COMPREHENSIVE EVERGLADES RESTORATION PLAN

LAKE OKEECHOBEE WATERSHED RESTORATION PROJECT

REVISED DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

July 2019

Appendix E

APPENDIX E
PLAN FORMULATION SCREENING

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Table of Contents

E PLAN FORMULATION SCREENING E-1
E.1 Water Storage Screening E-1
E.1.1 Level 1 Storage Management Measures Screening E-2
E.1.2 Level 2 Screening of Water Storage Management Measures E-3
E.2 Wetland Restoration Screening E-22
E.2.1 Level 1 Siting and Sizing of Wetland Restoration Management Measures E-22
E.2.2 Level 2- Best-buy Wetland Restoration Sites E-26
E.2.3 Results of Wetland Restoration Analysis E-28
E.3 Identification of Focused Array of Alternatives E-28
E.3.1 Alternative 1Bshlw E-29
E.3.2 Alternative 1BW E-30
E.3.3 Alternative 2Cr E-30

List of Tables

Table E-1. Screening of water storage management measures. E-2
Table E-2. Deep reservoir screening results. E-7
Table E-3. Shallow reservoir (5 ft.) screening results. E-8
Table E-4. Retained cost-effective WAF locations. E-10
Table E-5. WAF screening results. E-12
Table E-6. Components considered in the first round of analysis. E-19
Table E-7. Effectiveness of 'CERP-Like' LOWRP with the EAA storage reservoir and STA. E-19
Table E-8. Components considered in the second round of analysis. E-20
Table E-9. Economic analysis output in order of increasing costs for second group of water storage management components. E-21
Table E-10: Components considered in the third round of analysis. E-21
Table E-11. Description of features in retained water storage components. E-22
Table E-12. Performance measure scores for wetland restoration site. E-25
Table E-13. Wetland best-buy combinations. E-27

List of Figures

Figure E-1. Phased plan formulation strategy. E-1
Figure E-2. Deep reservoir sites considered during screening. E-5
Figure E-3. Shallow reservoir sites. E-9
Figure E-4. WAF locations. E-10
Figure E-5. Caloosahatchee Estuary high-discharge improvements with reservoir and ASR storage. E-15
Figure E-6. St. Lucie Estuary high-discharge improvements with reservoir and ASR storage. E-16
Figure E-7. Lake Okeechobee standard score for lake stage envelope with reservoir and ASR wells. E-17
Figure E-8. ASR-well-only option (with no reservoir) Lake Okeechobee performance. E-18

Figure E-9. Wetland restoration sites initially considered. E-23
Figure E-10. Retained wetland restoration sites. E-26
Figure E-11. Incremental cost per output of best buy wetland components. E-28
Figure E-12. Final array of alternatives. E-32

E PLAN FORMULATION SCREENING

This plan formulation appendix serves as supplemental supporting information to **Section 3** of the LOWRP PIR (referred as the "main report" in this appendix). It covers the formulation of water storage measures (Phase 1 Formulation) and wetland restoration measures (Phase 2 Formulation) **(Figure E-1**). These features were initially formulated and screened as separable elements, then were combined to form complete alternatives.

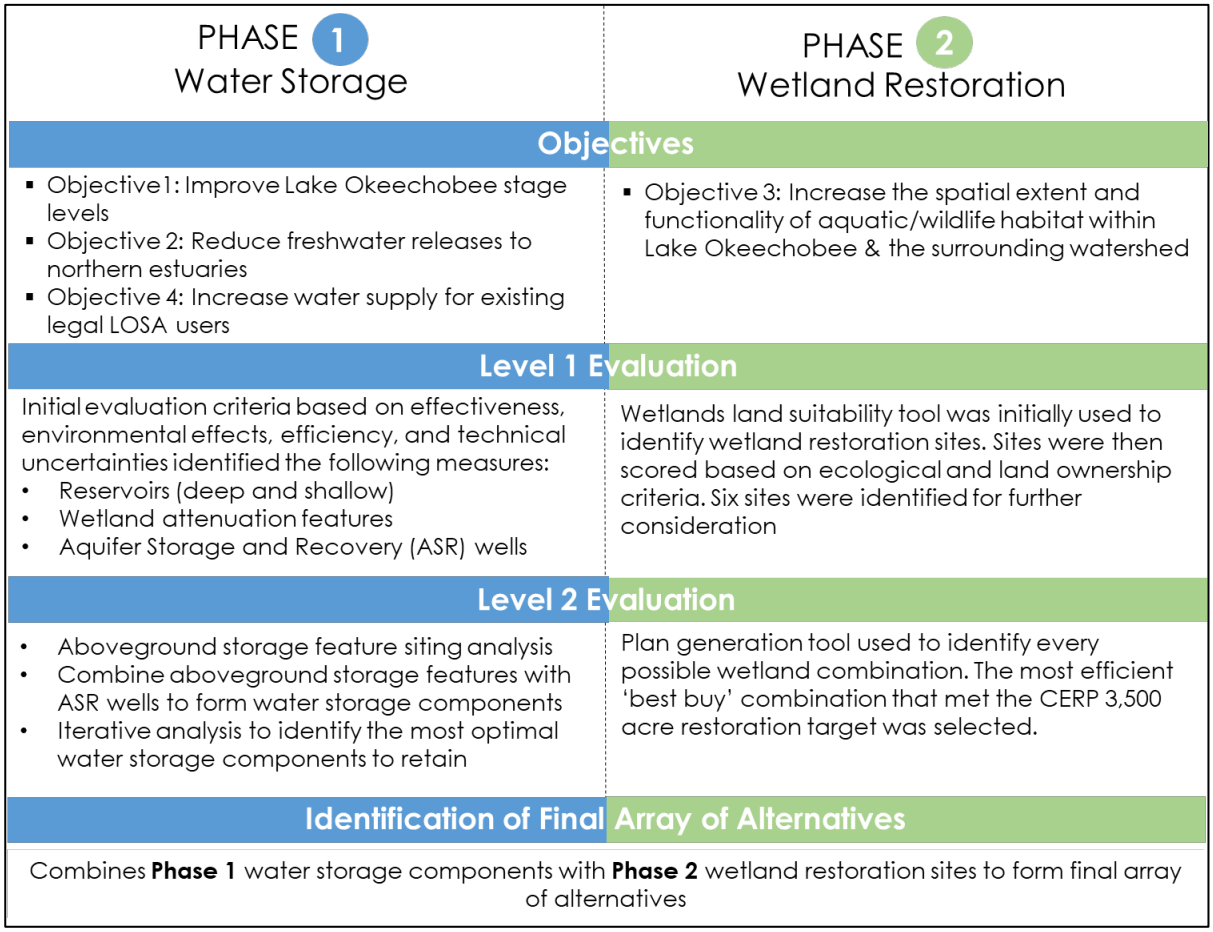


Figure E-1. Phased plan formulation strategy.

E.1 Water Storage Screening

The first phase of formulation identified individual water storage management measures that function to meet objectives 1, 2, and 4. By creating additional water storage north of Lake Okeechobee, LOWRP can facilitate improved flexibility in the timing and distribution of water into the lake, to the Northern Estuaries, and throughout the Lake Okeechobee watershed. Water can be stored during wet times to reduce undesirable high lake stages, and be released into the lake during dry times to reduce the adverse impacts of low lake stages. All project features that provide additional water to the system also provide ancillary benefits for water supply. By keeping the lake stage within the ecologically preferred band for longer

durations, LOWRP reduces the amount of time that the lake dips below the water shortage cutback levels which increases access to water supply (including agricultural and municipal & industrial).

Multiple water storage concepts, configurations, and sizes have been considered to address the timing and distribution of flows to and from Lake Okeechobee and to the Northern Estuaries. **Subsection E.1.1** and **subsection E.1.2** summarize this analysis.

E.1.1 Level 1 Storage Management Measures Screening

This section lists and describes major features and activities (i.e., management measures) and the rationale for their inclusion or exclusion as the basis for alternative development. Management measures included a mixture of measures proposed in the Restudy as well as measures identified during project scoping with stakeholders. The initial criteria are at the most conceptual level and generally use best professional judgment and information gained from other, related projects.

Initial screening criteria:

- Effectiveness: ability to meet objectives and avoid constraints
- Environmental Effects: avoidance of negative impacts
- Efficiency: relative cost-effectiveness in meeting objectives
- Technical Uncertainties: acceptable level of technical uncertainty

Table E-1 summarizes the results of the preliminary screening of management measures and identifies the management measures that are retained. Reasons for screening or retaining individual measures are described in more detail in text below the table.

Table E-1. Screening of water storage management measures.

Phase 1 Water Storage Management Measure	Results for Water Storage Components
Dredge Lake Okeechobee	Not retained due to environmental effects and efficiency.
Aboveground Reservoir	RETAINED (meets all criteria).
Wetland Attenuation Feature	RETAINED (meets all criteria).
ASR Well	RETAINED (meets all criteria).
Deep Injection Wells	Not retained due to technical uncertainties.
Dispersed Water Management	Not retained due to effectiveness.

Dredging Lake Okeechobee for Storage: This measure consists of dredging sediment from Lake Okeechobee and depositing it in an approved disposal site. Dredging of the lake would provide increased water storage capacity, decreasing the need for releases to the northern estuaries.

Although this measure is feasible from an engineering perspective, the cost to dredge such a large water body would be excessive. Disposal of the dredged material would require a massive containment area located near the lake for return water, creating environmental concern. This measure was not retained.

Aboveground Storage Reservoir: Aboveground storage reservoirs would be used to capture and hold normal and peak flows. Water would then be discharged when flows are needed for the natural system. Deep storage reservoirs have relatively high construction costs when compared to shallow reservoirs due to additional dam safety requirements. However, both shallow and deep reservoirs are operationally flexible and offer the potential to improve the timing and distribution of water to the natural system. Storage reservoirs would experience dry-outs during extended drought periods and do not offer substantial wildlife habitat value. Aboveground storage reservoirs were retained for consideration.

Wetland Attenuation Feature: A wetland attenuation feature (WAF) is a flow-through wetland primarily used for surface water storage to attenuate peak flows and stages in adjacent areas (such as Lake Okeechobee). Although a WAF provides aboveground storage like a reservoir, water levels may be suitable for growth of wetland vegetation due to the water depths typically realized through operation of the facility. This measure was retained for consideration.

***Aquifer Storage and Recovery*:** Aquifer Storage and Recovery (ASR) is the belowground storage of available water within the aquifer, and the recovery of that water for use when there are system demands. ASR wells are conceptualized to be completed within two distinct zones of the Floridan Aquifer System: the Upper Floridan Aquifer (UFA), composed of porous limestone, lying 600–1,200 ft. below land surface and a deeper, and a more saline zone referred to as the Avon Park Permeable Zone (APPZ), composed of porous dolomite, found 1,600–2,000 ft. below land surface. ASR wells were retained for consideration as a cost-effective measure that would limit the need to acquire private lands to meet project objectives.

***Deep Injection Well*:** Deep injection wells (DIW) are high-capacity wells that permanently inject water not intended for recovery into a unique geologic formation at the base of the Floridan Aquifer System known as the Boulder Zone. Water pumped into the Boulder Zone is not recoverable and is permanently removed from the natural system. DIWs provide an additional outlet for excess Lake Okeechobee water to reduce releases to the coastal estuaries.

The LOWRP includes several CERP components that were originally envisioned and evaluated within the 1999 CERP PIR/EIS. DIWs were not a component of the 1999 evaluation. In order to evaluate the potential effects of DIWs within CERP, and potential effects on other CERP projects, a comprehensive regional analysis needs to be performed. This comprehensive regional analysis cannot be undertaken within the constraints of the LOWRP scope, schedule, or budget to meet USACE planning milestones. Due to these reasons, as well as the need to understand how DIWs may perform within the context of ecosystem restoration, DIWs were removed from further consideration within LOWRP.

Dispersed Water Management: Dispersed water management encourages property owners to retain water on their land (rather than rapidly drain the water), accept and detain regional runoff, or do both. Holding water on these lands is one tool to reduce the amount of water flowing into Lake Okeechobee during the wet season that is discharged to coastal estuaries for flood protection. Dispersed water management also provides valuable groundwater recharge for water supply, opportunities for water quality improvement, and rehydration of drained systems. This measure was not retained because an aboveground reservoir would be able to store more water and better meet project objectives.

E.1.2 Level 2 Screening of Water Storage Management Measures

The second level of evaluation focused on placement and scale of the retained storage management measures to ensure overall efficiency and effectiveness. This effort consisted of three steps:

1. Aboveground storage feature siting (deep reservoirs, shallow reservoirs, and wetland attenuation features).
2. Combining aboveground storage features and ASR wells to form water storage components.
3. Iterative water storage analysis to compare components.

E.1.2.1 Aboveground Water Storage Feature Siting Summary

The initial rationale behind the aboveground water storage formulation was to meet the CERP 'target,' which included 200,000 acre-feet of reservoir storage (North of Lake Okeechobee Storage Reservoir (CERP Component A)). Although this volume was a target for planning purposes, storage volumes above and below this amount were considered during LOWRP planning to provide a wide array of project costs and benefits. Deep reservoirs (15 ft. average pool depth) were initially considered to meet the storage target. Although deep storage reservoirs have relatively high construction costs when compared to shallow reservoirs, the overall cost per acre-foot of water storage is generally less than shallow storage because one deep reservoir generally requires less infrastructure than multiple shallow storage facilities.

Formulating to meet the storage target using deep storage proved to be a challenge for the following reasons: 1) In order to be effective, sites needed to be situated in areas with intake directly from the Lake Okeechobee pool or Pool E of the Kissimmee River; 2) The presence of nearby/downstream communities throughout the study area caused dam safety concerns, 3) Geotechnical exploration results showed high seepage rates in the project area, which would be exacerbated by the additional head of deep storage; and 4) Local communities have voiced concerns regarding the potential impacts of siting deep reservoirs on or near their property.

Due to the difficulties of siting deep reservoir storage, several configurations of shallow storage were formulated and evaluated. Therefore, deep reservoirs, shallow reservoirs, and wetland attenuation features were considered to meet project objectives.

E.1.2.1.1 Deep Reservoir Siting Analysis

The deep reservoir analysis began with conceptual reservoir sites with the fewest siting constraints, based on presence of wetlands or areas with high ecologic values, number of impacted parcels, known cultural resource impacts, regional economic considerations and real estate costs, public lands, and areas with minority or low-income populations (**Figure E-2)**. These sites are conceptual and have been revised throughout the planning process due to cultural resources, potential environmental impacts, analysis of topography, cost considerations, and feedback from local communities.

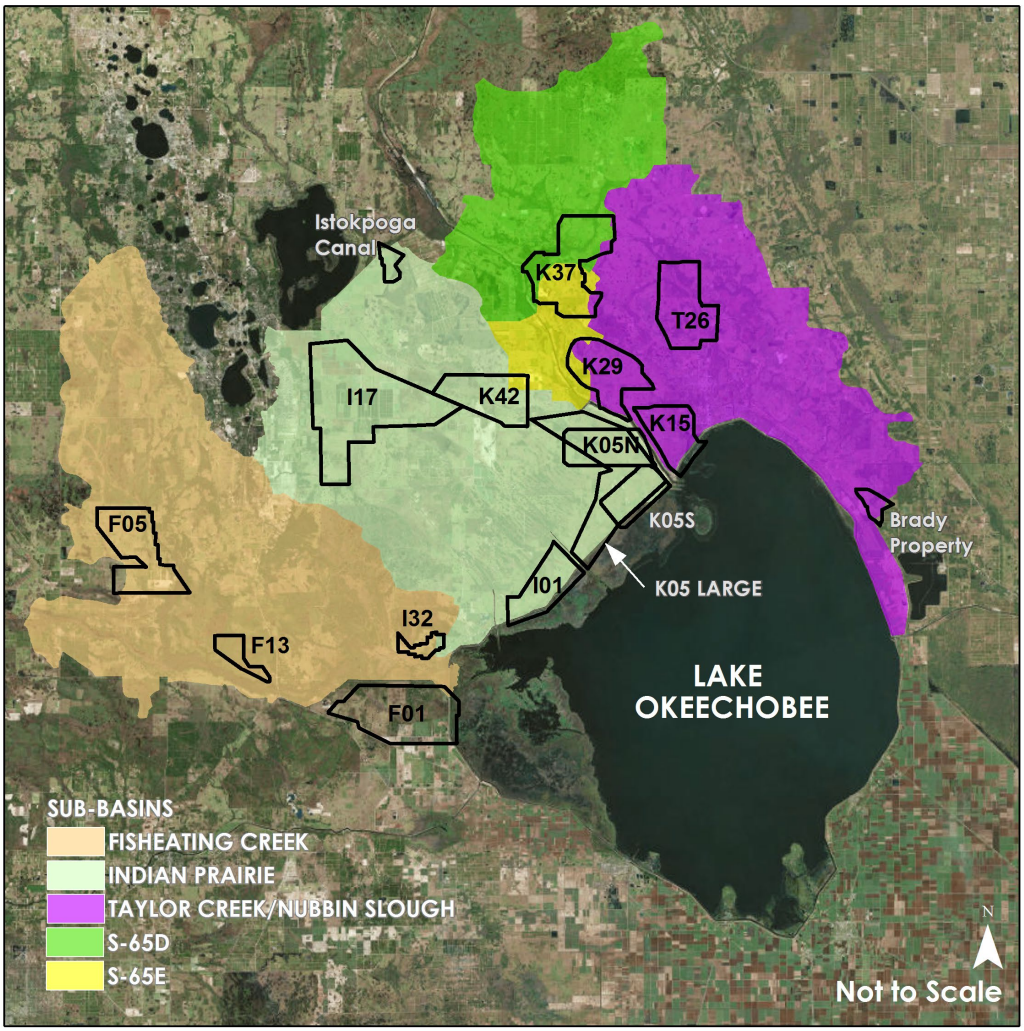


Figure E-2. Deep reservoir sites considered during screening.

The PDT analyzed spatial relationships between reservoir placement sites. Reservoirs that depended on flows from Fisheating Creek were dropped due to low/inconsistent water availability (based on the analysis of hydrographs). The PDT then analyzed the remaining sites in the Indian Prairie Basin, along the lower portions of the Kissimmee River (S-65D and S-65E), and in the Taylor Creek/Nubbin Slough Basins. Site-specific constraints were considered, such as the position within the watershed, incompatible land uses, infrastructure constraints, real estate considerations, topography, and the location of existing water conveyance features.

After the preliminary screening analysis, these sites were retained: I-17, K-42, K-05 Large, K-05 North, K-05 South, Istokpoga Canal, T-26, Brady Property, and I-01. Each of these sites was scored based on 4 criteria:

1. Consistency and availability of water inflows. Based on hydrologic modeling output and knowledge of the watershed, a direct connection with either the Kissimmee River (C-38) or Lake Okeechobee provides the most consistent source of water flows to ensure that reservoirs meet project objectives. These scores were weighted highest because a reliable water source is critical to reservoir performance.

- Score 0: no connection with C-38 or Lake Okeechobee
- Score 3: connection with either C-38 or Lake Okeechobee
- Score 6: connection with both C-38 and Lake Okeechobee

2. Percentage of public land ownership within the reservoir footprint. The percentage of public and private land ownership within the reservoir footprint was considered as a screening criteria. Public lands within the study are owned by the non-Federal sponsor have already been acquired for the purposes of environmental restoration. The use of public lands to the extent practicable minimizes impacts to local tax rolls, avoids risks of unwilling sellers, and implementation of eminent domain authority, reducing overall real estate acquisition costs and timelines. With private land, access may be delayed or not granted for surveys, leading to higher cost contingencies and potential schedule delays. It is also preferable to have public land in a project footprint due to ease of access for geotechnical, cultural, and environmental surveys to reduce overall project contingency costs and the risk of an unanticipated cultural or environmental discovery. The use of public lands also reduces overall real estate acquisition costs and timelines.

- Score 0: 0-5% public lands within footprint
- Score 1: 6-30% public lands within footprint
- Score 2: 31-60% public lands within footprint
- Score 3: 61-100% public lands within footprint

3. Co-location opportunities with proposed ASR wells and/or wetlands. Siting reservoirs near project wetlands and ASR wells provides additional operational flexibility.

- Score 0: no co-location opportunities with ASR or wetlands
- Score 1: co-location opportunities with either ASR or wetlands
- Score 2: co-location opportunities with both ASR and wetlands

4. Cost in dollars per acre-foot of water storage[1]. A parametric cost-estimating tool was used for screening level costs to enable an "order of magnitude" construction cost estimate for reservoirs, considering various depths and storage capacities. The full output is provided in **Annex A**. The tool takes into account soil conditions such as muck, sand, and clay, as well as local impacts such as the construction or removal of roads, bridges, transmission lines, railroads, rail yards, and/or railroad bridges, housing, farms, telemetry, etc. Depths of 4 to 18 ft. were considered. Reservoirs with a lower cost per acre-foot of water storage were given a higher score. This metric was weighted slightly higher to ensure that efficient reservoirs were retained. The costs from the parametric costing tool are provided in **Attachment A**.

- Score 0: cost/acre-foot of storage >$7,000
- Score 2: cost/acre-foot of storage $5,750-$7,000
- Score 4: cost/acre-foot of storage < $5,750

[1] The costs generated by this tool are screening level relative costs, not absolute costs. These costs are only used to compare the costs of Water Storage Measures relative to one another.

Reservoirs with a score of 7 or higher were retained (**Table E-2**). Upon further investigation, the Brady Property was screened out due to the comparably small storage the site would provide when compared to the other remaining sites. The remaining deep reservoirs (K-05 Large, K-05 North, K-05 South, I-01, and K-42) were carried forward for inclusion in the initial rounds of modeling, preliminary cost estimates, and habitat unit calculations.

Table E-2. Deep reservoir screening results.

Deep Reservoir ID	Source Water Score (0-6)	Public Ownership Score (0-3)	Co-Location Score (0-2)	Cost/acre-foot of Storage Score (0-4)	Total Score (out of 15)
K-05 Large	6	2	2	4	14
K-05 South	6	2	2	2	12
K-05 North	6	2	2	2	12
Brady Property	3	3	2	0	8
K-42	6	0	0	2	8
I-01	3	1	1	2	7
Istokpoga Canal	3	3	0	0	6
T-26	0	3	1	0	4
I-17	0	0	0	0	0

E.1.2.1.2 Shallow Storage Siting Analysis

Feedback from stakeholders, a planning-level dam safety analysis, results from geotechnical explorations, and cost considerations led the team to consider shallow storage in the form of shallow reservoirs (approximately 5-ft. average pool depth) and WAFs (approximately 4-ft. average pool depth). A 5-ft. average pool depth would reduce dam safety concerns and provide more storage than a WAF for a slightly higher overall cost. A shallower pool depth in a flow-through WAF provide for more wetland habitat than deeper storage options. Water source was one of the major considerations of siting shallow storage. Several different types of sites were considered for shallow storage:

- High-scoring sites from the deep reservoir analysis
- Sites with insufficient water sources for deep storage, but sufficient for shallow
- Sites closer to population centers (reduced safety concerns for shallow storage)

E.1.2.1.2.1 Shallow Reservoir Siting:

The top 4 sites identified in the deep storage siting (**Figure E-3**) were converted to shallow storage (5 ft.) and re-evaluated based on 4 criteria[2]:

[2] Water source availability was not scored for shallow reservoir siting because all shallow reservoirs obtain water from Lake Okeechobee.

1. Percentage of public land ownership within the reservoir footprint.

- Score 0: 0-5% public lands within footprint
- Score 1: 6-30% public lands within footprint
- Score 2: 31-60% public lands within footprint
- Score 3: 61-100% public lands within footprint

2. Co-location opportunities with proposed wetlands. Siting surface storage near project wetlands allows the system additional operational flexibility. Surface could be used to rehydrate wetlands and potentially seepage management features could be eliminated, thus creating a more efficient plan.

- Score 0: no co-location opportunities with wetlands
- Score 2: co-location opportunities with wetlands

3. Co-location opportunities with proposed ASR wells. Siting surface near ASR wells allows the system additional operational flexibility. ASR wells could be used to enhance overall storage and to re-hydrate surface storage during dry times.

- Score 0: no co-location opportunities with ASR wells
- Score 2: co-location opportunities with ASR wells

4. Cost in dollars per acre-foot of water storage. A planning-level cost estimate was calculated using perimeter measurements, canals and embankments, pumps and culverts, real estate, along with contingency to enable an "order of magnitude" construction cost estimate. This metric was weighted slightly higher to ensure efficient reservoirs were retained.

- Score 0: cost/acre-foot of storage >$13,412
- Score 2: cost/ acre-foot of storage $10,730-$13,412
- Score 4: cost/ acre-foot of storage < $10,730

Table E-3 shows the results of the analysis. The K-05 Large shallow reservoir was the highest scoring combination and was retained for further evaluation.

Table E-3. Shallow reservoir (5 ft.) screening results.

Shallow Reservoir Site	Storage Estimate (ac-ft)	Cost/Acre-foot Score (0-4)	Land Ownership Considerations Score	Co-Location with wetlands Score	Potential for Reservoir-Assisted ASR Score	Total Score
K-05 Large	65,000	4	2	2	2	10
K-05 South	36,000	2	2	2	2	8
K-05 North	30,000	2	1	2	2	7
K-42 Shallow	73,000	4	0	0	0	4

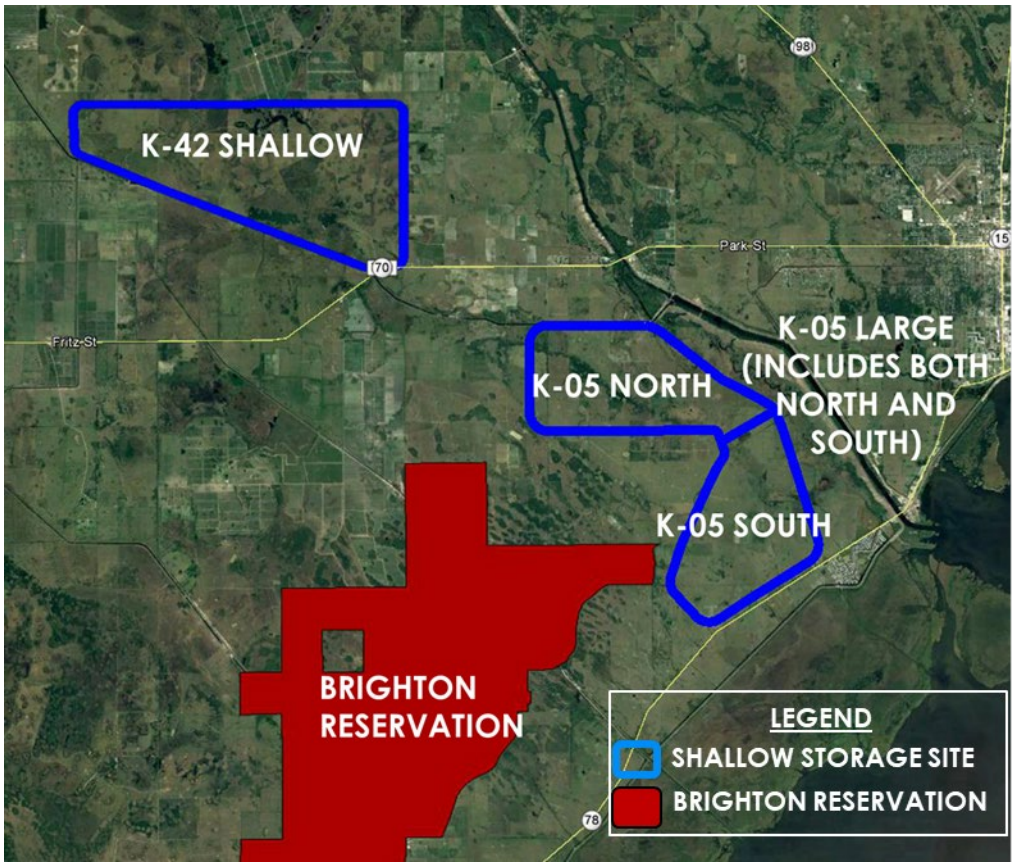


Figure E-3. Shallow reservoir sites.

E.1.2.1.2.2 Wetland Attenuation Feature Siting

Further analysis was performed to identify potential WAF sites (**Figure E-4**). Due to the shallow nature of a WAF, sites were able to be considered that were not retained for deeper reservoirs due to constraints of the proximity to nearby communities and water availability. Source water availability, contiguous land availability, potential to co-locate with ASR wells and/or wetland restoration sites, and cost considerations were the primary factors evaluated in the WAF siting.

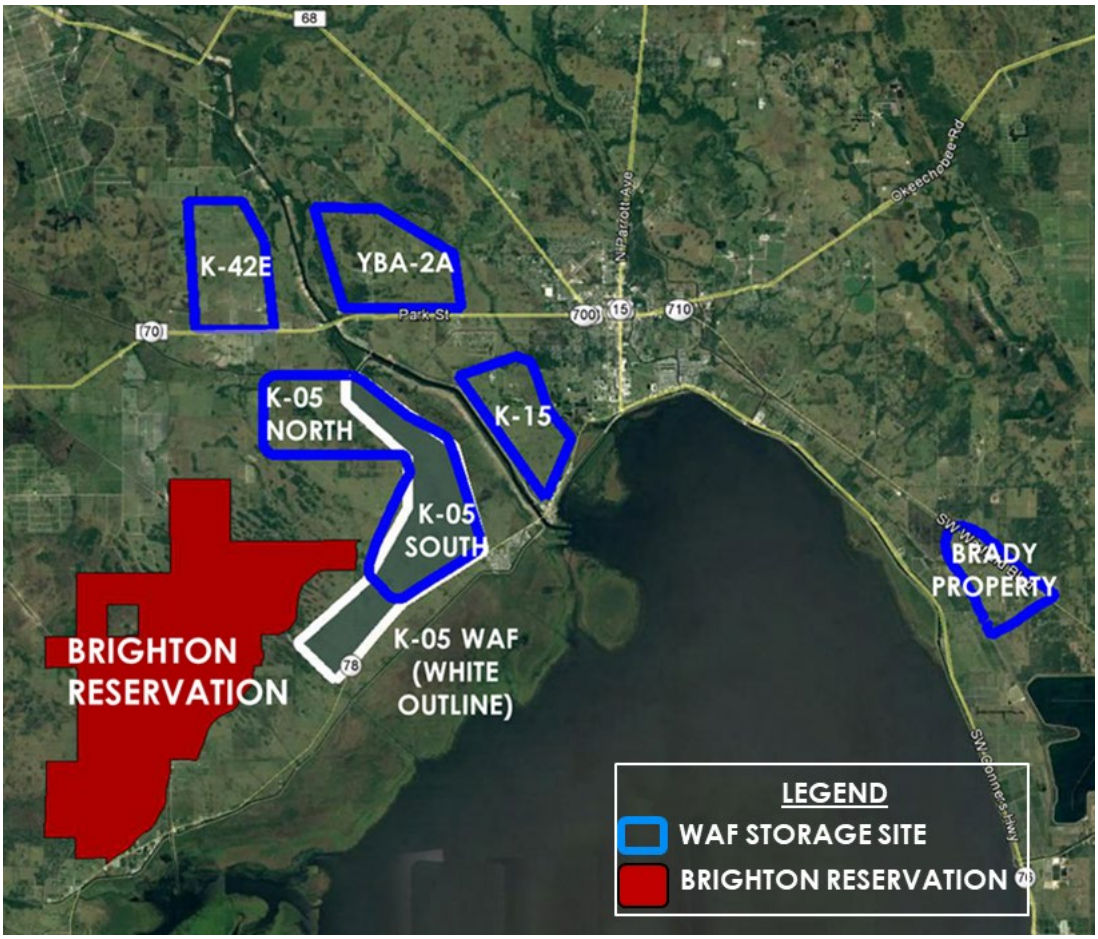


Figure E-4. WAF locations.

The Institute for Water Resources (IWR) Planning Suite II plan-generation tool was used to identify every possible WAF combination. These combinations were then compared to identify those that would produce greater levels of storage at the same or lesser cost than other combinations. Although 37 cost-effective WAF combinations were identified, only 13 were retained for additional consideration (**Table E-4**). The other configurations were dropped due to overall higher costs (above $1,000,000,000).

Table E-4. Retained cost-effective WAF locations.

WAF Combo	WAF Location	Total Cost	Total Storage (Acre-Feet)	Cost/ Acre-foot	Incremental Cost	Incremental Output (Acre-Foot Storage)	Incremental Cost Per Acre-foot
1	Brady Property (4 ft.)	**$270,603,200**	**8,000**	**$33,825**	**$270,603,200**	**8,000**	**$33,825**
2	K-15 (4 ft.)	**$357,584,000**	**19,000**	**$18,820**	**$86,980,800**	**11,000**	**$7,907**
3	K-05 South (4 ft.)	**$365,289,920**	**24,000**	**$15,220**	**$7,705,920**	**5,000**	**$1,541**
4	K-42 East Shallow (4 ft.)	**$371,607,200**	**25,000**	**$14,864**	**$6,317,280**	**1,000**	**$6,317**
5	YBA2A (4 ft.)	**$394,537,600**	**30,000**	**$13,151**	**$22,930,400**	**5,000**	**$4,586**
6	K-05 (4 ft.)	**$617,575,200**	**43,000**	**$14,362**	**$223,037,600**	**13,000**	**$17,157**

WAF Combo	WAF Location	Total Cost	Total Storage (Acre-Feet)	Cost/ Acre-foot	Incremental Cost	Incremental Output (Acre-Foot Storage)	Incremental Cost Per Acre-foot
7	K-15 (4 ft.)	$357,584,000	19,000				
	K-42 East Shallow (4 ft.)	$371,607,200	25,000				
	Total	**$729,191,200**	**44,000**	**$16,573**	**$111,616,000**	**1,000**	**$111,616**
8	K-05 South (4 ft.)	$365,289,920	24,000				
	K-42 East Shallow (4 ft.)	$371,607,200	25,000				
	Total	**$736,897,120**	**49,000**	**$15,039**	**$7,705,920**	**5,000**	**$1,541**
9	K-05 South (4 ft.)	$365,289,920	24,000				
	YBA2A (4 ft.)	$394,537,600	30,000				
	Total	**$759,827,520**	**54,000**	**$14,071**	**$22,930,400**	**5,000**	**$4,586**
10	K-42 East Shallow (4 ft.)	$371,607,200	25,000				
	YBA2A (4 ft.)	$394,537,600	30,000				
	Total	**$766,144,800**	**55,000**	**$13,930**	**$6,317,280**	**1,000**	**$6,317**
11	K-05 North (4 ft.)	$399,169,920	30,000				
	YBA2A (4 ft.)	$394,537,600	30,000				
	Total	**$793,707,520**	**60,000**	**$13,228**	**$27,562,720**	**5,000**	**$5,513**
12	K-05 (4 ft.)	$617,575,200	43,000				
	K-15 (4 ft.)	$357,584,000	19,000				
	Total	**$975,159,200**	**62,000**	**$15,728**	**$181,451,680**	**2,000**	**$90,726**
13	K-05 WAF (4 ft.)	$617,575,200	43,000				
	K-42 East Shallow (4 ft.)	$371,607,200	25,000				
	Total	**$989,182,400**	**68,000**	**$14,547**	**$6,317,280**	**1,000**	**$6,317**

Similar to the deep and shallow storage analyses, sites were further evaluated based on 5 criteria:

1. Consistency and availability of water inflows. Based on hydrologic modeling output and knowledge of the watershed, a direct connection Lake Okeechobee provides the most consistent source of water flows to ensure the WAF can meet project objectives. A direct connection with Pool E of the Kissimmee River provides a slightly less consistent source of water. A rim canal source would provide less water due to water control structures maintaining lower water levels for flood risk management purposes. If there is more than one WAF in a combination with different water sources, the average water source score was used. These scores were weighted highest because a reliable water source is critical to WAF performance.

- Score 0: Only rim canal water source
- Score 1: Rim canal and Pool E water source
- Score 2: Only Pool E water source
- Score 3: Pool E and Lake Okeechobee water sources
- Score 4: Only Lake Okeechobee water source

2. Percentage of public land ownership within the WAF footprint.

- Score 0: 0-5% public lands within footprint
- Score 1: 6-30% public lands within footprint
- Score 2: 31-60% public lands within footprint
- Score 3: 61-100% public lands within footprint

3. Co-location opportunities with proposed wetlands. Siting surface storage near project wetlands allows the system additional operational flexibility. Surface could be used to rehydrate wetlands and potentially seepage management features could be eliminated, thus creating a more efficient plan.

- Score 0: no co-location opportunities with wetlands
- Score 2: co-location opportunities with wetlands

4. Co-location opportunities with proposed ASR wells. Siting surface storage near ASR wells allows the system additional operational flexibility. ASR wells could be used to enhance overall storage and to re-hydrate surface storage during dry times.

- Score 0: no co-location opportunities with ASR wells
- Score 2: co-location opportunities with ASR wells

5. Cost in dollars per acre-foot of water storage. A planning-level cost estimate was calculated using perimeter measurements, canals and embankments, pumps and culverts, real estate, along with a cost contingency to enable an "order of magnitude" construction cost estimate. This metric was weighted slightly higher to ensure efficient reservoirs were retained.

- Score 0: cost/acre-feet of storage >$18,580
- Score 2: cost/acre-feet of storage $14,864 to $18,580
- Score 4: cost/acre-feet of storage < $14,864

Table E-5 shows the results of the analysis. WAF combination 6, which includes the K-05 WAF, was the highest scoring combination and was retained for further evaluation.

Table E-5. WAF screening results.

WAF Combo	WAF Site(s)	Cost/ Acre-foot Score	Water Source Options Score	Land Ownership Considerations Score	Co-Location with wetlands for 1 or 2 WAF Sites Score	Co-location with Proposed ASR for 1 or 2 WAF Sites Score	Total Score
1	Brady Property	0	0	3	0	2	5
2	K-15 (4 ft.)	0	4	0	0	2	6
3	K-05 South (4 ft.)	2	4	2	2	2	12

WAF Combo	WAF Site(s)	Cost/ Acre-foot Score	Water Source Options Score	Land Ownership Considerations Score	Co-Location with wetlands for 1 or 2 WAF Sites Score	Co-location with Proposed ASR for 1 or 2 WAF Sites Score	Total Score
4	K-42 East Shallow (4 ft.)	2	2	0	2	0	6
5	YBA-2A (4 ft.)	4	2	0	0	2	8
6	K-05 (4 ft.)	4	4	2	2	2	14
7	K-15 (4 ft.) K-42 East Shallow (4 ft.)	2	3	0	2	2	9
8	K-05 South (4 ft.) K-42 East Shallow (4 ft.)	2	3	1	2	2	10
9	K-05 South (4 ft.) YBA-2A (4 ft.)	4	3	1	2	2	12
10	K-42 East Shallow (4 ft.) YBA-2A (4 ft.)	4	2	0	2	2	10
11	K-05 North (4 ft.) YBA-2A (4 ft.)	4	3	1	2	2	12
12	K-05 WAF (4 ft.) K-15 (4 ft.)	2	4	1	2	2	11
13	K-05 WAF (4 ft.) K-42 East Shallow (4 ft.)	4	3	1	2	2	12

E.1.2.2 ASR Formulation

Adding ASR wells to the aboveground storage features identified in the previous section would create dynamic storage that would better address the project objectives. The number of ASR wells to be combined

with aboveground storage features was determined using the Reservoir Sizing and Operations Screening (RESOPS) model to predict water deliveries, timing of flow, Lake Okeechobee stages, potential ecological improvements, and reduction in discharge to the Northern Estuaries for multiple scales of reservoir and ASR combinations, along with data from the 2015 CERP ASR Regional Study. The ASR wells store water within two distinct zones within the Floridan Aquifer System, the UFA and the APPZ.

RESOPS runs that combined reservoir storage ranging 0–400,000 acre-feet and ASR well configurations containing 0–120 wells indicated that larger increments of storage provide commensurate increases in estuary performance for both high and low flows; more storage provides more estuary benefits. See **Figure E-5** and **Figure E-6**. Improvements in lower Lake Okeechobee stages are more apparent with the addition of 40–112 ASR wells to reservoir storage. Higher lake stages are less sensitive to storage north of the lake due to the large volume of water associated with high-stage events (**Figure E-7**).

The ASR range was initially set at 65–112 wells for the first round of alternatives, but was eventually reduced to 65–80 wells to maximize cost effectiveness. Conceptual ASR well locations along tributaries to Lake Okeechobee were identified in the 2015 ASR Regional Study. Watershed ASR well clusters are located along/near various Lake Okeechobee tributaries throughout the watershed.

In some locations, aboveground-storage-assisted ASR wells are proposed. They can be used to increase the total storage capacity of the storage feature (either a reservoir or a WAF). ASR wells will recharge using the aboveground storage feature surface water, and discharge back into the surface storage prior to release into the Kissimmee River.

Co-locating ASR with aboveground storage provides synergistic facility attributes and improves operational flexibility. For example, such aboveground storage features can potentially be filled more than once during a season or event as the ASR empties the aboveground storage feature, therefore creating additional available aboveground storage capacity. However, the siting of ASR wells is constrained by nearby water users because ASR wells may not cause adverse impacts to existing legal users. Therefore, aboveground-storage-assisted ASR wells are not possible for all storage locations (e.g., K-42).

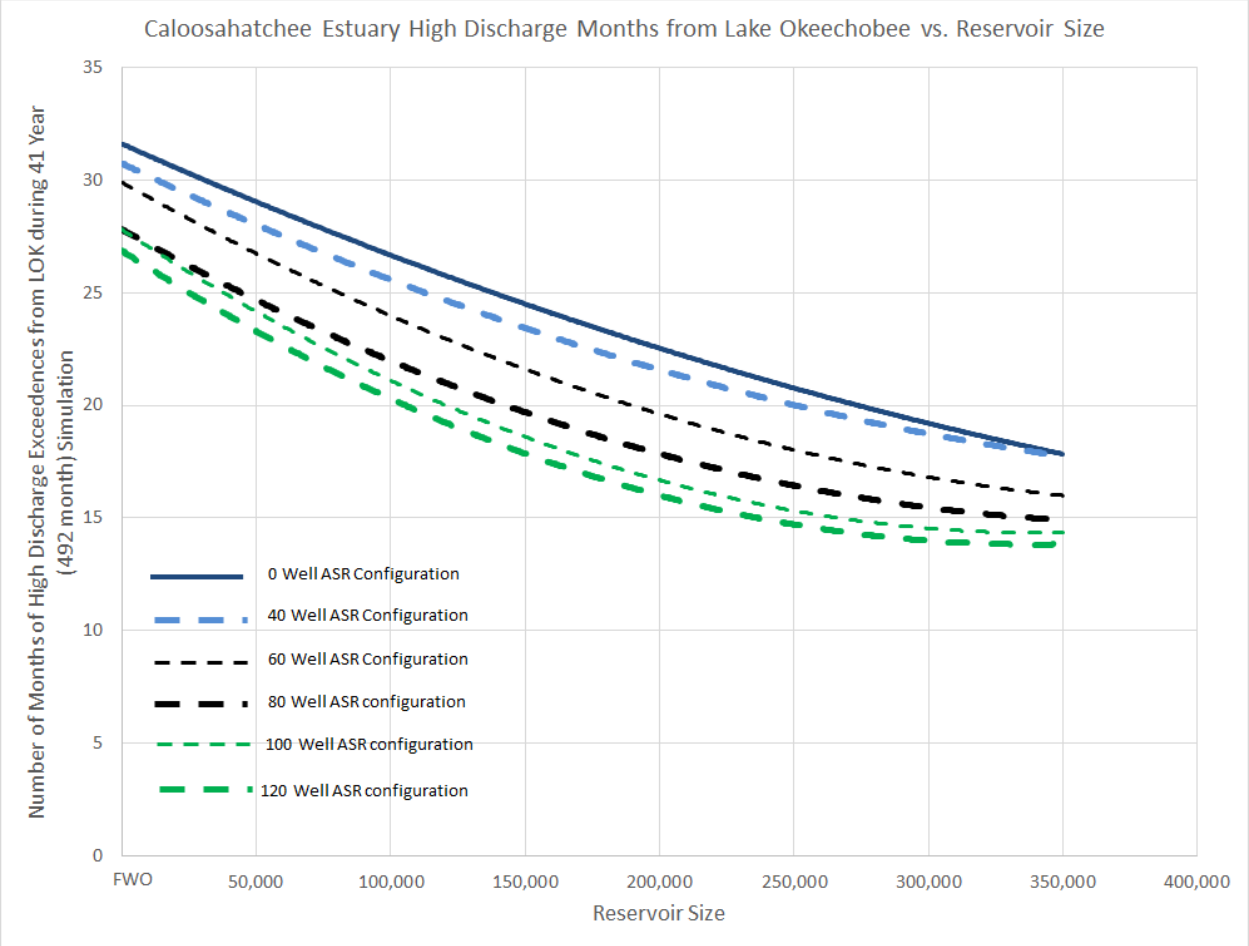


Figure E-5. Caloosahatchee Estuary high-discharge improvements with reservoir and ASR storage.

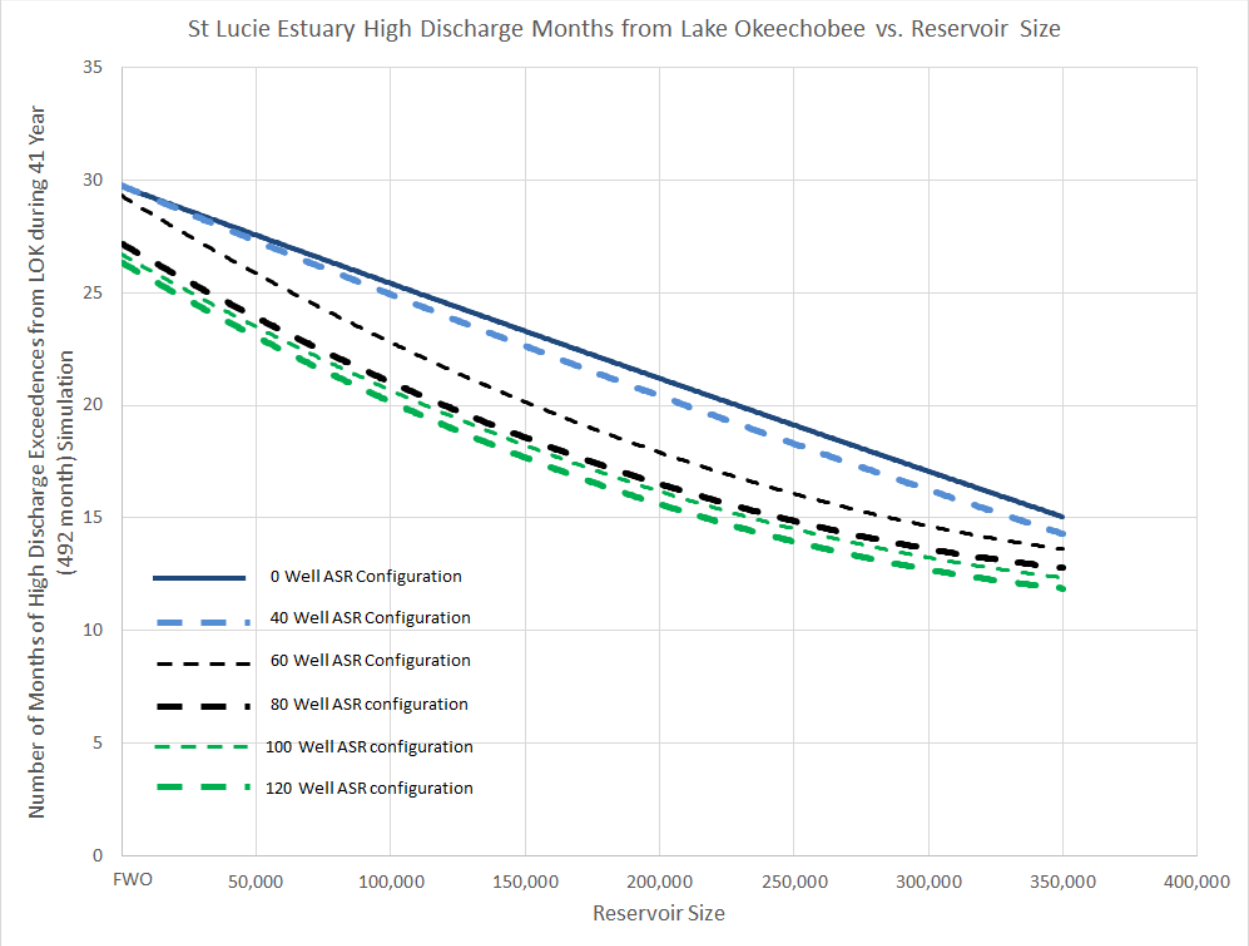


Figure E-6. St. Lucie Estuary high-discharge improvements with reservoir and ASR storage.

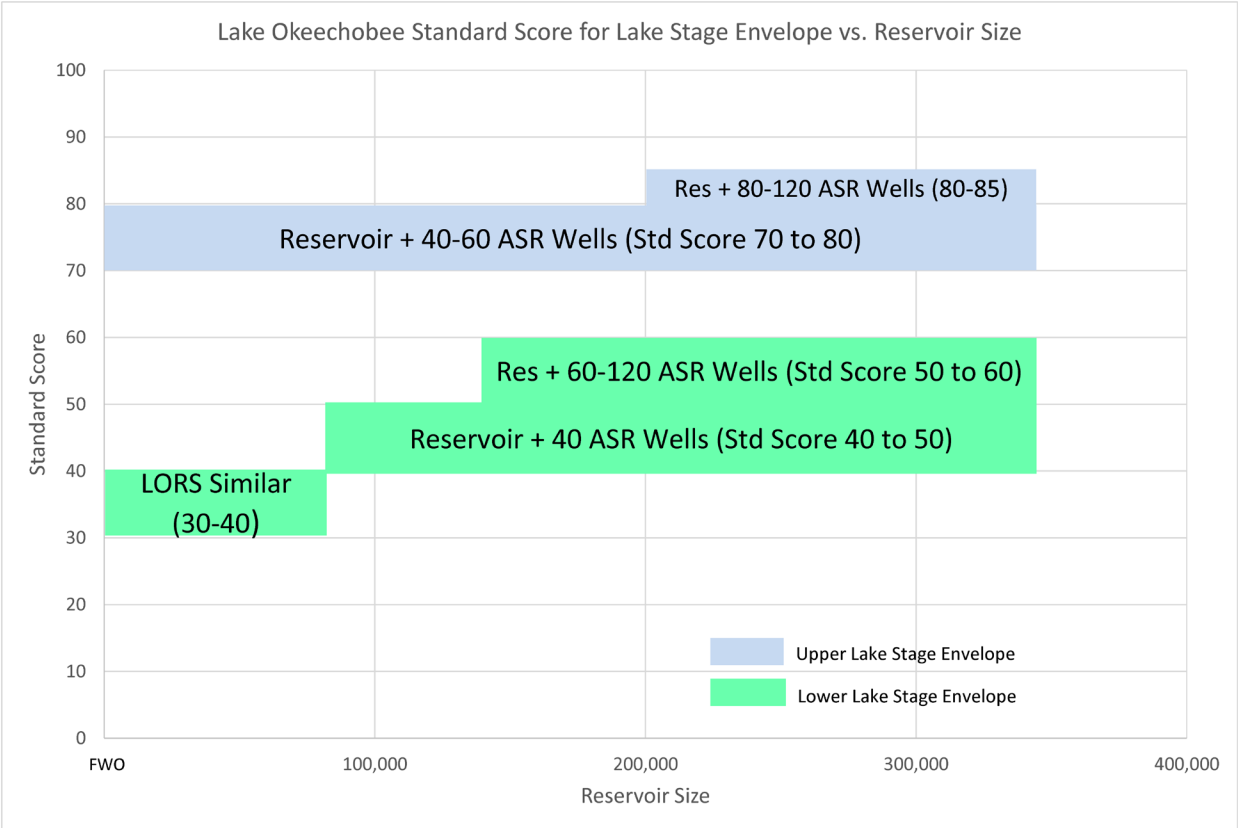


Figure E-7. Lake Okeechobee standard score for lake stage envelope with reservoir and ASR wells.

An ASR-well-only configuration (no reservoir storage) was also considered. Although this option shows improvement over the FWO condition, the projected Lake Okeechobee Habitat Unit benefits[3] are slightly lower than the existing conditions (**Figure E-8**). Improving Lake Okeechobee health is a significant goal of CERP and LOWRP, so this configuration was not retained.

[3] See **Appendix G** for more description of Lake Okeechobee Habitat Unit calculation.

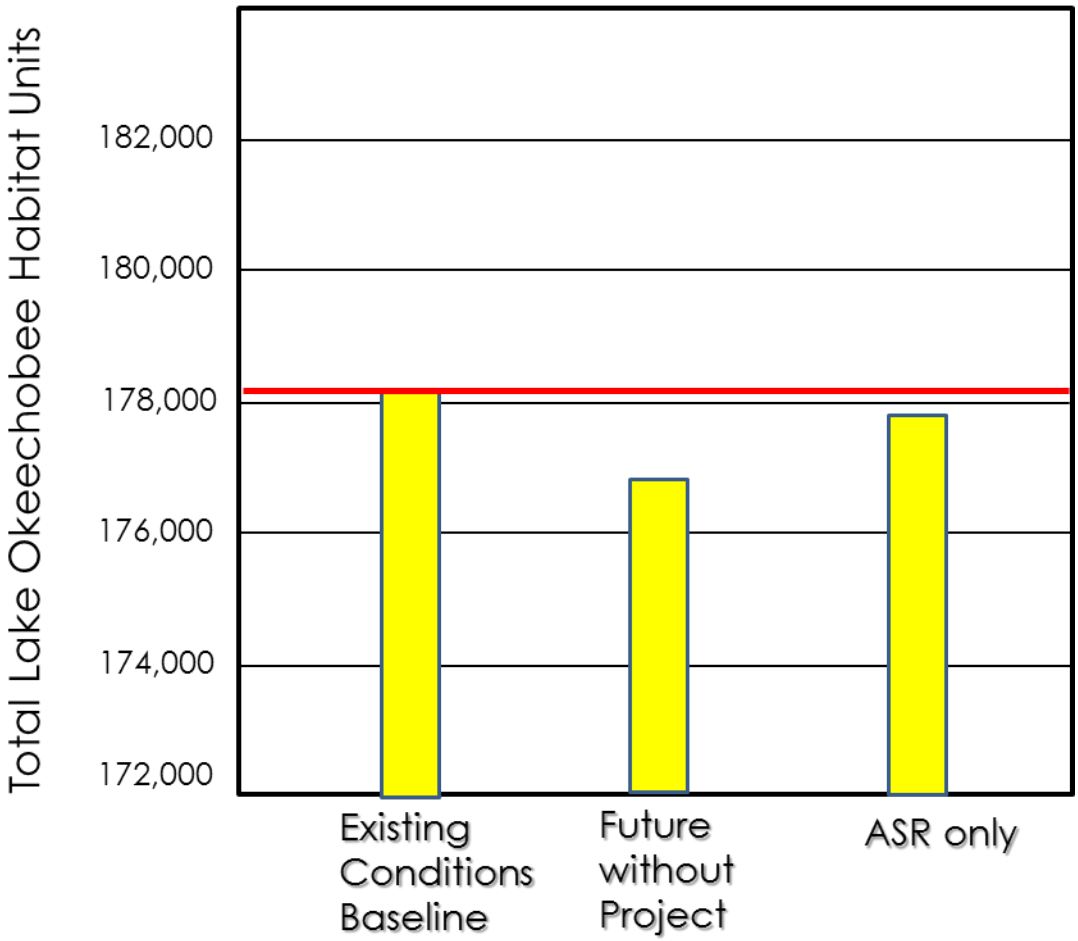


Figure E-8. ASR-well-only option (with no reservoir) Lake Okeechobee performance.

E.1.2.3 Iterative Water Storage Component Formulation Process

This section provides a summary of how water storage components were proposed, evaluated, revised, or removed from further consideration. In each round of analysis, the overall storage capacity, reservoir footprints, and costs were revised to optimize the performance. The first three rounds of alternatives include deep reservoir storage and ASR wells. However, local community feedback and additional dam safety analysis led the team to consider shallow storage as well.

E.1.2.3.1 First Round of Analysis

The first round of water storage components combined deep reservoirs to obtain the amount of storage initially proposed in the Restudy, which included 200,000 acre-feet of reservoir storage, 200 ASR wells, and a 2,500-acre STA. Since the original Restudy effort, new studies have refined knowledge of ASR siting within the project area, and the number of ASR wells was reduced to 112. In order to obtain storage capacities that come close to the Restudy target, reservoir storage ranged from 267,000 acre-feet to 437,000 acre-

feet in the first round of alternatives. This compensates for not including STAs, and the reduction in ASR wells.

Table E-6 shows the results of the first round of analysis. Water Storage Component 3 was not cost-effective, and was the least effective of the water storage measures. It was not carried forward for additional evaluation.

Table E-6. Components considered in the first round of analysis.

Water Storage Component	Deep Reservoir (s)	Reservoir Storage Capacity (total acre-feet)	Number of ASR wells	ASR Storage Capacity (acre-feet per year)	Rough Order of Magnitude Costs	Habitat Units
1A	K05 Large	267,000	110	616,000	$2.7B	18,134
2A	K-05 Large and K-42	437,000	110	616,000	$3.9B	21,054
3	K-42 and I-01	295,000	112	627,200	$2.9B	11,250

The LOWRP team also contemplated the 'CERP-like' alternative in the initial rounds of modeling, which included a 200,000-acre-foot reservoir and 80 ASR wells. At the time of this modeling effort, the Everglades Agricultural Area Storage Reservoir and Stormwater Treatment Area (EAA Storage Reservoir and STA) was in the planning process but not authorized or considered complete in the FWO condition. The LOWRP team anticipated that the LOWRP and EAA Storage Reservoir and STA would complement each other to improve conditions in Lake Okeechobee and Northern Estuaries.

To demonstrate this, a sensitivity analysis with the 'CERP-like' LOWRP alternative was conducted with the EAA Storage Reservoir and STA to determine additional Lake Okeechobee and northern estuary benefits. From an effectiveness standpoint, this alternative comes very close to achieving the total CERP goal in reducing the volumes of high-flow releases to the Northern Estuaries. The two projects also meet the CERP goal for lake-weighted improvements of Lake Okeechobee. **Table E-7** summarizes this analysis.

Table E-7. Effectiveness of 'CERP-Like' LOWRP with the EAA storage reservoir and STA.

Metric (36-year POR)*	CERP Goal	'CERP-Like' LOWRP Alternative	'CERP-Like' LOWRP + EAA STORAGE RESERVOIR AND STA
Reduction in number of high-flow estuary events	81%	67% (83% of CERP goal)	81% (100% of CERP goal)
Reduction in flow volumes from Lake Okeechobee to the Northern Estuaries	80%	57% (71% of CERP goal)	72% (90% of CERP goal)
Lake Okeechobee Index Score (% improvement)	11.7%	10.0% (85% of CERP goal)	13.7% (100% of CERP goal)

* Based on the 36-year modeled simulation period (1965-2000) available from RECOVER

Three general conclusions can be drawn from this analysis:

1. The 'CERP-Like' LOWRP alternative and the EAA Storage Reservoir and STA benefits are complementary. Although parallel planning efforts may illustrate similar trends between the two efforts, the combined effect of the projects is additive, not coincident.
2. The combination of the 'CERP-Like' LOWRP alternative and the EAA Storage Reservoir and STA project can come close to, or fully achieve, the CERP Goal in the Northern Estuaries.
3. The CERP goal is met for ecological Lake Okeechobee improvements and in the reduction of number of high-flow estuary events.

E.1.2.3.2 Second Round of Analysis

Only cost-effective components identified by the first round were carried forward for the second round of analysis. This round included a larger range of storage options to provide a wider array of costs and benefits. Water Storage Component 2A was retained in this round. The footprint of the K-05 reservoir was reduced to limit the proximity of this reservoir to the Brighton Reservation.

Table E-8. Components considered in the second round of analysis.

Water Storage Component	Deep Reservoirs	Reservoir Storage Capacity (acre-feet)	Number of ASR wells	ASR Storage Capacity (acre-feet per year)
1B	Revised K-05 North and revised K-05 South	190,000	80	448,000
2A	Revised K-05 North and revised K-05 South, and K-42	361,000	110	616,000
2B	Revised K-05 North and K-42	276,000	70	392,000
2C	K-42	171,000	50	280,000

RSM model output, planning-level costs, habitat units, and a CEICA analysis were run for the second round of water storage measures (see **Table E-9**). Water Storage Component 2A was identified as the most ecologically effective Water Storage Measure with the greatest overall habitat lift in the form of reduced releases to the Northern Estuaries and improvements to Lake Okeechobee stages. Water Storage Component 2C showed the least ecologic lift. All measures reduce the percentage of water supply cutbacks in the LOSA when compared to the future without project condition, although Water Storage Component 2B reduces cutbacks by the greatest amount and Water Storage Component 2C reduces cutbacks by the least amount. The economic analysis showed that Water Storage Component 1B provides benefits at the lowest cost per habitat unit, although all of the water storage measures are cost-effective.

Table E-9. Economic analysis output in order of increasing costs for second group of water storage management components.

	Water Storage Component 2C	Water Storage Component 1B	Water Storage Component 2B	Water Storage Component 2A
Total Implementation Cost	$1,405,000,000	$1,836,000,000	$2,490,000,000	$3,136,000,000
Lake O Annual Lift	2,847	5,598	6,668	8,179
Estuary Annual Lift	2,204	4,654	4,654	5,367
Combined Annual Lift	5,051	10,252	11,322	13,545
Cost Effective	Yes	Yes	Yes	Yes
Cost Per Habitat Unit	$278,000	$179,000	$220,000	$232,000

Water Storage Component 1B provides benefits at the lowest increment of cost. The PDT planned to refine this shape further to reduce overall costs.

Despite being the worst-performing and least cost-effective, Water Storage Component 2C is the STOF's least objectionable component because it is farthest away from Brighton Reservation. With input from the STOF, the PDT determined that this measure could be refined in a third round of analysis to improve performance.

E.1.2.3.3 Third Round of Analysis

Water Storage Component 1B became Water Storage Component 1Br due to a modification of the K-05 reservoir footprint to reduce overall costs. Water Storage Component 2C became Water Storage Component 2Cr due to modifications to include a direct connection with Lake Okeechobee via the C-41A canal, a slightly larger reservoir footprint, and 15 additional ASR wells. Water Storage Component 2A was carried forward for the third round with no changes as it is the most effective measure at meeting ecologic objectives. Water Storage Measure 2B was carried forward for the third round of analysis with no changes because it is the most efficient measure for meeting the water supply objective. See **Table E-10**.

Table E-10: Components considered in the third round of analysis.

Water Storage Component	Deep Reservoirs	Storage Capacity (acre-feet)	Number of ASR wells	Storage Capacity (acre-feet per year)
1Br	K-05 Revised	198,000	80	448,000
2A	K-05 and K-42a	361,000	110	616,000
2B	K-05 North and K-42a	276,000	70	392,000
2Cr	K-42b	195,000	65	364,000

E.1.2.4 Results of Aboveground Storage Analysis

Water Storage Component 2Cr was retained as the only deep reservoir option as the majority of other deep reservoir sites were screened out due to dam safety concerns. Shallow reservoirs and WAFs were considered after the third round of analysis as further described in **Shallow Storage Siting Analysis E.1.2.1.2** above. Water Storage Components 1Bshlw and 1BW were retained from that analysis and are included for further consideration. **Table E-11** shows the results of the aboveground storage analysis.

Table E-11. Description of features in retained water storage components.

Water Storage Components	Reservoir/WAF	Storage Capacity (acre-feet)	Number of ASR wells	Storage Capacity (acre-feet per year)
1Bshlw	K-05 shallow reservoir (5 ft. average depth)	65,000	80	448,000
1BW	K-05 WAF (4 ft. average depth)	43,000	80	448,000
2Cr	K-42 deep reservoir (15 ft. average water depth)	195,000	65	364,000

E.2 Wetland Restoration Screening

This section describes wetland restoration management measures initially considered and the rationale for their inclusion or exclusion as the basis for alternative development. The intent of the wetland restoration component of LOWRP is to increase the spatial extent and connectivity of freshwater wetlands (Lake Okeechobee Watershed Water Quality Treatment Facilities Other Project Elements (OPE)). Not only does the restoration of this area benefit the Kissimmee River and Lake Okeechobee, but it also has important benefits to the Greater Everglades Ecosystem in the form of hydrologic restoration and landscape connectivity. This is of great importance to the sustainability of federally and state-listed threatened and endangered species, as well as many unlisted plant and animal species. Without this restoration and connectivity, the diversity and abundance of plant and animal life in south Florida will likely continue to decline.

E.2.1 Level 1 Siting and Sizing of Wetland Restoration Management Measures

The PDT identified wetland sites for initial consideration based on the presence of hydric soils, connectivity to natural and public lands, contaminants, economic value, ecologic values, known cultural resources, impacts to minority and low-income populations, and current land uses (**Figure E-10**). Two of the initial wetland restoration sites (Fisheating Creek and Six Mile Marsh) were discovered to be part of other ongoing restoration efforts and were removed from further consideration.

The western portion of the lake has an existing, wide, expansive (approximately 200,000 acres) littoral and nearshore (to -6 feet NAVD88) habitat. Because the eastern portion of the lake lacks littoral zone habitat, the USACE Regional Sediment Management (RSM) Center also evaluated the possibility of creating/enhancing the littoral zone on the eastern side of the lake using Lake Okeechobee as a borrow source for the material. Multiple factors were considered for siting of the littoral zone enhancement, including the existing bathymetry; distance from borrow sources; known, strong, storm-driven waves and

currents; and the concept of habitat connectivity. Littoral zone creation was not retained for further consideration; it would be cost-prohibitive due to the lower depth of Lake Okeechobee on its eastern side, the large amounts of fill required to create additional habitat, and the additional structures required to protect the littoral zone from high wind and wave energy while it establishes.

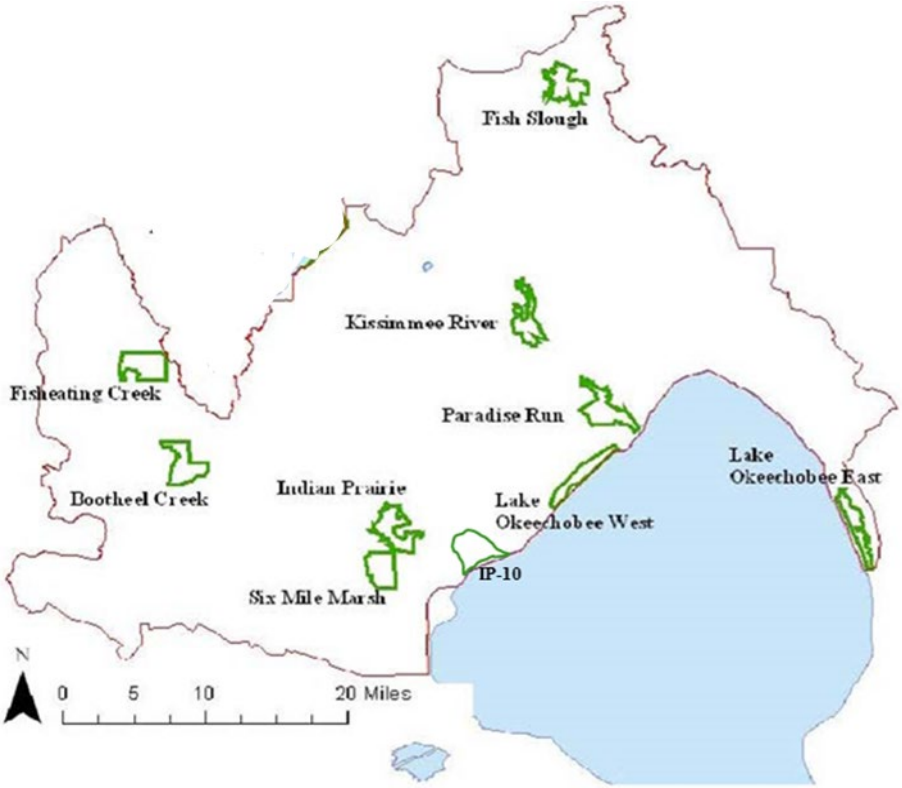


Figure E-9. Wetland restoration sites initially considered.

The remaining wetland sites were scored on a 0-1 scale based on the criteria listed below:

1. **Wading bird support**: Site is within 15 km of a known wading bird colony and would possess the proper hydrologic characteristics after restoration to support that colony.
2. **Connectivity**: Site is connected to other lands that are in public ownership or have other environmental protections such as conservation easements.
3. **Surface water connection**: Site has a surface water connection to another water body (lake, creek, river, canal, or wetlands) and would improve hydrologic connectivity and also maintain surface water quality.
4. **Restoration potential**: Site has a high percentage of lands needing restoration as opposed to lands currently in native habitat that could be preserved (with project).
5. **Percentage of public land ownership within the wetland footprint**: Use of public lands reduces costs and shortens timelines.
6. **Potential to co-locate with project reservoirs or ASR wells**: Co-locating wetlands with other LOWRP features wells has the potential to improve wetland performance and reduce overall costs.

More detail on scoring criteria development is located in Attachment B of this document. The four highest-scoring sites (Lake Okeechobee West, IP-10, Paradise Run, and Kissimmee River) were retained for further analysis (**Table E-12**).

Table E-12. Performance measure scores for wetland restoration site.

Site	Acreage	Wading Bird Colonies	Connectivity	Surface Water Connectivity	Restoration Potential	Co-location	Public Lands	Total	Retained
Lake O West	2,800	0.65	1	0.74	0.76	0.5	0	3.65	Yes
Paradise Run	3,847	0.47	0	1	0.49	1	0.5	3.46	Yes
Kissimmee River	2,595	0.47	0.16	0.75	0.33	0.5	1	3.21	Yes
IP-10	4,315	1	0.26	0.3	0.71	0.5	0	2.77	Yes
Bootheel Creek	3,432	0	0.79	0.52	0.39	0	0	1.7	No
Indian Prairie	5,370	0.47	0.39	0.1	0.53	0	0	1.49	No
Fish Slough	3,742	0	0.49	0.18	0.66	0	0	1.33	No
Lake O East	2,713	0.12	0	0	1	0	0	1.12	No

Due to the potential vast differences in restoration costs throughout the Kissimmee River site, it was further broken up into three smaller sites for additional analysis: Kissimmee River–North, Kissimmee River–Center, and Kissimmee River–South (**Figure E-10**).

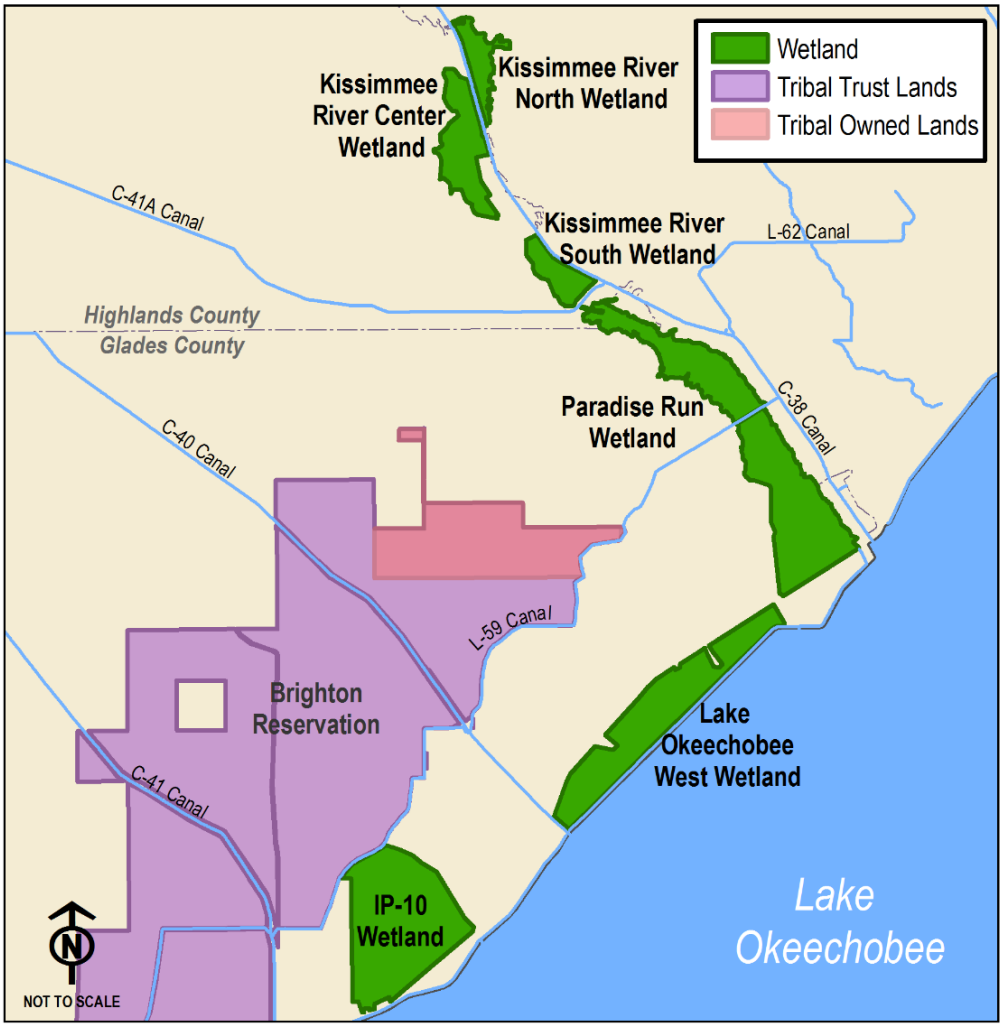


Figure E-10. Retained wetland restoration sites.

E.2.2 Level 2- Best-buy Wetland Restoration Sites

Planning-level costs were calculated for each site and the IWR Planning Suite II plan-generation tool was used to identify every possible combination of the six wetland sites. The IWR tool identified six best-buy wetland combinations, which were carried forward for consideration (**Table E-13**). The incremental cost per output for these best-buy wetland combinations is shown in **Figure E-11**.

Table E-13. Wetland best-buy combinations.

Wetland Component	Sites	Total Acres	Total First Costs (millions)	AAHU	AAC (millions)	AAC per AAHU	Incremental AAHU	Incremental AAC (millions)	Incremental AAC per AAHU
A	Kissimmee River–Center	1,200	$24	706	$0.889	$1,260	n/a	n/a	n/a
B	Kissimmee River–Center Paradise Run	5,300	$109	2,750	$4.0375	$1,470	2,044	$3.1485	$1,540
C	Kissimmee River–Center Paradise Run Lake Okeechobee West	8,100	$197	4,543	$7.2971	$1,610	1,793	$3.2596	$1,820
D	Kissimmee River–Center Paradise Run Lake Okeechobee West IP10	11,600	$329	6,760	$12.1865	$1,800	2,217	$4.8894	$2,210
E	Kissimmee River–Center Paradise Run Lake Okeechobee West IP10 Kissimmee River–South	12,200	$353	7,000	$13.0754	$1,870	240	$0.8889	$3,700
F	Kissimmee River–Center Kissimmee River Paradise Run Lake Okeechobee West IP10 Kissimmee River–South Kissimmee River–North	12,700	$577	7,255	$21.3726	$2,950	255	$8.2972	$32,570

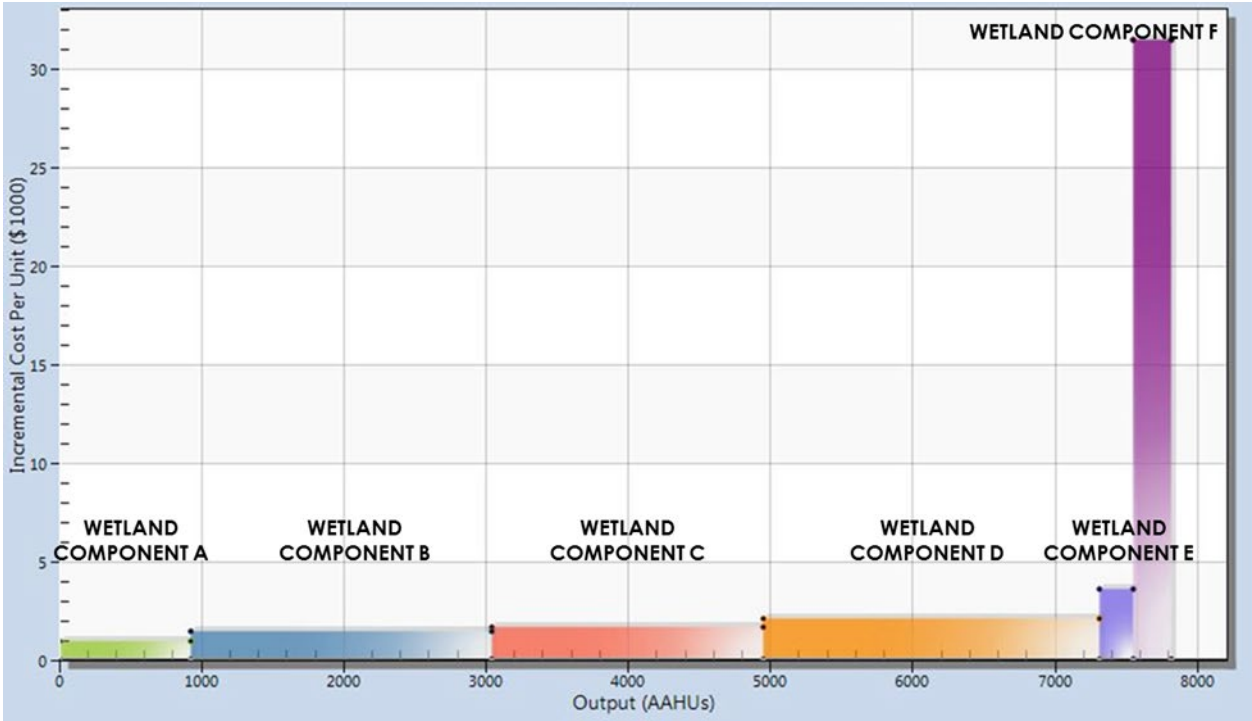


Figure E-11. Incremental cost per output of best buy wetland components.

E.2.3 Results of Wetland Restoration Analysis

Wetland Component B, which includes the Kissimmee River–Center and Paradise Run sites, was selected as the wetland restoration plan because it is the second-lowest cost best-buy plan that provides a meaningful amount of wetland restoration (5,300 acres) to restore hydrology. Although Wetland Component A was the first best-buy plan and the least-cost plan, 1,200 acres was determined to be insufficient to meet the intent of wetland restoration throughout the Lake Okeechobee watershed basin. Wetland Components E and F were dropped due to higher increments of cost per benefit. Wetland Components B, C, and D have similar incremental costs per habitat unit, but C and D are cost-prohibitive due to higher cost overall.

E.3 Identification of Focused Array of Alternatives

The PDT combined the selected water storage and wetland restoration components to create the focused array of alternatives. A key tenet of LOWRP formulation is the interdependency of project components. While management measures were initially formulated separately from a spatial perspective, the PDT recognizes the potential interdependencies between features to enhance both project performance and overall efficiency.

For example, ASR wells provide long-term storage but they have small pumps when compared to a reservoir or WAF, which can capture larger events more quickly. The co-location of ASR wells with aboveground storage would provide both long-term storage with the ASR wells and the ability to divert large amounts of water into the aboveground storage. The surface storage could also be filled more than once during a season or event as the ASR empties it, as opposed to a standalone surface storage facility

with limited storage volume. If an aboveground storage feature borders a wetland restoration site, there may be an additional benefit: seepage management features may not be required at areas where the two features are connected, resulting in overall cost savings.

Although each project feature would provide benefits on its own, overall performance is enhanced when features work in conjunction with each other. The alternatives are described in greater detail below in **subsections E.3.1**, **E.3.2**, and **E.3.3**, and in **Figure E-12**.

E.3.1 Alternative 1Bshlw

Alternative 1Bshlw includes a shallow reservoir located in the K-05 footprint, 80 total ASR wells (55 watershed ASR wells and 25 reservoir-assisted wells), and the Paradise Run and Kissimmee River Center wetland restoration sites.

Shallow Reservoir: The shallow reservoir is located in the K-05 footprint within the Indian Prairie sub-watershed west of the C-38 canal, north of SR 78, east of the Seminole Tribe of Florida Brighton Reservation, and south of the C-41A canal. The average pool depth of the reservoir will be about 5 feet. This reservoir will be operated to capture flows into Lake Okeechobee from the Kissimmee River Basin and maximize regional benefits, meaning operations will not be constrained to maintain habitat within this feature. The reservoir footprint, including the embankments, seepage canal, and other perimeter features, is approximately 14,800 acres, with a total storage capacity of approximately 65,000 acre-feet Reservoir-assisted ASR wells can be used to enhance this capacity. A pump station located downstream of the existing S-84 structure on the C-41A canal serves as the water source for the proposed shallow reservoir. The pump draws water from the downstream area that is considered to be part of Lake Okeechobee.

Aquifer Storage and Recovery Wells: 80 ASR wells are proposed in clusters in various locations throughout the watershed. The number of wells in each location has not yet been determined. The wells will utilize the Upper Floridan Aquifer and the Avon Park Permeable Zone for storage and recovery.

- **Reservoir-Assisted ASR Wells:** Reservoir-assisted ASR wells can be used to increase the total storage capacity of the shallow reservoir. There are three well clusters (approximately 25 wells total) located adjacent to the WAF. ASR wells will recharge using the reservoir surface water, and discharge water into the reservoir prior to its release into the Kissimmee River, thus providing dynamic storage.
- **Watershed ASR wells:** The remaining ASR wells are located throughout the watershed.
    - One proposed cluster is located adjacent to the C-44 canal in Port Mayaca. This would discharge out of the C-44 into Lake Okeechobee or to the St. Lucie River Estuary.
    - Three potential cluster areas are located in the S-191 sub-watershed. Some of the wells would be adjacent to the L-63N canal and the rest would be adjacent to the L-63S canal. These would all flow into the lake at the S-191 structure.
    - One cluster is located along Taylor Creek, downstream of S-192 and upstream of the S-133 pump station that discharges to Lake Okeechobee.
    - Two potential clusters are located adjacent to the C-38 canal downstream of S-65E that can discharge back into the C-38 canal.

- There is a well cluster along the C-40 canal downstream of S-72 that can discharge to Lake Okeechobee.
- There is a well cluster along the C-41 canal downstream of S-71 that can discharge to Lake Okeechobee.
- There is a well cluster along the C-43 canal in Moore Haven that can discharge to Lake Okeechobee or the Caloosahatchee River.

Wetland Restoration Sites: Wetland restoration includes the Paradise Run and Kissimmee River Center features. The Paradise Run site, approximately 4,000 acres, contains the historic Kissimmee River channel and floodplain. The site is located downstream of S-65E on the west bank of the C-38 canal, between the C-41A canal and the Buckhead Ridge community. A pump station on the C-41A canal downstream of S-84 serves as the water source for the wetland project which is intended to restore natural flow to the river and natural hydroperiod to the flood plain wetlands. The pump station will draw water into the historic Kissimmee River channel running through the Paradise Run site. About 24,500 linear feet of channel excavation will be performed. An overflow weir will be placed between the north and south sections of Paradise Run to control the flow and to connect both sides through the L-59 berms. The flow will discharge back into the C-38 canal by way of a culvert through the Herbert Hoover Dike on the southeast corner of the site. The Kissimmee River–Center site, approximately 1,200 acres, is located on the west bank of the C-38 canal about halfway between S-65D and S-65E. A submerged weir will be placed in the C-38 canal at the north end of the site to divert water to the west into a created river channel that mimics the historic Kissimmee River. About 21,500 feet of channel excavation will be performed to create riverine habitat and new floodplain wetlands.

E.3.2 Alternative 1BW

Alternative 1BW includes a WAF located in the K-05 footprint, 80 ASR wells (55 watershed ASR wells, 25 WAF-assisted wells in the K-05 area), and the Paradise Run and Kissimmee River–Center wetland restoration sites.

Wetland Attenuation Feature: The WAF is located in the K-05 footprint within the Indian Prairie sub-watershed west of the C-38 canal, north of SR 78, east of the Seminole Tribe of Florida Brighton Reservation, and south of the C-41A canal. The WAF is primarily used for surface water storage to attenuate peak flows and stages in adjacent areas (such as Lake Okeechobee). Although a WAF provides above ground storage like a reservoir, water levels may be suitable for growth of wetland vegetation due to the water depths typically realized through operation of the facility. The WAF footprint, including the embankments, seepage canal, and other perimeter features, is approximately 12,500 acres with a storage capacity of approximately 43,000 acre-feet. A pump station located downstream of the existing S-84 structure on the C-41A canal serves as the water source for the proposed WAF. The pump draws water from the downstream area that is considered to be part of Lake Okeechobee.

Aquifer Storage and Recovery Wells: The ASR well configuration is the same as Alternative 1Bshlw.

Wetland Restoration Sites: The wetland restoration sites are the same as Alternative 1Bshlw.

E.3.3 Alternative 2Cr

Alternative 2Cr includes a deep reservoir in the K-42 footprint, 65 watershed ASR wells, and the Paradise Run and Kissimmee River–Center wetland restoration sites.

Deep Reservoir: The reservoir, including the embankments, seepage canal, and other perimeter features, is approximately 14,600 acres. The average pool depth is about 15 feet, with a total storage capacity of about 195,000 acre-feet. Two pumps will be used for inflow in order to access water in the C-38 canal downstream of S-65E. The first pump is located downstream of S-84 and moves water into the C-41A canal. The second pump is located on the C-41A canal between S-83 and S-84 and pumps directly into the reservoir. The most likely location for an outflow culvert is back into the C-41A canal between S-83 and S-84.

Aquifer Storage and Recovery Wells: 65 ASR wells are proposed in clusters in various locations throughout the watershed. The number of wells in each location has not yet been determined. The wells will utilize the Upper Floridan Aquifer and the Avon Park Permeable Zone for storage and recovery.

- **Reservoir-Assisted ASR Wells:** There are no reservoir-assisted ASR wells in this alternative due to the presence of multiple agricultural irrigation wells nearby.
- **Watershed ASR wells:** All 65 ASR wells are placed in the same locations as described in Alternative 1Bshlw.

Wetland Restoration Sites: The wetland restoration sites in this alternative are the same as Alternative 1Bshlw.

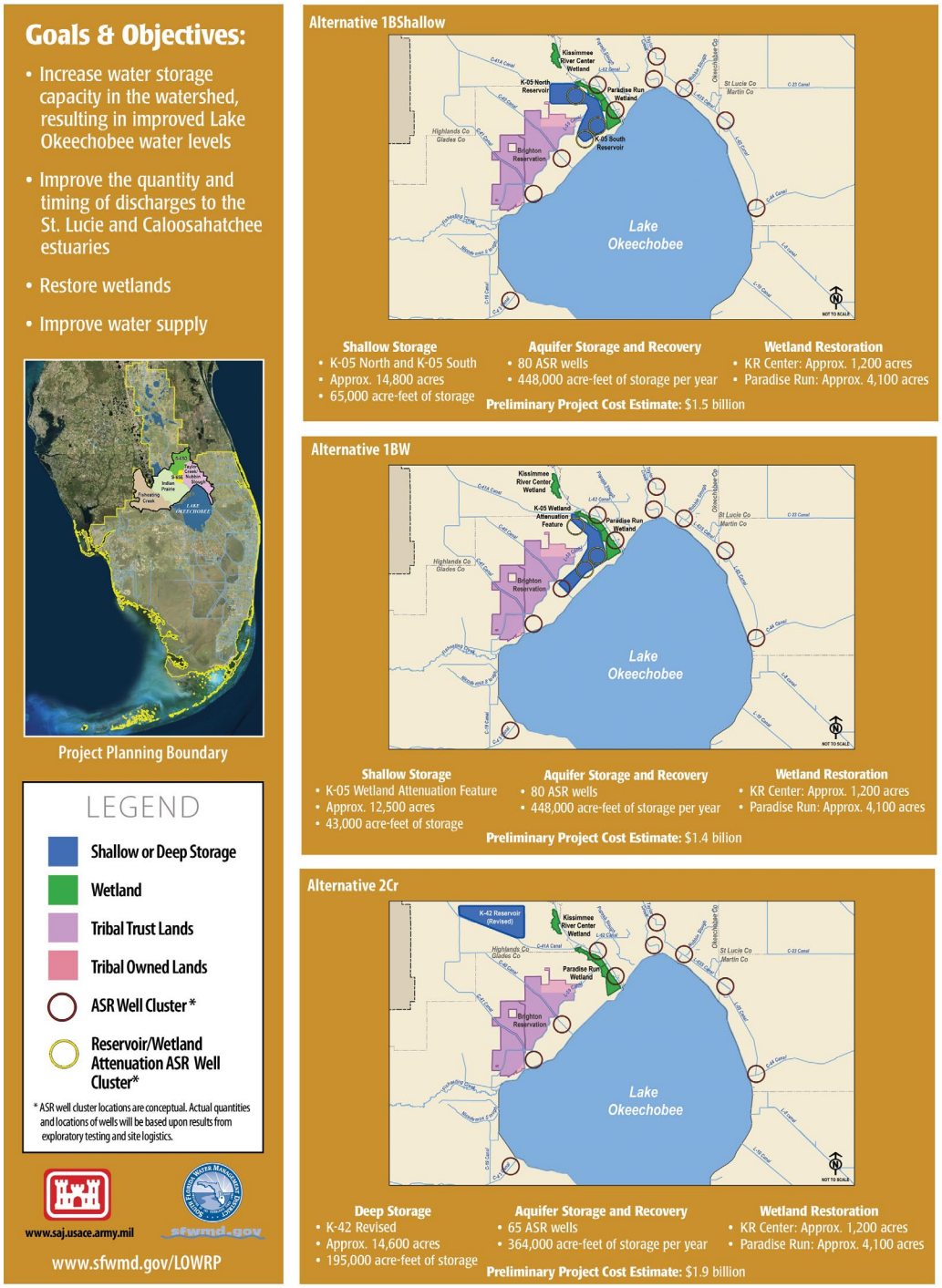


Figure E-12. Final array of alternatives.

Plan Formulation Attachment A- Parametric Tool Reservoir Cost Estimates Used During Initial Screening

All reservoir storage and cost estimates provided below were used during the initial screening phase. After the initial screening, more accurate storage capacities and rough order of magnitude costs were calculated.

Attachment Table 1. Total storage (acre-feet).

Depth (ft.)	YBA-01A Reservoir	YBA-02A Reservoir	YBA-02B Reservoir	YBA-03A Reservoir	I-17 Reservoir	K-42B West Reservoir	T-26 Reservoir TSP	K05 New Horizontal	K05 New Vertical	K05 New Med	K05 New BIG	Istokpoga-Canal New	T-26 Reservoir	Brady New	I-01
4												6,025	6,304	6,236	
8								89,172	89,220		151,93	11,407	12,043	11,813	63,334
10								111,006	111,066		189,214	14,087	14,902	14,589	78,801
12								132,841	132,913		226,493	16,766	17,761	17,366	94,268
14								154,554	154,638	208,144	263,584	19,400	20,580	20,095	109,637
16								176,144	176,240	237,276	300,487	21,988	23,358	22,778	124,909
18								197,612	197,720	266,257	337,203	24,530	26,096	25,413	140,083
10 YB	50,000	14,200	20,590												
11.5 YB				201,250											
16 TSP					79,560	161,263									
18 TSP							32,000								

Attachment Table 2. Cost to construct reservoirs (2012 USD).

Depth (ft.)	YBA-01A Reservoir	YBA-02A Reservoir	YBA-02B Reservoir	YBA-03A Reservoir	I-17 Reservoir	K-42B West Reservoir	T-26 Reservoir TSP	K05 New Horizontal	K05 New Vertical	K05 New Med	K05 New BIG	Istokpoga-Canal New	T-26 Reservoir	Brady New	I-01
4												129,341,862	121,855,764	120,647,391	
8								422,159,151	422,161,707		655,981,251	215,027,144	197,461,550	208,581,157	352,587,460
10								526,759,347	526,761,902		826,299,998	254,326,962	232,079,241	248,926,938	436,267,647
12								648,892,168	648,894,723		1,024,317,491	300,213,979	272,499,382	296,035,327	533,973,895
14								788,551,063	788,553,618	1,005,856,121	1,250,023,727	352,685,825	318,719,831	349,903,741	645,700,993
16								945,736,006	945,738,561	1,207,312,372	1,503,418,705	411,742,465	370,740,559	410,532,244	771,448,973
18								1,124,711,286	1,124,713,841	1,436,121,377	1,791,061,280	478,986,036	429,972,862	479,565,563	914,629,204
10 YB	326,823,667	232,658,725	247,060,551												
11.5 YB				952,284,362											

Depth (ft.)	YBA-01A Reservoir	YBA-02A Reservoir	YBA-02B Reservoir	YBA-03A Reservoir	I-17 Reservoir	K-42B West Reservoir	T-26 Reservoir TSP	K05 New Horizontal	K05 New Vertical	K05 New Med	K05 New BIG	Istokpoga-Canal New	T-26 Reservoir	Brady New	I-01
16 TSP					572,615,221	904,167,713									
18 TSP							449,904,075								

Attachment Table 3. Cost to purchase estimated additional land for reservoirs (2012 USD).

Depth (ft.)	YBA-01A Reservoir	YBA-02A Reservoir	YBA-02B Reservoir	YBA-03A Reservoir	I-17 Reservoir	K-42B West Reservoir	T-26 Reservoir TSP	K05 New Horizontal	K05 New Vertical	K05 New Med	K05 New BIG	Istokpoga-Canal New	T-26 Reservoir	Brady New	I-01
4												10,644,000	10,872,000	11,004,000	
8								72,438,000	72,474,000		122,502,000	10,644,000	10,872,000	11,004,000	51,948,000
10								72,438,000	72,474,000		122,502,000	10,644,000	10,872,000	11,004,000	51,948,000
12								72,438,000	72,474,000		122,502,000	10,644,000	10,872,000	11,004,000	51,948,000
14								72,438,000	72,474,000	96,852,000	122,502,000	10,644,000	10,872,000	11,004,000	51,948,000
16								72,438,000	72,474,000	96,852,000	122,502,000	10,644,000	10,872,000	11,004,000	51,948,000
18								72,438,000	72,474,000	96,852,000	122,502,000	10,644,000	10,872,000	11,004,000	51,948,000
10 YB	32,424,000	9,660,000	13,770,000												
11.5 YB				112,482,000											
16 TSP					32,496,000	61,686,000									
18 TSP							11,904,000								

Attachment Table 4. Annual cost to operate and maintain reservoirs (2012 USD).

Depth (ft.)	YBA-01A Reservoir	YBA-02A Reservoir	YBA-02B Reservoir	YBA-03A Reservoir	I-17 Reservoir	K-42B West Reservoir	T-26 Reservoir TSP	K05 New Horizontal	K05 New Vertical	K05 New Med	K05 New BIG	Istokpoga-Canal New	T-26 Reservoir	Brady New	I-01
4												919,000	913,000	923,000	
8								1,643,000	1,616,000		2,128,000	995,000	981,000	1,001,000	1,430,000
10								1,643,000	1,616,000		2,128,000	995,000	981,000	1,001,000	1,430,000
12								1,643,000	1,616,000		2,128,000	995,000	981,000	1,001,000	1,430,000
14								1,643,000	1,616,000	1,631,000	2,128,000	995,000	981,000	1,001,000	1,430,000
16								1,643,000	1,616,000	1,631,000	2,128,000	995,000	981,000	1,001,000	1,430,000
18								1,643,000	1,616,000	1,631,000	2,128,000	995,000	981,000	1,001,000	1,430,000

Depth (ft.)	YBA-01A Reservoir	YBA-02A Reservoir	YBA-02B Reservoir	YBA-03A Reservoir	I-17 Reservoir	K-42B West Reservoir	T-26 Reservoir TSP	K05 New Horizontal	K05 New Vertical	K05 New Med	K05 New BIG	Istokpoga-Canal New	T-26 Reservoir	Brady New	I-01
10 YB	1,208,000	978,000	1,017,000												
11.5 YB				2,069,000											
16 TSP					1,218,000	1,550,000									
18 TSP							996,000								

Attachment Table 5. Total capital and operations cost of reservoirs (2012 USD).

Depth (ft.)	YBA-01A Reservoir	YBA-02A Reservoir	YBA-02B Reservoir	YBA-03A Reservoir	I-17 Reservoir	K-42B West Reservoir	T-26 Reservoir TSP	K05 New Horizontal	K05 New Vertical	K05 New Med	K05 New BIG	Istokpoga-Canal New	T-26 Reservoir	Brady New	I-01
4												140,904,862	133,640,764	132,574,391	
8								496,240,151	496,251,707		780,611,251	226,666,144	209,314,550	220,586,157	405,965,460
10								600,840,347	600,851,902		950,929,998	265,965,962	243,932,241	260,931,938	489,645,647
12								722,973,168	722,984,723		1,148,947,491	311,852,979	284,352,382	308,040,327	587,351,895
14								862,632,063	862,643,618	1,104,339,121	1,374,653,727	364,324,825	330,572,831	361,908,741	699,078,993
16								1,019,817,006	1,019,828,561	1,305,795,372	1,628,048,705	423,381,465	382,593,559	422,537,244	824,826,973
18								1,198,792,286	1,198,803,841	1,534,604,377	1,915,691,280	490,625,036	441,825,862	491,570,563	968,007,204
10 YB	360,455,667	243,296,725	360,455,667												
11.5 YB				1,066,835,362											
16 TSP					606,329,221	967,403,713									
18 TSP							462,804,075								

Attachment Table 6. Cost per acre-foot (2012 USD).

Depth (ft.)	YBA-01A Reservoir	YBA-02A Reservoir	YBA-02B Reservoir	YBA-03A Reservoir	I-17 Reservoir	K-42B West Reservoir	T-26 Reservoir TSP	K05 New Horizontal	K05 New Vertical	K05 New Med	K05 New BIG	Istokpoga-Canal New	T-26 Reservoir	Brady New	I-01
4												23,387	21,197	21,258	
8								5,565	5,562		5,137	19,870	17,380	18,673	6,409
10								5,412	5,409		5,025	18,880	16,369	17,884	6,213
12								5,442	5,439		5,072	18,599	16,009	17,738	6,230

Depth (ft.)	YBA-01A Reservoir	YBA-02A Reservoir	YBA-02B Reservoir	YBA-03A Reservoir	I-17 Reservoir	K-42B West Reservoir	T-26 Reservoir TSP	K05 New Horizontal	K05 New Vertical	K05 New Med	K05 New BIG	Istokpoga-Canal New	T-26 Reservoir	Brady New	I-01
14								5,581	5,578	5,305	5,215	18,779	16,063	18,009	6,376
16								5,789	5,786	5,503	5,418	19,255	16,379	18,550	6,603
18								6,066	6,063	5,763	5,681	20,001	16,931	19,343	6,910
10 YB	7,209	17,133	17,506												
11.5 YB				5,301											
16 TSP					7,621	5,998									
18 TSP							14,462								

Plan Formulation ATTACHMENT B- Wetland Restoration Screening

Performance Measures Names and Numbers Used For Habitat Units Scoring

LOWRP PM# 1– Lake Okeechobee Watershed Wetlands Restoration

Justification

Historically the Lake Okeechobee Watershed project (LOWRP) area was about 40 percent wetlands. Today about 15 percent remains resulting in a loss of about 330,000 acres of wetlands. Historically these were cypress and bay tree forests, inland swamps, freshwater marsh, wet prairie, and sawgrass marsh (Davis 1943). Land use changes over the last 150 years have resulted in a general conversion to agriculture, primarily pasture (51 percent of the area). This loss of wetland habitat has resulted in less water storage on the landscape, increased storm-water runoff, and more flashy hydroperiods in Fisheating Creek, Kissimmee River, Taylor Creek and Nubbin Slough. According to the Lake Okeechobee Conceptual Ecological Model (Havens 2003), conversion to agricultural and residential land uses in the watershed along with water management have resulted in increased nutrient and sediment concentrations and more extreme and frequent high and low stages in Lake Okeechobee. These stressors can negatively affect waterfowl and wading birds, fish and other aquatic fauna, and native aquatic vegetation.

Wetland restoration in LOWRP supports the following CERP Objectives:

1. Increase Habitat and Functional Value;
2. Increase Native Plant and Animal Species Abundance and Diversity; and
3. Increase Economic and Social Well Being via a) Reducing flood damages; b) providing recreational opportunities; and c) increasing groundwater recharge for water supply.

Wetland restoration also supports the following LOWRP Objectives:

1. Increase Habitat Within the Watershed;
2. Increase Water Supply in the Watershed;
3. Increase Recreational Opportunities; and
4. Restudy target = minimum of 3,500 acres.

Indicator Regions: The Lake Okeechobee Watershed has no CERP Indicator Regions other than the Lake itself. The sub watersheds (Fisheating Creek, Indian Prairie, Kissimmee River, and Taylor Creek and Nubbin Slough) have varying hydrology (and flashiness) due to their overall size and varying ecological conditions due to the level of previous land use changes. Fisheating Creek has conservation easements throughout its watershed resulting in generally better habitat for fish and wildlife. Habitat within the Brighton Seminole Reservation is also in a much more native state than the remainder of the Indian Prairie basin. Kissimmee River is a large watershed and provides most of the surface flow to Lake Okeechobee on annual basis. The upper portion is being restored and is upstream of the LOWRP project area, but should reduce the flashiness of its hydroperiod as restoration is completed in a few years. Taylor Creek and Nubbin Slough tend to be the flashiest watersheds, and at times no surface flow is visible.

CERP Evaluation Target

The Restudy target was a minimum of 3,500 acres of wetlands restored with no stated maximum goal. The study team, realizing that about 330,000 acres of wetlands have been lost in the LOWRP area, did not use size as a constraint, but rather decided that more wetland acres restored would generally be better. One of the goals of the LOWRP is to achieve appropriate depth, duration and frequency targets in the Lake Okeechobee watershed wetlands. This will serve to increase habitat, water supply, and recreation in the watershed. The performance measure has five sub-metrics that establish the wetland targets. Each sub-metric uses the top-scoring and lowest-scoring wetland candidates as the determinants for the zero to 1.0 score. The sub-team also agreed to target potential restoration lands that possessed at least 85 percent hydric soils (historic and current combined) in an effort to minimize acquisition of large areas of non-hydric soils that could undermine wetland restoration potential. Nine sites were evaluated **(Figure 1)**. Other constraints included:

1. No or minimal adverse impacts to T&E species as a result of restoration activities;
2. Site does not have potential for high chemical contaminant load based on historic land use that would interfere with restoration; and
3. Site does not have significant archaeological or cultural resources that would be adversely impacted by restoration activities.

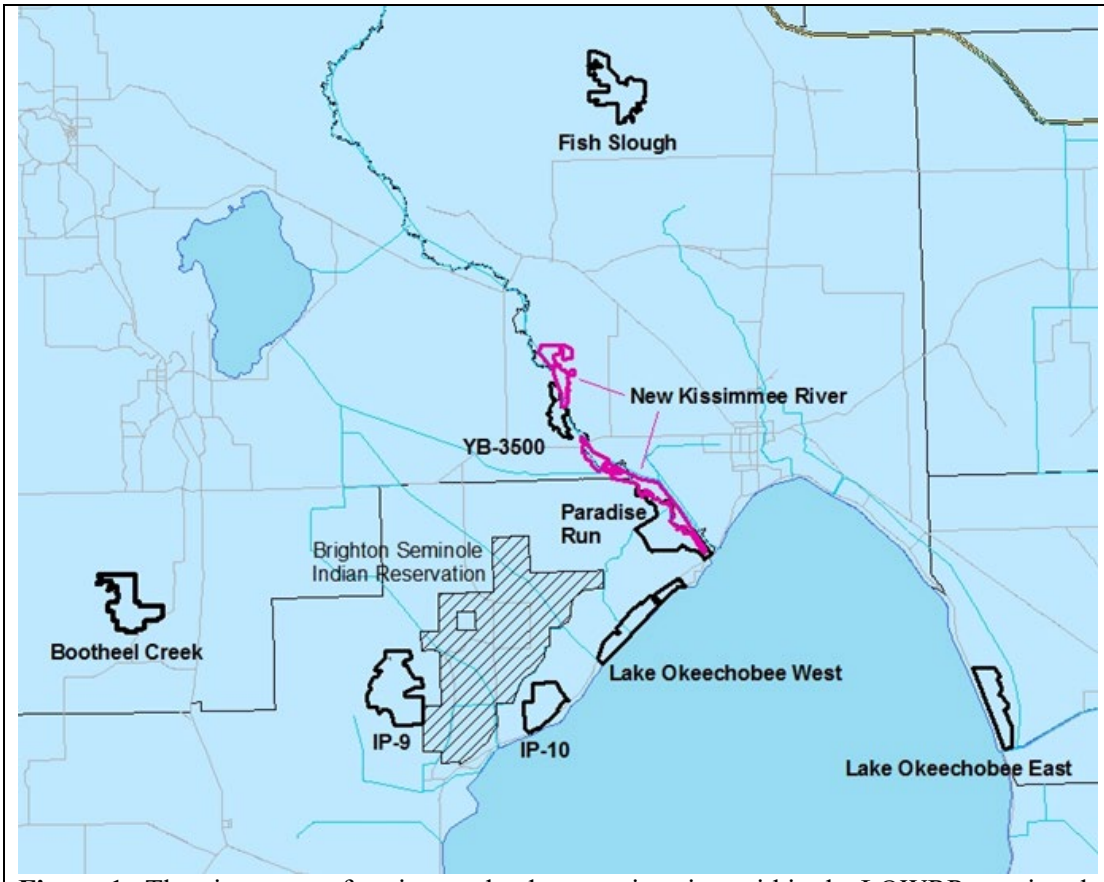


Figure 1. The nine top-performing wetland restoration sites within the LOWRP area in relation to the Brighton Seminole Indian Reservation. The wetland site in pink (New Kissimmee River) is underlain by SFWMD-owned land. The remainder of the sites are on privately-owned land.

Five sub metrics for the wetland restoration performance measure were developed.

1. Wading Bird Support: **Site is within 15 km of an active wading bird colony and would possess the proper hydrologic characteristics after restoration to support that colony.** Based on information in Cox et al (1994), wading birds typically forage in wetlands that are within 15 km of their nesting area during the breeding season. The 15 km distance is measured as the shortest distance from the colony center to the closest edge of the potential wetland site (**Figure 2**). The number of active wading bird colonies that would be supported by a potential wetland site ranged from 0 to 17; therefore, the site with the most colonies (*e.g.,* IP-10) received a score of 1.00 and the sites with no colonies (*e.g.,* Bootheel Creek and Fish Slough) received scores of 0.00 (**Table 1**).

Table 1. Scores for the number of active colonies for the remaining sites.

Site Name	Acres of Site	Active Colonies	Score
Bootheel Creek	3432	0	0.00
Lake O West	2750	11	0.65
Fish Slough	3742	0	0.00
IP-9	5370	8	0.47

IP-10	2595	17	1.00
New Kiss River	4315	8	0.47
Lake O East	2713	2	0.12
Paradise Run	3847	8	0.47
YB-3500	1145	1	0.06

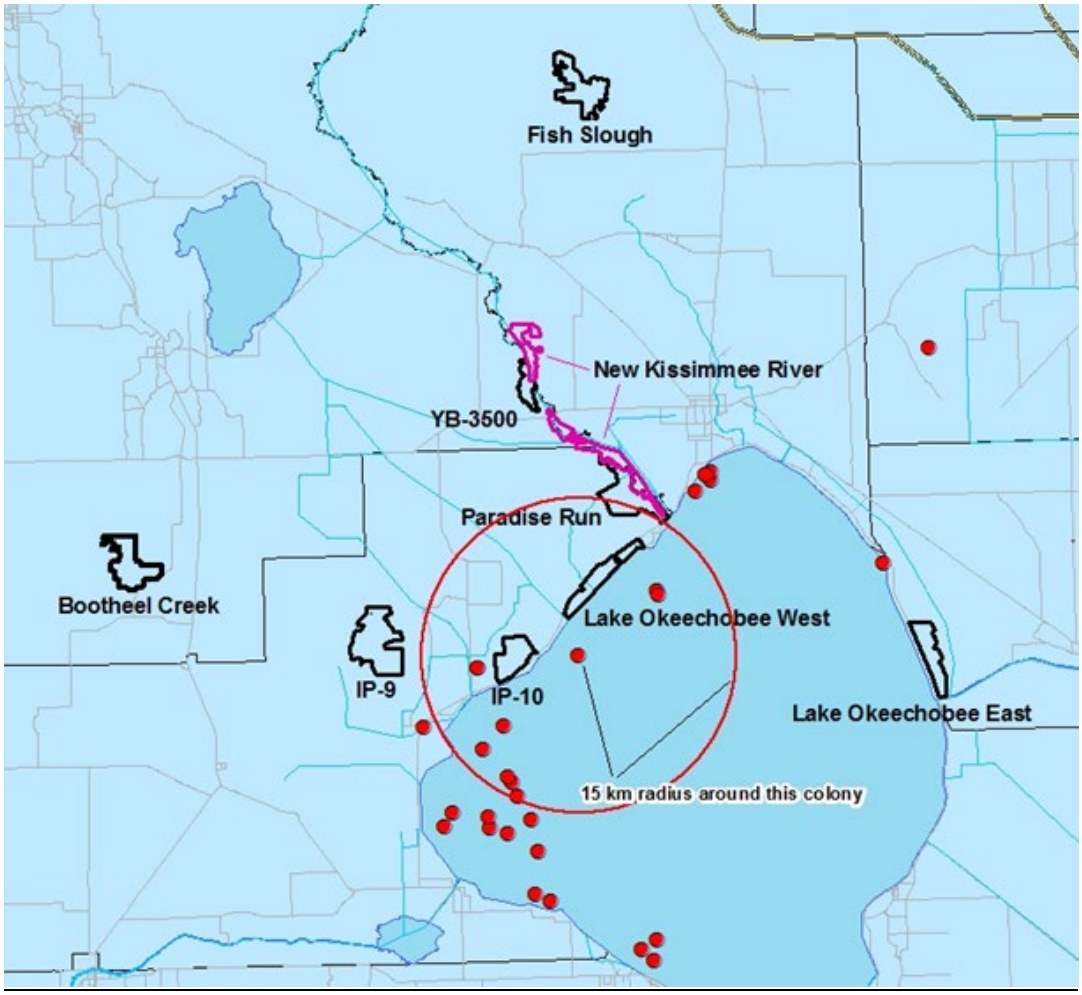


Figure 2. The active wading bird colony data, including two wood stork colonies and the 15 km buffer used to score the wetland sites.

2. Percent Connectivity: **Site is connected to other lands that are in public ownership or have other environmental protections such as conservation easements.** Connecting a restoration site to an existing natural area should increase the success of the restoration component by maximizing patch size. We therefore, attempted to maximize direct perimeter connectivity to other public or privately protected high ecological value lands. Connectivity was measured as a percentage of the potential restoration site's perimeter that was connected to public lands [as described in Florida Natural Areas Inventory's Florida Lands Managed Areas (FLMA) spatial data file] (**Figure 3**). Percent Connectivity for all the potential wetland sites ranged from 0 percent to 41 percent (see table below). Scores were calculated as a percentage of the maximum connectivity. For example, the Lake O West site had the maximum amount of connectivity (41 percent), and so received a score of 1.00. The intervening sites were scored based on their percentage of maximum; therefore, a 20 percent

connectivity = 20/41 = score of 0.49 (**Table 2**).

Table 2. Percent Connectivity scores for all the sites.

Site Name	Perimeter (meters)	Perimeter connected to conservation lands (meters)	Percent connected to conservation lands	Score
Bootheel Creek	24661	7880	0.32	0.79
Lake O West	24768	10070	0.41	1.00
Fish Slough	32592	6428	0.20	0.49
IP-9	26355	4215	0.16	0.39
IP-10	14942	1562	0.10	0.26
New Kiss River	65059	4194	0.06	0.16
Lake O East	18957	0	0.00	0.00
Paradise Run	28730	0	0.00	0.00
YB-3500	13938	0	0.00	0.00

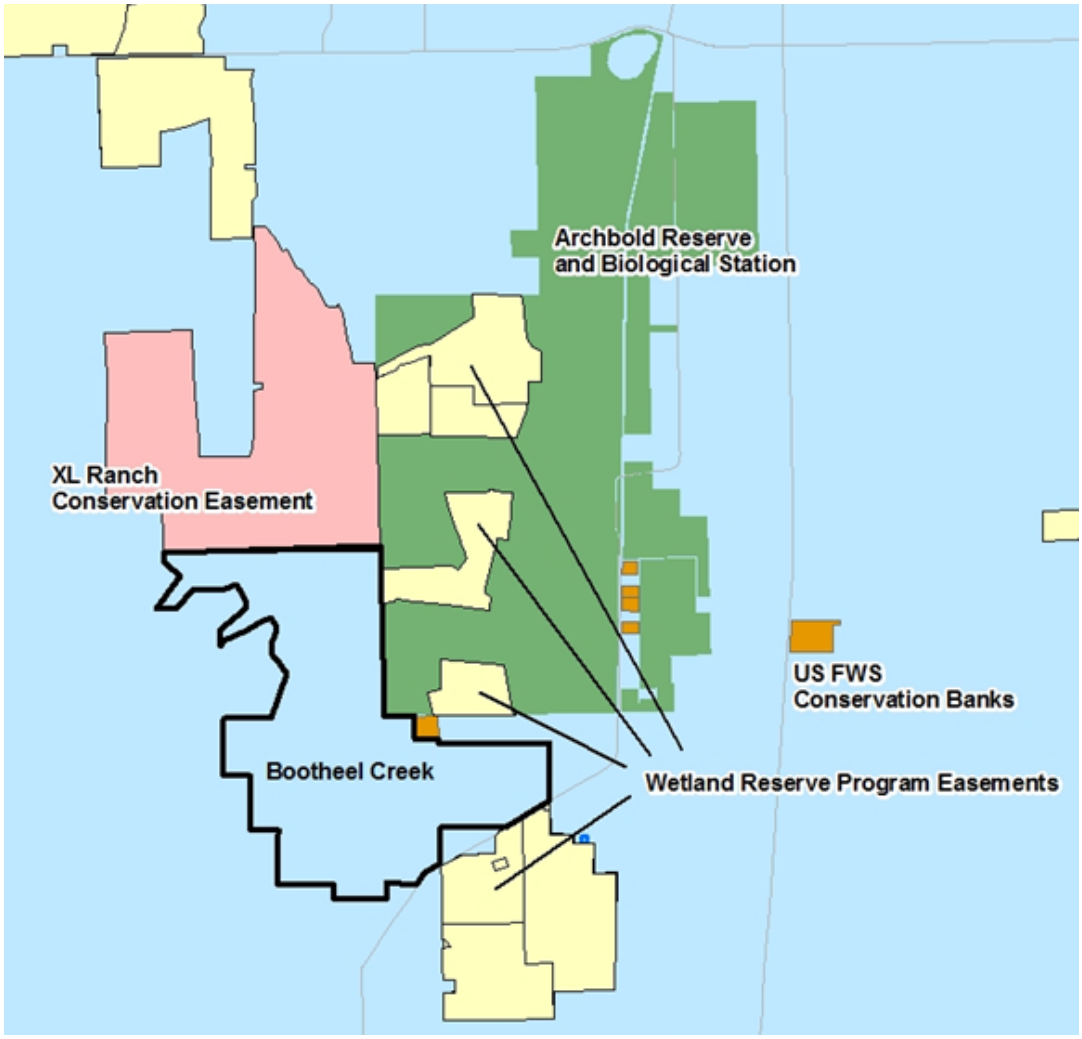


Figure 3. The placement of the Bootheel Creek wetland restoration site in relation to adjacent lands that are under conservation easements (Conservation Land Connectivity metric).

3. Surface Water Connection: **Site has a surface water connection to another water body (lake, creek, river, canal, or wetlands) and would improve hydrologic connectivity and maintain surface water quality .** This performance measure was based on the percentage of the perimeter of the site that had connectivity to adjacent surface water. Determinations were based on USGS hydrography spatial data layer and 2015 land use data (**Figure 4**). Shoreline measurements for sites that were connected to both sides of a water body would be doubled. Surface Water Connection for all the potential wetland sites ranged from 0 percent to 59 percent (**Table 3**). Scores were calculated as a percentage of the maximum connectivity. For example, the Paradise Run site had the maximum amount of connectivity (59 percent), and so received a score of 1.00. The other sites were scored based on their percentage of the maximum connectivity.

Table 3. Surface water connection for wetland sites.

Site Name	Perimeter (meters)	Percent of wet adjacent	Score
Bootheel Creek	24661	0.30	0.52
IP-9	24768	0.06	0.10
IP-10	32592	0.18	0.30
Lake O West	26355	0.43	0.74
Lake O East	14942	0.00	0.00
Paradise Run	65059	0.59	1.00
YB-3500	18957	0.18	0.31
Fish Slough	28730	0.11	0.18
New Kiss River	13938	0.44	0.75

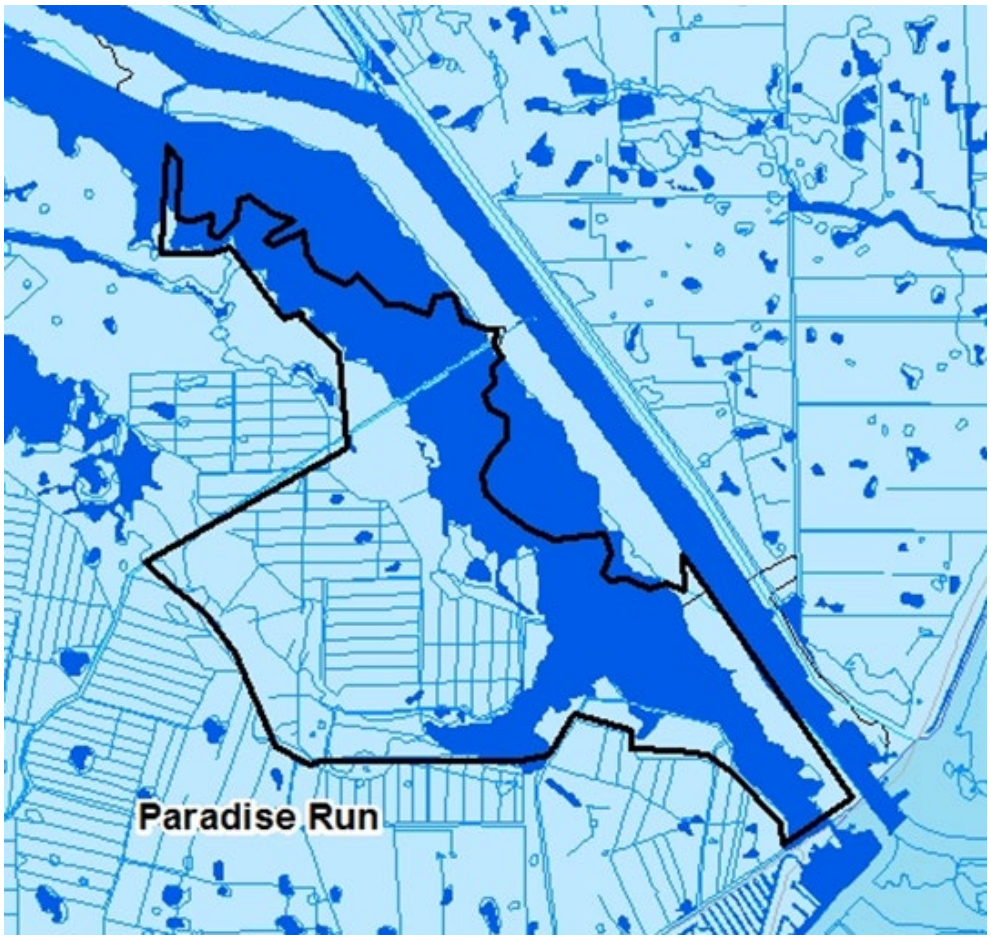


Figure 4. The hydrology in and around the Paradise Run wetland restoration site showing a high degree of surface

water connectivity (open water, wetlands, and ditching land use codes are shown in dark blue).

4. Restoration Potential Percent: **Site has a high percentage of lands needing restoration as opposed to lands currently in native habitat that could be preserved (with project)**. Sites with higher restoration potential are likely to result in maximum project benefits following restoration and may be easier to justify than sites with high preservation value (*i.e.*, sites already possessing high ecological quality). Restoration potential was measured as the percentage of non-native habitats (based on SFWMD 2015 land use data) (**Figure 5**). All potentially restorable land uses (*i.e.,* we excluded urban and residential areas) were assigned a value between 0 and 0.99 based on the degree to which the study team believed the land cover diverged from the fully restored condition (**Table 4**). For example, more disturbed land uses like sod farms, or row crops received higher values and highly functioning wetlands received lower values. **Table 6** lists the values (i.e., Restoration Potential Value) per land use code. Then the spatial percentages of each land cover were summed and divided by the total acreage of the site to estimate the overall restoration potential. For example, a 100 acre site with 90 percent improved pasture (restoration potential value of 0.80) and 10 percent freshwater marsh (value of 0.00), received a score of: (0.8 x 90%) + (0.0 x 20%) = 0.72. The sites ranged from a low of 32 percent (New Kissimmee River) to a maximum of 97 percent restorable (Lake O East). The scores were normalized (see table below) and ranged from 0.33 to 1.00.

Table 4. Restoration potential of wetland sites.

Site Name	Restoration Potential Percent	Score
Bootheel Creek	0.39	0.40
Fish Slough	0.64	0.66
IP-10	0.69	0.71
IP-9	0.51	0.53
Lake O East	0.97	1.00
Lake O West	0.74	0.76
New Kiss River	0.32	0.33
Paradise Run	0.48	0.49
YB-3500	0.56	0.58

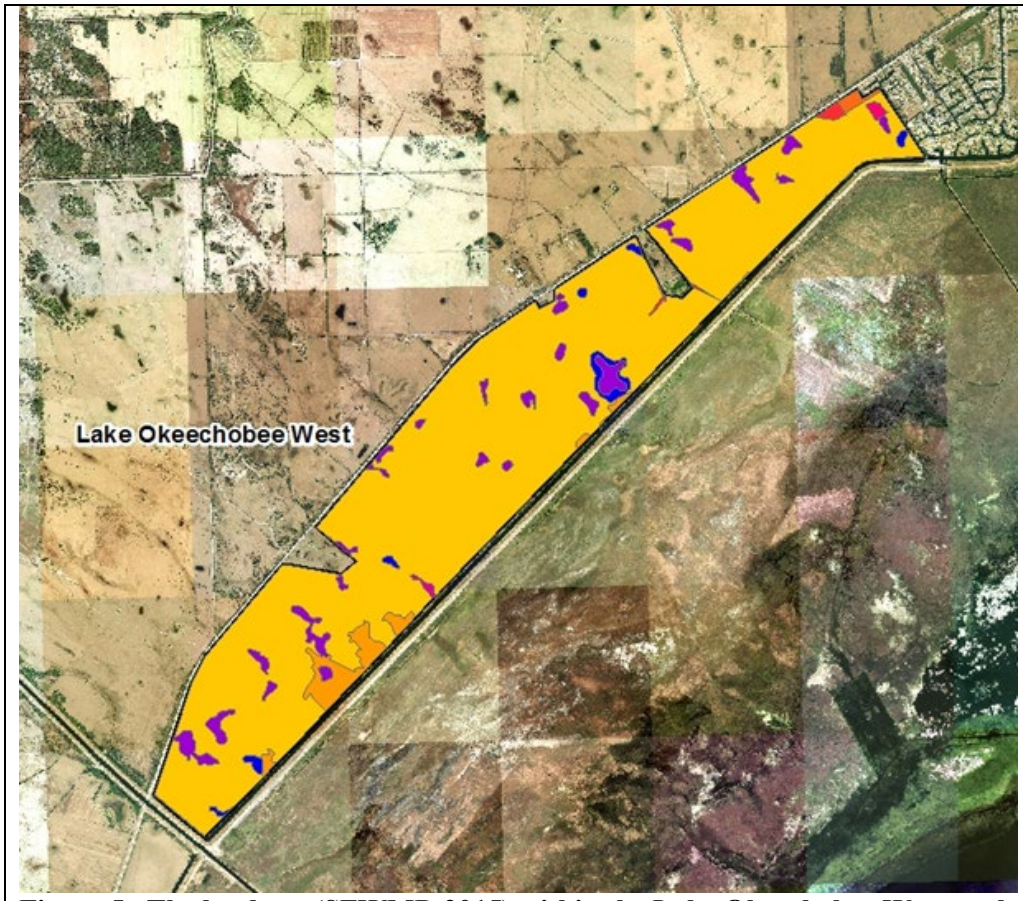


Figure 5. The land use (SFWMD 2015) within the Lake Okeechobee West wetland restoration site displayed on 2012 natural color aerial photography. The site has a high restoration potential because it is primarily improved and unimproved pasture (yellow and gold), with scattered freshwater marsh (purple) and wet prairie (blue) wetlands.

5. Public Access: **Site has high potential for public access and would support wildlife-related recreation thereby supporting a goal of the original C&SF Project as well as the CERP's Master Recreation Plan.** Sites will be evaluated based on their distance from existing population centers. Ten population centers were identified and split into two classes based on US Census Bureau classification scheme and population data. The larger population centers, possessing greater than 10,000 people were City of Okeechobee-Taylor Creek, Sebring, Avon Park, Fort Pierce, and Port St. Lucie. The smaller population centers, possessing between 5,600 and 8,000 people, were Pahokee, Clewiston, Arcadia, and Indiantown. Population centers with less than 2,500 people (*e.g.*, Lake Placid, Buckhead Ridge, and Moore Haven) were excluded from this analysis. Around each analyzed population center, a 120-mile diameter "bulls-eye" (*i.e.,* a series of six, 10-mile radial-interval concentric circles) was drawn (**Figure 6** shows an example for the City of Okeechobee). Points within each 10-mile band were ascribed as follows. For the larger population centers, a potential wetland site that fell within the innermost circle scored a 10. For each successive 10-mile increment, the scores were 8, 6, 4, 2, and 0. For the smaller population centers, a potential wetland site that fell within the innermost circle scored a 5. For each successive 10-mile increment, the scores were 4 3, 2, 1, and 0. Then, the number of points each potential wetland site received for all the bull's-eyes were then summed. The scores ranged from a low of 20 (Bootheel Creek Site) to a maximum of 35 points (New Kissimmee River Site). As with the previous metrics, an interim scoring site would be based on how well they compared percentage-wise to the highest scoring site. The points and scores are presented in **Table 5**.

Table 5. Public access points and scores for each wetland site.

Site Name	Okeechobee	Sebring	Avon	Fort	Port St. Lucie	Pahokee	Clewiston	Arcadia	Indiantown	Total Points	Score
Bootheel Creek	4	6	4	0	0	1	2	3	0	20	0.57
Fish Slough	8	6	4	4	0	0	0	0	1	23	0.66
IP-10	8	4	2	2	2	3	4	0	2	27	0.77
IP-9	8	4	2	0	0	2	3	1	1	21	0.60
Lake O East	8	0	0	4	6	4	3	0	5	30	0.86
Lake O West	10	2	2	2	2	3	3	0	3	27	0.77
New Kiss River	10	6	4	4	2	3	3	0	3	35	1.00
Paradise Run	10	4	2	4	2	3	3	0	3	31	0.89
YB-3500	8	4	4	2	2	2	2	0	2	26	0.74

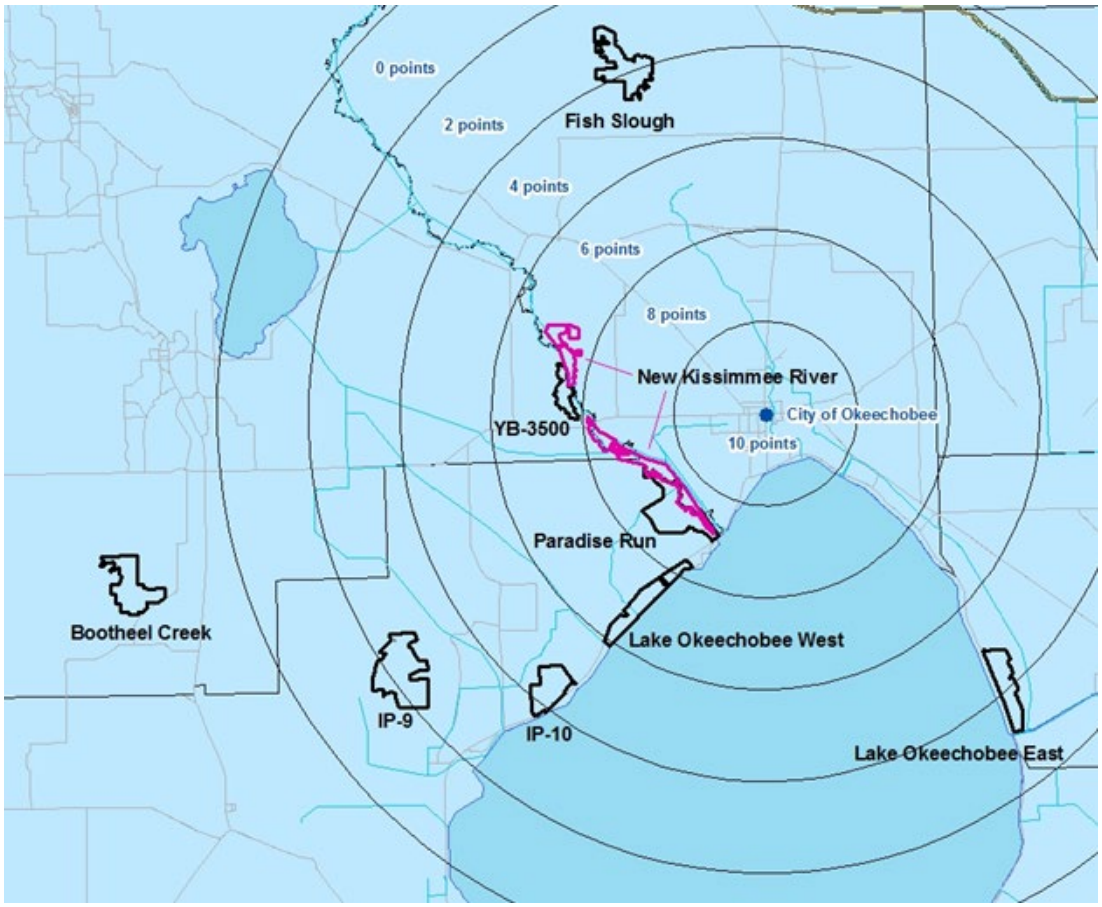


Figure 6. The "bulls-eye" scoring method used for the Public Access metric using the City of Okeechobee as an example.

Table 6. Land use (FLUCCS) codes and their Restoration Potential Score for Performance Measure Sub-metric #4.

FLUCCS Level 4 Code	FLUCCS Code Description	FLUCCS Code Description Category	Restoration Potential Score
1009	Mobile Home Units Any Density	Residential	0.99
1100	Residential Low Density <2 du/ac	Residential	0.80
1110	Fixed Single Family Units <2 du/ac	Residential	0.80
1130	Mixed Units (Fixed and mobile home units)<	Residential	0.80
1190	Low Density Under Construction<2 du/ac	Residential	0.99
1200	Residential Medium Density 2-5 du/acre	Residential	0.99
1210	Fixed Single Family Units 2-5 du/ac	Residential	0.99
1230	Mixed Units (Fixed and mobile home units)	Residential	0.99
1290	Medium Density Under Construction 2-5 du/a	Residential	0.99
1300	Residential High Density	Residential	0.99
1310	Fixed Single Family Units	Residential	0.99
1320	Mobile Home Units (6 or more du/acre)	Residential	0.99
1330	Multiple Dwelling Units Low Rise	Residential	0.99
1340	Multiple Dwelling Units High Rise	Residential	0.99
1350	Mixed Units <Fixed and mobile home units>	Residential	0.99
1400	Commercial and Services	Commercial & Services	0.99
1410	Retail Sales and Services	Commercial & Services	0.99
1411	Retail Sales and Services - Shopping Centers	Commercial & Services	0.99
1420	Wholesale Sales and Services	Commercial & Services	0.99
1423	Wholesale Sales and Services - Junk Yards	Commercial & Services	0.99
1430	Professional Services	Commercial & Services	0.99
1440	Cultural and Entertainment	Commercial & Services	0.99
1450	Tourist Services	Commercial & Services	0.99
1453	Travel Trailer Parks	Commercial & Services	0.90
1470	Mixed Commercial and Services	Commercial & Services	0.99
1480	Cemeteries	Commercial & Services	0.90
1500	Industrial Under Construction	Industrial	0.99
1510	Food Processing	Industrial	0.99
1550	Other Light Industrial	Industrial	0.99
1560	Other Heavy Industrial	Industrial	0.99
1600	Extractive	Industrial	0.99
1620	Sand and Gravel Pits	Industrial	0.99
1700	Institutional	Institutional	0.99
1710	Educational Facilities	Institutional	0.99
1720	Religious	Institutional	0.99
1730	Military	Institutional	0.70
1740	Medical and Health Care	Institutional	0.99
1750	Governmental	Institutional	0.99
1761	State Prisons	Institutional	0.90
1763	Juvenile Centers	Institutional	0.90
1800	Recreational	Recreational	0.70
1820	Golf Courses	Recreational	0.80
1830	Race Tracks	Recreational	0.99
1840	Marinas and Fish Camps	Recreational	0.80
1841	Marinas (Basins)	Recreational	0.80
1850	Parks and Zoos	Recreational	0.70
1860	Community Recreational Facilities	Recreational	0.90

1890	Other Recreational	Recreational	0.80
1900	Open Land	Open Land	0.50
1910	Undeveloped Land within urban areas	Open Land	0.80
1920	Inactive Land with street pattern	Open Land	0.99
1930	Urban Land in transition	Open Land	0.90
1940	Other Open Land	Open Land	0.50
2100	Cropland and Pastureland	Cropland/Pastureland	0.99
2110	Improved Pastures	Pastureland	0.80
2120	Unimproved Pastures	Pastureland	0.50
2130	Woodland Pastures	Pastureland	0.40
2140	Row Crops	Cropland	0.99
2150	Field Crops	Cropland	0.99
2156	Field Crops - Sugar Cane	Cropland	0.99
2200	Tree Crops	Tree Crops	0.80
2210	Citrus Groves	Tree Crops	0.80
2220	Fruit Orchards	Tree Crops	0.80
2230	Other Groves	Tree Crops	0.80
2320	Poultry Feeding Operations	Feeding Operations	0.90
2400	Nurseries and Vineyards	Nurseries & Vineyards	0.80
2410	Tree Nurseries	Nurseries & Vineyards	0.80
2420	Sod Farms	Nurseries & Vineyards	0.90
2430	Ornamentals	Nurseries & Vineyards	0.90
2450	Floriculture	Nurseries & Vineyards	0.80
2500	Specialty Farms	Specialty Farms	0.80
2510	Horse Farms	Specialty Farms	0.80
2520	Dairies	Specialty Farms	0.90
2540	Aquaculture	Specialty Farms	0.70
2549	Aquaculture	Specialty Farms	0.70
2600	Other Open Lands Rural	Open Land	0.70
2610	Fallow Crop Land	Cropland	0.80
3100	Herbaceous Rangeland	Rangeland	0.40
3200	Shrub and Brushland	Rangeland	0.40
3210	Palmetto Prairies	Rangeland	0.40
3290	Other Shrubs and Brush	Rangeland	0.40
3300	Mixed Rangeland	Rangeland	0.40
4000	Upland Forests	Upland Forests	0.30
4100	Upland Coniferous Forest	Upland Forests	0.30
4110	Pine Flatwoods	Upland Forests	0.30
4119	Pine Flatwoods - Melaleuca Infested	Upland Forests	0.50
4120	Longleaf Pine - Xeric Oak	Upland Forests	0.30
4130	Sand Pine	Upland Forests	0.30
4140	Pine - Mesic Oak	Upland Forests	0.30
4200	Upland Hardwood Forest	Upland Forests	0.30
4210	Xeric Oak	Upland Forests	0.30
4220	Brazilian Pepper	Upland Forests	0.80
4230	Oak - Pine - Hickory	Upland Forests	0.30
4240	Melaleuca	Upland Forests	0.80
4250	Temperate Hardwood	Upland Forests	0.30
4270	Live Oak	Upland Forests	0.30
4280	Cabbage Palm	Upland Forests	0.30
4310	Beech - Magnolia	Upland Forests	0.30
4320	Sand Live Oak	Upland Forests	0.30
4330	Western Everglades Hardwoods	Upland Forests	0.30

4340	Hardwood Conifer Mixed	Upland Forests	0.30
4350	Dead Trees	Upland Forests	0.50
4370	Australian Pine	Upland Forests	0.80
4380	Mixed Hardwoods	Upland Forests	0.30
4400	Tree Plantations	Silvaculture	0.60
4410	Coniferous Plantations	Silvaculture	0.60
4430	Forest Regeneration Areas	Silvaculture	0.60
5100	Streams and Waterways	Open Water	0.00
5200	Lakes	Open Water	0.00
5210	Lakes larger than 500 acres	Open Water	0.00
5220	Lakes larger than 100 acres - less than 50	Open Water	0.00
5230	Lakes Larger than 10 acres - less than 100	Open Water	0.00
5240	Lakes less than 10 acres	Open Water	0.00
5300	Reservoirs	Open Water	0.50
5310	Reservoirs larger than 500 acres	Open Water	0.50
5320	Reservoirs larger than 100 acres - less than 500 acres	Open Water	0.50
5330	Reservoirs larger than 10 acres - less than 100 acres	Open Water	0.50
5340	Reservoirs less than 10 acres	Open Water	0.50
5600	Slough Waters	Open Water	0.00
6100	Wetland Hardwood Forest	Wetlands	0.00
6110	Bay Swamps	Wetlands	0.00
6120	Mangrove Swamps	Wetlands	0.00
6140	Titi Swamps	Wetlands	0.00
6150	Stream and Lake Swamps (Bottomland)	Wetlands	0.00
6160	Inland Ponds and Sloughs	Wetlands	0.00
6170	Mixed Wetland Hardwoods	Wetlands	0.00
6171	Mixed Wetland Hardwoods - Willows	Wetlands	0.00
6172	Mixed Wetland Hardwoods - Mixed Shrubs	Wetlands	0.00
6200	Wetland Coniferous Forest	Wetlands	0.00
6210	Cypress	Wetlands	0.00
6218	Cypress - Melaleuca Infested	Wetlands	0.30
6219	Cypress - with Wet Prairies	Wetlands	0.00
6220	Pond Pine	Wetlands	0.00
6240	Cypress - Pine - Cabbage Palm	Wetlands	0.00
6300	Wetland Forested Mixed	Wetlands	0.00
6400	Vegetated Non-Forested Wetlands	Wetlands	0.00
6410	Freshwater Marshes	Wetlands	0.00
6411	Freshwater Marshes - Sawgrass	Wetlands	0.00
6412	Freshwater Marshes - Cattail	Wetlands	0.30
6420	Saltwater Marshes	Wetlands	0.00
6430	Wet Prairies	Wetlands	0.00
6439	Wet Prairies - with Pine	Wetlands	0.00
6440	Emergent Aquatic Vegetation	Wetlands	0.00
6520	Shorelines	Wetlands	0.00
6530	Intermittent Ponds	Wetlands	0.00
7200	Sand Other Than Beaches	Barren Land	0.90
7400	Disturbed Land	Barren Land	0.90
7410	Rural land in transition	Barren Land	0.80
7420	Borrow Areas	Barren Land	0.50
7430	Spoil Areas	Barren Land	0.90
7450	Burned Areas	Barren Land	0.80

8000	Transportation, Communication, Utilities	Transportation, Communication and Utilities	0.99
8100	Transportation	Transportation, Communication and Utilities	0.99
8110	Airports	Transportation, Communication and Utilities	0.99
8120	Railroads	Transportation, Communication and Utilities	0.99
8140	Roads and Highways	Transportation, Communication and Utilities	0.99
8160	Canals and Locks	Open Water	0.90
8213	Antenna Farms	Transportation, Communication and Utilities	0.99
8300	Utilities Under Construction	Transportation, Communication and Utilities	0.99
8310	Electrical Power Facilities	Transportation, Communication and Utilities	0.99
8320	Electrical Power Transmission Lines	Transportation, Communication and Utilities	0.99
8340	Sewage Treatment	Transportation, Communication and Utilities	0.99
8349	Sewage Treatment	Transportation, Communication and Utilities	0.99
8350	Solid Waste Disposal	Transportation, Communication and Utilities	0.99

Evaluation Protocol

As a result of the scoring, up to five sites were considered to be the best sites to carry on for additional planning **(Table 7**). They were Lake O West, IP-10, Paradise Run, New Kissimmee River, and Bootheel Creek. All sites will be evaluated for potential for chemical contamination based on historic land uses. A cultural resources review by a Corps' archeologist will also indicate if any recorded sites occur within the top candidates.

Table 7. Combined wetland PM scores for wetland sites.

		Wading Birds	Percent Connectivity	Surface Water Connectivity	Restoration Potential	Public Access	Total Score (out of 5)
Rank	**Sites**	**Score**	**Score**	**Score**	**Score**	**Score**	**Score**
1	Lake O West	0.65	1.00	0.74	0.76	0.77	**3.92**
2	IP-10	1.00	0.26	0.30	0.71	0.77	**3.04**
3	Paradise Run	0.47	0.00	1.00	0.49	0.89	**2.85**
4	New Kiss River	0.47	0.16	0.75	0.33	1.00	**2.71**
5	Bootheel Creek	0.00	0.79	0.52	0.39	0.57	**2.27**
6	IP-9	0.47	0.39	0.10	0.53	0.60	**2.09**

7	Fish Slough	0.00	0.49	0.18	0.66	0.66	**1.99**
8	Lake O East	0.12	0.00	0.00	1.00	0.86	**1.98**
9	YB-3500	0.06	0.00	0.31	0.56	0.74	**1.67**

Benefits Analysis:
With Project Calculations of Habitat Units

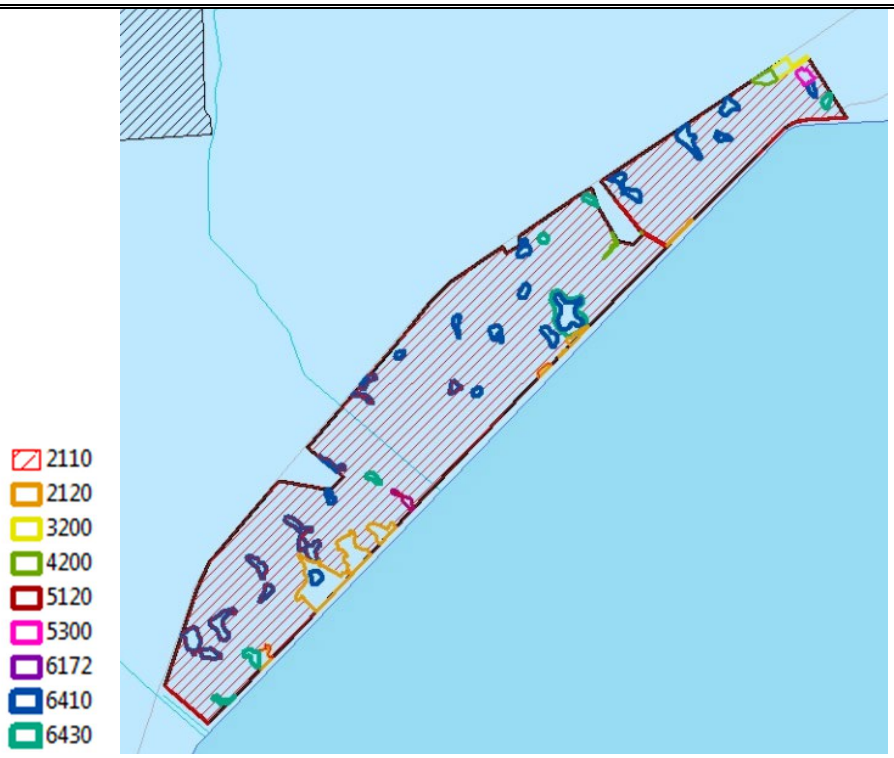
Using the scores from the wetland metrics, the top 5 potential restoration sites were selected. A "quality factor"(called Ecological Value; EV) was assigned for each habitat type within all of the potential restoration sites based on land use code (FLUCCS; from the 2015 SFWMD shapefile) **(Table 6**) using best professional judgment, supplemented by limited field evaluations. FLUCCS that are more ecologically degraded received lower EVs, but more native or natural habitats received higher EVs (on a scale of 0.0 to 1.0). FLUCCS that indicated permanent inundation (*e.g.,* 6440 Emergent Aquatic Vegetation, and 5600 Slough Waters) were assigned the highest EVs of 0.7. Other wetlands were assumed to show some level of adverse impact (due to a high percentage of non-native land uses around these wetlands); therefore, received a maximum EV of 0.5. Using ArcGIS, the size of each FLUCCS polygon within each potential restoration site was measured and multiplied by its EV to arrive at a HU for that polygon (**Figure 7**). All polygons inside the restoration site were then summed to calculate the total HUs.

Habitat Units were calculated in **Table 8** below as follows:

Existing $\text{Eco-Value}_{FLUCCS2110} \times \text{Acres}_{FLUCCS2110} = HU_1$ *e.g.,* 0.2 x 2521.61 = 504.32 HUs
and then summed as $HU_1 + HU_2 + \ldots HU_9 = HU_{total}$ *e.g.,* 504.32 +33.49 + … 17.01 = 633.21 HUs

Table 8. Summation of the Existing Habitat Units for the Lake Okeechobee West site.

			Lake Okeechobee West		
FLUCCS	**Description**	**Existing Eco-Value**	**Acres**	**Percent of Area**	**Existing HUs**
2110	Improved Pastures	0.2	2521.61	0.901	504.32
2120	Unimproved Pastures	0.4	83.74	0.030	33.49
3200	Shrub and Brushland	0.4	9.24	0.003	3.70
4200	Upland Hardwood Forest	0.4	8.88	0.003	3.55
5120	Channelized waterways, canals	0.5	3.51	0.001	1.75
5300	Reservoirs	0.5	5.51	0.002	2.76
6172	Mixed Wetland Hardwoods - Mixed Shrubs	0.5	3.58	0.001	1.79
6410	Freshwater Marshes	0.5	129.67	0.046	64.83
6430	Wet Prairies	0.5	34.02	0.012	17.01
Grand Total			2799.76	1.00	633.21



For the estimated total restored HUs under with-project conditions, all EVs are assumed to be restored to 1.0. These would primarily be wetland HUs but could include some small amount of upland HUs. The total HUs would then equal the total acres of the site (2799.76 HUs). Therefore, the HUs created by the LOWRP within the Lake Okeechobee West wetland site would be 2799.76 – 633.21 = 2,166.55 HUs.

Add HU Tables for other wetland sites here

Without Project Calculations of Habitat Units

To estimate HUs under without-project conditions, the team made assumptions about how the wetland and upland land covers would change over time. Because CERP projects have a 50-year life span, the possible land use change scenarios were estimated as: 1) no change within the site; 2) the site is restored by another entity such as the Wetland Reserve Easement Program; or 3) the ecological value of the site is reduced. The LOWRP area is generally rural, however given the proximity of Lake Okeechobee as a water resource and the relatively good transportation and utility infrastructure, combined with the recent increase in population immigration into Florida and the possibility that as sea levels rise, the coastal populations of humans will move inland, it was assumed that it is more likely that these wetland sites would be degraded over time (*i.e.,* converted to more developed conditions). Sites farther from human population centers (*e.g.,* Fish Slough) are probably less likely to undergo habitat degradation, but it is not possible to accurately predict the relative degree. **Table 9** and **Table 10** show the anticipated conversions in ecological quantity and quality without the project within the study area. The discussion of the assumptions follows the tables.

Table 9. Landscape change predictions over time for habitat quantity.

Without Project Condition	
Resource Type	**Changes in Quantity from Baseline to 2078**
Functioning Wetlands	Wetlands <0.5 acres are converted to Drained Wetlands; Wetlands >0.5 acres do not change size
Drained Wetlands	Acreage increases slightly due to above
Native Uplands	Conversion of 50% to Non-native Uplands
Non-native Uplands	Increases in quantity due to above 50% conversion
Open/Deep Water	No change in quantity

Table 10. Landscape change predictions over time for habitat quality.

Without Project Condition	
Resource Type	**Changes in Quality from Baseline to 2078**
Functioning Wetlands	Ecological Value for wetlands < 0.5 ac drops to 0.19; for wetlands > 0.5 ac that are surrounded by native or natural uplands, the quality is reduced by 25% due to conversion of native uplands.
Drained Wetlands	No change in quality
Native Uplands	Ecological Value for 50% of the acreage drops to 0.19
Non-native Uplands	No change in quality
Open/Deep Water	No change in quality

Given the changes in land use patterns that have occurred and continue to take place in the project study area, it was predicted that Existing Condition HUs for functioning wetlands would decrease over time. LOWRP project authorization is anticipated to occur in 2028; therefore, the project's life span lasts until 2078. One assumption was that no project benefits were assumed to have accrued by 2028. Therefore, the 2028 "with project" and "without project" HUs are the same. Benefits would not begin to accrue until 2028 plus one day (with project).

The EVs were updated to reflect the projected losses of wetland, upland, and open water habitats likely to occur from 2028 to 2078 without the project. Wetlands were separated into functional or drained classes; and uplands into native and non-native classes as follows:

a. Functional Wetlands were defined and those represented by FLUCCS 6000 Series.
b. Drained or Non-functioning Wetland habitats were defined as areas with historic hydric soils that currently do not exhibit wetland function (although they should have some upland function). These areas are comprised of lands classified by FLUCCS Level 4 Codes in the 2000 (Agriculture), 3000 (Rangeland), 4000 (Upland Forest), or 7000 (Barren Land) Series. In general, many of these EVs are low; therefore, the resulting HUs are also low.
c. Uplands were broadly defined as areas underlain by non-hydric soils that retain some degree of upland ecological functionality [all FLUCCS Level 4 Codes except 5000 (Open Water) and 6000 (Wetlands) Series]. Native and Natural Uplands were defined as areas underlain by non-hydric soils that retain a high degree of upland ecological functionality. Specifically, these were unimproved or woodland pasture (FLUCCS 2120 and 2130), rangeland (FLUCCS 3000 Series), rural lands in transition (FLUCCS 7410), and upland forests (FLUCCS 4000 Series) with the exception of those land uses infested with exotic plants.
d. Non-native Uplands were FLUCCS Codes 4119, 4220, 4240, 4350, 4400 and 4410. In addition, these included all FLUCCS Codes on non-hydric soils in the 1000, 2000, 7000 (except FLUCCS 7410), and 8000 Series.
e. Open or Deep-Water habitats included FLUCCS Series 5000 (Open Water) and 8160 (Canals). Within our restoration sites these areas included more natural systems like the partially disconnected Kissimmee River oxbows, large ponds, canals, or channelized streams.

Implicit in the above definitions was the need for soil data to separate out uplands from drained wetlands because the some

non-native upland FLUCCS codes could occur on both hydric and non-hydric soils. The 2010 U.S. Department of Agriculture spatial data were used for this analysis.

Changes in Quantity

Future wetland losses across the study area were predicted based on current State and Federal regulations. For example, the SFWMD does not require an Environmental Resource Permit for wetlands less than 0.50 acres in size; therefore, mitigation is not a requirement. Similarly, for wetland losses of 0.10 acre or less, the Corps' district engineer determines on a case-by-case basis if compensatory mitigation is required (to ensure that the activity does not result in adverse effects on the aquatic environment). Due to the potential lack of protection by law, it was assumed that all isolated wetlands less than 0.50 acres in size would be converted to other land uses by 2078 and would no longer provide functioning wetland HUs in 2078 without the project. However, it is possible that such areas would provide some low quality upland-type HUs. Within all the potential wetland restoration sites, there are very few remaining wetlands less than 0.5 acre; therefore, we expect this loss to be very low.

For wetlands larger than 0.5 acres, no losses in quantity were projected through 2078. The rationale for this is that State and Federal regulations in effect now would protect the spatial extent of those wetlands (either in-place or through mitigation).

For native and natural uplands, it was assumed 50 percent would be converted by 2078 to more intensive land uses. The rationale for this was that the rate of development in Florida is now again increasing (after the housing market crash of 2007 to 2012), and whereas one would expect that all the native uplands on private lands would be converted to intensive land uses by 2078, there are some county restrictions (*e.g.,* in Martin and St. Lucie Counties) that protect certain percentages of native uplands on private lands from development. We anticipate that the remaining counties in the study area would adopt similar regulations or that some land owners will take it upon themselves to protect these ecologically valuable areas as they become rarer in south Florida. This conversion of native or natural uplands results in a 50 percent increase in the quantity of non-native uplands by 2078 (without the project).

Open or deep-water habitats were not anticipated to change in quantity by 2078 without project. The spatial extent of these areas within any of the potential restoration sites was very low with the exception of the New Kissimmee River site (8.4 percent), and the Paradise Run site (3.7 percent).

Changes in Quality

The predicted loss of wetlands less than 0.5 acres in size resulted in a drop in their existing conditions EV to 0.19. The value of 0.19 was used because it was not possible to accurately predict these individual wetlands' future value on a case by case basis, and this new value equals the arithmetic mean of all intensive land use EVs (*i.e.,* the mean of all EVs for FLUCCS 1000 and 2000 Series in the watershed with the exception of FLUCCS Codes 2120 and 2130 – unimproved and woodland pastures, respectively).

For wetlands greater than 0.5 acres in size, the predicted change in quality over time without the project was dictated by changes in the surrounding uplands. As mentioned previously, it was assumed that there would be a 50 percent loss in native upland quantity due to conversion to intensive land uses by 2078 (without the project). Any wetland greater than 0.5 acres that was also surrounded by at least half native uplands, had their EV reduced by 25 percent (*e.g.,* a 2028 wetland with a value of 0.7 was reduced to a value of 0.52 in 2078 without the project). In the event that value reduction would result in a new EV less than 0.19, then the new EV would be set at 0.19.

For changes to native upland quality, it was assumed that 50 percent of the uplands that are currently classified as unimproved or woodland pasture (FLUCCS Codes 2120 and 2130), rangeland (FLUCCS 3000 Series), upland forests (FLUCCS 4000 Series), or rural lands in transition (FLUCCS Code 7410) would be converted into more intensive residential, agricultural, or commercial land uses (FLUCCS 1000, 2000, or 8000 Series) by 2078. As mentioned previously, it was difficult to predict to which of the more intensive land uses that these native uplands would be converted (the more intensive land uses have low ecological values ranging from 0.01 to 0.20). Therefore, the average EV for all intensive land uses (*i.e.,* 0.19) was used for future without project native upland HU losses.

For drained wetlands and non-native uplands, no changes in quality under future without project conditions were assumed because the values were already low. For open or deep-water habitats, changes in quality were also not anticipated by 2078 without the project, but these ecological values are moderate.

Using the Lake Okeechobee West site as an example, these are the calculations for the predicted future without project HUs.

Functioning Wetlands less than 0.5 acres = 0 acres or 0 existing condition HUs
Functioning Wetlands greater than 0.5 acres = 167.27 acres or 83.64 existing condition HUs
Drained Wetlands on FLUCCS 2110 = 1194.18 acres or 238.84 existing condition HUs
Drained Wetlands on FLUCCS 2120 and 3200 = 58.10 acres or 34.24 existing condition HUs
Native Uplands = 8.88 acres or 3.55 existing condition HUs
Non-native Uplands (on non-hydric soils) = 1362.31 acres or 268.43 existing condition HUs
Open/Deep Water = 9.02 acres or 4.51 existing condition HUs

Since there are no existing wetlands less than 0.5 acres, there was no loss in those HUs. For functioning wetlands, quality loss was based on adverse impacts over time to surrounding native uplands. Since there were no native uplands adjacent to any wetlands, there was no change in those HUs either. Similarly, the drained wetlands do not change in quality or quantity, but those HUs (238.84 and 34.24) were subtracted from the total HUs for FLUCCS Codes 2110 2120, and 3200 (541.51) resulting in 268.43 HUs for existing non-native uplands. This value is used in a subsequent calculation.

Native uplands are converted to non-native uplands by 50 percent of their spatial extent. As their quantity drops, those acres become non-native quality (i.e., ecological value dropped from 0.4 to 0.19). Therefore:

8.88 acres Upland Hardwood Forest x 50% = 4.44 acres; and
4.44 acres (unaffected) x 0.4 = 1.78 HUs (native uplands); and
4.44 acres (reduced) x 0.19 = 0.84 HUs (added to the non-native upland HUs).

So, the total future without Native Upland HUs = 1.78 (or 50 percent reduction from the 3.55 existing condition HUs). For 2078 non-native uplands, the spatial extent increases slightly due to the above conversion but the 2028 EVs do not change. Therefore, the future without non-native uplands HUs are 0.84 + 268.43 = 269.27 HUs.

For open or deep-water there are no changes and therefore no loss of HUs without the project. Therefore, the total HU without the project in 2017 is:

Functioning Wetlands less than 0.5 acres =	0.00	HUs
Functioning Wetlands greater than 0.5 acres =	83.64	HUs
Drained Wetlands on FLUCCS 2110 =	238.84	HUs
Drained Wetlands on FLUCCS 2120 and 3200 =	34.24	HUs
Native Uplands =	1.78	HUs
Non-native Uplands (on non-hydric soils) =	269.27	HUs
Open/Deep Water =	4.51	HUs
TOTAL FWO =	**632.28**	**HUs**

The existing conditions HUs for the Lake Okeechobee West site was 633.21 HUs, therefore the loss in HUs without the project (0.93) was very small. Over 90 percent of this site is improved pasture (EV=0.20; **Table 11**). Had this site been in better ecological quality, the loss of future without project HUs would have been greater.

Table 11. Existing Condition Ecological Value for each land use within the wetland restoration sites.

FLUCCS	Description	Existing Eco-Value
2110	Improved Pastures	0.20
2120	Unimproved Pastures	0.40
6410	Freshwater Marshes	0.50
2156	Field Crops - Sugar Cane	0.01
3100	Herbaceous Rangeland	0.20
6430	Wet Prairies	0.50
4271	Oak - Cabbage Palm Forest	0.40
6440	Emergent Aquatic Vegetation	0.70
6172	Mixed Wetland Hardwoods - Mixed Shrubs	0.50
4340	Hardwood Conifer Mixed	0.40
6300	Wetland Forested Mixed	0.50
7430	Spoil Areas	0.10
4110	Pine Flatwoods	0.40
6170	Mixed Wetland Hardwoods	0.50
6180	Cabbage Palm Savannah	0.40
5120	Channelized waterways, canals	0.50
6110	Bay Swamps	0.50
5110	Streams and Waterways	0.50
5600	Slough Waters	0.70
6411	Freshwater Marshes - Sawgrass	0.50
4200	Upland Hardwood Forest	0.40
4280	Cabbage Palm	0.40
5300	Reservoirs	0.50
6250	Wet Pinelands Hydric Pine	0.50
4220	Brazilian Pepper	0.10
3200	Shrub and Brushland	0.40
4270	Live Oak	0.40
6216	Cypress - Mixed Hardwoods	0.50
8115	Grass Airports	0.10
6240	Cypress - Pine - Cabbage Palm	0.50
3210	Palmetto Prairies	0.40
2430	Ornamentals	0.10
7400	Disturbed Land	0.10
1230	Mixed Units (Fixed and mobile home units) 2-5	0.01
3300	Mixed Rangeland	0.40
2510	Horse Farms	0.20

Sources

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