans are likely to have the following effects compared to the future without project condition:

- Increasing the period of time during which flows from the S-79 structure fall within the desirable flow envelope for the Caloosahatchee Estuary
- Decreasing the frequency and duration of low flows to the Caloosahatchee Estuary via S-79
- Decreasing the frequency and duration of moderate and extreme high flows to the Caloosahatchee Estuary via S-79
- Decreasing level of service for water supply in the LOSA and LECSA for frequency, duration, and severity of cutbacks

In conjunction with other CERP and non-CERP projects within neighboring basins, the Caloosahatchee River (C-43) West Basin Storage Reservoir project is expected to reach CERP system-wide restoration goals for the frequency and duration of moderate and extreme high flow events, and to meet CERP restoration targets for flow distributions to the estuary up to 84% of the time. Given the cumulative effects of project benefits, the coordination of the Caloosahatchee River (C-43) West Basin Storage Reservoir project with other CERP project is even expected to provide additional benefits than those that are currently able to be documented using available ecologic and hydrologic models.

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