APPENDIX E
PLAN FORMULATION SCREENING

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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.

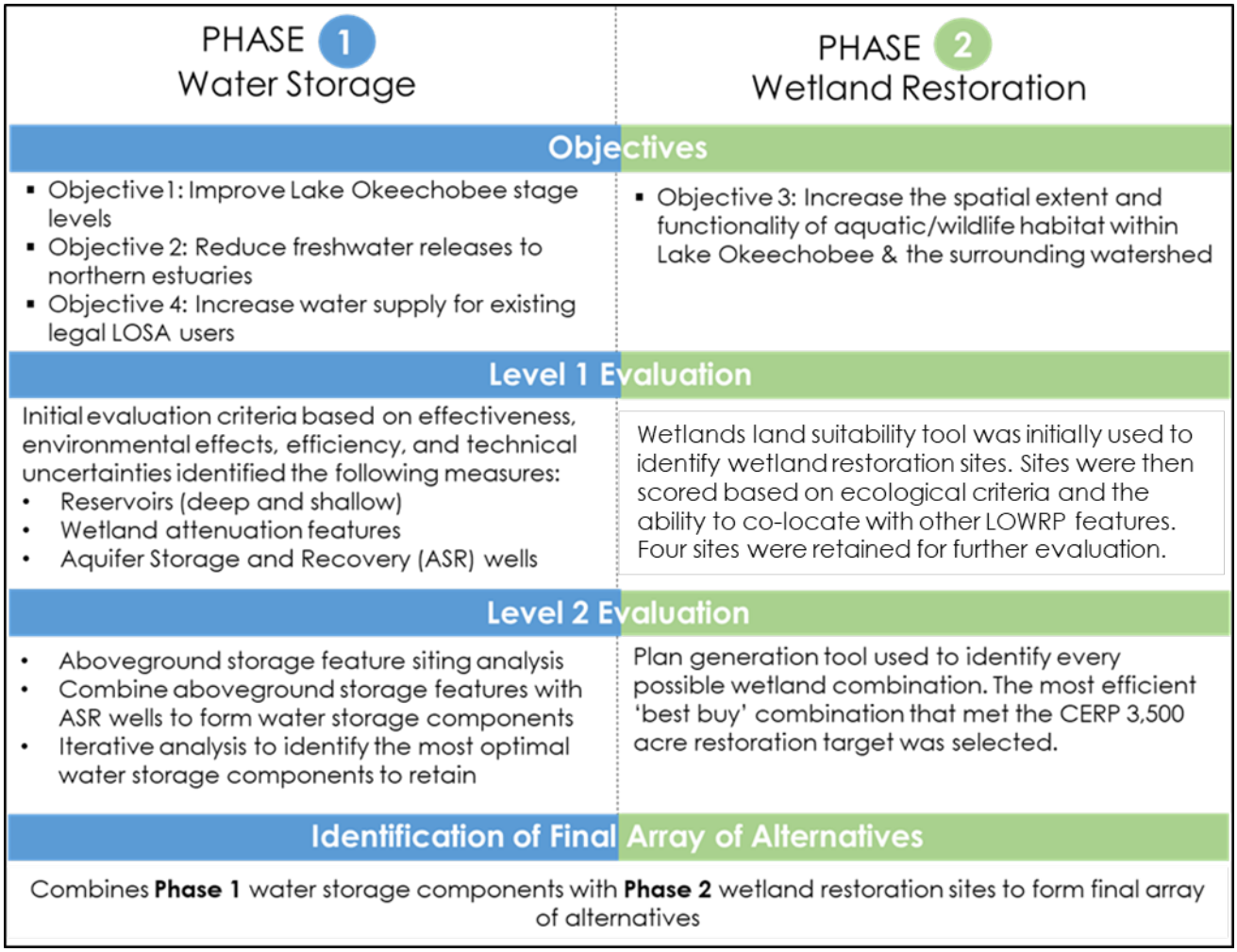

Figure E-1. Phased plan formulation strategy.

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 high lake stages that impact lake ecology and downstream ecosystems, 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 threshold. Therefore water levels remain above that threshold longer and more often in the ideal ecological band, which was the focus of plan formulation, and by keeping the lake levels within that band the cutbacks are not triggered. This provides water supply benefits (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. For Level 1 screening the initial criteria are at the most conceptual level and generally use best professional judgment and information gained from other, related projects.

For perspective, Lake Okeechobee covers 730 square miles and is the second largest lake contained entirely within the contiguous 48 United States, second in size only to Lake Michigan. As added reference, it is larger than Lake Pontchartrain of New Orleans, which covers 630 square miles. The management measures below were screened in consideration of the Lake's size and associated challenges.

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.

Level 1 Water Storage Management Measure	Results of Screening
Dredge Lake Okeechobee	Not retained due to costs and efficiency.
Aboveground Reservoir	RETAINED (meets all criteria).
Wetland Attenuation Feature	RETAINED (meets all criteria).
ASR Wells	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 location or utilizing it in a beneficial manner. Dredging of the lake would increase its depth and by doing so would provide increased water storage capacity in the lake, decreasing flows 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 and inefficient when compared to other storage options on a volume of storage created basis. Similarly, the transportation and management of the dredged material would prove challenging from a lands perspective adding further to the cost and efficiency of the management measure. This measure was not retained.

Aboveground Storage Reservoir: Aboveground storage reservoirs would be used to capture and hold normal and peak flows from events such as rain storms, which could then be released when flows are needed for the natural system that LOWRP will restore. 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 but they met the screening criteria and 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 transport and storage of water to belowground capacity within the aquifer, and the recovery of that water for use when there are needs in the ecosystem that LOWRP will restore. ASR wells are not deep injection wells. The difference is that ASR wells bring the water back to the surface when needed rather than permanently leaving it in the aquifer. Florida's aquifer is composed of porous limestone that is thousands of feet deep with many layers of limestone that have different characteristics and conditions. ASR water storage would be located within two distinct zones of the Floridan Aquifer System: the Upper Floridan Aquifer (UFA), composed of porous limestone and lying 600–1,200 ft. below land surface, and a deeper and more saline zone referred to as the Avon Park Permeable Zone (APPZ). That zone is composed of porous dolomite, which is a type of rock similar to limestone and found 1,600–2,000 ft. below land surface. ASR wells would allow for long-term storage with an advantage over reservoirs on land because their water does not evaporate while underground which is important compared to aboveground reservoirs that are exposed to hot, sunny conditions that cause significant evaporation. ASR may be able to provide additional water during dry times. They would increase overall storage capacity with a smaller aboveground footprint than reservoirs that could provide the same volume of water. ASR wells met the screening criteria and were retained for consideration as a management measure.

Deep Injection Well**:** Deep injection wells (DIW) are high-capacity wells that permanently inject water into the aquifer and not intended for recovery. They inject 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 aboveground natural ecosystems. DIWs provide an additional outlet for excess Lake Okeechobee water to reduce flows to the coastal estuaries.

The LOWRP includes several CERP components that were originally envisioned and evaluated within the 1999 CERP PIR/EIS "Restudy". 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. Due to these reasons, as well as the need to understand how DIWs may perform within the context of ecosystem restoration, DIWs did not meet the screening criteria and were removed from further consideration in LOWRP.

Dispersed Water Management: Dispersed water management is a land management program or system that encourages property owners to retain water on their extensive lands over a temporary lease period 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 sent to coastal estuaries for flood protection. Dispersed water management also provides valuable groundwater recharge that helps to restore natural hydrology, can improve water supply, and can have opportunities for water quality improvement. However since the water is widely dispersed, subject to individual property holdings and availability, temporary in nature and is subject to more evapotranspiration than reservoirs, among other factors, this measure is less effective for meeting ecosystem restoration objectives than an aboveground reservoir.

E.1.2 Level 2 Screening of Water Storage Management Measures

Management measures can work together as a system to maximize their ability to provide water to the ecosystem being restored with more ideal timing, volumes, and distribution on the landscape. The second level of evaluation focused on placement and scale of the retained storage management measures to improve overall efficiency and effectiveness. This effort consisted of four steps:

1. Initial sensitivity runs for testing of various reservoir sizes and ranges of ASR wells to identify storage goals
2. Aboveground storage feature siting in the project area to improve and optimize the ability of the storage features (deep reservoirs, shallow reservoirs, and wetland attenuation features) to achieve LOWRP's restoration objectives.
3. Combining aboveground storage features and ASR wells to achieve synergy of water storage and delivery abilities. Such partnered management measures are referred to as components and the ability of the measures to achieve a synergy if they were combined was considered in the screening.
4. Iterative water storage analysis to compare components more extensively than in Level 1 for their ability to meet restoration objectives.

E.1.2.1 Initial Sensitivity Runs

The Reservoir Sizing and Operations Screening (RESOPS) model[1] was used to quickly test the performance of various storage configurations and scenarios to identify feasible ideas for further in-depth analysis. The sensitivity and screening runs would assist the team with identifying an overall storage goal by identifying the Lake Okeechobee and northern estuaries environmental performance of a broad range of storage volumes. **Figure E-2** shows that the number of high flow exceedences from Lake Okeechobee reduces in a

[1] Coarse-scale water management simulation model

near linear line for both estuaries. This informed the team that the larger the reservoir, the greater the predicted environmental benefits up until 350,000 ac-ft (the maximum reservoir storage considered in the sensitivity runs).

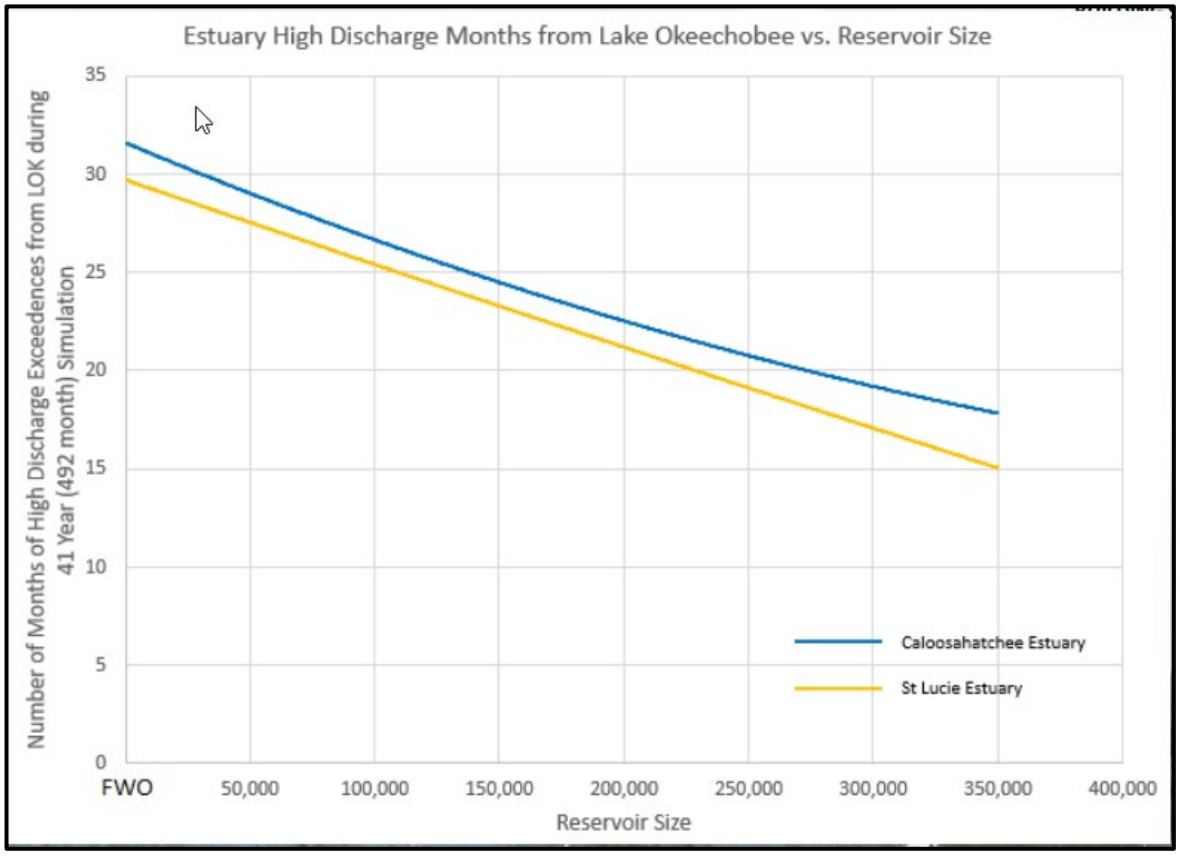

Figure E-2. Estuary high discharge months from Lake Okeechobee vs. reservoir size

RESOPS simulations used the Lake Okeechobee Stage Envelope Standard Scores, which measures the departure of the lake stage from the LORS 08 (current lake regulation schedule) defined upper and lower limits. The standard score for the upper lake stage envelope measures the departures of lake stage above the upper lake stage limit and the standard score for the lower lake stage envelope measures the departures below the lower stage limit. A higher overall score means fewer departures and improved lake ecology. These runs also showed a potential benefit to lake ecology with the improved lower lake stage score with the addition of an approximately 80,000 ac-ft reservoir but no change to the upper lake stage envelope score (**Figure E-3**).

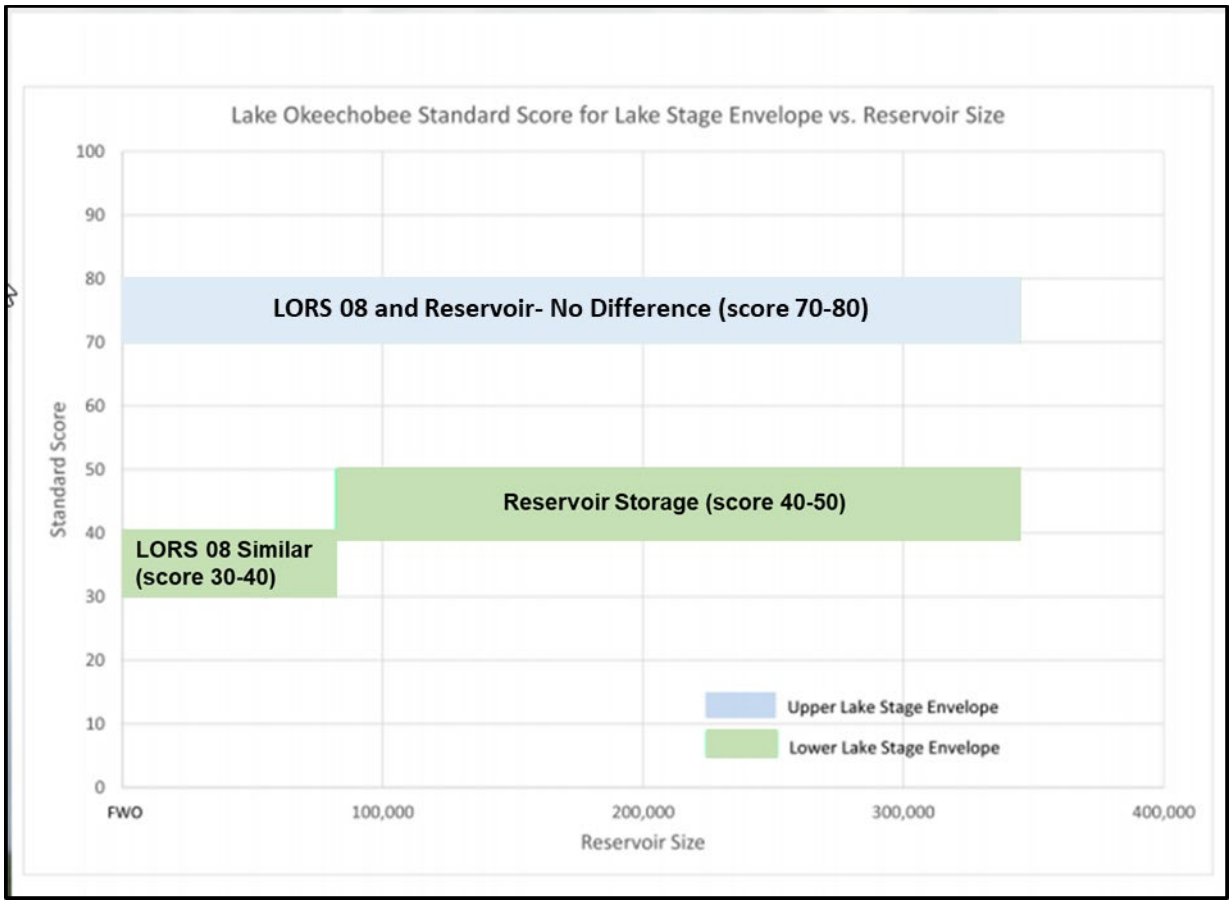

Figure E-3. Lake Okeechobee standard score for lake stage envelope vs. reservoir size

Subsequent sensitivity runs were performed with both reservoir and ASR storage. These runs indicated that larger increments of storage provide commensurate increases in estuary performance for both high and low flows; more storage provides more estuary benefits by reducing the number of months of high flow exceedences from Lake Okeechobee over the 41 year period of record (**Figure E-4** and **Figure E-5).**

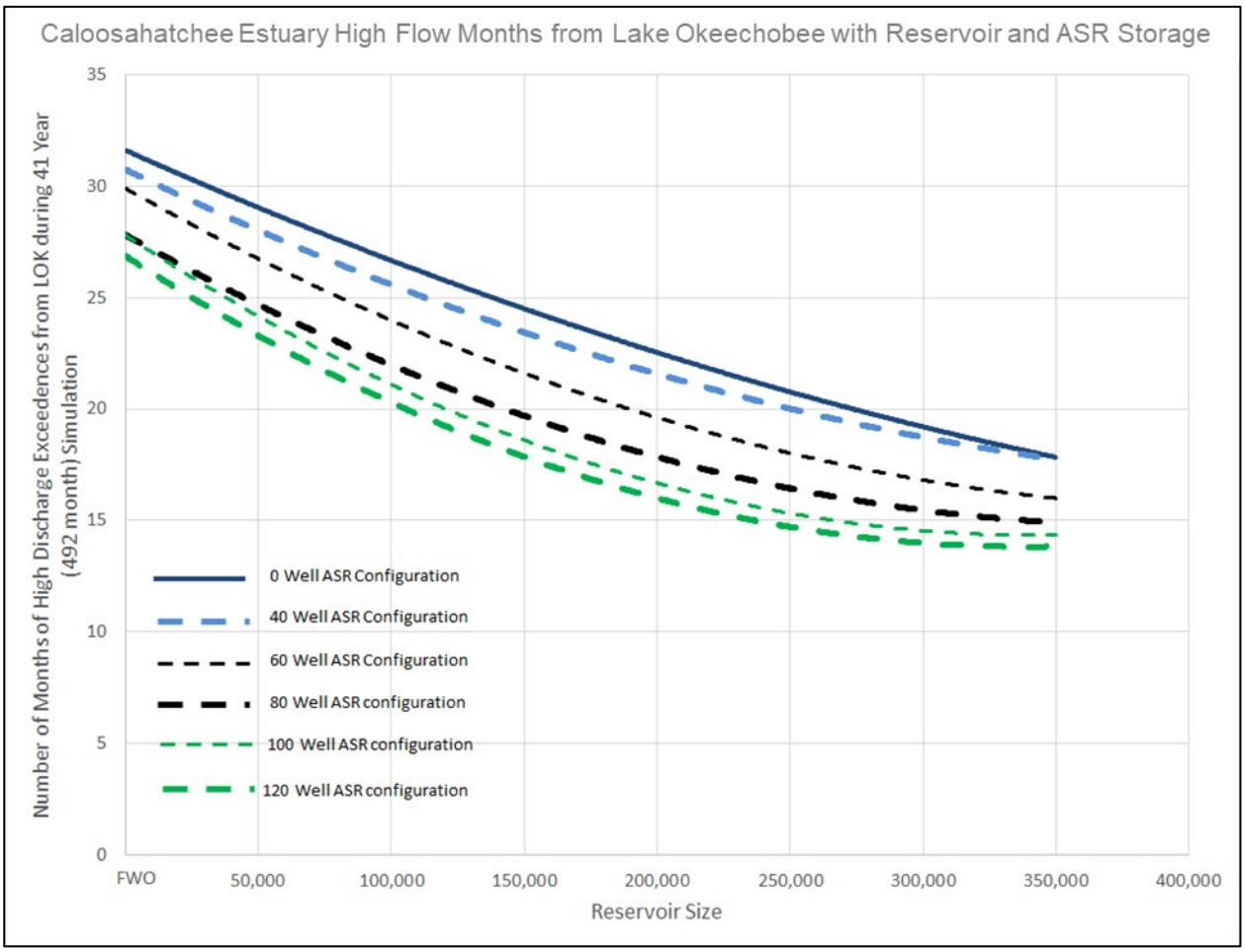

Figure E-4. Caloosahatchee Estuary high-flow improvements with reservoir and ASR storage.

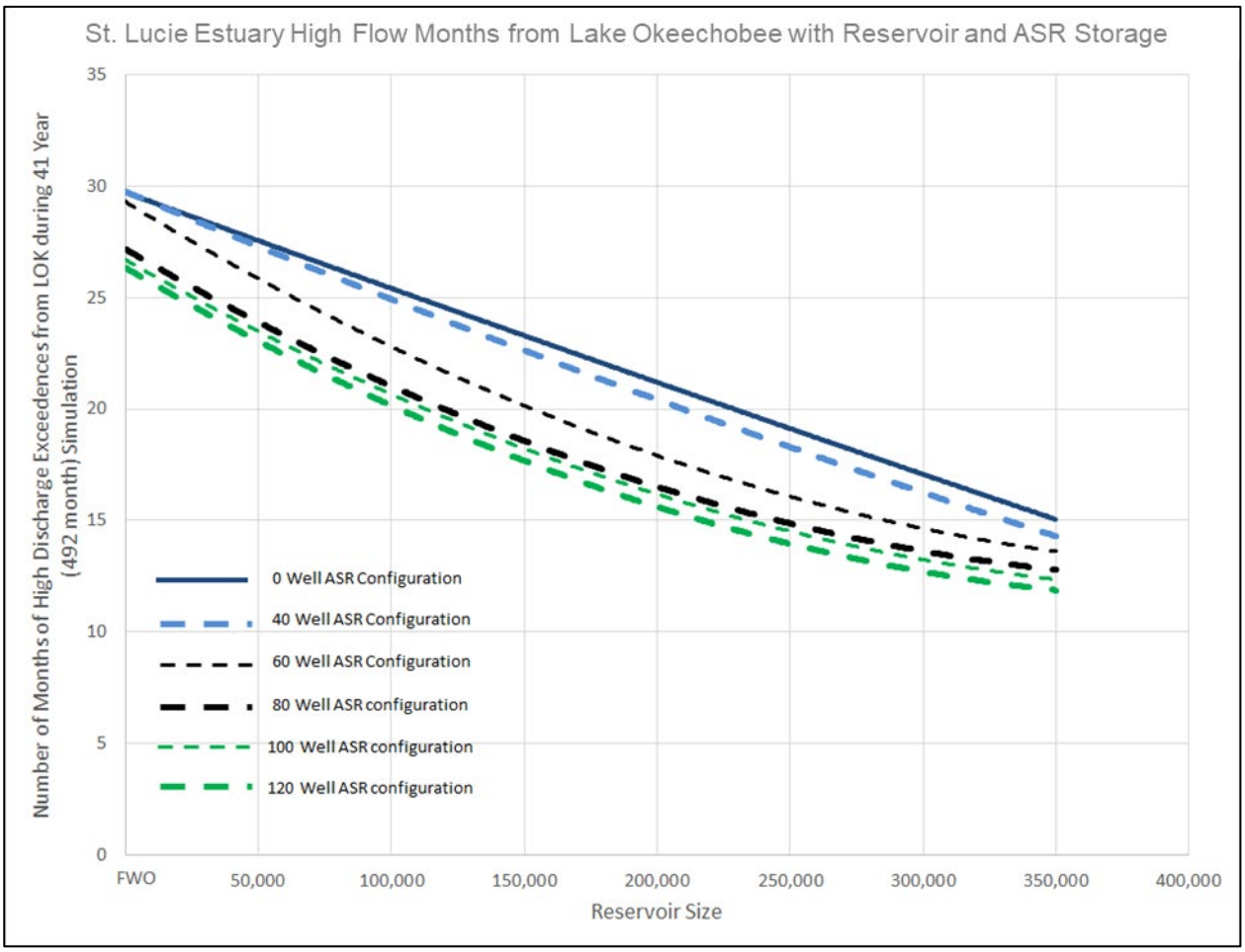

Figure E-5. St. Lucie Estuary high-flow improvements with reservoir and ASR storage.

Figure E-6 below shows the lake standard scores for the RESOPS runs with various reservoir and ASR combinations as compared to a condition similar to the current lake regulation schedule, LORS 2008. This shows an improvement in the lower lake stage score with the combination of an approximately 80,000 ac-ft. reservoir and 40 ASR wells and continues to improve with the addition of 60-120 ASR wells and additional reservoir storage. The upper lake stage score is less sensitive to north of lake storage and shows some improvement with 200,000 ac-ft reservoir and 80-120 ASR wells. This is likely due to the large volume of water associated with high-stage events

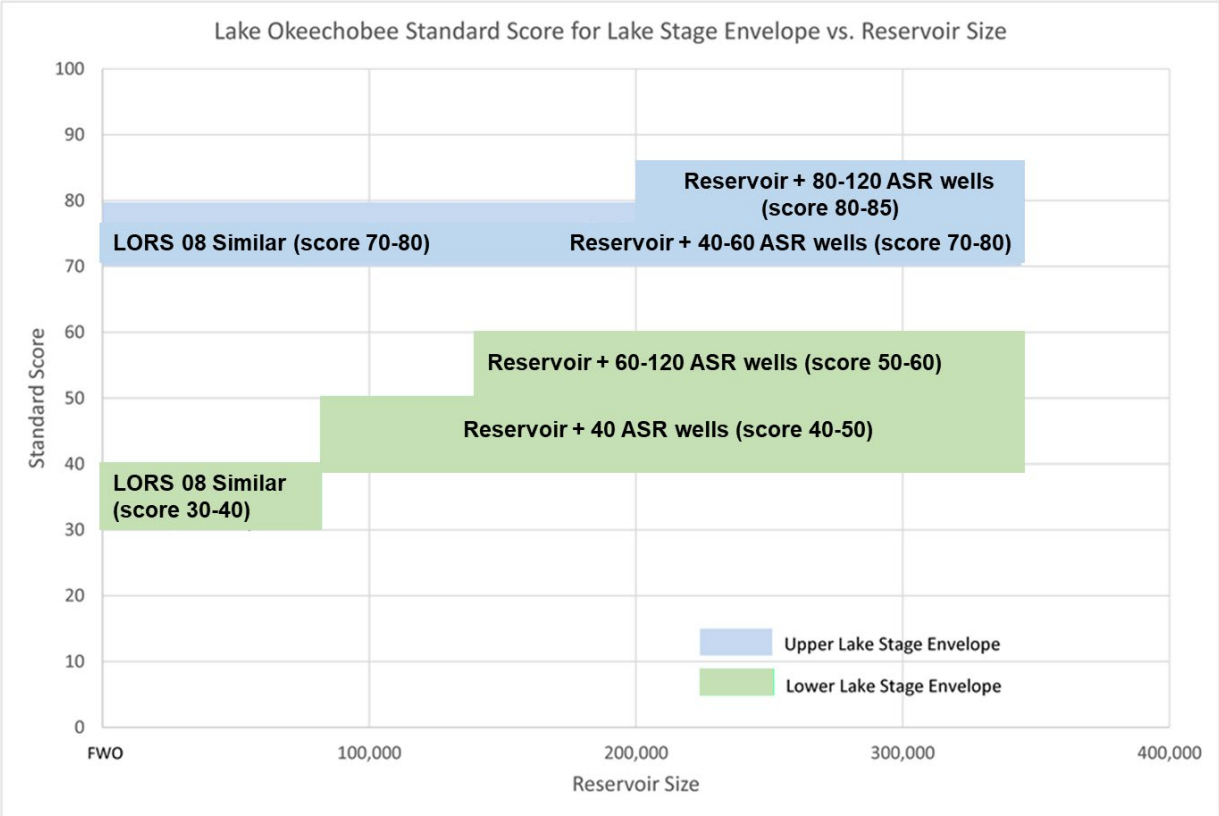

Figure E-6. Lake Okeechobee standard score for lake stage envelope with reservoir and ASR wells.

While testing different combinations of reservoirs and ASR wells, the LOWRP team also contemplated the 'CERP-like' alternative (also referred to as the Yellow Book Alternative as originally described in the Restudy) in the initial rounds of modeling, which included a 200,000-acre-foot reservoir and 80 ASR wells[2]. At the time of the LOWRP existing conditions baseline and future without modeling effort in 2016, the Everglades Agricultural Area Storage Reservoir and Stormwater Treatment Area (EAA Storage Reservoir and STA) was in the planning process but not yet authorized. Consistent with plan formulation policy for development of FWO conditions, LOWRP planning conditions included projects that are authorized, under construction, or completed, notably the Central Everglades Planning Project (CEPP) authorized in 2016 which includes the Flow Equalization Basin on the A-2 parcel. A full discussion of the FWO project condition is located in **Section 2** of the main report.

[2] **Section 3.5** in the main report provides a full description of the 'CERP-Like' alternative and why technical modifications were made.

However, as the LOWRP and EAA Storage Reservoir and STA and STA planning projects progressed, the LOWRP team anticipated that these projects would complement each other to improve conditions in Lake Okeechobee and Northern Estuaries. Additionally, it seemed reasonably foreseeable that the EAA Storage Reservoir and STA would be authorized. Although this project was not included in the FWO condition, the LOWRP decided to perform a sensitivity run of the potential compatibility of project benefits provided by both projects or if storage south of the lake would reduce the need of storage north of the lake.

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 flows to the Northern Estuaries. The two projects also meet the CERP goal for lake-weighted improvements of Lake Okeechobee. From this sensitivity run, the LOWRP team learned that storage is necessary both north and south of the lake to meet the restoration purposes described in the CERP. The Restudy identified storage north and south of Lake Okeechobee as necessary individual components of CERP for restoration of the natural system. While both storage locations improve operational flexibility for Lake Okeechobee, they do so in different ways. Functionally, because the volume of water in the Lake system itself, (Lake Okeechobee is second largest freshwater lake in the contiguous US), the water within Lake Okeechobee is larger than can be stored either north or south of the lake. Adding storage in either location does not affect the ability of the other to store water, but it reduces the strain on the lake and the Herbert Hoover Dike. Having storage in both locations, per the CERP plan, minimizes the need to release water to the estuaries during wet conditions and enhances the ability to provide water to all parts of the system during dry times. **Table E-2** summarizes this analysis.

Table E-2. 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

<u>Lessons Learned from Sensitivity Runs</u>

<u>The results of these sensitivity runs will be considered in the aboveground (deep reservoir, shallow reservoir, and wetland attenuation feature) storage formulation as well as the ASR well formulation.</u>

- Based on the results of the RESOPS analysis, larger reservoirs were initially considered and the ASR range was initially set at 65–112 wells for the first round of alternatives to maximize project benefits.
- 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.

- 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.
- 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.
- When the 'CERP-Like' LOWRP alternative and the EAA Storage Reservoir and STA are implemented, the CERP goal is met for ecological Lake Okeechobee improvements and in the reduction of number of high-flow estuary events.

E.1.2.2 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. This is Component A in the CERP. 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. However, due to the difficulties of siting deep reservoir storage as discussed in **Section E.1.2.2.2**, several configurations of shallow storage and wetland attenuation features were also formulated and evaluated.

E.1.2.2.1 Deep Reservoir Siting Analysis (Storage option 1 of 4)

The deep reservoir analysis began with conceptual reservoir sites from the previous LOWRP effort that was paused in 2006. This previous effort used a GIS analysis to identify potential reservoir locations with the fewest siting impacts, based on presence of wetlands or areas with high ecologic values, number of impacted real estate parcels, known cultural resource site impacts, regional economic considerations and real estate costs, and Environmental Justice considerations for areas with minority or low-income populations. The results of this analysis are shown in **Figure E-7**. To facilitate visual interpretation, the GIS output was color coded. Parcels that had the fewest siting constraints and that were highly suitable for locating a reservoir were shown in a light color. Locations that were characterized by numerous undesirable characteristics, i.e. that were not suitable for locating a reservoir, were shown in a dark color.

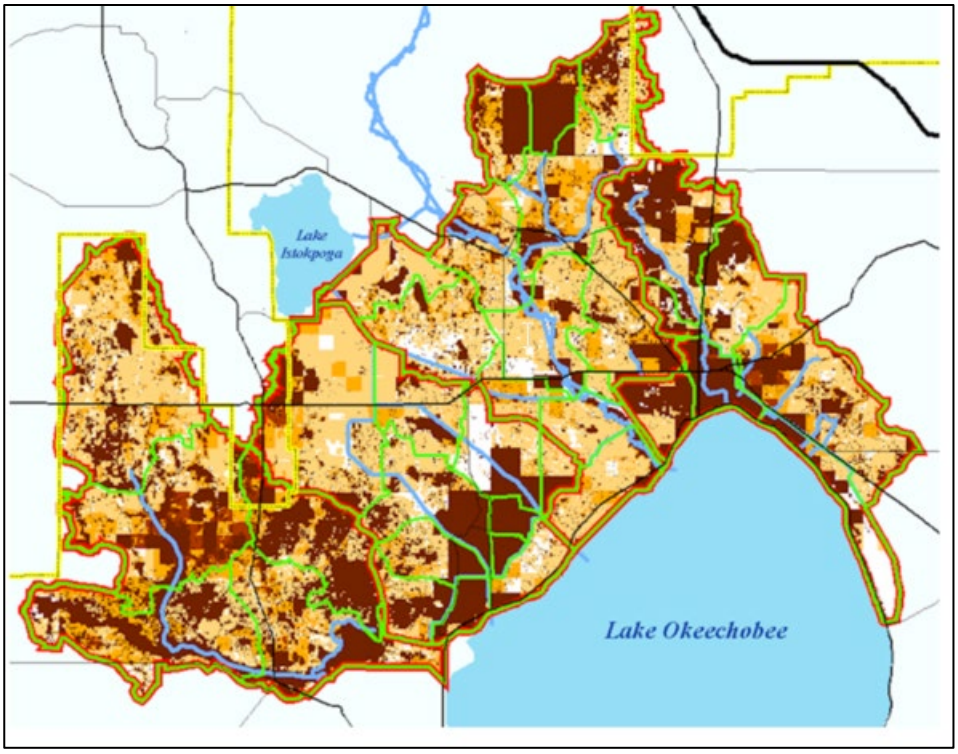

Figure E-7. 2006 analysis of siting constraints (lighter sites are more suitable)

The results of this GIS analysis were then converted into potential reservoir sites as shown in **Figure E-8,** outlined in black and numbered. The numbers are referenced throughout the plan formulation that followed. These sites are conceptual and have been revised throughout the Corps' iterative planning process to improve cost effectiveness, avoid known cultural sites, avoid site-specific constraints, and to incorporate feedback from local communities during the iterations.

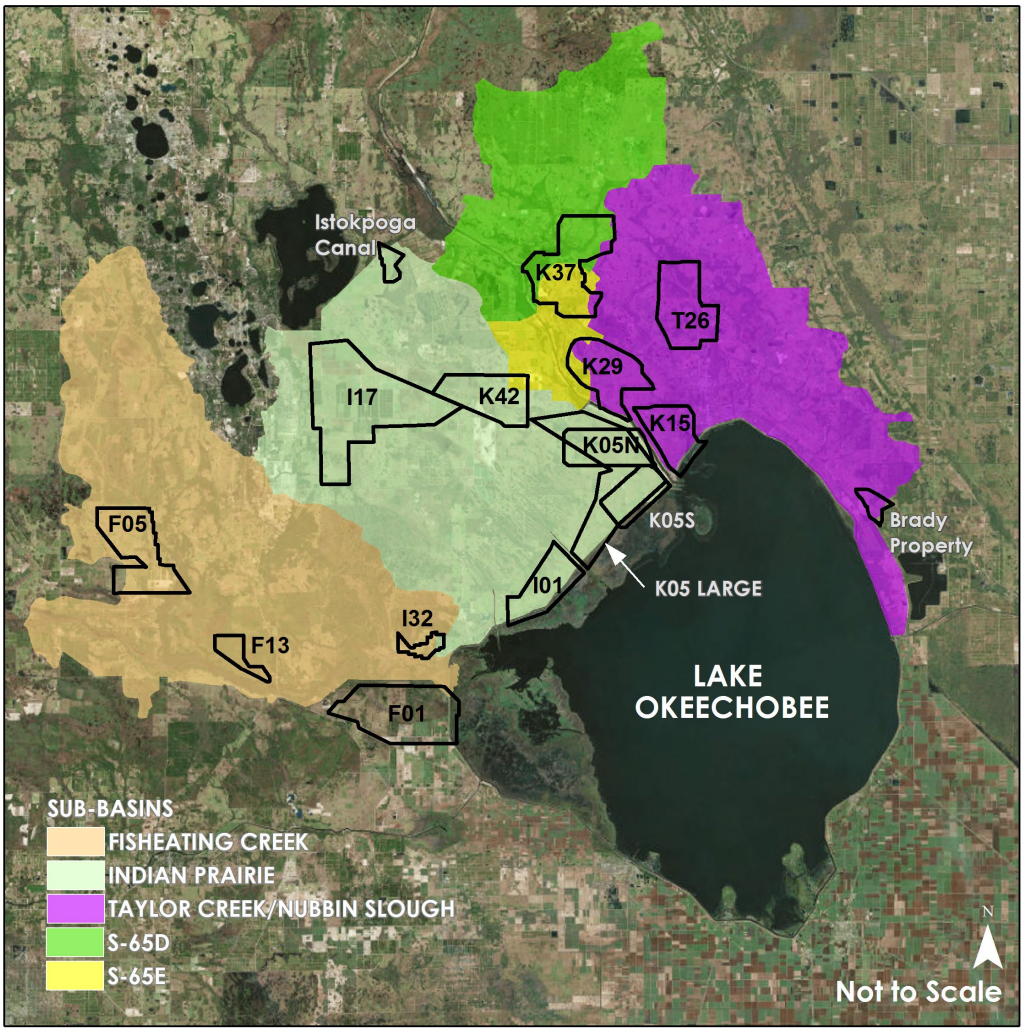

Figure E-8. Deep reservoir sites considered during screening, outlined in black and numbered.

The PDT analyzed spatial relationships between reservoir placement sites and effects the sites would have on the ability to achieve an optimal volume of storage to accomplish the restoration objectives. 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. Additionally, the PDT considered the location of sites throughout the project area. In general, reservoir sites that are located in the extreme downstream portion of the respective basins will provide more efficient and effective performance. Downstream sites provide access to the entire basin runoff and provide greater opportunity for storage and/or water quality treatment. A reservoir located in an upstream portion of the basin may not have access to all or a portion of the basin runoff for a particular rainfall event.

Additional site-specific constraints were considered, such as incompatible land uses, infrastructure constraints, real estate considerations, and the location of existing water conveyance features that make water sources reliable in order to best achieve the potential of the measures. After the preliminary screening analysis, the following 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.

The next step was to further evaluate the suitability of the remaining potential reservoir sites. A reliable water source, the ability to co-locate reservoirs with other proposed project features, and the initial planning-level cost-effectiveness analysis (in this case measured by cost per acre-foot of reservoir storage) were considered the three most significant technical criteria for project scoring and siting of reservoirs during this iteration. The team carefully considered public land ownership within the reservoir footprint for each potential site, but it was not a scoring criteria to carry sites forward. Amongst high scoring sites, this criteria could be used as an additional consideration or tiebreaker to differentiate between reservoirs. Dam safety was also a consideration, but not scored. If a site was determined to cause unacceptable risk, it was immediately screened. The analysis is presented in the Engineering Appendix (**Appendix A**). The criteria scoring and evaluation process is described in more detail in the section below.

Deep Reservoir Scoring Criteria

- **Reliable water source.** A reliable water source is critical to reservoir performance and is the primary consideration for reservoir siting. As the objectives for the storage components of this project include increasing water supply availability and maintaining healthy lake stage levels even during dry periods, proper functioning of this reservoir includes reliable accessibility to a water source. **Figure E-9** displays regional water availability inflow to Lake Okeechobee. A direct connection with Lake Okeechobee provides the most consistent source of water to ensure that reservoirs meet project objectives. A connection with the Kissimmee River (C-38) would provide a slightly more constrained water source due to water control structures within the C-38 that create impounded reservoirs or "pools" of water (Pools A–E) and because the Kissimmee River and their associated pools amount to just half of the water input to Lake Okeechobee. Further constraining the reliability of the Kissimmee River (C-38) and its associated pools is that it remains the principle water source serving the needs of the Kissimmee River Restoration project located immediately upstream of the pools. Despite these constraints the C-38 (Kissimmee River and its associated pools) were determined to be a reliable but constrained water source. If a water storage feature could not have a connection with either the C-38 or Lake Okeechobee, then the water source would be potentially unpredictable and not as reliable as a Lake Okeechobee or C-38 water source.
    - Score 2. Fully Meets Criteria: Water source is Lake Okeechobee
    - Score 1. Partially Meets Criteria: Water source is C-38
    - Score 0. Does Not Meet Criteria: No connection with C-38 or Lake Okeechobee

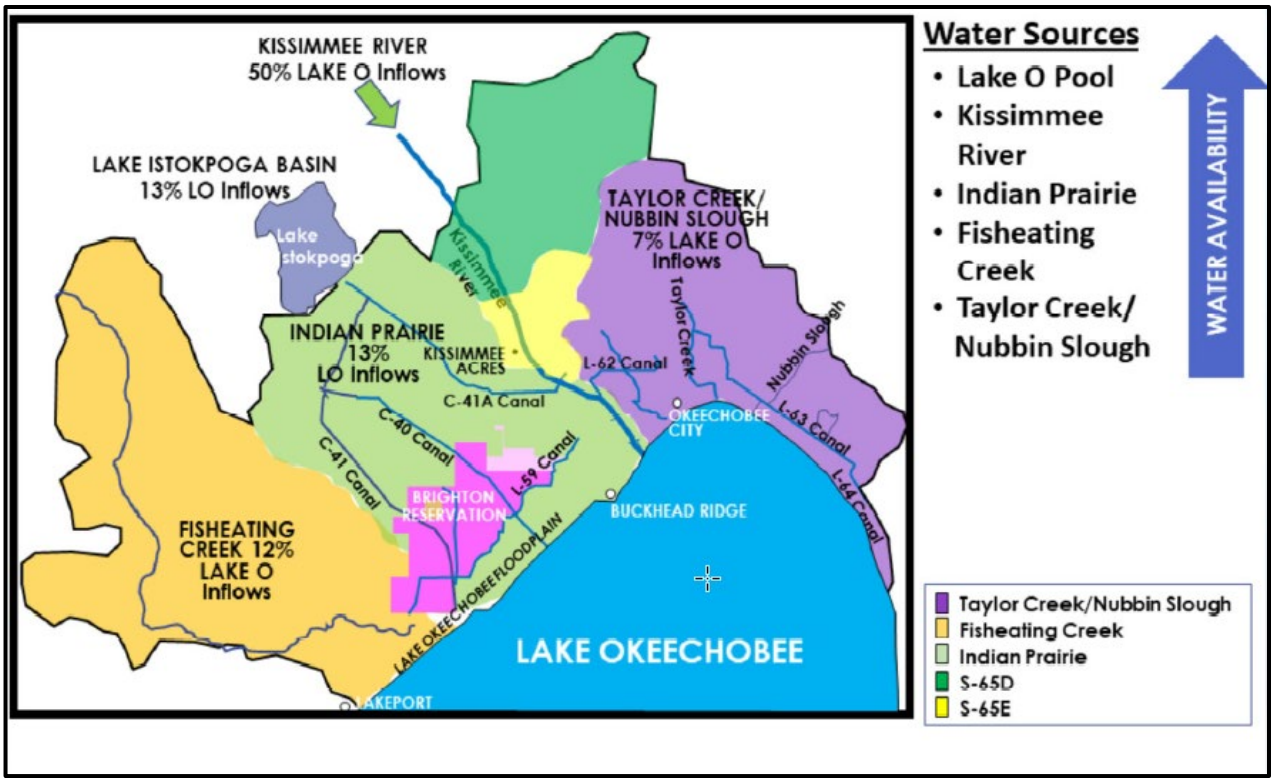

Figure E-9. Regional water availability

- **Co-location potential for synergy of project features**. This criteria considered if reservoirs could potentially be co-located with ASR wells and/or proposed LOWRP wetland restoration sites. Siting reservoirs near project wetlands and ASR wells provides almost essential operational flexibility, storage feature efficiency and effectiveness.
    - Co-location with ASR wells: With the capacity to input 5 million gallons per day into the aquifer for later use, ASR wells that are co-located with a storage feature act as a capacity enhancer as they operate increasing volume capacity for the storage feature. Co-location of ASR wells enables the storage feature to continually take in water (recharge), even during wet times, where non-co-located facilities would be limited in intake capacity or be otherwise full.
    - Colocation with wetland restoration sites offers similar benefits and minimizes the need for additional infrastructure. Typical above ground storage features within South Florida, and due to the unique and porous geology associated with the area, typically have seepage canals surrounding them to catch the seeping water from the storage feature and to redirect that seeped water back to the facility. Seepage canals require additional construction costs to build and additional pumping to collect and recirculate the seepage water back into the storage system. A wetland restoration site located immediately adjacent to a storage feature enables more efficient construction as seepage from the storage facility can be directed immediately into the adjacent wetland restoration facility rather than pumped back to the storage feature. Similarly, the storage feature and associated seepage act as a hydrology source aiding to maintain the health of the wetland restoration feature.

Colocation of ASR or wetland restoration facilities saves capital construction costs and long-term operations and maintenance requirements. Co-locating ASR with the WAF increases overall WAF storage capabilities without increasing the project footprint.

- Score 2. Fully Meets Criteria: Co-location with both ASR wells and wetlands
- Score 1. Partially Meets Criteria: Co-location with either ASR wells or wetlands
- Score 0. Does Not Meet Criteria: No co-location opportunities

- **Cost in dollars per acre-foot of water storage.** Prior to generating rough order of magnitude costs, a parametric cost-estimating tool was used for screening level costs to enable an "order of magnitude" construction cost estimate (considering various depths and storage capacities) for reservoirs. 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. For this analysis, it was assumed that more overall reservoir storage would generally allow for more environmental benefits (the consistency and availability of water sources is addressed in the first criteria above). 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. To obtain cost grouping values, the range of costs from the lowest cost option to the highest cost option was divided into three categories: high (cost/ac-foot of storage >$7,000), medium (cost/ac-foot storage $5,750-$7,000), and low (cost/ac-foot of storage <$5,750). The costs from the parametric costing tool are provided in Attachment A of this plan formulation appendix.
    - Score 2. Fully Meets Criteria: Low costs
    - Score 1. Partially Meets Criteria: Medium costs
    - Score 0. Does Not Meet Criteria: High costs

<u>Additional Deep Reservoir Considerations Not Used for Scoring</u>

- **Public land ownership**. The team carefully considered public land ownership within the reservoir footprint for each potential site. The percentage of public lands within the reservoir footprint was a consideration and may have been used as a deciding factored between two equally scored alternatives but ultimately was not a deciding factor when evaluating potential sites. A significant reason why the public land ownership was considered is the feedback received from both local land owners and local governmental entities in response to the project. Via public meeting input and through circulation of the draft report, feedback included that the use of public lands to the extent practicable reduces displacement of people, minimizes impacts to local tax rolls, and avoids risks of unwilling sellers and implementation of eminent domain authority, reducing overall real estate acquisition costs and timelines. It is also generally 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.
- **Dam Safety.** In cases where a reservoir would be located upstream of a potential population at risk, dam safety was a significant consideration. This factor was not scored during the screening process. If a site was determined to cause a potential dam safety risk, it was evaluated through a subsequent qualitative engineering analysis and presented in the Engineering Appendix (**Appendix**

A).-Sites ultimately found to present unacceptable dam safety risks were screened from further consideration.

Table E-3 discusses the rational for screening or retaining sites. Sites were scored on three criteria as follows: 0 = does not meet criteria, 1 = partially meets criteria, and 2 = fully meets criteria for a total possible score of 6. If the total score equals 3 or above, the reservoir site at the minimum partially meets at least half of the criteria and is carried forward for further analysis and inclusion in the initial rounds of modeling, preliminary cost estimates, and habitat unit calculations. If the total rating is less than 3, the reservoir site is not considered further.

Table E-3. Deep reservoir scoring and siting considerations

Deep Reservoir ID	Siting Criteria 1: Reliable Water Source. 2 = Meets Criteria 1= Partially Meets Criteria 0 = Does Not Meet Criteria	Siting Criteria 2: Co-Location Potential for Synergy of Project Features. 2 = Meets Criteria 1= Partially Meets Criteria 0 = Does Not Meet Criteria	Siting Criteria 3: Cost/acre-foot of Storage. 2 = Meets Criteria 1= Partially Meets Criteria 0 = Does Not Meet Criteria	Total Score (out of 6)	% of Footprint in Public Ownership to reduce # of parcels impacted and Incompatibility of Land Use[3]	Retained	Discussion
K-05 Large	2	2	2	6	31-60%	Yes	This reservoir site was retained because it has a reliable water source, it has the potential to be co-located with both ASR wells and wetlands, the overall cost/ac-ft of storage is low when compared to other sites. The proximity of this site to both the Seminole Tribe of Florida Brighton Reservation and the Buckhead Ridge community has been noted and additional dam safety evaluations will be performed during later iterations to determine if this site could be retained or must be screened based on this criteria.
K-05 South	2	2	1	5	31-60%	Yes	This reservoir site was retained because it has a reliable water source, it has the potential to be co-located with both ASR wells and wetlands, the overall cost/ac-ft of storage is medium when compared to other sites. The proximity of this site to both the Seminole Tribe of Florida Brighton Reservation and the Buckhead Ridge community has been noted and additional dam safety evaluations will be performed during later iterations to determine if this site could be retained or must be screened based on this criteria.
K-05 North	2	2	1	5	31-60%	Yes	This reservoir site was retained because it has a reliable water source, it has the potential to be co-located with both ASR wells and wetlands, the overall cost/ac-ft of storage is medium when compared to other sites. The proximity of this site to both the Seminole Tribe of Florida Brighton Reservation and the Buckhead Ridge community has been noted and additional dam safety evaluations will be performed during later iterations to determine if this site could be retained or must be screened based on this criteria.
K-42	2	0	1	3	<5%	Yes	Although this site could not be co-located with ASR wells or wetlands, it has been retained because this reservoir uses Lake Okeechobee as a water source and the cost/ac-ft is medium. It is important to note that this site would require 2 pump stations to utilize Lake Okeechobee as a water source, which would increase overall costs. The upstream proximity of this site to a downstream community has been noted and additional dam safety evaluations will be performed during later iterations to determine if this site could be retained or must be screened based on this criteria.
I-01	0	2	1	3	6-30%	Yes	This site does not have a consistently reliable water source, but was retained because there is the potential to co-locate the reservoir with both ASR wells and wetlands, the overall cost/ac-ft of storage is medium. It is important to note that while this site was initially carried forward for the first round of more detailed analysis, it was not cost-effective and was subsequently screened. This analysis is provided in **Section E.1.2.2.1**.
Brady Property	0	1	0	1	>60%	No	Although this site could potentially be co-located with ASR wells, it was not retained because the cost is high and because the water source is an inflow canal sourced from local drainage.

[3] Percent of public ownership was not used as a scoring criteria

Istokpoga Canal	1	0	0	1	>60%	No	This site was not retained because there is no co-location potential and the cost/ac-ft of storage is high.
T-26	0	1	0	1	>60%	No	This site was not retained because the water source is unreliable and the cost/ac-foot of storage is high.
I-17	0	0	0	0	<5%	No	This site was not retained because the water source is unreliable, there is no co-location potential, and the cost/ac-foot of storage is high.

[4]

[4] Percent of Land in Public Ownership was not used as a scoring criteria

E.1.2.2.2 Shallow Storage Siting Analysis (Shallow Reservoirs and Wetland Attenuation Features)

Formulating to meet the storage target using deep storage proved to be a challenge due to 1) the presence of nearby/downstream communities throughout the study area, which raised caused dam safety concerns, 2) geotechnical exploration results showed high seepage rates in the project area, which would be exacerbated by the additional head of deep storage; and 3) local communities have voiced concerns regarding the potential impacts of siting deep reservoirs on or near their property. These concerns led the PDT 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. Several different types of sites were considered for shallow storage:

- **Shallow Reservoirs:** High-performing sites from the deep reservoir analysis retained from **Section E.1.2.2.1** (with the exception of the I-01 site, which was initially carried forward for the first round of more detailed analysis, but was found to be not cost-effective and was subsequently screened. This analysis is provided in **Section E.1.2.2.1**)
- **Wetland Attenuation Features:** Sites with insufficient water sources for deep storage, but sufficient for shallow and sites closer to population centers that were not initially considered for deep storage (reduced safety concerns for shallow storage)

E.1.2.2.2.1 Shallow Reservoir Siting (Storage Option 2 of 4):

The top 4 sites identified in the deep storage siting were converted to shallow storage (5 ft.) and have been scored on water source considerations, co-location potential for synergy of project features, an initial planning-level cost-effectiveness analysis (in this case measured by cost per acre-foot of reservoir storage), overall storage capacity, the ability to avoid wetland sites and Florida grasshopper sparrow habitat. Similar to the deep siting analysis, the team carefully considered public land ownership within the reservoir footprint for each potential site, but it was not a scoring criteria to carry sites forward. Amongst high scoring sites, this criteria could be used as an additional consideration or tiebreaker to differentiate between reservoirs. Dam safety was also a consideration, but not scored. If a site was determined to cause dam safety risk, it was further evaluated via a qualitative engineering analysis. That analysis is presented in the Engineering Appendix (**Appendix A**). The criteria scoring and evaluation process is described in more detail in the section below.

<u>Shallow Reservoir Scoring Criteria</u>

- **Water source considerations.** A reliable water source is critical to reservoir performance and is the primary consideration for reservoir siting. Because Lake Okeechobee is the water source for all 4 shallow reservoirs, this criteria was scored differently than deep reservoirs and instead considered the overall effectiveness and efficiency of water access for each shallow reservoir. For example, a single pump station would be more effective and efficient at meeting objectives than 2 or more pump stations.
    - Score 2. Fully Meets Criteria: Single pump station to achieve water access
    - Score 1. Partially Meets Criteria: Two pump stations to achieve water access

- Score 0. Does Not Meet Criteria: More than two pump stations to achieve water access
- **Co-location potential for synergy of project features**. This criteria considered if reservoirs could potentially be co-located with ASR wells and/or proposed LOWRP wetland restoration sites. Siting reservoirs near project wetlands and ASR wells provides almost essential operational flexibility, storage feature efficiency and effectiveness.
    - Co-location with ASR wells: With the capacity to input 5 million gallons per day into the aquifer for later use, ASR wells that are co-located with a storage feature act as a capacity enhancer as they operate increasing volume capacity for the storage feature. Co-location of ASR wells enables the storage feature to continually take in water, even during wet times, where non-co-located facilities would be limited in intake capacity or be otherwise full.
    - Colocation with wetland restoration sites offers similar benefits and minimizes the need for additional infrastructure. Typical above ground storage features within South Florida, and due to the unique and porous geology associated with the area, typically have seepage canals surrounding them to catch the seeping water from the storage feature and to redirect that seeped water back to the facility. Seepage canals require additional construction costs to build and additional pumping to collect and recirculate the seepage water back into the storage system. A wetland restoration site located immediately adjacent to a storage feature enables more efficient construction as seepage from the storage facility can be directed immediately into the adjacent wetland restoration facility rather than pumped back to the storage feature. Similarly, the storage feature and associated seepage act as a hydrology source aiding to maintain the health of the wetland restoration feature.
- Score 2. Fully Meets Criteria: Co-location with both ASR wells and wetlands
- Score 1. Partially Meets Criteria: Co-location with either ASR wells or wetlands
- Score 0. Does Not Meet Criteria: No co-location opportunities

- **Cost in dollars per acre-foot of water storage.** Prior to generating rough order of magnitude costs, 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 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. For this analysis, it was assumed that more overall reservoir storage would generally allow for more environmental benefits (the consistency and availability of water sources is addressed in the first criteria above). 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. To obtain cost grouping values, the range of costs from the lowest cost option to the highest cost option was divided into three categories: high (cost/ac-foot of storage >$13,400), medium (cost/ac-foot storage $10,700-$13,400), and low (cost/ac-foot of storage <$10,700).
    - Score 2. Fully Meets Criteria: Low costs
    - Score 1. Partially Meets Criteria: Medium costs
    - Score 0. Does Not Meet Criteria: High costs

- **Overall storage capability.** The original CERP storage goal is 200,000 ac-ft. Due to various constraints, meeting this goal has been challenging. It is more cost-effective to build a single larger shallow reservoir than numerous smaller shallow reservoirs with the same/similar capacity. For this reason, a shallow reservoir that has higher storage capacity is more preferable. The PDT recognized that cost-effectiveness is a significant consideration, but wanted to also consider the cost-effective but potentially less efficient larger storage options. Since none of the shallow reservoir sites come close to the 200,000 ac-ft goal, the difference between the highest capacity shallow storage reservoir (73,000 ac-ft) and the lowest capacity reservoir (30,000 ac-ft) was divided into 3 categories to facilitate the comparison.
    - Score 2. Fully Meets Criteria: Top third of storage potential (58,668-70,000 ac-ft)
    - Score 1. Partially Meets Criteria: Middle third of storage potential (40,334-58,667 ac-ft)
    - Score 0. Does Not Meet Criteria: Lower third of storage potential (30,000-44,333 ac-ft)
- **Avoids wetlands.** While the majority of the land use/land cover for each reservoir is improved and unimproved pastures, there are some wetlands that will be affected in the construction of each reservoir. **Figure E-10,** displays wetlands within the reservoir footprint area, mostly freshwater emergent wetlands. More detail on the wetland analysis is located in **Appendix C Part 2**.
    - Score 2. Fully Meets Criteria: Fully avoids wetlands
    - Score 1. Partially Meets Criteria: Partially avoids wetlands
    - Score 0. Does Not Meet Criteria: Does not avoid wetlands

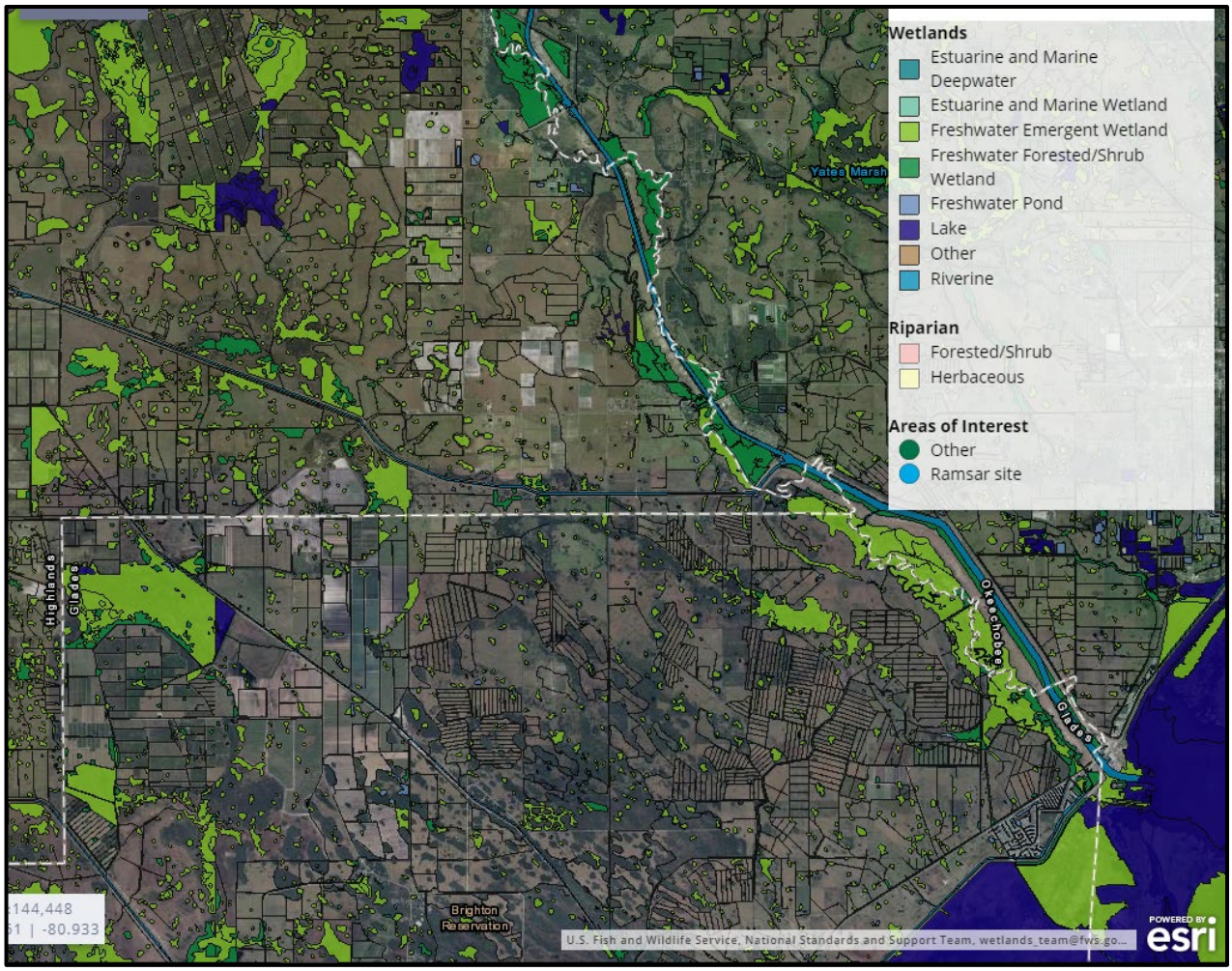

Figure E-10. Wetlands within the shallow reservoir footprint (USFWS 2020)

- **Avoids Florida Grasshopper Sparrow habitat.** The Florida grasshopper sparrow is a subspecies of grasshopper sparrow that is endemic to the dry prairie of central and southern Florida. This subspecies is extremely habitat specific and relies on fire every two to three years to maintain its habitat. The endangered Florida grasshopper sparrow is restricted to the dry prairie ecosystem of central and south Florida as displayed in **Figure E-11**. The sparrow is highly endangered (i.e., less than 100 individuals) due in large part to its exclusive dependence upon Florida dry prairie habitat, more than 85% of which has been destroyed. More detail on the Florida grasshopper sparrow analysis is located in **Appendix C Part 2**.
    - Score 2. Fully Meets Criteria: Fully avoids Florida grasshopper sparrow habitat
    - Score 1. Partially Meets Criteria: Partially avoids Florida grasshopper sparrow habitat
    - Score 0. Does Not Meet Criteria: Does not avoid Florida grasshopper sparrow habitat

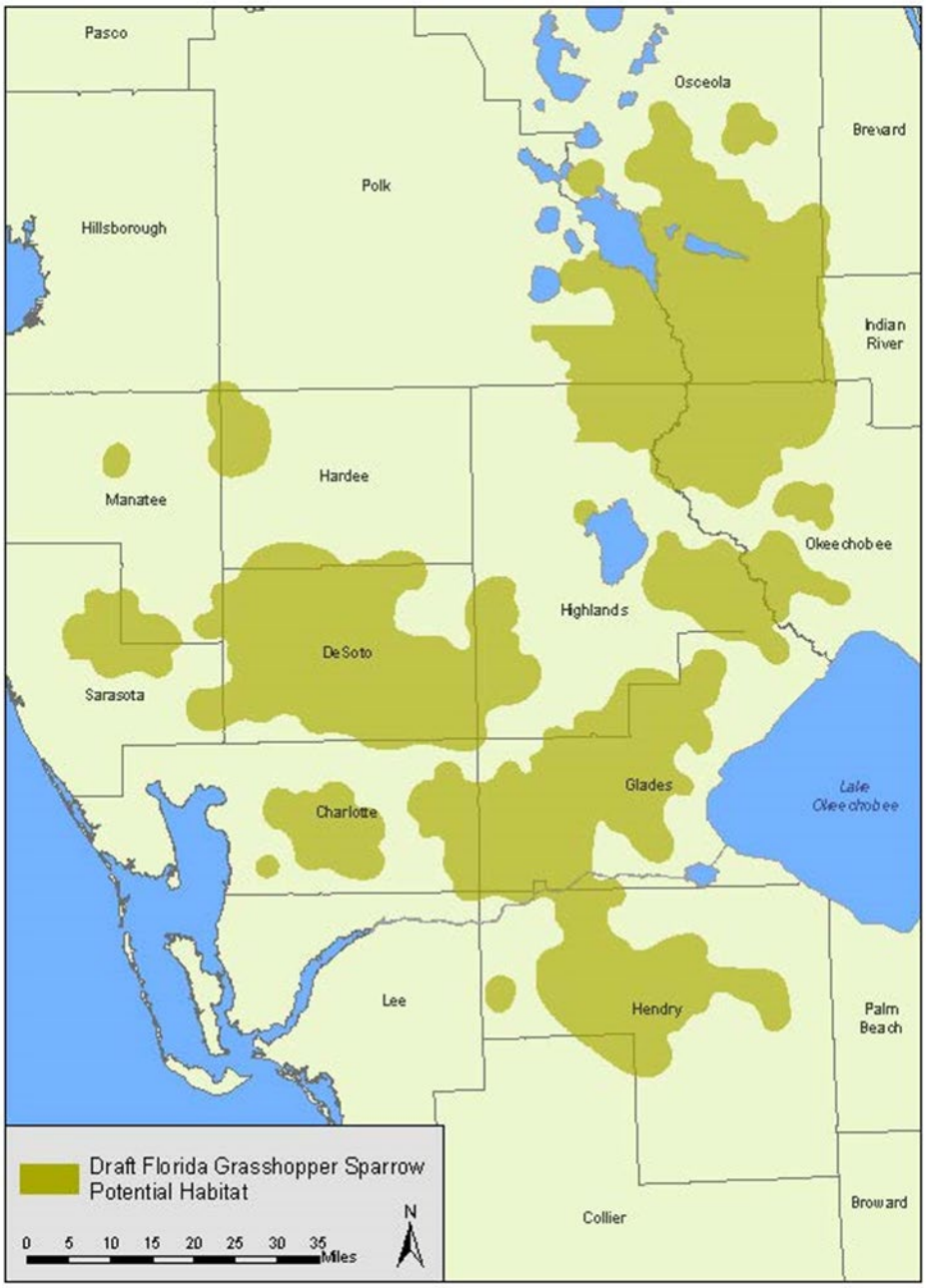

Figure E-11. Draft Florida grasshopper sparrow potential habitat (USFWS 2017).

<u>Additional Shallow Reservoir Considerations Not Used for Scoring</u>

- **Public land ownership**. Similar to the deep reservoir siting analysis, the team carefully considered public land ownership within the reservoir footprint for each potential site.
- **Dam Safety.** Similar to the deep reservoir siting analysis, Sites ultimately found to present unacceptable dam safety risks were screened from further consideration.

Table E-4 discusses the rational for screening or retaining sites. Sites were scored on six criteria as follows: 0 = does not meet criteria, 1 = partially meets criteria, and 2 = fully meets criteria for a total possible score

of 12. If the total score equals 6 or above, the reservoir site at the minimum partially meets at least half of the criteria and is considered for further evaluation. If the total rating is less than 6, the reservoir site is not considered further.

Based on this scoring methodology, the K-42 shallow reservoir site was screened and the K-05 large shallow, K-05 south shallow, and K-05 north shallow sites were retained as they retained high scores. Upon further evaluation, the K-05 north and south shallow sites were not retained as they are similar but less efficient than the larger site and provide less overall storage. Therefore, the K-05 Large Shallow site was the only site retained from this analysis.

Table E-4. Shallow reservoir (5 ft.) screening results.

Shallow Reservoir ID	Siting Criteria 1: Water Source Accessibility. 2 = Fully Meets Criteria 1= Partially Meets Criteria 0 = Does Not Meet Criteria	Siting Criteria 2: Co-Location Potential for Synergy of Project Features. 2 = Fully Meets Criteria 1= Partially Meets Criteria 0 = Does Not Meet Criteria	Siting Criteria 3: Cost/acre-foot of Storage. 2 = Fully Meets Criteria 1= Partially Meets Criteria 0 = Does Not Meet Criteria	Siting Criteria 4: Overall Storage Capacity. 2 = Fully Meets Criteria 1= Partially Meets Criteria 0 = Does Not Meet Criteria	Siting Criteria 5: Avoids Wetlands. 2 = Fully Meets Criteria 1= Partially Meets Criteria 0 = Does Not Meet Criteria	Siting Criteria 6: Avoids Florida Grasshopper Sparrow Habitat. 2 = Fully Meets Criteria 1= Partially Meets Criteria 0 = Does Not Meet Criteria	Total Score (out of 12)	Retained	Discussion
K-05 Large Shallow	2	2	2	2	1	2	11	Yes	This site was retained because it is low cost and has the potential to co-locate with both ASR wells and wetlands.
K-05 South Shallow	2	2	1	1	1	2	9	No	Although this site scored above the threshold, it was not retained because it is similar to K-05 Large Shallow but it provides less storage than K-05 large and has a higher cost/ac-ft. of storage.
K-05 North Shallow	2	2	1	1	1	2	9	No	Although this site scored above the threshold, it was not retained because it is similar to K-05 Large Shallow but it provides less storage than K-05 large and has a higher cost/ac-ft. of storage.
K-42 Shallow	1	0	2	2	0	0	5	No	This site was not retained as a shallow reservoir primarily because a deep storage reservoir is more cost-effective in this location. It is less efficient as a shallow reservoir because it would require 2 pumps in order to access water, thereby further reducing overall efficiencies of a shallow K-42 reservoir. Additionally, this site scored less than others due to the higher presence of wetlands and the presence of grasshopper sparrow habitat within the footprint.

E.1.2.2.2.2 Wetland Attenuation Feature Siting (Storage Option 3 of 4)

The PDT recognized during this iteration of plan formulation that, due to the shallow nature of wetland attenuation features (WAFs), numerous WAFs would be needed to come close to the overall CERP storage target of 200,000 ac-ft and this option would be much less cost effective than building a single deep reservoir of the same size. However, due to the challenges of siting deep reservoirs due to dam safety concerns, geotechnical considerations (deep storage features seep significantly more than shallow features), and opposition/concerns from local communities to deep storage, the PDT decided to consider this less cost-effective shallower storage option that may be more acceptable to local communities and may provide for ancillary wetland habitat and water quality benefits within the WAF.

Further analysis was performed to identify potential WAF sites (**Figure 12**). The following types of sties were considered: 1) Sites were considered that had performed well in the previous shallow reservoir siting analysis, 2) Sites with relatively reliable water sources, and 3) Sites that were previously not retained due to dam safety concerns as deep reservoirs but would have significantly reduced concerns due to the shallow nature of a WAF.

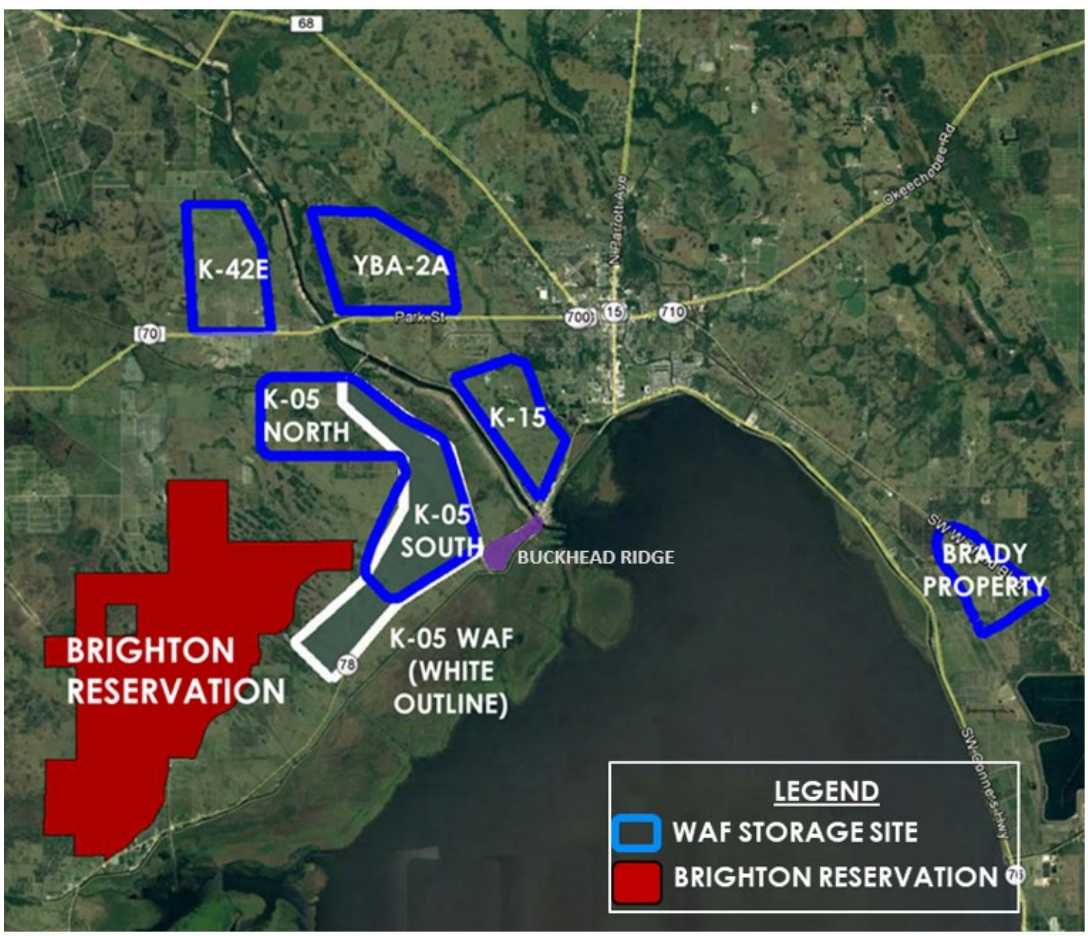

Figure E-12. WAF locations.

Combinations of WAF storage sites were considered due to the smaller capacity and reduced overall cost of WAF storage sites when compared to deeper storage options. 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-5**). The other configurations were dropped due to overall higher costs (a planning figure of $1,000,000,000 was used to identify a high cost WAF storage option).

Table E-5. Retained cost-effective WAF locations.

WAF Combo	WAF Location	Total Cost[5]	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 WAF (4 ft.)	**$617,575,200**	**43,000**	**$14,362**	**$223,037,600**	**13,000**	**$17,157**
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**

[5] Planning level costs

WAF Combo	WAF Location	Total Cost[5]	Total Storage (Acre-Feet)	Cost/ Acre-foot	Incremental Cost	Incremental Output (Acre-Foot Storage)	Incremental Cost Per Acre-foot
12	K-05 WAF (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**

The next step was to further evaluate the suitability of the remaining individual or combination of wetland attenuation feature sites. Source water availability, an initial planning-level cost-effectiveness analysis (in this case measured by cost per acre-foot of reservoir storage) potential to co-locate with ASR wells and/or wetland restoration sites, preliminary storage estimates based on contiguous land availability, and avoidance of highly endangered grasshopper habitat were the primary factors evaluated in the WAF siting.

Wetland Attenuation Feature Scoring Criteria

- **Reliable water source.** 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 (C-38) provides a slightly less consistent source of water that may be subject to restrictions more often than Lake Okeechobee. A rim canal source would also provide less water due to being sourced by local drainage and water control structures which maintain lower water levels for flood risk management purposes. If there are two water sources then the score will be averaged.
    - Score 2. Fully Meets Criteria: Water source is Lake Okeechobee
    - Score 1. Partially Meets Criteria: Water source is pool E of C-38
    - Score 0. Does Not Meet Criteria: Other sources
- **Cost in dollars per acre-foot of water storage.** Prior to generating rough order of magnitude costs, 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 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. For this analysis, it was assumed that more overall reservoir storage would generally allow for more environmental benefits (the consistency and availability of water sources is addressed in the first criteria above). 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. To obtain cost grouping values, the range of costs from the lowest cost option to the highest cost option was divided into three categories: high (cost/ac-foot of storage >$18,600), medium (cost/ac-foot storage $14,900-$18,600), and low (cost/ac-foot of storage <$14,900).
    - Score 2. Fully Meets Criteria: Low costs
    - Score 1. Partially Meets Criteria: Medium costs

  - Score 0. Does Not Meet Criteria: High costs

- **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. Co-location with both wetlands and ASR wells were considered together in a single category during deep and shallow reservoir formulation, but during this iteration later on in the formulation process the PDT recognized the importance of these criteria and broke them up into separate categories to further distinguish between potential WAF sites.
  - Score 2. Fully Meets Criteria: Co-location with wetlands (if 2 sites then both can co-locate with wetlands)
  - Score 1. Partially Meets Criteria: If 2 sites then only 1 site can co-locate with wetlands
  - Score 0. Does Not Meet Criteria: No co-location opportunities
- **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. As discussed in the 'Co-location with proposed wetlands' category above, co-location with ASR wells is considered significant on its own and has been broken up into a separate category to further distinguish between potential WAF sites.
  - Score 2. Fully Meets Criteria: Co-location with ASR wells (if 2 sites then both can co-locate with ASR wells)
  - Score 1. Partially Meets Criteria: If 2 sites then only 1 site can co-locate with ASR wells
  - Score 0. Does Not Meet Criteria: No co-location opportunities
- **Avoids Florida Grasshopper Sparrow habitat.** The Florida grasshopper sparrow is a subspecies of grasshopper sparrow that is endemic to the dry prairie of central and southern Florida. This subspecies is extremely habitat specific and relies on fire every two to three years to maintain its habitat. The endangered Florida grasshopper sparrow is restricted to the dry prairie ecosystem of central and south Florida as displayed in **Figure E-11.** The sparrow is highly endangered (i.e., less than 100 individuals) due in large part to its exclusive dependence upon Florida dry prairie habitat, more than 85% of which has been destroyed. More detail on the Florida grasshopper sparrow analysis is located in **Appendix C Part 2.** If there are two sites then the score will be averaged.
  - Score 2. Fully Meets Criteria: Fully avoids Florida grasshopper sparrow habitat
  - Score 1. Partially Meets Criteria: Partially avoids Florida grasshopper sparrow habitat
  - Score 0. Does Not Meet Criteria: Does not avoid Florida grasshopper sparrow habitat
- **Overall storage capability.** The original CERP storage goal is 200,000 ac-ft. Due to various constraints, meeting this goal has been challenging. It is more cost-effective to build a single larger shallow reservoir than numerous smaller shallow reservoirs with the same/similar capacity. For this reason, a WAF that has higher storage capacity is more preferable. The PDT recognized that cost-effectiveness is a significant consideration, but wanted to also consider the cost-effective but potentially less efficient larger storage options. Since none of the WAF sites come close to the 200,000 ac-ft goal, the difference between the highest capacity reservoir (68,000 ac-ft) and the lowest capacity reservoir (8,000 ac-ft) was divided into 3 categories to facilitate the comparison.
  - Score 2. Fully Meets Criteria: Top third of storage potential (48,001-68,000 ac-ft)

- Score 1. Partially Meets Criteria: Middle third of storage potential (28,001-48,000 ac-ft)
- Score 0. Does Not Meet Criteria: Lower third of storage potential (8,000-28,000 ac-ft)

Additional Wetland Attenuation Feature Considerations Not Used for Scoring

- **Public land ownership**. Similar to the deep reservoir siting analysis, the team carefully considered public land ownership within the reservoir footprint for each potential site.
- **Dam Safety.** Similar to the deep reservoir siting analysis, Sites ultimately found to present unacceptable dam safety risks were screened from further consideration.

Table E-6 discusses the rational for screening or retaining sites. Sites were scored on criteria as follows: 0 = does not meet criteria, 1 = partially meets criteria, and 2 = fully meets criteria for a total possible score of 12. Because so many of the sites scored high on the criteria as compared to deep and shallow reservoir evaluation, only WAF sites that meet at least 75% of this criteria (total score equals 9 or above) are considered for further evaluation. If the total rating is less than 9, the WAF site(s) is not considered further. WAF combinations 3, 6, 9, 11, 12, and 13 were retained for further consideration.

Table E-6. WAF screening results.

WAF Combo	WAF Site(s)	Water Source	Cost/ Acre-foot	Co-Location with LOWRP wetlands	Co-location with Proposed ASR	Avoids Florida Grasshopper Sparrow Habitat	Preliminary Storage Estimate	Total Score (out of 12)	Retained for Further Analysis	Discussion
1	Brady Property	0	0	0	2	2	0	2	No	This site was not retained due to its reduced cost-effectiveness, inability to co-locate with wetlands, and the overall small storage capacity.
2	K-15 (4 ft.)	2	0	0	2	2	0	6	No	This site was not retained due to its reduced cost-effectiveness, inability to co-locate with wetlands, and the overall small storage capacity.
3	K-05 South (4 ft.)	2	1	2	2	2	0	9	Yes	This site was retained because of the water source and the ability to co-locate with both wetlands and ASR wells.
4	K-42 East Shallow (4 ft.)	1	1	2	0	0	0	4	No	This site was not retained because it cannot be co-located with ASR wells, it does not avoid grasshopper sparrow habitat, and the overall smaller storage capacity.
5	YBA-2A (4 ft.)	1	2	0	2	1	1	7	No	Although this site is cost-effective and can be co-located with ASR wells, it does not score as high as other options with more reliable water sources, avoiding grasshopper sparrow habitat, and overall storage capacity. Additionally, this site cannot be co-located with wetlands.
6	K-05 WAF(4 ft.)	2	2	2	2	2	1	11	Yes	This site was retained because it scores the highest on all of the criteria with the exception of overall storage capacity.
7	K-15 (4 ft.) and K-42 East Shallow (4 ft)	1.5	1	1	1	1	1	6.5	No	This combination was not retained because it only partially meets all of the criteria.
8	K-05 South (4 ft.) and K-42 East Shallow (4 ft.)	1.5	1	2	1	1	2	8.5	No	This combination was not retained because it includes K-42 East Shallow, which cannot be co-located with ASR wells, and the water source is limited when compared to other options.
9	K-05 South (4 ft.) and YBA-2A (4 ft.)	1.5	2	1	2	1.5	2	10	Yes	This combination has been retained due to the low cost and potential to co-locate with ASR wells for both sites.
10	K-42 East Shallow (4 ft.) and YBA-2A (4 ft.)	1	2	1	1	1.5	2	8.5	No	Although this site fully meets the cost-effectiveness criteria and storage capacity criteria, it only partially meets the remaining criteria.

11	K-05 North (4 ft.) and YBA-2A (4 ft.)	1.5	2	1	2	1.5	2	10	Yes	This combination has been retained due to its cost-effectiveness, potential to co-locate with ASR wells for both sites, and overall higher storage capacity.
12	K-05 WAF (4 ft.) and K-15 (4 ft.)	2	1	1	2	2	2	10	Yes	This combination was retained because both sites can be co-located with ASR wells, avoid grasshopper sparrow habitat, and of the overall higher storage capacity.

Table E-7 displays the WAF combinations 3, 6, 9, 11, 12, and 13 that scored highest based on the WAF evaluation criteria. Of these sites, the WAF Combination 6 was selected to retain because it is one of the most cost-effective of the remaining options, it has an optimal water source, and it can co-locate with both ASR wells and wetlands, which would further improve the overall cost-effectiveness of this option during detailed design and future cost estimates, and it completely avoids highly endangered Florida grasshopper sparrow habitat.

Table E-7. Final WAF screening criteria

WAF Combo #	WAF Site(s)	Discussion
3	K-05 South (4 ft.)	**Not retained.** This site is very similar to WAF Combination 6 but is slightly cost-effective and provides less overall storage. Therefore, it was not retained.
6	K-05 WAF(4 ft.)	**Retained.** This site was retained because is one of the most cost-effective of the remaining options, it has an optimal water source, and it can co-locate with both ASR wells and wetlands, which would further improve the overall cost-effectiveness of this option during detailed design and future cost estimates, and it completely avoids endangered grasshopper sparrow habitat.
9	K-05 South (4 ft.) and YBA-2A (4 ft.)	**Not retained.** Although this option has fully met the cost-effectiveness, co-location with ASR, and overall storage capacity criteria, the YBA-2A site cannot co-locate with wetlands, does not have a Lake Okeechobee water source, and does not fully avoid grasshopper sparrow habitat. For these reasons, this combination, although well performing, does not perform as well as WAF Combination 6 and was not retained.
11	K-05 North (4 ft.) and YBA-2A (4 ft.)	**Not retained.** Although this option has fully met the cost-effectiveness, co-location with ASR, and overall storage capacity criteria, the YBA-2A site cannot co-locate with wetlands, does not have a Lake Okeechobee water source, and does not fully avoid grasshopper sparrow habitat. For these reasons, this combination, although well performing, does not perform as well as WAF Combination 6 and was not retained.
12	K-05 WAF (4 ft.) and K-15 (4 ft.)	**Not retained.** This option performs well because both sites can co-locate with ASR wells, avoid grasshopper sparrow habitat, and has a higher overall storage capacity, but the inclusion of the K-15 site reduces the overall cost-effectiveness and cannot be co-located with wetlands. Therefore, this option does not perform as well as WAF combination 6 and has not been retained.
13	K-05 WAF (4 ft.) and K-42 East Shallow (4 ft.)	**Not retained.** This option fully meets the cost-effectiveness criteria, both sites can co-locate with wetlands and has a higher overall storage capacity, but was not retained because K-42 East Shallow cannot co-locate with ASR wells, does not avoid grasshopper sparrow habitat.

E.1.2.3 ASR Formulation (Storage Option 4 of 4)

ASR wells as a management measure were also considered as a potentially viable management measure to meet project objectives. ASR wells were considered both as a stand-alone storage option and as a

measure that could be combined with above-ground storage to create dynamic storage that would better address the project objectives and can be a more efficient management measure opportunity that ASR storage alone.

The ASR wells store water within two distinct zones within the Floridan Aquifer System, the UFA and the APPZ. 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 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. 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.

The Restudy proposed a series of ASR wells adjacent to Lake Okeechobee with a capacity of one billion gallons per day, which is the equivalent of approximately 200 ASR wells (Lake Okeechobee Aquifer Storage and Recovery Component GG). However, the 2015 CERP ASR Regional Study reduced the number of ASR wells that could be constructed within the northern Lake Okeechobee Basin on SFWMD-owned lands based on hydrogeologic conditions to approximately 112 wells[6]. Sensitivity runs as discussed previously identified an initial ASR target of 65-112 ASR wells to add to reservoir storage to maximize project benefits.

ASR-well-only configurations (no reservoir storage) were initially considered but subsequently screened for not meeting project objectives. **Figure E-13** displays Lake Okeechobee ecology results of an ASR only-plan with 75 ASR wells. Although this option shows improvement over the FWO condition, the projected Lake Okeechobee Habitat Unit benefits[7] are slightly lower than the existing conditions Improving Lake Okeechobee health is a significant goal of CERP and LOWRP, and the ASR-only option was not retained. The next step in the formulation process is to combine reservoir locations retained from the screening analysis described previously with various ranges of ASR wells.

[6] Initially up to 112 ASR wells were considered for LOWRP. This includes approximately 30 boulder zone wells, which were subsequently screened from the LOWRP project.

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

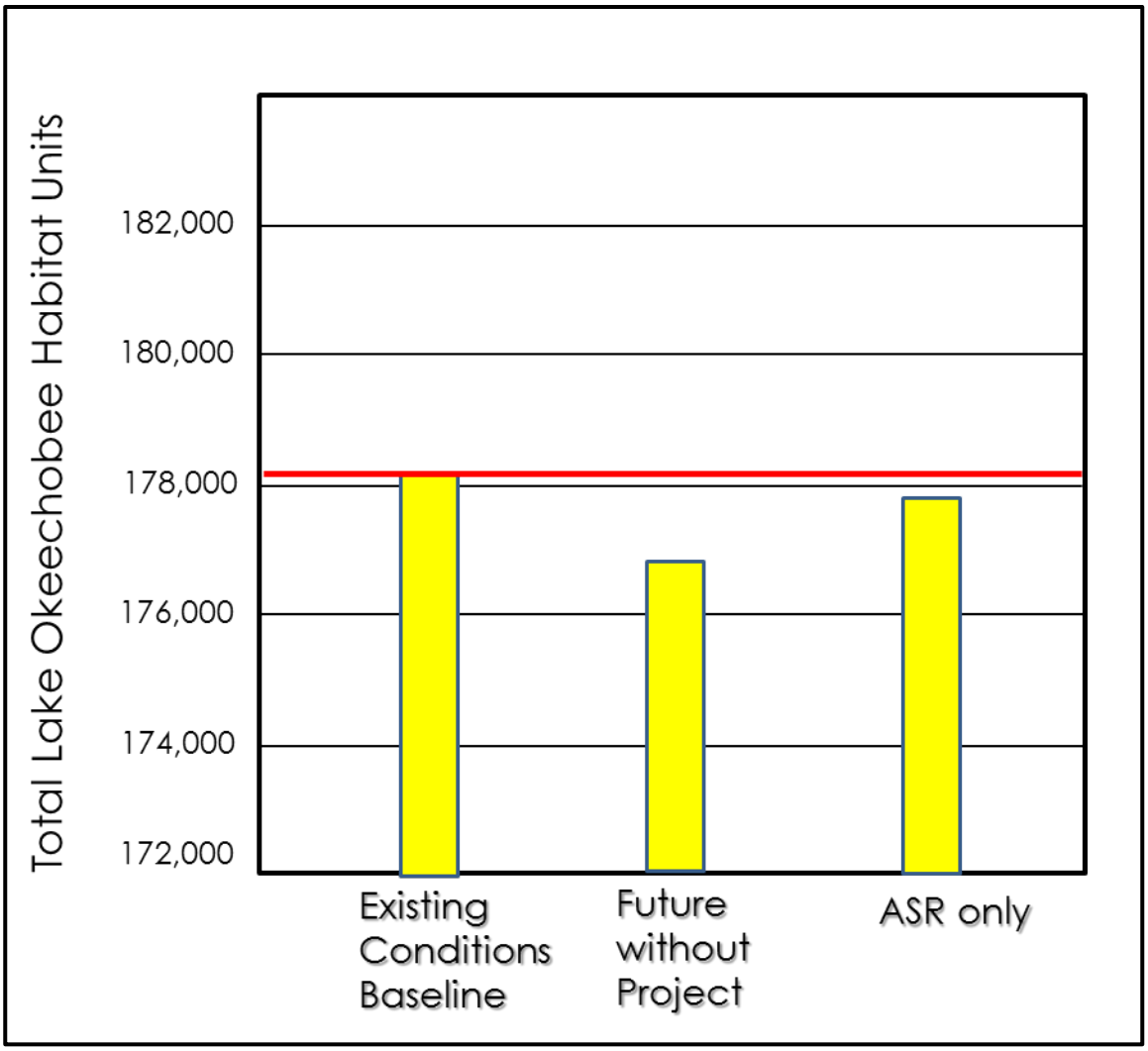

Figure E-13. 75 ASR-well-only option (with no reservoir) Lake Okeechobee performance.

E.1.2.1 Results of Aboveground and Belowground Storage Analysis

The text below summarizes the results from the analysis described in **Section E.1.2.2 Aboveground Water Storage Feature Siting Summary** through **Section E.1.2.3 ASR Formulation (Storage Option 4 of 4)**. These results will be considered in the iterative water storage component formulation process described in **Section E.1.2.2** below.

- **Deep aboveground storage:** Deep storage (average 15-ft. pool depth) within the K-05 Large, K-05 North, K-05 South, I-01, and K-42 footprints were retained for further analysis.
- **Shallow aboveground storage:** Shallow storage (average 5-ft. pool depth) within the K-05 footprint provides 65,000 acre-feet of storage and reduces dam safety risks. This site is approximately 14,800 acres and would be operated to maximize regional (Northern Estuaries and Lake Okeechobee) storage benefits.
- **Wetland attenuation feature:** A WAF within the K-05 footprint would be used for surface water storage (43,000 acre-feet) to attenuate peak flows, although water levels may be suitable for growth of wetland vegetation due to the water depths typically realized through operation of the

facility. During attenuation periods, water levels could rise to an average 4-ft. pool depth. The WAF footprint is approximately 12,500 acres.

- **ASR storage.** ASR-well-only configurations (no reservoir storage) were initially considered but subsequently screened for not meeting project objectives. The results of early sensitivity runs identified an initial ASR target of 65-112 ASR wells to add to reservoir storage to maximize project benefits.

E.1.2.2 Iterative Water Storage Component Formulation Process

This section provides a summary of how ASR wells were combined with above ground storage features (deep reservoirs, shallow reservoirs, and wetland attenuation features) to become water storage components and how these components were proposed, evaluated, revised, or removed from further consideration. Unlike the initial screening analysis, this iterative process is a more detailed analysis using the full suite of performance measures, a more sensitive RSMBN model, rough order of magnitude costs, the calculation of habitat units, and a cost effectiveness evaluation.

In each round of analysis, the overall storage capacity, reservoir footprints, and costs were revised to optimize the performance, improve cost-effectiveness, and increase acceptability to local communities. 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.1.2.2.1 First Round of Analysis

The first round of water storage components combined deep reservoirs and ASR wells 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-8 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-8. 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

E.1.2.2.2 Second Round of Analysis

Only cost-effective components identified by the first round were carried forward for the second round of analysis (**Table E-9**). 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-9. 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

Regional Simulation Model – Basins (RSM-BN) output, planning-level costs, habitat units, and Cost Evaluation and Incremental Cost Analysis (CE/ICA) were evaluated for the second round of water storage measures (see **Table E-10**). 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 flows 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-10. 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 Components 2A and 2B were retained since they were identified as the most ecologically effective management measures. Water Storage Component 1B provides benefits at the lowest increment

of cost, so it was also retained. Despite being the worst-performing and least cost-effective, Water Storage Component 2C is the Seminole Tribe of Florida (STOF)'s least objectionable component because it is farthest away from the 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.1.2.2.3 Third Round of Aboveground Storage Analysis

In the third round of analysis, the K-05 and K-42 reservoir footprints were revised to improve efficiency and effectiveness. 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 from the previous round of analysis with no changes as it was 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 was the most efficient measure for meeting the water supply objective. Water storage components evaluated in the third round of analysis are shown in **Table E-11**. Subsequent to this round of analysis a qualitative dam safety was performed and deep reservoirs were subsequently screened from the K-05 footprint due to unacceptable risks.

Table E-11: 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.1.3 Results of Aboveground Storage Analysis (Fourth and Final Round)

Water Storage Component 2Cr was retained as the only deep reservoir option as the majority of other deep reservoir sites were not retained due to dam safety concerns. The retained K-05 shallow reservoir and K-05 WAF were added to the analysis for the fourth and final round. The documentation of how these shallow sites were scored and selected is discussed in **Section E.1.2.2.2** above. **Table E-12** shows the results of the aboveground storage analysis. These water storage components will be combined with the top performing wetland restoration sites to form the final array of alternatives to be evaluated and compared in **Section 4** of the main report.

Table E-12. Description of features in retained water storage components.

Water Storage Components	Reservoir/WAF	Reservoir/WAF Storage Capacity (acre-feet)	Number of ASR wells	Maximum ASR Storage Capacity (acre-feet per year)
1Bshlw	K-05 shallow reservoir (5 ft. average depth)	65,000	80	448,000

Water Storage Components	Reservoir/WAF	Reservoir/WAF Storage Capacity (acre-feet)	Number of ASR wells	Maximum ASR Storage Capacity (acre-feet per year)
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 wetland restoration analysis began with conceptual sites from the previous LOWRP effort that was paused in 2006. This effort included a GIS analysis to identify the following factors considered important for wetland restoration: soils, connectivity to other areas of protected habitat, presence of known contaminants, economic value, ecologic value, cultural resources, and environmental and economic equity. The sites retained from the previous analysis are shown in **Figure E-14**.

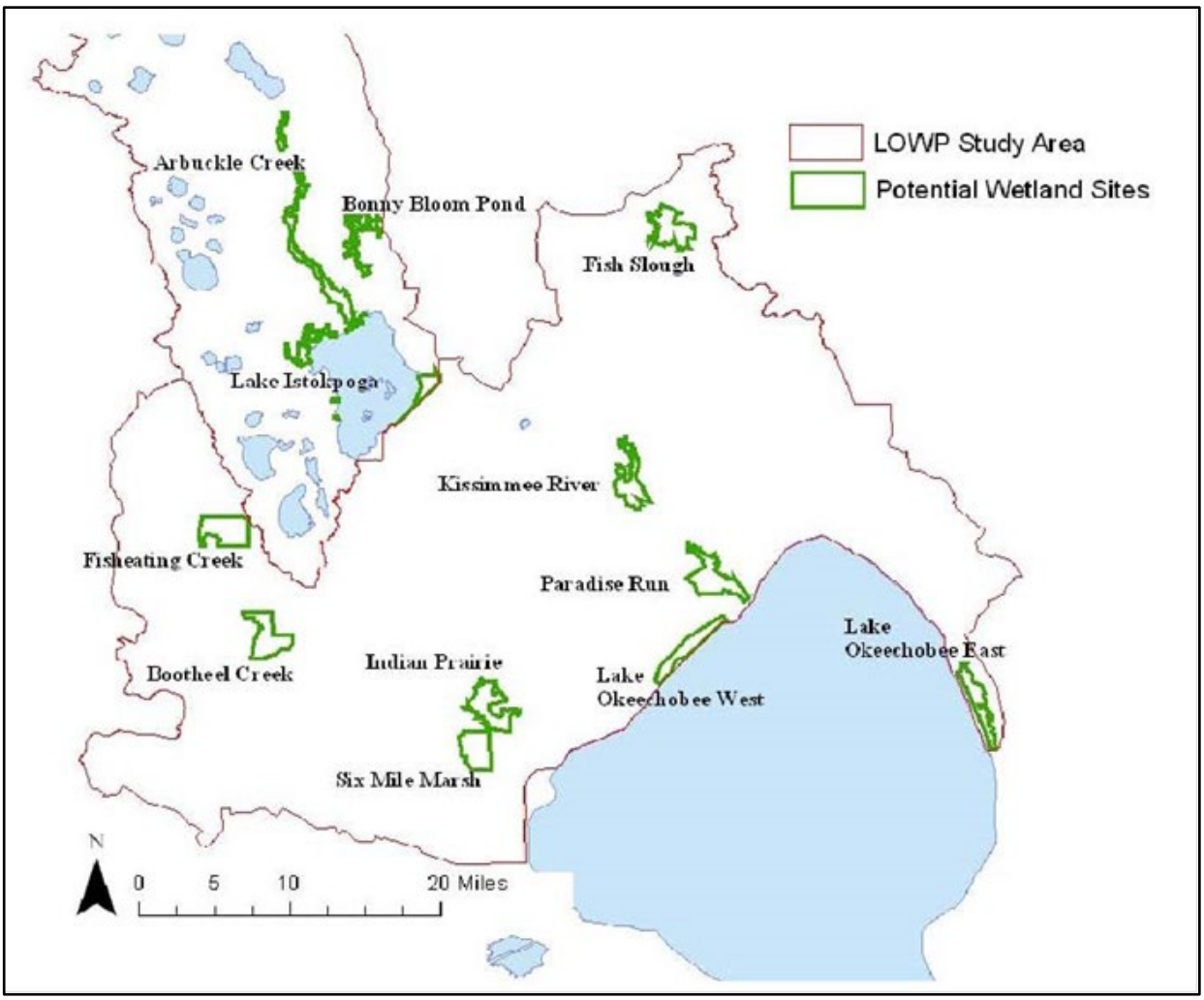

Figure E-14. Wetland sites identified from previous LOWRP analysis

These sites were further evaluated based on the revised project footprint as the Istokpoga tributary was removed from the footprint. Arbuckle Creek and Bonny Bloom Pond were removed because they are outside of the updated project footprint. Fisheating Creek and Six Mile Marsh were discovered to be part of other ongoing restoration efforts (Fisheating Creek is part of wetland reserve perpetual easement program by the United States Department of Agriculture's National Resource Conservation Service and Six Mile Marsh is within a Lykes Brothers Conservation Easement) and were removed from further consideration to avoid redundancy.

Additional littoral zone restoration sites were also considered. 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.

The remaining wetland sites were scored on a 0-1 scale based on the criteria listed below. More detail on scoring criteria development for criteria 1-4 is located in **Attachment B** of this document.

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 has direct perimeter connectivity to other public or privately protected high ecological value lands.
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. **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.
    - Score 1: Potential to co-locate with both ASR wells and proposed project surface storage features
    - Score 0.5: Potential to co-locate with either ASR wells or proposed project surface storage features
    - Score 0: No potential to co-locate with either ASR wells or proposed project surface storage features

A total of eight wetland restoration sites were scored. The four highest-scoring sites (Lake Okeechobee West, IP-10, Paradise Run, and Kissimmee River) were retained for further analysis and the 4 lower scoring sites were removed from further consideration (**Table E-13**).

Table E-13. Performance measure scores for wetland restoration site.

Site	Acreage	Wading Bird Colonies	Connectivity	Surface Water Connectivity	Restoration Potential	Co-location	Total (Out of 5)	Retained
Lake O West	2,800	0.65	1	0.74	0.76	0.5	3.65	Yes
Paradise Run	3,847	0.47	0	1	0.49	1	2.96	Yes
IP-10	4,315	1	0.26	0.3	0.71	0.5	2.77	Yes
Kissimmee River	2,595	0.47	0.16	0.75	0.33	0.5	2.21	Yes
Bootheel Creek	3,432	0	0.79	0.52	0.39	0	1.7	No
Indian Prairie	5,370	0.47	0.39	0.1	0.53	0	1.49	No
Fish Slough	3,742	0	0.49	0.18	0.66	0	1.33	No
Lake O East	2,713	0.12	0	0	1	0	1.12	No

Due to the potential vast differences in restoration costs throughout the Kissimmee River site based on topography, it was further broken up into three smaller sites for additional analysis: Kissimmee River–North, Kissimmee River–Center, and Kissimmee River–South (**Figure E-15**).

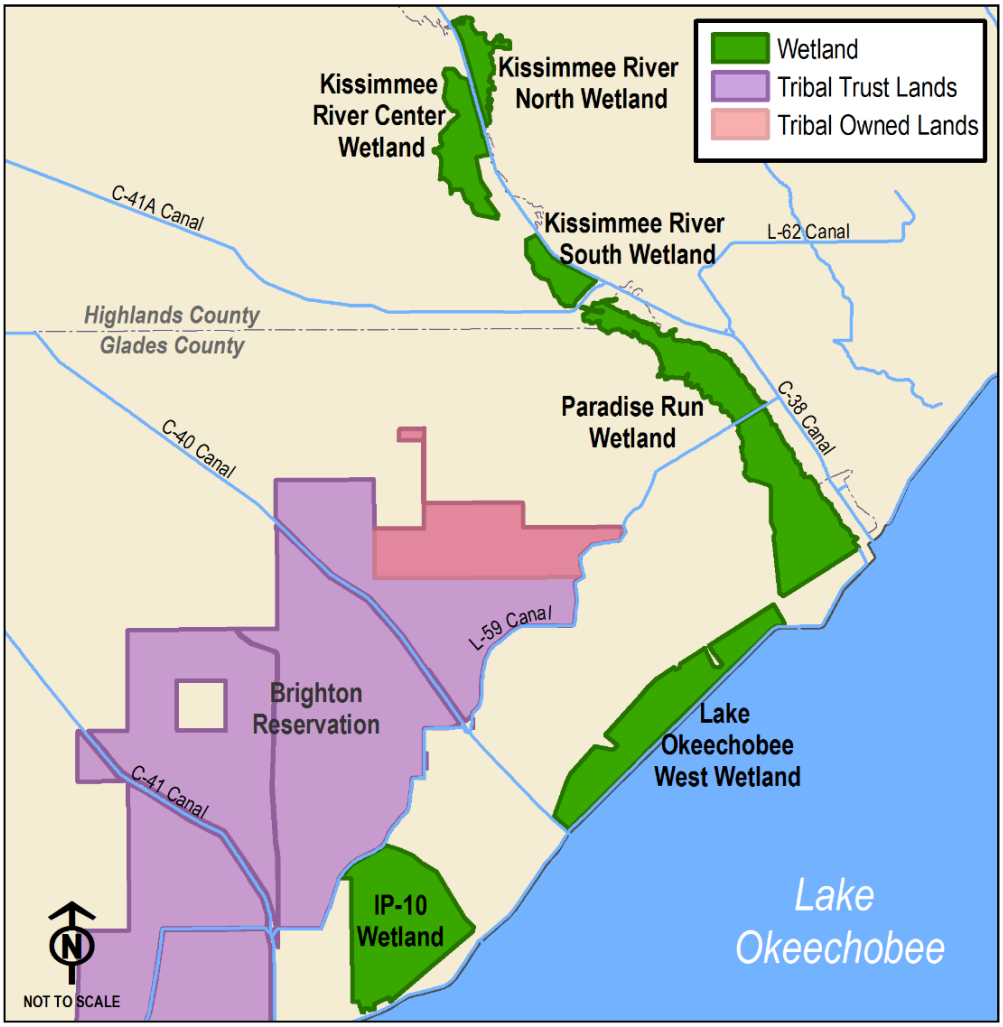

Figure E-15. Retained wetland restoration sites.

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-14**). The incremental cost per output for these best-buy wetland combinations is shown in **Figure E-16**.

Table E-14. 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

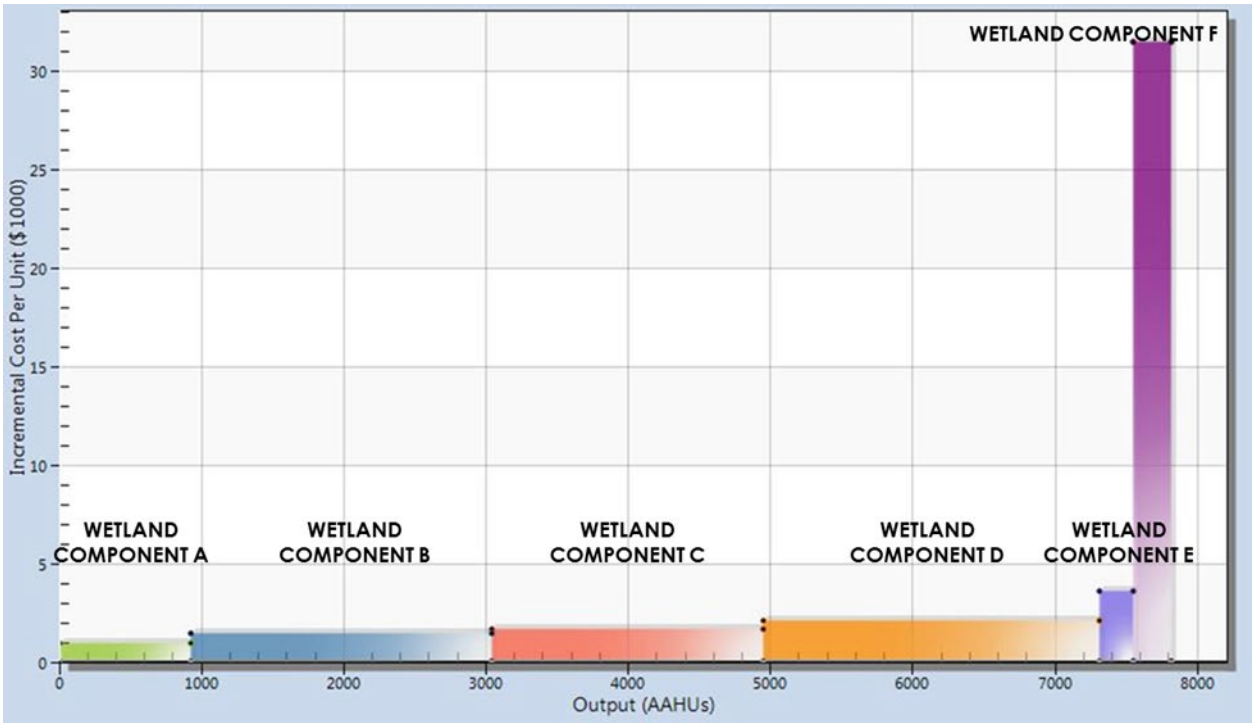

Figure E-16. Incremental cost per output of best buy wetland components.

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-16**

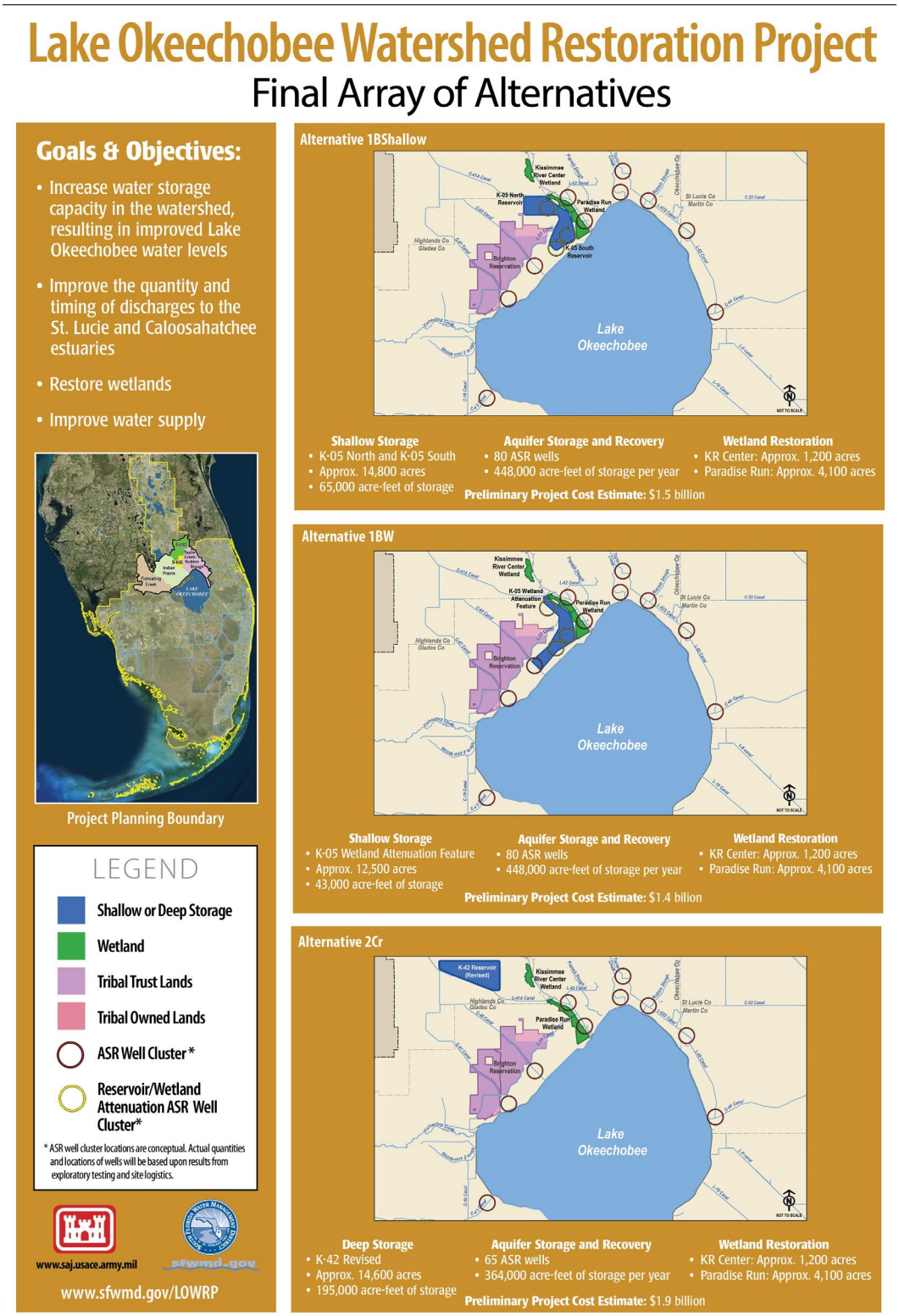

Figure E-17. Final array of alternatives

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 of the 80 total) located within the footprint of the WAF (also referred to as co-located ASR wells). 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. The wells will be adjacent to the L-63N, L-63S, or L-64 canals that can discharge to Lake Okeechobee.
    - One cluster is located along Taylor Creek, downstream of S-192 and upstream of the S-133 pump station that release fresh water 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.

E.4 Risk and Uncertainty Regarding the Identification of Focused Array of Alternatives

The LOWRP team considered numerous types of water storage management measures to meet project objectives throughout the alternative evaluation process. Initial considerations included effectiveness, environmental effects, efficiency and technical uncertainty regarding proposed management measures. Because the project area is so large, additional screening criteria was developed to further narrow down the options to get to a final array of alternatives as discussed in **Section E.1.2** above. Much of the screening level analysis was completed with planning-level cost estimates, GIS data, existing environmental and cultural survey data, and best professional judgment. It is possible that other viable, but less efficient and/or cost-effective, surface storage sites exist in the project area and could be pursued and evaluated in the future.

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

This is a reference document for the costs and storage estimates in the appendix. 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