APPENDIX E.2 SUPPORTING INFORMATION

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E.2 INTRODUCTION

The purpose of the Combined Operational Plan (COP) is to define operations for the constructed features of the Modified Water Deliveries (MWD) to Everglades National Park (ENP) and Canal 111 (C-111) South Dade Projects, while maintaining the congressionally authorized purposes of the Central and Southern (C&SF) Florida Project to include flood control; water supply for agricultural irrigation, municipalities and industry; regional groundwater control and prevention of saltwater intrusion; enhancement of fish and wildlife; water supply for ENP; and recreation. The COP will result in a comprehensive integrated water control plan for the operation of water management infrastructure associated with the MWD and C-111 South Dade Projects. Implementation of the COP is anticipated to increase the availability of water deliveries from Water Conservation Area (WCA 3A) to ENP through Northeast Shark River Slough (NESRS) and improve hydrologic conditions in Taylor Slough, the Rocky Glades, and the eastern panhandle of ENP.

Plan formulation efforts identified the desire to modify the current Rainfall Plan of water delivery to ENP. Under current operations, water enters NESRS primarily from WCA 3A via S-333, and then to the L-29 canal and subsequent passage through several sets of culverts and the one-mile Tamiami Trail bridge (completed as part of the MWD project in 2013) under Tamiami Trail. S355A and S-355B are also used to deliver water from WCA 3B to the L-29 canal for subsequent passage through the culverts to NESRS. The discharges made from WCA 3A through the S-12 structures and S-333 are target flows determined from the Rainfall Plan (USACE 2012). Under the Rainfall Plan, water deliveries are computed and operations adjusted weekly, if necessary based on the sum of two components: a rainfall response component and a WCA 3A supplemental regulatory component. The Rainfall Plan is a component of the current 2012 Water Control Plan for the WCAs, ENP, and ENP to South Dade Conveyance System (SDCS).

The Rainfall Plan provides for the rainfall response component within all zones of the WCA 3A Regulation Schedule, with the additional regulatory release requirement added when the WCA 3A water levels fall within the higher regulation schedule zones above Zone E, including Zone E1. Under current water management practice, discharge capacity from S-333 into the L-29 canal and NESRS is maximized prior to utilization of the S-12 structures, in order to limit potential effects from WCA 3A discharges on the Cape Sable Seaside Sparrow western subpopulation (CSSS-Ax). When flows through the S-12 structures are determined necessary by the WCA 3A Regulation Schedule and the Rainfall Plan, water managers prioritize flow through the easternmost S-12 (C and D) structures as capacity allows, in order to minimize flow through the S-12A and S-12B structures.

This document presents the targets (stage hydrographs) to be utilized within WCA 3 and ENP for purposes of informing Everglades Rain Driven Operations (ERDO). The regional hydrologic modeling tool used for this effort was the iModel. The iModel emulates the hydrologic response characteristics of the Regional Simulation Model – Glades Lower East Coast Service Area (RSM-GL) and unlike traditional hydrologic models, the iModel is “inverse” in that inputs to the iModel are hydrologic targets (water depths and durations) and outputs are the optimized operations of structures that provide the overall best fit to the hydrologic targets. The iModel domain includes WCA 3A, WCA 3B and ENP, as well as WCAs 1 and 2. For the purposes of the COP, targets were not established for WCA 1 and 2, as changes to the regulation schedules for WCA 1 and 2 were not being considered within the COP scope. Hydrologic targets were developed to inform Round 2 modeling efforts (Alternatives (ALT) N2, O, and Sensitivity Runs S1, S2, S3, and S4).

E.2.1 Documentation of iModel targets in WCA 3 and ENP to Support Everglades Rain Driven Operations

Restoration Coordination and Verification (RECOVER) is an interagency and interdisciplinary scientific and technical team that provides essential support to the Comprehensive Everglades Restoration Plan (CERP) by organizing and applying scientific and technical information at a system-wide level to facilitate the planning and implementation of the CERP. The members of RECOVER have extensive experience working in south Florida and Everglades wetlands ecosystems and are considered by their peers to be the experts in their fields. RECOVER has developed a set of system-wide hydrologic and ecologic performance measures for CERP that are used in the evaluation of alternative plans and assessment of CERP performance from a system-wide perspective. RECOVER performance measures receive several levels of review to include a RECOVER-wide review and a public review. Each of the project performance measures for the COP planning effort were derived from those performance measures approved for use by RECOVER, as goals and objectives for the COP are compatible with CERP in increasing the availability of water deliveries from WCA 3A to ENP through NESRS and to improve hydrologic conditions in Taylor Slough, the Rocky Glades, and the eastern panhandle of ENP.

Compilation of empirical evidence indicates the Everglades pre-drainage ridge and slough landscape was an extensive, interconnected system comprising the majority of modern day Loxahatchee National Wildlife Refuge (NWR, also WCA 1), WCA 2, WCA 3, and Shark River Slough (McVoy et al., 2011; Plate 5). The tree island-ridge-slough patterned landscape is among the most charismatic features of the Everglades landscape. This patterned landscape, wherein higher elevated tree islands and linear elevated ridges (dominated by sawgrass) are interspersed within a matrix of deeper sloughs (dominated by submerged and floating leaved species) is thought to arise from the coupled ecological processes controlling organic matter accumulation/oxidation. The tree island-ridge-slough plant communities are found in areas with different ground surface elevation and soil nutrient content. In general, tree islands are 1-1.5 meters (m) (3.5 feet (ft)) above the surrounding slough and depending on their geographical location within the Everglades, tree islands may remain inundated 6-9 months a year. In contrast, ridges are only 0.4 m (1.5 ft) above the surrounding slough and may remain inundated all year around.

The paleoenvironmental record provides scientific evidence that *Nymphaea odorata* (white water lily) was a characteristic plant species within historic Everglades sloughs (Saunders et al., 2008; Bernhardt et al., 2004; Willard et al., 2001; Willard et al., 1997). During pre-drainage conditions, naturally occurring slough communities associated with tree islands and dense stands of *Cladium jamaicense* (sawgrass) were abundant within the ridge and slough habitat of the Everglades. This topography is termed “ridge and slough”, since the dense sawgrass ridge was historically approximately 1.5 ft (46 cm) higher than the adjacent slough (Willoughby, 1898; Stewart, 1907; Baldwin and Hawker, 1915; Marchman, 1947; Lodge, 2005). During pre-drainage times, the ridges and sloughs were oriented parallel to the direction of flow. This landscape was estimated to extend from the pine flatwoods of the coastal ridge on the east, to the Big Cypress Swamp on the west, to the sawgrass plains on the north, and to the mangrove estuary to the south (McVoy et al., 2011).

Implementation of the C&SF project altered hydropatterns and associated physical patterning processes causing a detrimental effect on the Everglades landscape. The ridge and slough landscape has become more uniform both in topography and plant community composition (Richards et al., 2009; Sklar et al., 2000). The physical patterning of the ridge and slough topography has been significantly degraded compared to historical conditions with only a 0.33 ft (10 centimeters (cm)) average elevation difference now existing between ridges and sloughs within WCA 3A, WCA 3B, and Shark River Slough compared to

1.5 ft (46 cm) historically (Richards et al., 2009). The central portion of many sloughs, once thought to be a *N. odorata* dominated plant community, now contain plant species characteristic of more transitional ridge and slough environments such as *Eleocharis cellulose* (coastal spikerush) (Richards et al., 2009). Hydropatterns (i.e., water depth) reported in modern day Everglades "sloughs" in WCA 3A, WCA 3B, and Shark River Slough provide evidence that conditions have become more suitable for transitional species to invade the central portions of sloughs in WCA 3, and Shark River Slough (Richards et al., 2009). While distinct physiochemical and plant species composition differences still exist in ridges and sloughs today, shifts in plant species composition and physical degradation of the ridge and slough habitat indicate that core ecological functions and processes in vegetation communities have degraded since pre-drainage times (RECOVER, 2011; Richards et al., 2009).

E.2.1.1 Slough Vegetation Performance Measure: WCA 3A and NESRS

Performance measures were used to evaluate the COP alternatives and to make the correlation between hydrologic output and ecosystem function. Performance measures within the Greater Everglades were used to measure depth, distribution and duration of surface flooding, timing and distribution of flows, and suitability for slough vegetation. Each of the project performance measures for the COP planning effort were derived from those approved for use by RECOVER. Each performance measure included a predictive metric and a desired target representative of historical conditions or pre-drainage hydropatterns within the study area. One of the objectives for the COP is to improve water deliveries (timing, location, volume) within the study area and to take steps to restore natural hydrologic conditions given current C&SF infrastructure. Improvements in water deliveries should help return hydropatterns that support the development and sustainability of the ridge and slough topography and the associated ecological functions provided by ridge and slough communities in areas that are currently and historically were defined as ridge and slough habitat in WCA 3A, WCA 3B and ENP, as well as the restoration of flows to Taylor Slough. The Slough Vegetation performance measure provides the target to restore the ridge and slough habitat which provides critical habitat for forage fish, the prey source of wading birds. The Slough Vegetation performance measure documentation sheet is available upon request.

The Slough Vegetation performance measure provides a target that describes a full-restoration, pre-drainage pattern of hydroperiods within sloughs, with the expectation that suitable water depths for slough vegetation will provide the desired restoration condition for the ridge and slough landscape. A time series derived from the Slough Vegetation performance measure or directly from the Natural Systems Regional Simulation Model (NSRSM) was utilized in alternative modeling to provide the correct depths for the ridge and slough landscape. An offset was applied to regions of the Everglades that have experienced significant ecological impacts such as, peat fires, loss of microtopography, or extensive reduction in sloughs or ridges, for extended periods of time. An offset is defined here as a consistent multiplier for above ground water depths (2.2 ft full depth target x 0.5 multiplier equal to 1.1 ft) from some hydrologic target or goal, applied to a hydrologic time series (in this case: the time series is daily from 1965-2005). These regions require transitional targets to foster a return to a slow peat accreting ridge and slough landscape (**Figure E.2-1**). Targets that attempt to restore full restoration to every region, e.g., northern WCA 3A north of Alligator Alley, have the potential to create undesired environmental impacts such as, loss of tree islands, microtopography, or wading bird foraging habitat.

The Slough Vegetation performance measure has the hydrologic characteristics of the Shark River Slough white lily community. If the Everglades ground surface had not subsided these last 100 years and if the current system was not compartmentalized, this would be the perfect performance measure and target for 90% of WCA 3 and the entire Shark River Slough habitat in ENP. A 50% offset was applied to gauge

locations that are located north of I-75 in northwest and northeast WCA 3A which captures the need for keeping peat saturated to prevent peat fires (except in extreme droughts) while fostering hydroperiods that are conducive for ridge and tree island restoration (Gauges 3A-NW, 3A-11, 3A-NE, 3A-3, and E-4). The target for central and southern WCA 3A was set at the fully restored time series (Gauges 3A-4 and 3A-SW in central WCA 3A and Gauges 3A-28, 3A-S, and W-2 in southern WCA 3A). A fully restored slough time series was also used for northeastern and central ENP (Gauges NE-2 and P-33) (**Figure E.2-2** and **Figure E.2-3**).

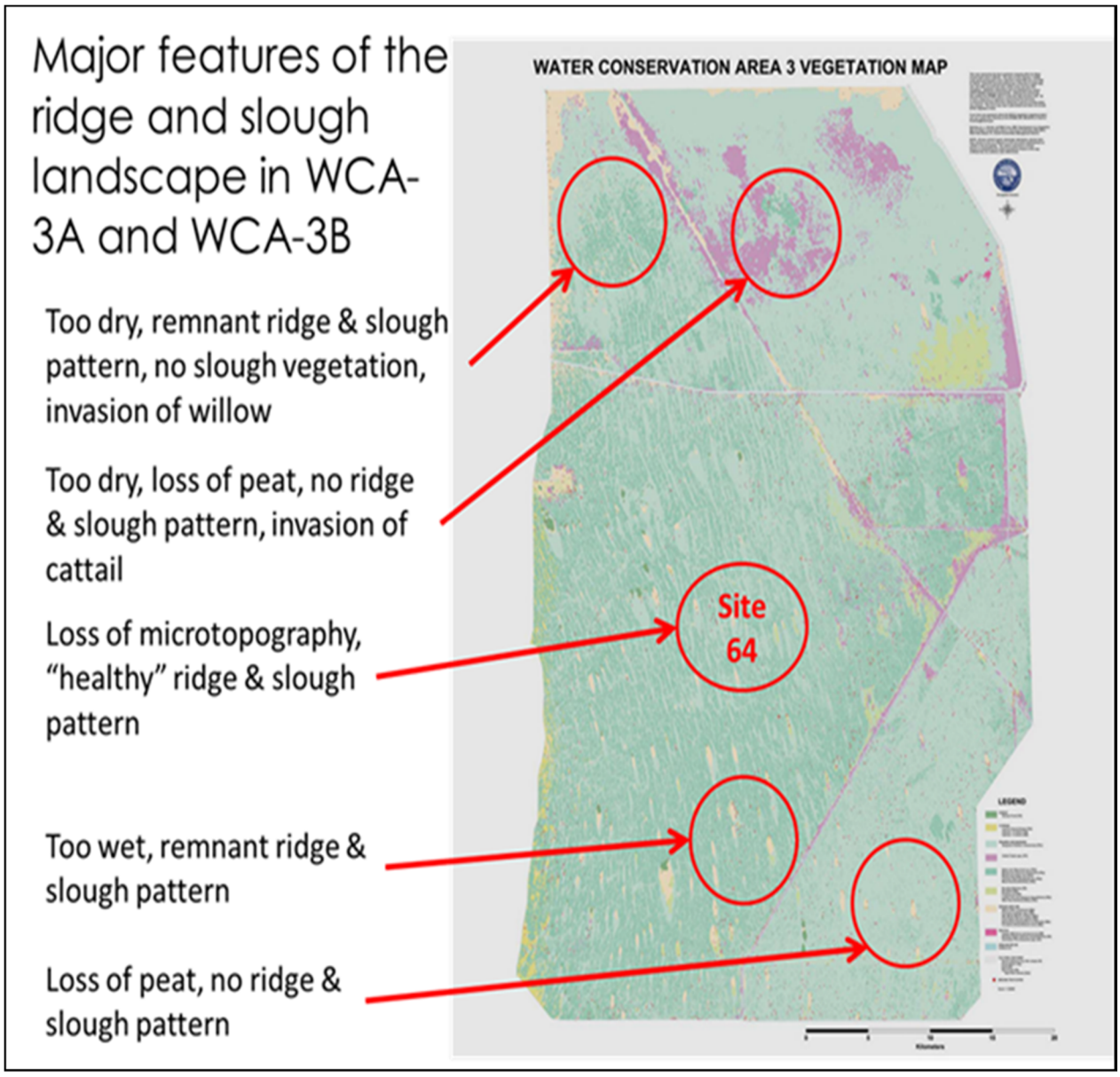


Figure E.2-1. Ridge and slough landscape features in WCA 3A and WCA 3B.

Gage Locations for iModel Targets in WCA 3A & WCA 3B

iModel targets

50% slough vegetation time series:

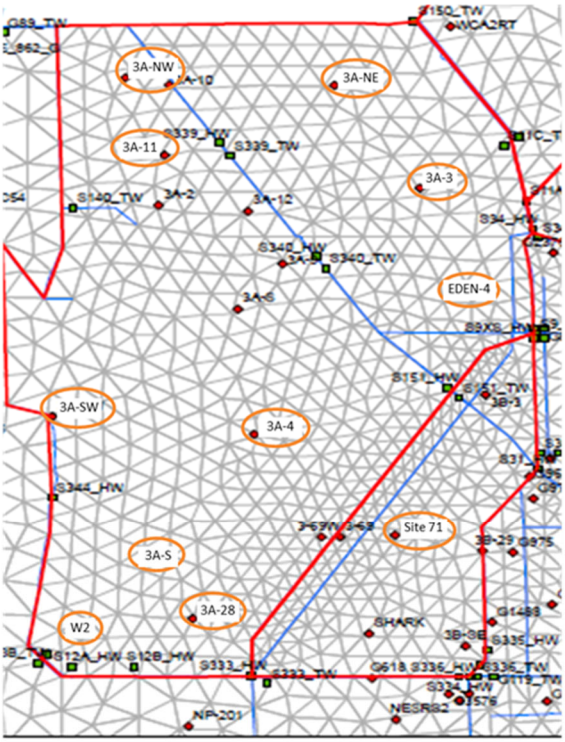
- 3A-NW
- 3A-NE
- 3A-11
- 3A-3
- Eden-4

100% slough vegetation time series:

- 3A-SW
- 3A-4
- 3A-S
- W2
- 3A-28

NSRSM:

- Site 71*



*NSRSM at Site 71 meets the criteria of 2.5' not to exceed 60 days discontinuous hydroperiod for more than 3 consecutive years

Figure E.2-2. iModel targets for WCA 3A and WCA 3B.

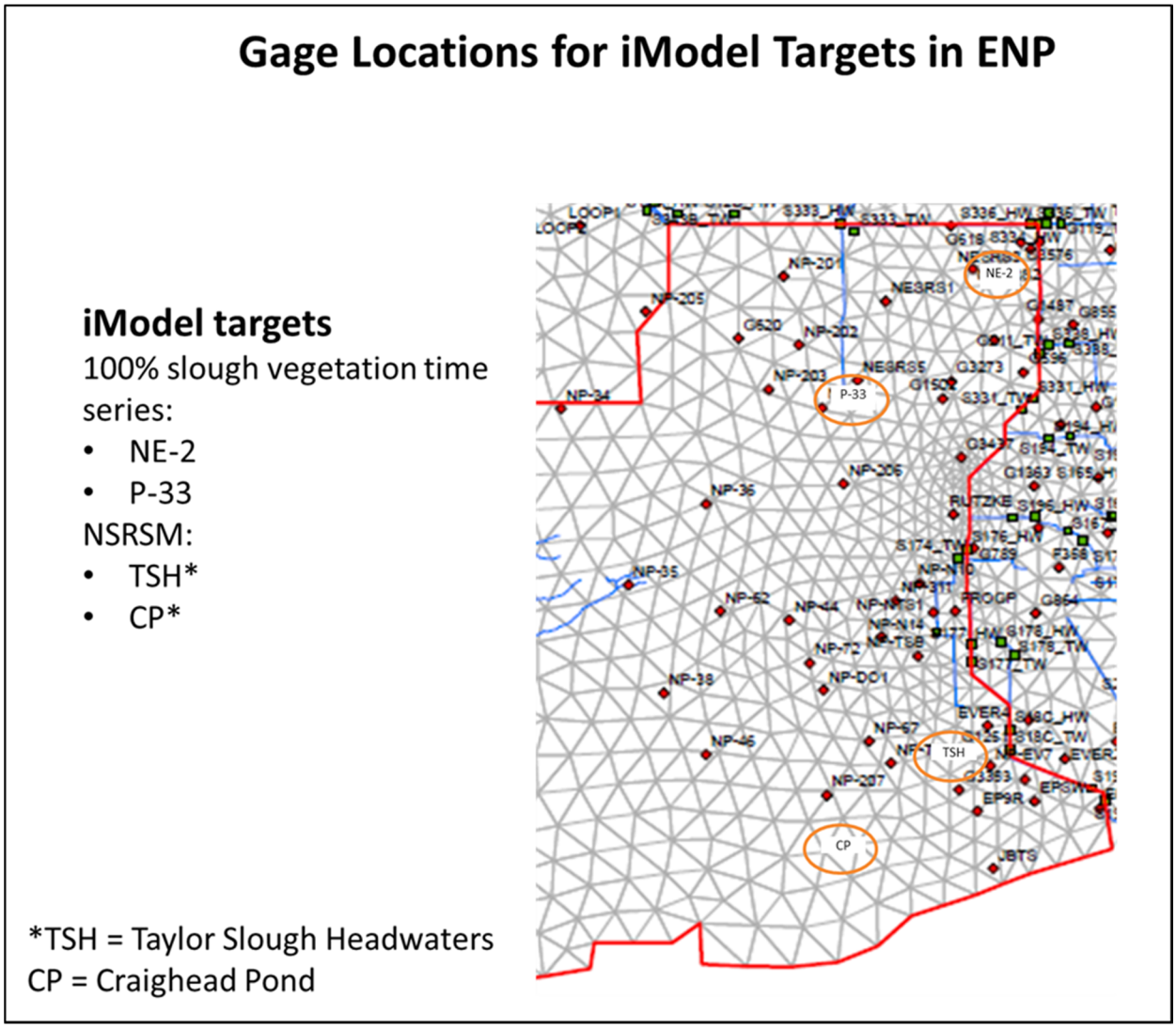


Figure E.2-3. iModel targets for ENP.

E.2.1.2 NSRSM: WCA 3B and Taylor Slough

For WCA 3B a time series was developed independently from the Slough Vegetation performance measure in order to foster hydroperiods that are conducive for ridge, slough and tree island restoration within this portion of the project area (**Figure E.2-2**). Within WCA 3B, the ridge and slough landscape has been severely compromised by the virtual elimination of overland sheetflow since the construction of the L-67 canal and levee system. WCA 3B has become primarily a rain-fed compartment, experiencing very little overland flow and has largely turned into a sawgrass monoculture where relatively few sloughs or tree islands remain. Loss of sheetflow to WCA 3B has also accelerated soil loss reducing elevations of the remaining tree islands in WCA 3B, making them vulnerable to high water stages. The target for Site 71 was set to not exceed the tree island threshold identified by the SFWMD (2.5 feet depth not to exceed 60 days discontinuous hydroperiod for more than 3 consecutive years) and was based on the time series as simulated under the NSRSM. No offset to the time series at Site 71 was applied.

For Taylor Slough, two sites were identified for purposes of setting the iModel targets, Craighead Pond (CP) and Taylor Slough Headwaters (TSH). Similar to WCA 3B, the target at these two locations was based on the time series as simulated under the NSRSM. No offset to the time series at gauges CP and TSH was applied.

E.2.1.3 Marl Prairie Performance: ENP

Cape Sable seaside sparrows (CSSS) are non-migratory residents of freshwater to brackish marshes and their range is restricted to the lower Florida peninsula. They were listed as an endangered species by the U.S. Fish and Wildlife Service (USFWS) in 1967. CSSS prefer mixed marl prairie communities that include muhly grass (*Muhlenbergia filipes*) for nesting (Stevenson and Anderson 1994). Marl prairie communities have short-hydroperiods (the period of time during which a wetland is covered by water) and contain a mosaic of moderately dense, clumped grasses, interspersed with open space that permit ground movements by the sparrows (USFWS 1999). CSSS are generally not found in communities dominated by dense sawgrass, cattail (*Typha spp.)* monocultures, long-hydroperiod wetlands with tall, dense vegetative cover, spike rush marshes, and sites supporting woody vegetation (Werner 1975, Kushlan and Bass 1983). CSSS also avoid sites with permanent water cover (Curnutt and Pimm 1993). The combination of hydroperiod and periodic fire events are critical in the maintenance of suitable mixed marl prairie communities for the CSSS (Kushlan and Bass 1983).

CSSS nest in the spring when the marl prairies are dry. While the majority of nesting activities have been observed between March 1 and July 15 when Everglades marl prairies are dry, (Lockwood et al. 1997, 2001), nesting has been reported as early as late February (Werner 1975), and as late as early August (Dean and Morrison 2001). Successful CSSS breeding requires that breeding season water levels remain at or below ground level in the breeding habitat. Nott et al. (1998) cited a "10 cm" rule for maximum water depth over which the CSSS will initiate nesting. This conclusion was based upon observations from ENP range-wide surveys in which no singing males were heard when water depths exceeded that level. However, Dean and Morrison (1998) demonstrated that nesting may occur when average water depths exceed this rule. CSSS construct their nests relatively close to the ground in clumps of grasses composed primarily of muhly, beakrushes (*Rhynchospora spp*.), and Florida little bluestem (*Schizachyrium rhizomatum*) (Pimm et al. 2002). The average early season nest height is 17 cm (6.7 inches) above ground, while the average late season nest height is 21 cm (8.3 inches) above ground (Lockwood et al. 2001). The shift in average nest height after the onset of the wet season rainfall pattern, which typically begins in early June (Lockwood et al. 2001), appears to be an adaptive response to rising surface water conditions. In general, the CSSS will raise one or two broods within a season; however, if weather conditions permit, a third brood is possible (Kushlan et al. 1982, USFWS 1983). A new nest is constructed for each successive brood. The end of the breeding season is triggered by the onset of the rainy season when ground water levels rise above the height of the nest off the ground (Lockwood et al. 1997).

Presently, the known distribution of the CSSS is restricted to two areas of marl prairies east and west of Shark River Slough in the Everglades region (within ENP and BCNP) and the edge of Taylor Slough. To set hydrologic targets for the iModel for marl prairie habitat an analysis was completed to identify metrics that relate marl prairie hydrologic suitability to CSSS prevalence, a key indicator species in the marl prairie habitat.

Two sets of time series targets were developed to inform iModel operations for the CSSS and adjacent marl prairie habitat. These are described below as Rnd2_Base and Rnd2_ MarlSens.

Method 1 (Rnd2_Base):

Depth targets from RSM-GL cells for marl prairie east of Shark Slough bound the existing hydrologic conditions on the wet and dry ends of CSSS habitat that were found to have CSSS presence that exceeded 50%. Based on ENP range-wide surveys, percent presence within each RSM-GL cell was calculated as the number of survey points with CSSS present divided by the total number of survey points within the cell. Additionally, at the request of the USFWS, the target time-series were slightly altered for depths below -1.0 ft, so that the target depths never fell below ~-3.0 feet, a condition found to be damaging to marl prairie vegetation. West of Shark Slough, in CSSS sub-population A, the habitat presently is too degraded to select a target depth time series from the existing conditions baseline. For this sub-population, simulated depths from the Western Everglades Restoration Project (WERP) and the Central Everglades Restoration Project (CEPP) (current and prior CERP planning efforts) were reviewed by the USFWS for suitable targets. From this review, the USFWS found the depths from the CEPP time series at the RSM-GL cell 1317 (WERP Future Without Project Condition (WFWO)) to be within the target range for the greatest percent of time for the 1965 to 2005 period. Full time series targets throughout the RSM-GL existing condition baseline (ECB) period of record (1965-2005) were suggested for use as targets as they are generally representative of the conditions during which field data are available. Other considerations in choosing marl prairie cells in the RSM-GL included: (1) number of birds found as an indication of habitat quality, (2) topographic relief in the RSM-GL cell; (3) proximity to gages; and (4) in the case of subpop F, close ties to water management operations. iModel target time series for the COP were as follows: for subpop A, cell id 1316 (between NP-205 and P-34), CEPP time series for cell 1317; for subpop B, cell ids 2510 and 3123, ECB time series for those cells; for subpop F, cell id 3376 (near Rutzke), ECB time series from cell id 2510. iModel targets for the marl prairies are shown in **Figure E.2-4**. The time series targets developed for the CSSS subpopulations and marl prairies described under this methodology were utilized to inform ERDO operations for ALTs N2 and O and are referred to as “Rnd2_Base”. ALTs N2 and O include the current seasonal closures and capacity constraints for S12-A, S12-B, S-343A/B and S-332D identified within the 2016 Everglades Restoration Transition Plan (ERTP) Biological Opinion (BO). Sensitivity runs S3 and S4 also utilized these targets.

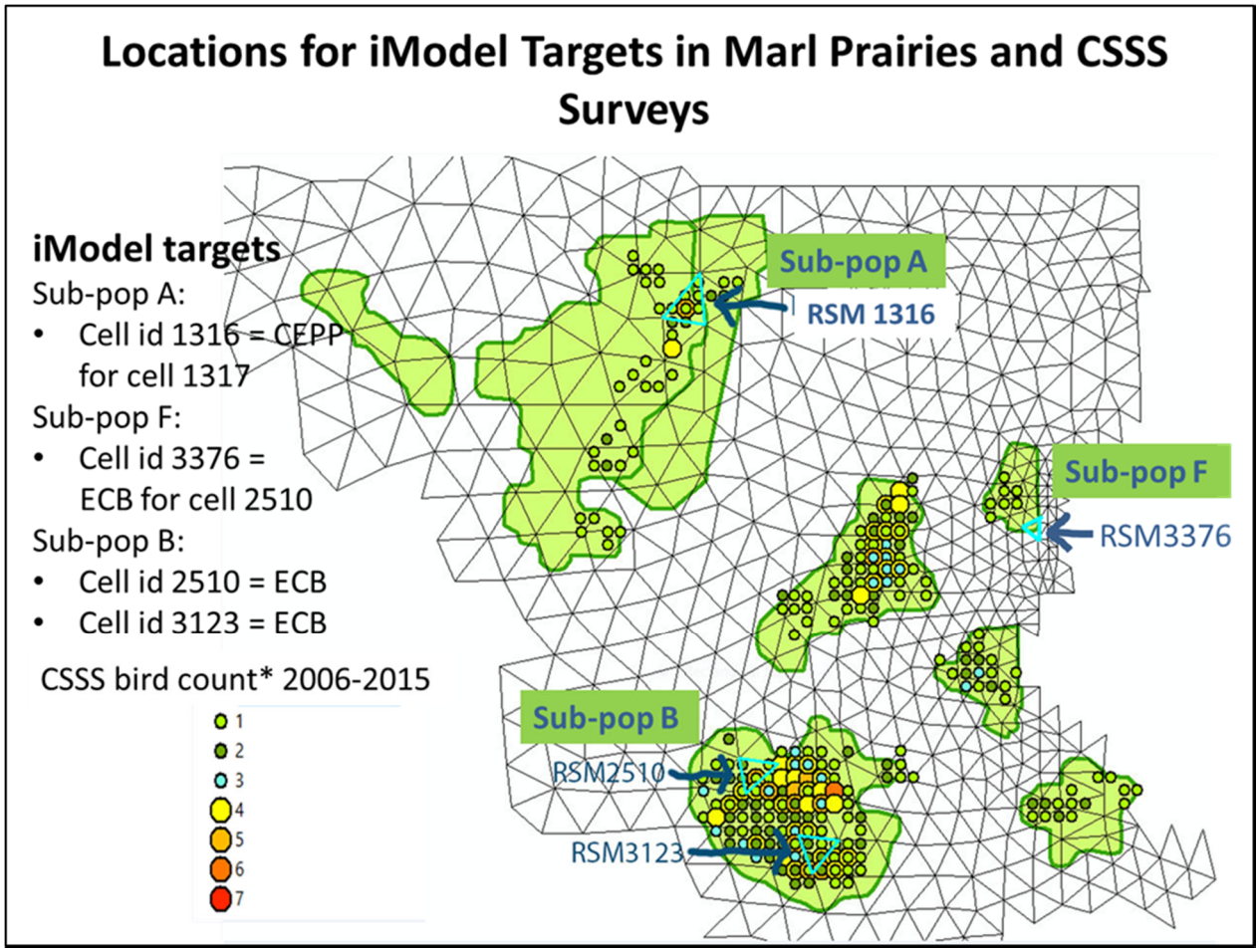


Figure E.2-4. iModel targets for marl prairies.

Method 2 (Rnd2_MarlSens):

In addition to the methodology developed above, the project team also developed a second set of time series targets based on requirements of the 2016 ERTP BO for the CSSS (USFWS 2016). The two most critical performance metrics for maintaining and enhancing the chances for CSSS survival are the number of consecutive days during the CSSS nesting season (March 1 – July 15) when there is no surface water (i.e. dry nesting days) and the total number of days when there is water above ground surface during the year (i.e. annual discontinuous hydroperiod) (USFWS 2016). Since it takes the CSSS, a ground nesting bird (nests on average are 17 cm above ground), approximately 45 days to nest and fledge young, the 2016 ERTP BO has set a target of providing at least 90 consecutive dry nesting days between March 1 and July 15, over at least 24,000 acres within and adjacent to CSSS-Ax, and across at least 40 percent of each of the eastern subpopulations (B-F), to allow for multiple broods during each nesting season in order to stabilize and potentially increase the population. Since, an average annual discontinuous hydroperiod of between 90 and 210 days, which normally occurs outside of the nesting season, is required to maintain suitable marl prairie habitat for the CSSS, the 2016 ERTP BO has set a target of providing a four year running average discontinuous hydroperiod of 90-210 days over at least 24,000 acres within and adjacent to CSSS-Ax, and across at least 40 percent of each of the eastern subpopulations (B-F). If the number of days with surface water is consistently more than 210 days, the habitat will convert to sawgrass. If it is

consistently too dry (less than 90 days) woody vegetation encroaches on the habitat and there is an increased risk of fire and predation on CSSS from aerial predators (raptors).

Water level gauge based operational bands were optimized for the above habitat metrics. To develop the operational bands which informed the iModel, the process consisted of the following 4 steps for each of the relevant sub-populations:

1. Regression models were calculated between relevant water level gauges and downscaled RSM-GL (modeled) water surfaces at High Accuracy Elevation Data (HAED) grid scale (400m). This step produced several hundred to a couple of thousand relationships depending on the area of the sub-population.
2. The regression models calculated in the first step were then simulated with millions of hydrograph curves for each water level gauge with two constraints for high (beginning of October) and low (end of April) water levels.
3. The resulting annual daily water level surfaces and calculated water depths from the second step for each sub-population were evaluated for the nesting condition and habitat metrics.
4. The hydrographs which met the 40% target for each subpopulation nesting condition and habitat metrics were aggregated and summarized to generate the minimum and maximum operational bands for each relevant water level gauge. Examples can be seen in **Figure E.2-5** through **Figure E.2-9** below, which exhibit minimum and maximum operational bands that met the 40% targets and optimal curves that represent hydrographs with the largest percent area of nesting condition and habitat metrics (typically over 95% of the individual subpopulation area). A target time series trace with brackets was developed from the minimum and maximum operational bands for purposes of informing the iModel (trace curves are not represented on the figures). Target time series were developed for CSSS-Ax (SPARO Gauge, NP-205 Gauge) CSSS-C (Gauge R3110), CSSS-D (EVER4 Gauge), and CSSS-E (RG2 Gauge).

The time series targets developed from the above identified operational bands, for the CSSS subpopulations and marl prairies were utilized to inform ERDO operations for sensitivity runs S1 and S2 and are referred to as “Rnd2_MarlSens”. The S1 and S2 sensitivity runs relax the seasonal closures and capacity constraints for S12-A, S12-B, S-343A/B and S-332D based on the identified time series targets.

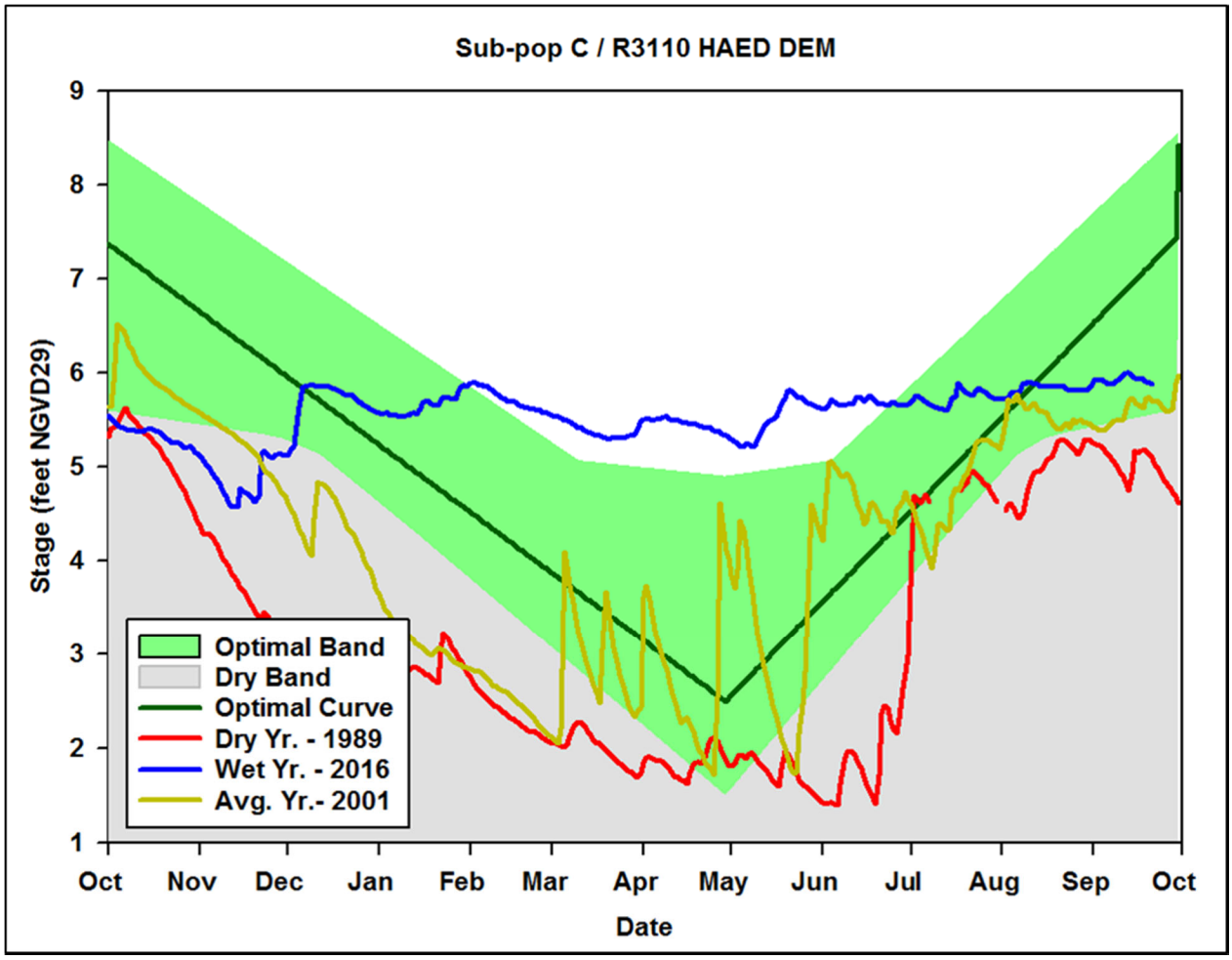


Figure E.2-5. Optimized "Operational Band" for CSSS nesting condition and habitat metrics in Sub-population C (R3110 Gauge).

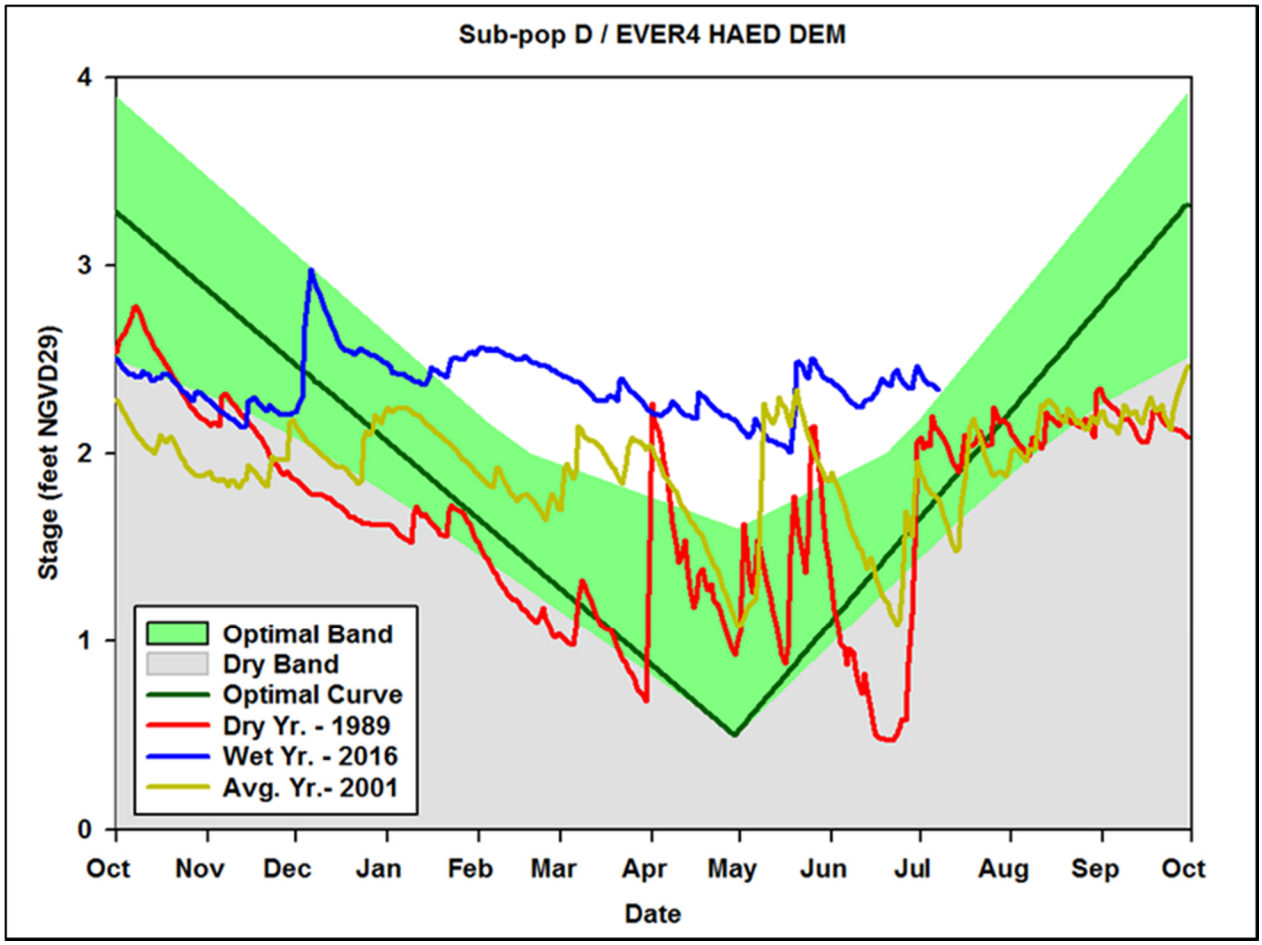


Figure E.2-6. Optimized "Operational Band" for CSSS nesting condition and habitat metrics in sub-population D (EVER4 Gauge).

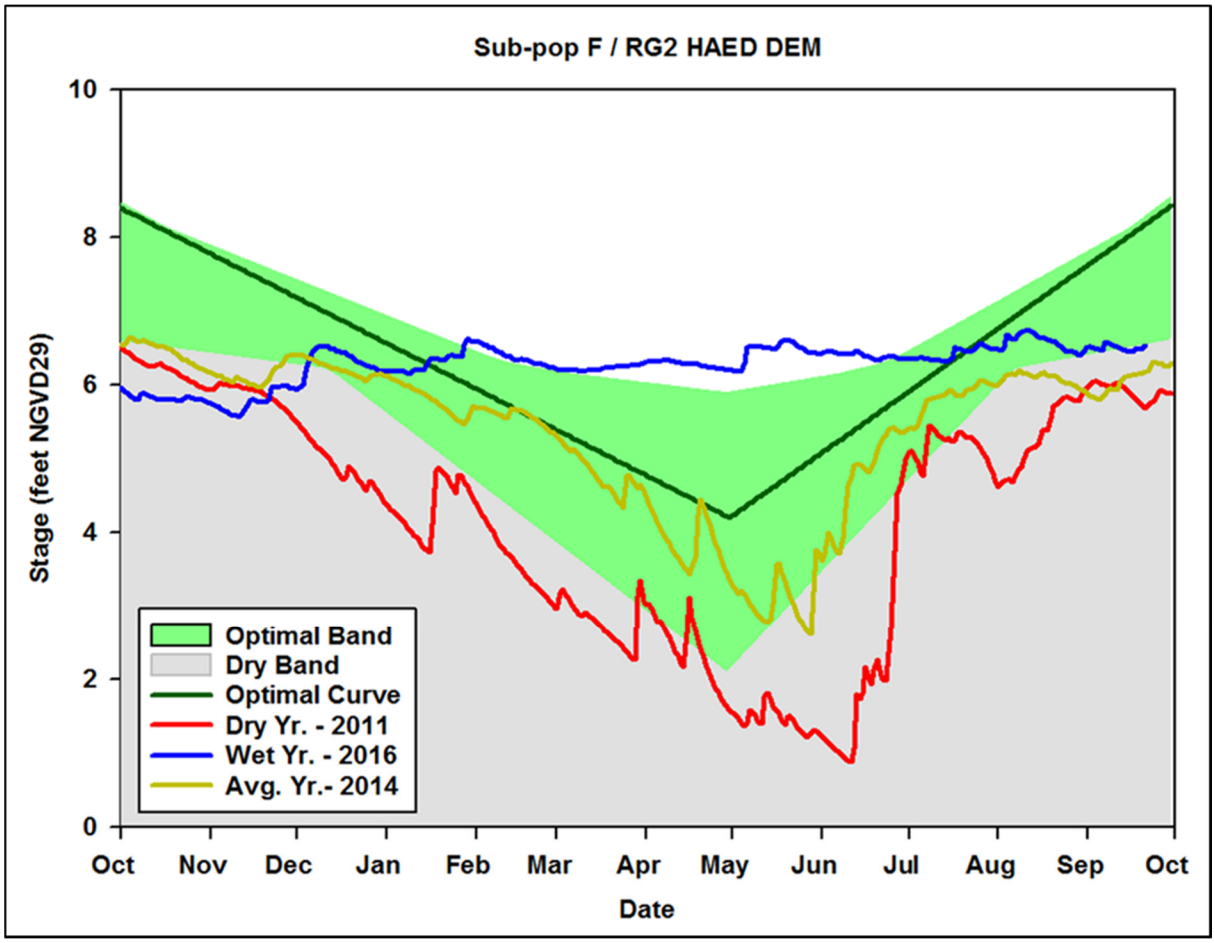


Figure E.2-7. Optimized "Operational Band" for CSSS nesting condition and habitat metrics in sub-population F (RG2 Gauge).

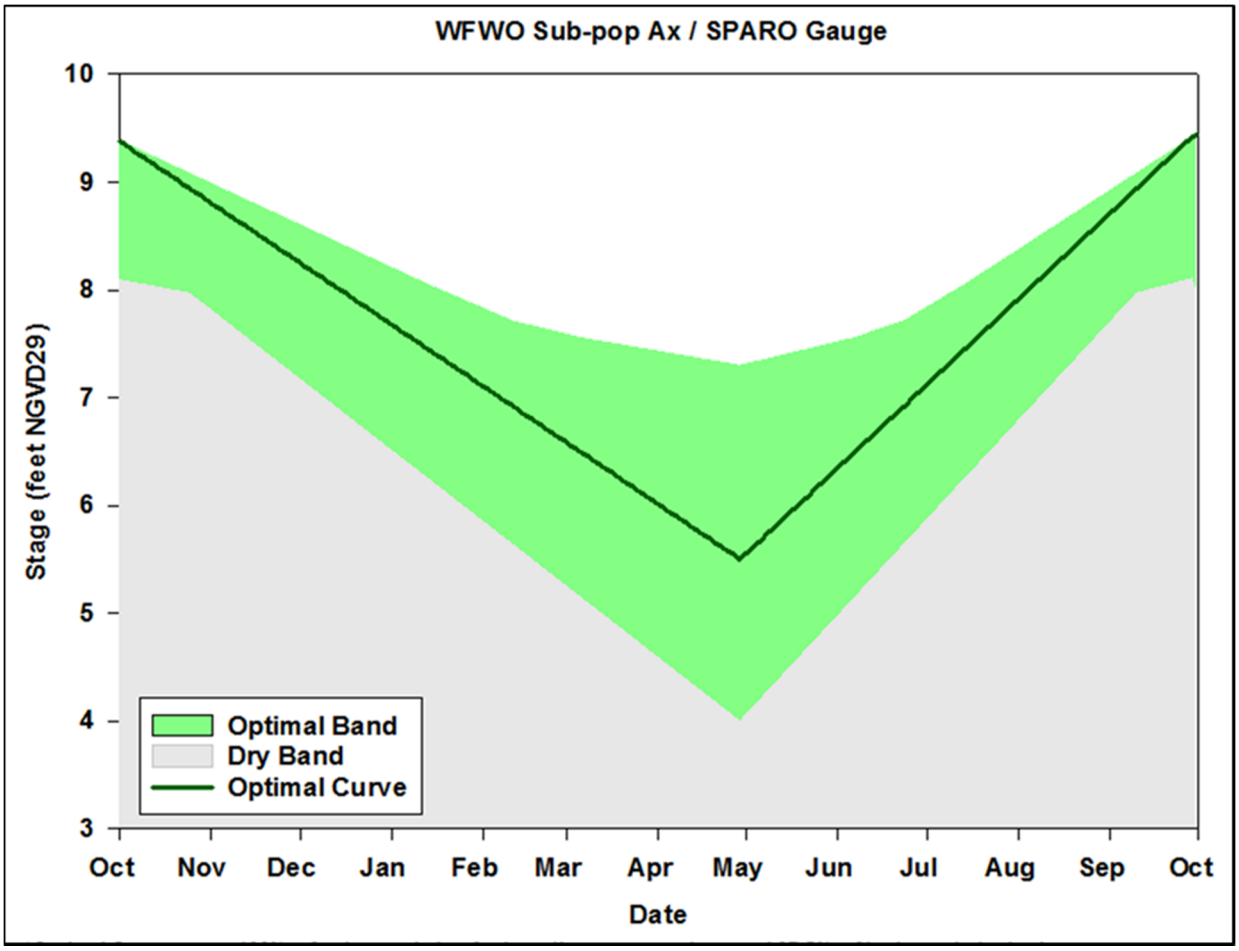


Figure E.2-8. Optimized "Operational Band" for CSSS nesting condition and habitat metrics in sub-population Ax (Sparo Gauge).

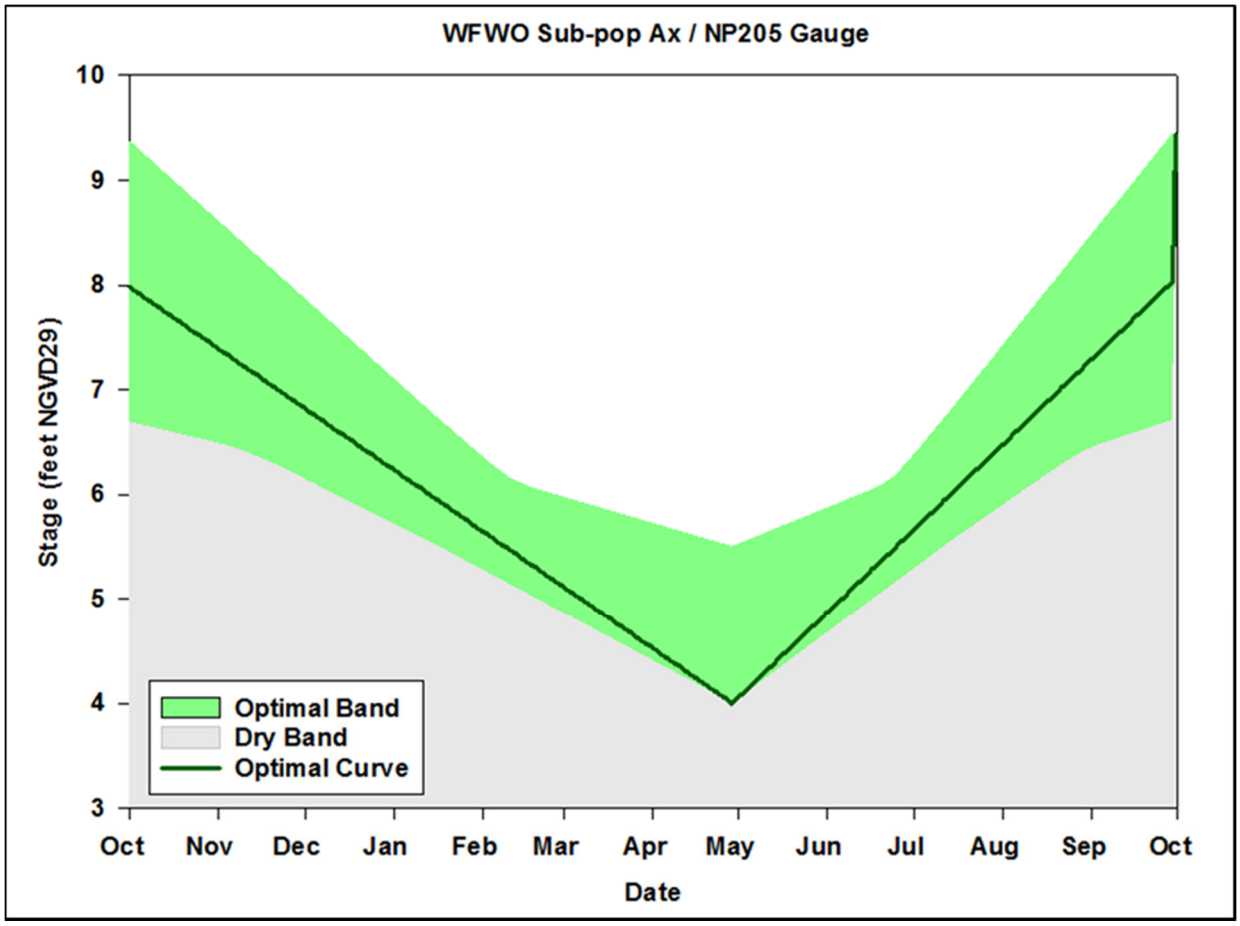


Figure E.2-9. Optimized "Operational Band" for CSSS nesting condition and habitat metrics in sub-population Ax (NP205 Gauge).

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