APPENDIX H

COMBINED OPERATIONAL PLAN

HYDRAULICS & HYDROLOGY

ANNEX 1
MODELING STRATEGY

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H-1 MODELING STRATEGY

H-1.1 COMBINED OPERATIONAL PLAN MODELING STRATEGY

COMBINED OPERATIONAL PLAN MODELING STRATEGY

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COMBINED OPERATIONAL PLAN MODELING STRATEGY

1 INTRODUCTION

The Combined Operational Plan (COP) is an integrated operational plan for two modifications of the Central and Southern Florida (C&SF) project – known as Modified Water Deliveries (MWD) to Everglades National Park (ENP) and the Canal 111 (C-111) South Dade (SD) projects (See Figure 1 1 for locations for project features). The purpose of COP is to define the operations for the MWD and C-111 SD projects that would be consistent with project purposes as defined by the authorizing legislation and further refined by subsequent general design memoranda (GDM), general reevaluation reports (GRRs), and limited reevaluation reports (LRRs). The proposed operations will also be consistent with the original purposes of the C&SF Project to provide flood control, water supply for agricultural irrigation, municipalities and industry, and ENP, regional groundwater control and prevention of saltwater intrusion, enhancement of fish and wildlife, and recreation. The project team will produce a Water Control Plan and Environmental Impact Statement for COP. The goals, objectives, and constraints established by the COP project team are provided in Appendix A.

Hydrologic modeling will be used to assist development of the operational plan for the project. The selected system-wide sets of operational criteria will be simulated to estimate the effects of each alternative, with results displayed using a predetermined range of "standard" and project-specific performance measures. The performance measures will be prepared by the Ecological Sub-team and the Flood Risk Sub-team of the COP Project Delivery Team (PDT). The baseline simulations will be followed by two rounds of alternative modeling. The alternative selected after the second round will further be modeled for plan optimization and followed by a design storm analysis for extreme rainfall events. This modeling strategy will describe the hydrological models that will be used in simulations, the modeling scenarios for planning alternatives, and the review process for the selected tools.

2 HYDROLOGIC MODELING FOR COP

The Regional Simulation Model (RSM) developed by the South Florida Water Management District (SFWMD) will be used as the primary hydrological modeling tool for COP. The RSM modeling suite includes a set of applications with unique capabilities. The modeling scenarios for COP will be run with two of these applications: Regional Simulation Model for the Everglades and Lower East Coast Service Areas (RSMGL) and a newly developed sub-regional Miami-Dade application of Regional Simulation Model (MDRSM). Both of these applications are integrated ground water and surface water models.

Hydrologic modeling simulations will be developed to simulate operational intent to the maximum extent practicable, given the models' capabilities and limitations. However, the hydrologic modeling tools may not be able to fully or effectively simulate all aspects of adaptive

management and flexible operations (for example, the ERTP multi-species transition strategy). The PDT evaluation of the COP hydrologic modeling results will consider these limitations.

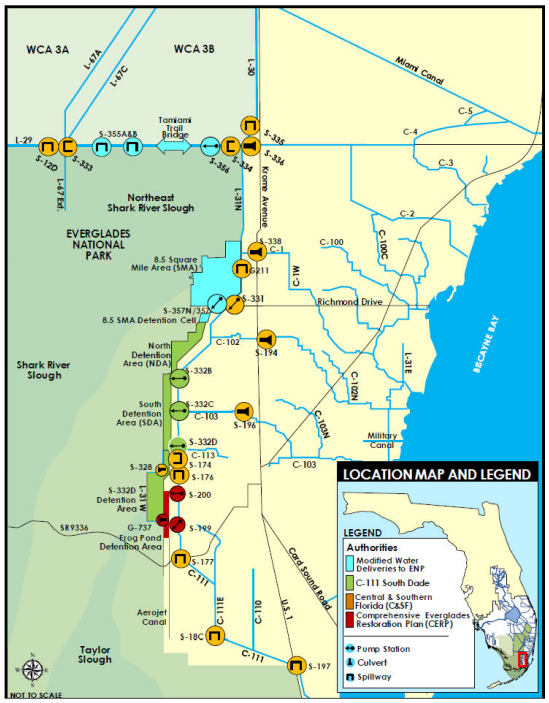

Figure 1. Location map for COP water control features.

2.1 Modeling Tasks for COP

It is expected that the two primary hydrologic modeling tools (RSMGL and MDRSM) will provide the basic hydrologic information during the evaluation process. Other models will also be used to supplement the primary tools and/or provide additional insights into the project's performance measures as determined by Ecological and Flood Risk Subteams. RSMGL has previously been applied to various CERP projects, including WCA-3A Decompartmentalization, the Central Everglades Planning Project (CEPP), and the ongoing Western Everglades Restoration Project (WERP). The RSM is approved through the USACE Engineering Software Validation requirements. Review of the MDRSM, to include a technical review by the CERP Interagency Modeling Center (IMC) and USACE Agency Technical Review (ATR) for the COP model application, is pending completion of the ongoing SFWMD model development and calibration efforts. The MDRSM model applied for the COP will replace the MODBRANCH model previously utilized by

the USACE for the 8.5 SMA GRR and previous efforts to develop the MWD and C-111SD operational plan. The model has been under development by the SFWMD for initial application for the SFWMD C-111 Spreader Canal (SC) Project. Due to delays in the development of the model, the COP will be the first application of the MDRSM. C-111 SC application is not expected to start until FY 2019.

Additional enhancements to the RSMGL are ongoing in support of the CERP WERP. The current period of record for the RSMGL is 1965-2005 (41 years). If an extended RSMGL period of record is available and certified for use by the IMC for application modeling prior to the initiation of COP modeling, this latest version of the RSMGL will be utilized for all COP baseline and alternative modeling analysis that relies on the RSMGL. Similar to the USACE MODBRANCH model, the MDRSM model will simulate conditions for a wet year, average year, and dry year. The modeling subteam for COP is currently working on review of historical rainfall data in order to select years to represent wet, average, and dry hydrologic conditions for modeling purposes.

Anticipated modeling-related activities with the primary modeling tools are listed below:

A. Develop Modeling Strategy

B. Develop Evaluation Methodology
   1. Flood Risk Performance Measures
   2. Flood Risk Modeling Tools (Design storm development)
   3. Ecological Performance Measures
   4. Ecological Modeling Tools
   5. Spreadsheets
   6. Post Processing Scripts/Tools
   7. Evaluation of results at the end of baseline and planning alternatives simulations

C. Modeling Activities for RSMGL
   1. RSMGL enhancements completed for the WERP Existing Condition Baseline (ECB) 2017 model (updates independent of COP)
   2. Base Condition Simulation
      a. ECB2019 (Boundary conditions from RSMBN)
   3. Round 1 Alternatives (3 alternatives)
   4. Round 2 Alternatives (1-2 alternatives)
   5. TSP Optimization (if needed)

D. Modeling Activities for MDRSM
   1. Model Development
   2. Model Calibration (For Year 2012)
   3. Model Verification (For Year 2008, or another year with reliable rainfall data). Additional verification will also be conducted for 2017 for 8.5 SMA
   4. Detailed USACE review that includes IMC technical review and ATR review for COP modeling strategy

5. Base Condition Simulations
    a. 2019 ECB (Boundary conditions from RSMGL)
    b. 1994 GRR C111-Base (Boundary conditions TBD[1])
    c. 1983 Base (Boundary conditions TBD[1])
6. Round 2 Alternatives (1-2 alternatives)
7. TSP Optimization
8. Develop Design Storm Events and Analysis Methods
9. Design Storm Simulations for Extreme Rainfall Events

E. Modeling Activities with iModel in support of RSMGL runs:
1. Model training during RSMGL Round 1 Alternative simulations
2. Model application for RSMGL Round 2 Alternative simulations

Table 1. List of Modeling Scenarios with RSMGL and MDRSM.

Primary Model	Model Run	Remarks
RSMGL Runs	2019 ECB (1 month)	Include updates from WERP 2017 ECB. Boundary conditions from RSMBN
	Round 1 (3 Alternatives) (2.5 months)	iModel is trained
	Round 2 (1-2 Alternatives) (2 months)	iModel is used to optimize operations
	TSP Optimization (1 month)	Performed only if needed
MDRSM Runs	2019 ECB (1-2 months)	Boundary conditions from RSMGL
	1983 MWD Base (2 months)	Boundary Conditions TBD[1]
	1994 C-111 GRR Base (2 months)	Boundary Conditions TBD[1]
	Round 2 (1-2 Alternatives) (2 months)	Same alternative(s) with RSMBL. Boundary conditions from RSMGL
	TSP Optimization (1 month)	Optimization of preliminary preferred alternative
	Design Storm Analysis (1 months)	For flood risk management focusing on 8.5 SMA and C-111 SD Basin
Evaluation and Analysis	Will be done at the end of each round of modeling.	

[1] Boundary conditions for 1983 and 1994 Base Runs are currently under development.

2.2 Alternatives

The PDT will formulate alternatives and evaluate plans for the COP based on hydrologic performance measures and ecological planning tools to determine potential effects on MWD, C111 SD, and C&SF project purposes and objectives, listed species and habitat, cultural resources, and public safety. Based on previous work in the area and consideration of public and agency scoping comments, the COP PDT is anticipated to consider the following measures to address the planning objectives:

- Raise the maximum operational limit in the L-29 canal;
- Relax the 6.8 feet NGVD constraint at G-3273;
- Operate pump station S-356;
- Develop modifications to the Rainfall Plan for discharges from WCA-3A;
- Modifications to the WCA-3A Regulation Schedule below Zone A (including IOP/ERTP Column 1 and Column 2 operations);
- Modified operation of the C&SF structures for flood protection (including S-197);
- Operation of S-328 (proposed under the SFWMD Florida Bay Initiative in 2016); and
- Ecological water deliveries to Taylor Slough;
- Regulation schedule changes for Lake Okeechobee, WCA-1, and WCA-2 will not be included in the COP effort.

In order to maintain progress consistent with the COP proposed schedule, draft versions of initial alternatives will be developed by a small team (USACE, SFWMD, and ENP) and will serve as a basis for discussion by the larger interagency PDT and public stakeholders. The PDT will then develop/establish the alternatives that will be modeled and evaluated. In Round 1, the selected 3 alternatives and the no Action alternative (a base condition) will be modeled by RSMGL. The No Action alternative is the same as the future without project condition for the COP Water Control Plan, since the plan will be immediately implementable following approval of the Record of Decision.

After analysis of the first round of alternatives, 1-2 new alternatives will be developed that incorporate the best components from the first 3 alternatives. The Round 2 alternative(s) will be analyzed utilizing the same RSMGL modeling and evaluation approach as the first set of alternatives, while also incorporating the application of the MDRSM model. The Round 2 modeling will also include application of the iModel to develop operational criteria which support changes to the WCA-3A Regulation Schedule with Rain-Driven Operations (RDO). All modeled alternatives for Round 1 and Round 2 will be considered during selection of the preliminary recommended plan. A schematic showing the scenarios that will be simulated with each primary modeling tool is shown in Figure 2.

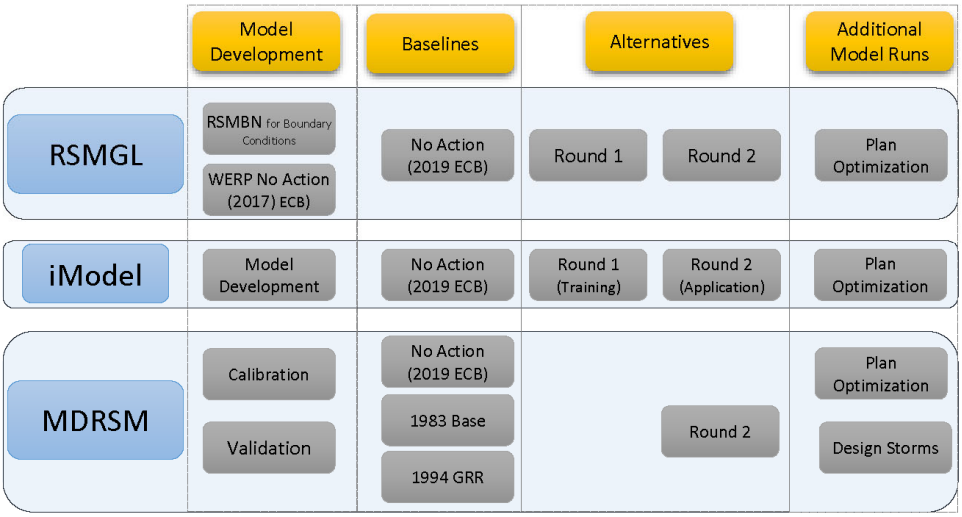

Figure 2. Primary modeling tools and model runs for COP.

2.3 Performance Measures

Two sets of performance measures (PMs) will be identified by Ecological Subteam and Flood Risk Subteam. These sets of PMs will be used to measure the performance of alternative plans. The Ecological Subteam determined the appropriate system-wide performance measures that includes a combination of performance measures from RECOVER and other resources used previously in CERP, such as 2016 ERTP Biological Opinion Metrics, Ecological Planning Tools, etc. (refer to COP Evaluation Methodology Tools, January 2018, document for a complete list). Similarly, a document detailing the PMs for Flood Risk issues will also be prepared by the Flood Risk Subteam. Once the draft tables of performance measures and targets are developed, the performance measures will be linked to the planning objectives. These tables will be reviewed and possibly streamlined and simplified prior to initiation of the COP alternative modeling, if the modeling schedule requires prioritization of performance measures for Round 1 or Round 2.

2.4 Order of Execution of Modeling Tasks

The sequence and dependencies of modeling tasks discussed in Section 2.1 is presented in Figure 3. The modeling efforts for COP will start with modifying the RSMGL baseline model developed for the WERP project that reflects the hydrological conditions that were in place in 2017 (2017 ECB). This model uses the output from RSMBN as the boundary condition to represent Northern Everglades and the Everglades Agricultural Area (EAA) (See Figure 6). The COP modeling team will then develop the 2019 ECB model to simulate the hydrological conditions that are expected to be in place by 2019, including the Increment 1.1/1.2 of the Modified Water Deliveries Project.

Once the 2019 ECB is modeled by RSMGL, Round 1 alternative runs will start. The iModel for optimization of WCAs, BCNP and ENP operations will use the RSMGL ECB to train the model that will be used in Round 2 runs. RSMGL Round 2 runs will also be used as the boundary conditions for MDRSM Round 2 simulations that will start after the model is calibrated, validated, and applied to develop the three base conditions listed in Section 2.1.

The evaluation of the model results at the end of each set of simulations will be done with input from PDT members and Ecological and Flood Risk Subteams. Once the Round 2 simulations are completed, a preliminary preferred alternative will be selected and further plan optimization modeling may be conducted, if needed. The selected preferred alternative will further be modeled for the design storms.

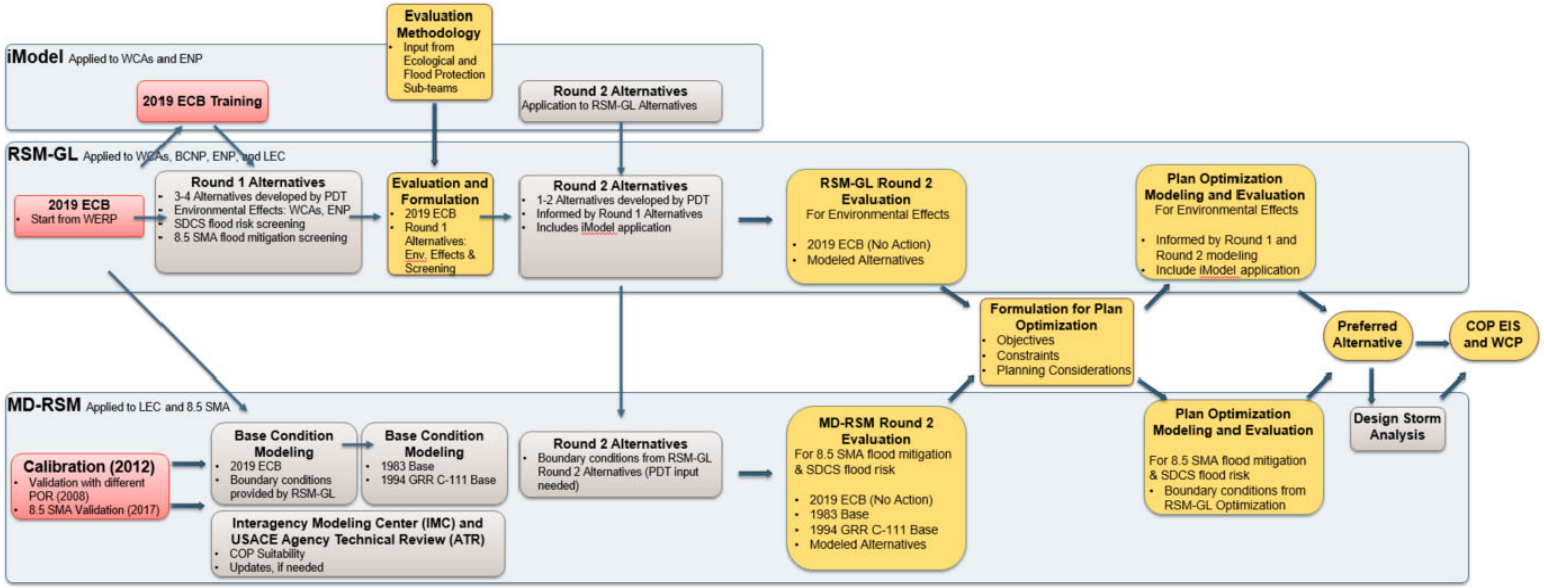

Figure 3. COP modeling tasks and dependencies.

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2.5 Evaluations/Comparisons of Alternatives

The effect on resources in natural areas will be assessed by comparing each modeled alternative to the ECB conditions, using hydrological and ecological performance measures and ecological planning tools. The performance of each alternative for flood risk management concerns will be conducted using the 1983 Base (used for MWD 8.5 SMA) and 1994-C111 GRR base conditions (used for the C-111 SD Basin). The evaluation methods described below may need to be further refined or modified once the specific performance measures are finalized by the COP PDT, or based on additional information following development and calibration of the MDRSM model.

2.5.1 Round 1 Runs- Initial Screening

Initial screening-level analysis of the Round 1 alternatives will use RSMGL outputs. The effect on resources in natural areas will be assessed by comparing each modeled alternative to the ECB conditions, using hydrological and ecological performance measures and ecological planning tools. Performance for flood protection for C-111 basin will ultimately be assessed by comparing each modeled alternative to the 1994 GRR C-111 base, which represents the level of flood protection authorized by the C-111 South Dade Project, the MDRSM representation of 1994 GRR C111 Base will not be available until Round 2. Flood protection performance for the urban and agricultural areas east of the L-31N Canal will also be assessed by comparing the alternatives against the ECB, which represents the conditions expected to be in place in 2019, if COP is not implemented.

Initial screening-level flood mitigation analysis for the 8.5 SMA is different from the flood protection for the C-111 Basin and other urban and agricultural areas east of L-31N. The 8.5 SMA is not authorized as a flood protection project, but as a flood mitigation project for effects of MWD flows within ENP. Thus, the features and operations must maintain the conditions in the 8.5 SMA that were in place before MWD was constructed, which is represented by the pre-project base condition evaluated in the original 1992 MWD General Design Memorandum (1983 Base). Initial analysis of performance of each alternative for flood mitigation in the 8.5 SMA will be assessed by the comparison of the modeled alternatives to the 1983 Base using MDRSM output; the spatial resolution of the RSMGL (used for Round 1 alternative modeling) is too coarse to effectively resolve the flood mitigation features for the 8.5 SMA. This flood mitigation analysis will only be performed for the acreage within the perimeter levees surrounding 8.5 SMA.

2.5.2 Round 2 Runs – Alternative Modeling

Once the initial screening of alternatives is completed using the Round 1 RSMGL runs, 1-2 additional alternatives will be developed by the PDT to further simulate for environmental and flood risk effects. For this round, RSMGL simulations will include the iModel application for optimization of operations for WCAs, and the ENP which support changes to the WCA-3A Regulation Schedule with Rain-Driven Operations (RDO). The results of RSMGL runs will be used as boundary conditions for the MDRSM runs that will simulate the conditions from the same alternatives. The effect on resources in natural areas will be assessed by comparing each modeled alternative to the ECB conditions, using hydrological and

ecological performance measures and ecological planning tools. Performance for flood protection for C-111 basin will be assessed by comparing each modeled alternative to the 1994 GRR C-111 base, which represents the level of flood protection authorized by the C-111 South Dade Project. Flood protection performance for the urban and agricultural areas east of the L-31N Canal will also be assessed by comparing the alternatives against the ECB, which represents the conditions expected to be in place in 2019, if COP is not implemented.

2.5.3 Selection of Preliminary Recommended Plan

A preliminary recommended plan will be identified from the array of alternatives using the results of the RSMGL runs supplemented with evaluation of the 8.5 SMA flood mitigation and C-111 flood protection constraints using the MDRSM simulations. The selection will be based primarily on the comparison of the performance of each alternative toward the ecosystem restoration objectives. The preliminary recommended plan must also satisfy the planning constraints.

The detailed flood performance evaluation of the preliminary recommended plan in the 8.5 SMA, the C-111 basin, and the remainder of the urban and agricultural areas east of L-31N will be compared to the 2019 ECB and their corresponding base conditions. The MDRSM analysis will provide greater detail on potential flooding effects than can be performed with the RSMGL output.

2.5.4 Optimization Runs – Preferred Alternative

If the flood mitigation and flood protection constraints are passed, the preliminary recommended plan will be confirmed as the COP Tentatively Selected Plan (TSP). Although this is not currently anticipated within the draft COP schedule, if adverse impacts are identified through the detailed MDRSM assessment of flood mitigation and flood protection criteria, additional formulation, hydrologic modeling analysis, performance assessments, and/or real estate assessments may be required under COP through an optimization modeling process. Plan optimization would also provide opportunities to enhance ecological performance, including additional adjustments to the WCA-3A Regulation Schedule changes.

2.5.5 Design Storm Runs – Preferred Alternative

The MDRSM model will be used for a design storm analysis on the TSP plan using 3-5 storm events selected from the Standard Project Flood (SPF), 100-yr, 50-yr, 25-yr, 10-yr, and 2-yr events. The design storm analysis will assess potential effects from the Preferred Alternative during extreme rainfall events beyond the historical events modeled in the RSMGL and MDRSM simulation periods. This analysis was previously conducted for the 1994 C-111 Canal GRR and the USACE has determined that application to the COP Preferred Plan is necessary to complete the C-111 SD Project.

2.5.6 Sensitivity Runs

Additional model simulations may be requested to investigate the effects of other operational criteria not included in Round 1, Round 2, or optimization runs. These sensitivity runs would be structures to include changes in minimum number of variables (informed by previous model runs) so that the project

performance from these changes can be distinguished. Schedule indicated in Section 7 may need to be revised depending on the selected sensitivity run scope.

3 PRIMARY HYDROLOGIC MODELS

The Regional Simulation Model (RSM) and its sub-regional applications will be used as the primary hydrological models for COP. RSM was developed by the SFWMD to simulate the hydrology and water management of the South Florida region, providing modeling support to regional restoration, flood control, and water supply planning efforts. RSM provides the computational framework for developing more complete and numerically sound integrated surface water and groundwater models where both components receive equal attention. The RSM was developed to replace the SFWMD South Florida Water Management Model (SFWMM) for simulating water management in the C&SF Project. The RSM currently is applied to sub-regions within the south Florida domain. Each of the sub-regional models was created to address specific water resource management issues or to support alternative plan formulations for the Comprehensive Everglades Restoration Plan (CERP).

The RSM is an implicit, finite-volume, continuous, distributed, and integrated surface-water and ground-water model. It can simulate one-dimensional canal/stream flow and two-dimensional overland and groundwater flow in arbitrarily shaped areas using a variable triangular mesh. The overland and groundwater flow components are fully coupled in the RSM for a more realistic representation of runoff generation. It has physically-based formulations for the simulation of overland and groundwater flow, evapotranspiration, infiltration, levee seepage, and canal and structure flows. The model uses the diffusive wave approximation of Saint-Venant's equation to simulate canal and overland flows. The model is capable of simulating features that are unique to south Florida such as low-relief topography, high water tables, saturation-excess runoff, depth-dependent roughness and very permeable soils.

The RSM consists of two distinct components: (1) the Hydrologic Simulation Engine (HSE); and (2) the Management Simulation Engine (MSE). The HSE, which contains the hydrologic processes, simulates natural hydrology, water conveyance systems (canals), and natural bodies of water. The HSE component solves the governing equations of water movement through both the natural hydrologic system and the man-made structures. The MSE contains the water management rules, policies and constraints. The MSE was developed separately from the HSE to maintain a clear distinction between the integrated surface water/groundwater model and the management practices for flood control, water supply, and environmental projection that are imposed on the regional system. These two components work seamlessly to conduct the long term modeling necessary for this complex region.

The RSM has been applied to various projects in South Florida. There are various applications and versions of the RSM model, such as RSMGL, RSMBN, MDRSM, or NSRSM. For COP, two applications of the RSM will be used as the primary hydrologic modeling tools, Regional Simulation Model, Glades – Lower East Coast Service Area (RSMGL) and Miami-Dade Application of the Regional Simulation Model (MDRSM). These models provide detailed estimates of hydrology across the project area and the rest of the system. They simulate rainfall-runoff processes and flow routing as a response to infrastructure and corresponding operating rules. The hydrologic boundary conditions for RSMGL, which will remain

unchanged between COP 2019 ECB and the COP alternatives, will be provided by another, link-node model: RSMBN for the Northern Everglades and the Everglades Agricultural Area (EAA)
The RSMGL and RSMBN provide daily estimates of hydrology across the 41-year period of record (1965-2005). The RSMGL simulates the region's complex hydrology using south Florida's climate records and technical details on regional canals, water control structures, and local topography and storage reservoirs. One of the model's strongest features is its regional simulation capability. Optimum operation of specific water control structures in a local watershed and flexibility in simulating local scenarios within a regional model is a powerful tool for enhancing resource management across all of south Florida. The RSM has been applied to several Everglades restoration projects, including the SFWMD's Northern Everglades and Estuaries Protection Program, the CERP Biscayne Bay Coastal Wetlands (BBCW), the CERP C-111 Spreader Canal, WCA-3 Decompartmentalization, and CEPP.

Significant effort has been invested in the development and calibration of regional and subregional hydrologic models. However, recognition of model uncertainty is needed when interpreting the ecological significance of model output. There is uncertainty in the predictions derived from these models that stems from input variability, measurement errors, parameter uncertainty, model structure uncertainty and algorithmic uncertainty. These uncertainties are translated into uncertainty as to whether the specific performance indicators and measures used to characterize the overall system performance actually capture the overall performance. The likelihood of capturing all the natural and man-made processes occurring in a system as complex as the COP project area within simulation models is low. There will always be some uncertainty present in predicting benefits associated with any regional-scale project because of the size and complexity of the Everglades ecosystem, as well as because of the difficulty in fully understanding its physical and biological processes. However, the outputs of the sub-regional hydrologic models and PMs used to quantify ecosystem benefits for the COP utilize the best data available to predict the most-likely hydrologic and ecological changes as a result of the project.

3.1 Regional Simulation Model Glades-LECSA (RSMGL)

The RSMGL is a sub-regional model that includes Palm Beach, Broward, and Miami-Dade counties, the WCAs, ENP, and Big Cypress National Preserve (BCNP). The model links two distinctly different hydrologic areas together: Glades and LECSA. The Glades area is representative of the native wetlands areas of the WCAs, ENP, and BCNP, while LECSA and the highly urbanized and developed areas of Miami-Dade, Broward, and Palm Beach (See Figure 4).

The RSMGL model encompasses an area of 5,825 square miles. It covers six counties (some partially) and 13 hydrologic basins: 1) L-28 Interceptor; 2) L-28 Gap; 3) Feeder Canal; 4) East Collier; 5) Everglades National Park (ENP); 6) Water Conservation Area 1 (WCA-1) ; 7) WCA-2A; 8) WCA-2B; 9) WCA-3A; 10) WCA-3B; 11) Lower East Coast Service Area 1; 12) Lower East Coast Service Area 2;and, 13) Lower East Coast Service Area 3. The southern, eastern and southwestern boundaries of the model are comprised of Florida Bay, the Atlantic Ocean/Biscayne Bay and the Gulf of Mexico coastlines, respectively.

The model uses historical and modeled boundary condition data to simulate major components of south Florida's hydrology including evapotranspiration, infiltration, overland and groundwater flow, canal flow, canal-groundwater seepage, and levee seepage. The RSMGL simulates the historical climatological

conditions for a period of simulation from 1965-2005. It can incorporate current or proposed water management control structures and operational rules. The RSMGL simulates hydrology on one day time steps and is not capable of modeling storm events on the feature-level scale. The RSMGL was not developed to simulate synthetic, user-specified rainfall inputs outside of the conditions observed during historical period of record.

The RSMGL can simulate one-dimensional canal/stream flow and two-dimensional overland and groundwater flow using a variable triangular mesh. The RSMGL model mesh consists of 5,794 triangular cells with an average cell size of approximately one square mile. The mesh is designed to conform to all important flow controlling features, such as roads and levees within the model domain. The model uses the diffusive wave approximation of Saint-Venant's equation to simulate canal and overland flows. This model is capable of simulating features that are unique to South Florida such as low-relief topography, high water tables, saturation-excess runoff, depth-dependent roughness and very permeable soils.

The RSMGL model simulates an extensive canal network. This network includes all primary canals that are maintained by the SFWMD. It also includes several secondary canals that are of importance. In addition, the model uses the Water Control District (WCD) feature available in the RSM to simulate some secondary and tertiary canals as well. Relevant structure operations associated with the WCDs and the canal network are simulated using the functionality available in the model. Only the surficial aquifer is simulated in the RSMGL model. The RSMGL was not developed to simulate deep groundwater flows. Other surface water models, including the SFWMM, have used similar approaches. The WCAs and ENP contain a significant peat layer that affects stages within those areas. This surficial peat layer is simulated explicitly in the RSMGL using a stage-volume converter feature that is unique to the RSM. The model-domain contains several hundred Public Water Supply (PWS) wells that tap the surficial aquifer. These are also simulated in the model through the use of time-series data. The model domain contains several roads and levees that act as overland flow barriers. The canal and regional groundwater seepage contributions across these levees are explicitly simulated in the RSMGL model.

Northern boundary flows are imposed based on output from the SFWMM or other regional models such as the RSMBN model, which incorporates areas north of the Water Conservation Areas. A combination of results from SFWMM and RSMBN can also be used as boundary conditions. For example, for RSMGL simulations to support WERP, SFWMM was used to provide the northern boundary groundwater/surface water flows, while the RSMBN was the source of the northern boundary structural flows. The boundary condition generation for COP is still under development by COP Modeling Subteam as of March 2018. It is expected that WERP RSMBN boundary conditions and SFWMM results will be used in tandem for COP RSMGL simulations. The same boundary conditions will be used for base condition and alternative runs simulated by the RSMGL.

The RSMGL application was used to support various CERP projects. The model was specifically calibrated to support the evaluation of proposed project features for the CERP WCA-3 Decompartmentalization and Sheetflow Enhancement project (Decomp). In addition to the CERP Decomp application, the RSMGL model was applied by the USACE SAJ to support planning and alternative evaluations under the CERP Central Everglades Planning Project (CEPP) during 2012-2013. The model calibration report was prepared by the SFWMD in 2007. Enhancements to the RSMGL model were implemented as a part of

WERP modeling efforts. A PowerPoint document was prepared by the SFWMD and presented to the WERP PDT on January 22, 2017 (Appendix B).

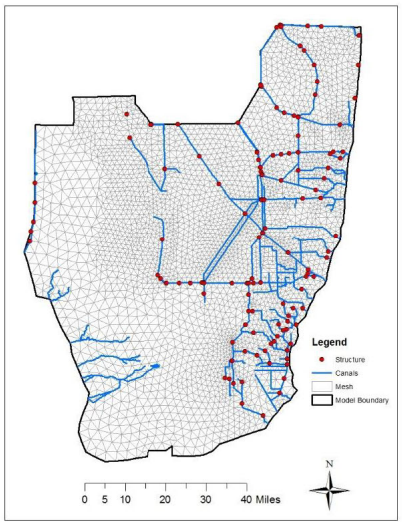

Figure 4. RSMGL Model Domain.

3.2 Miami Dade Regional Simulation Model (MDRSM)

The Miami-Dade sub-regional application of RSM is a model designed to investigate current and future operational alternatives for flood control and water supply in South Miami Dade County. MDRSM was designed to overcome some of the limitations of the RSMGL model to simulate at a sub-daily time-step water supply and flood control operational strategies considered in the South Dade Conveyance System and the C-111 Spreader Canal Project. Its irregular, triangular mesh is highly resolved along the East Coast Protective Levee - the interface between the ENP and the WCAs with the developed agricultural, residential and urban areas to the east.

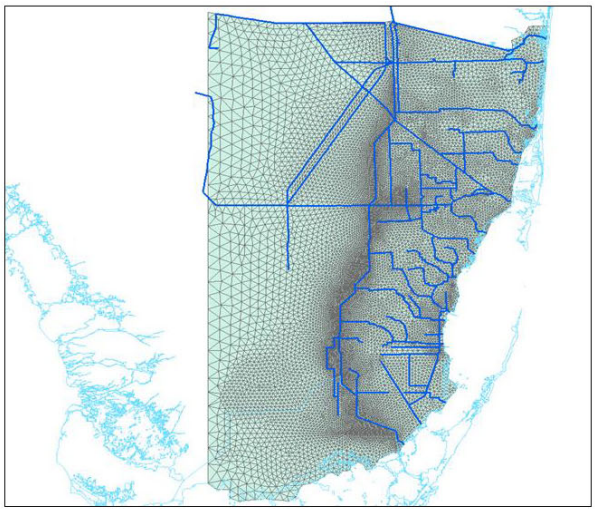

Figure 5. MDRSM Model Domain.

The main purpose of MDRSM simulations for COP will be to evaluate flood risk management for the C - 111 South Dade Basin and the 8.5 SMA. MDRSM uses the same modeling engine as RSMGL with a finer mesh and time steps. The total model area is smaller than RSMGL with 2,700 mi^2 including LEC, parts of WCA 3A & ENP (Figure 5). The model has a sub-daily time step (15-minute capability) and average cell size of 53 acres.

The MDRSM Model is calibrated using the observed hydrological variables of 2012, and will be validated using the observed variables in 2008. The calibration software PEST is used to obtain the parameters yielding the closest results to the observed conditions. The set of parameters used in PEST for MDRSM calibration includes: aquifer hydraulic conductivity, aquifer storage coefficient, canal conductance, canal roughness coefficients, levee seepage coefficients, ET Kveg, and overland flow roughness coefficients in some marsh areas.

Calibration of the model is expected to demonstrate:

- Input variables, rainfall and ET are verified.
- Selection of the wet/average/dry years is verified.
- Surface runoff is modeled accurately.
- Groundwater seepage is modeled accurately.
- Water budget is closed for the modeled basins on annual and seasonal basis.
- Water budget is closed for select canal reaches

Once the model calibration is completed, the model will be validated using observed hydrologic conditions of year 2008. Due to the importance of capturing the effects of high water events in the 8.5

SMA, additional validation for 2017 extreme high water conditions is also expected. Additional information on the model and its calibration/validation will be included in the model calibration report that will be prepared by the SFWMD.

3.3 iModel

The iModel is an inverse modeling tool that reverses the process of a traditional model. A traditional model predicts a system's response (e.g., stage) to the system's input (e.g., inflows, outflows). The iModel computes a system's required input (e.g., inflows, outflows) to achieve a system's desired response (e.g., stage). It is an optimization modeling tool for system-wide operations in both real time and planning and it also addresses water quantity and water quality problems. The iModel was used in previous projects within the Everglades such as CEPP, River of Grass, and Loxahatchee NWR Water Quality Improvement. It was also used as a screening tool for the central and southern part of the Everglades system, including the WCAs and ENP. For COP, it will be run to meet the base stage targets within the WCAs and ENP. These simulated optimal flows will be used as input to the RSMGL, where corresponding stage and transect flow targets are to be obtained.

4 SUPPLEMENTAL MODELS OVERVIEW

In addition to the primary hydrologic models to support COP, supplemental models may be applied to complement or assist the regional hydrologic models in analyzing system features. The list of detailed models may expand or contract based on project requirements.

4.1 Regional Simulation Model Basin (RSMBN)

The RSMBN is a link-node model designed to simulate the transfer of water from a predefined set of watersheds, lakes, reservoirs or any water body that receives or transmits water to another adjacent water body. The model domain covers Lake Okeechobee and four major watersheds related to the northern portions of South Florida; Kissimmee, Lake Okeechobee, St. Lucie River, Caloosahatchee River and the EAA (Figure 6). The watersheds are further divided into sub-watersheds until fundamental waterbodies can be considered as separate model nodes. Individual operating rules were encapsulated into the model that define how water is moved between two nodes. Taken together, the set of management rules define the linkage of all nodes within the model domain.

RSMBN uses the same source code as the mesh-based Regional Simulation Model. The model is considered a lumped model in hydrologic engineering terms. Thus, local-scale features within a watershed, e.g. stages at individual gauging stations or flows across specific transects, are not simulated. Instead, simulated stages represent average water level conditions for the entire waterbody. No systematic detailed verification relative to historical data was done during initial model set-up; however, the model was validated by making comparative runs with established legacy models currently in use within the model domain: the UKISS for the Upper Kissimmee Watershed and selected sub-areas in South Florida Water Management Model. Additionally, historical information (in some cases, full calibration efforts) has been used in the development of nodes representing the C-139 basin, Stormwater

Treatment Areas and 298 districts within the EAA, a procedure never employed in previous regional hydrologic modeling of these areas.

Input data for the model includes daily records of hydrologic and meteorological data (rainfall and potential evapotranspiration), as well as discharges at the boundaries for a 41-year period between 1965 and 2005. Other model input data includes the physical description of management features (e.g., reservoir stage-storage relationship and structure capacities) and corresponding operating rules (e.g., maximum operating levels and reservoir outflow priorities).

Runoff and supplemental irrigation demands can be simulated in the different waterbodies in RSMBN, or they can be read-in as time series boundary conditions, as in the case for the Caloosahatchee and St. Lucie basins. Stages in waterbodies and flows at inlet and outlet structures are basic output data from the model.

The RSMBN model provides a very capable tool for describing the water budget interactions in a complex hydrologic system. The model input requirements are not as rigorous and computational needs are not as CPU-intensive as other mesh–based models. The model is also an effective tool in comparing the relative performance of the proposed alternatives. In order to make an effective comparison, raw model outputs are summarized in a way that fits the basins or metrics associated with the selected performance measure. Post-processing scripts are available that temporally (weekly, monthly, seasonal, etc.) and spatially (individual waterbody or collection of waterbodies) summarize model output. Generation of some performance measure graphics are automated as they have been previously defined and vetted in other model application projects, e.g. CERP, LECPLAN, CEPP, etc. The RSMBN precursor, the Northern Everglades Regional Simulation Model (NERSM), has been implemented to assess the hydrologic impact of selected alternatives for SFWMD planning efforts under the Northern Everglades program, specifically the Lake Okeechobee Phase 2 Technical Plan (LOP2TP) and the River Watershed Protection Plan (RWPP).

RSMBN provides boundary conditions to RSMGL by representing the flows and stages caused by the hydrological features in the northern part of South Florida. These tools are able to communicate iteratively using a set of shared boundary conditions along the Everglades Protection Area border. The RSMBN boundary condition is expected to remain unchanged between the COP 2019 ECB and the COP alternatives, since changes within Lake Okeechobee and the Everglades Agricultural Area are outside of MWD and C-111 SD project authority; the RSMBN boundary condition time series developed for WERP will be applied for COP.

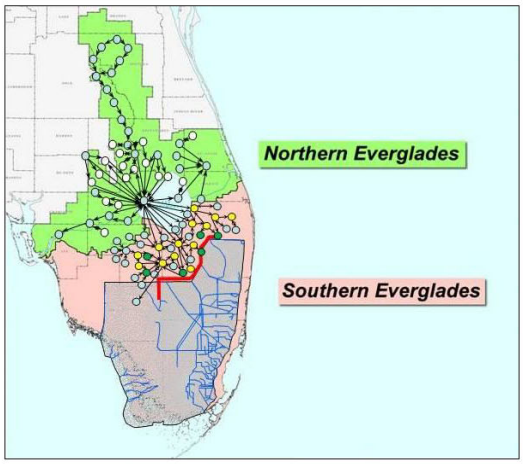

Figure 6. Model domains for RSMGL (marked with linked nodes) and RSMBN (gray polygon).

4.2 Natural System Regional Simulation Model (NSRSM)

The Natural System Regional Simulation Model or NSRSM simulates the natural system hydrology prior to drainage in South Florida. NSRSM was created using the same object-oriented methods and conceptualization with the RSM's other managed-system applications. It runs primarily the Hydrologic Simulation Engine (HSE) of the RSM and was created to supersede the Natural System Model (NSM, 1991). Initially released in 2006, the model was peer-reviewed in 2007 and was successfully applied in the River of Grass Phase II Technical Planning Project in 2010. In its current form, the NSRSM covers the majority of SFWMD's boundaries, spanning from Lower Kissimmee Basin down to Florida Bay (Figure 7). The model covers around 12,000 square miles and is composed of approximately 7,500 triangular elements with an average size of 1.6 square miles. It has the same model input requirements as RSMGL, without the specifications for managing structures and conforming operating rules associated with canals and lakes. Hydrologic performance of NSRSM was "soft" calibrated by comparing model results (stages and flows) with reference ranges, some anecdotal in nature, from peer reviewed literature. The current release of NSRSM is v3.5.2 (2013). A suite of post-processing tools were developed for NSRSM that generate inundation duration plots, transect flows, flow vectors, among others. Figure 8 shows the average overland flow vectors (using 1965-2005 meteorological input) as simulated by NSRSM.

The strength of NSRSM lies on its ability to estimate natural hydrology which, in turn, can be used as a strong line of evidence to assist in estimating restoration targets, especially in the remnant Everglades. Output from the model is used in conjunction with other models, related studies and corroborating information to estimate how flows across different current-day natural systems, e.g., Shark River Slough in the Everglades National Park or Mullet Slough in the Big Cypress National Preserve, might have existed in a purely rain-driven system. The 2007 peer review strongly recommended that NSRSM "should be

used in an adaptive management framework to help guide management experiments aimed at restoring hydrologic regimes, and more importantly ecological function".

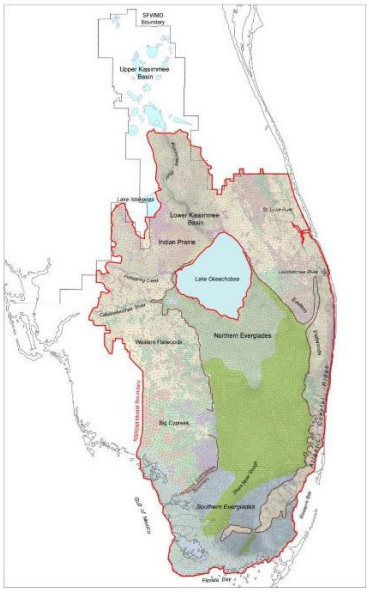

Figure 7. Model Boundary of NSRSM.

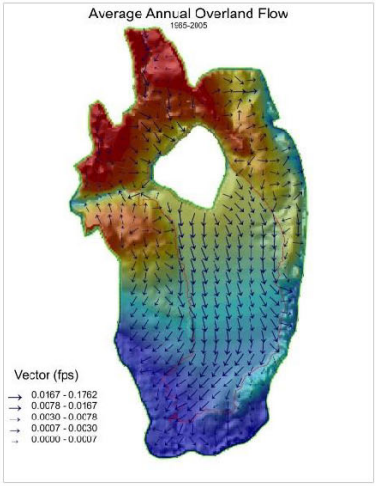

Figure 8. Overland Flow Vectors as Predicted by NSRSM.

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4.3 Natural System Model (NSM)

The Natural System Model (NSM) is another model developed by the SFWMD to simulate the hydrologic response of a pre-drained Everglades system. Similar to NSRSM, NSM does not attempt to simulate the pre-drained hydrology; the data necessary to perform such a simulation are not available. Rather, the use of recent climatic data (e.g., rainfall, potential evapotranspiration, tidal and inflow boundaries) allows for meaningful comparisons between the current managed system and the natural system under identical climatic conditions. Information pertaining to these regional hydrologic models including an overview of the models and comparisons relative to each other can be found at the following website: https://www.sfwmd.gov/science-data/nsm-model#level7. The NSM results will be used for evaluation of performance measures for the COP.

4.4 MIKE Flood (for BAMM)

The WCA flood routing model developed under the USACE's ongoing Baseline and Modification Modeling (BAMM) study will be used to supplement the COP modeling efforts. The primary purpose of the BAMM study is to analyze peak stages within the WCAs under standard project flood (SPF) conditions. Both the existing conditions and the 1967 authorized conditions (C&SF as-built condition of the WCA system) will be evaluated and results will help identify the level of service of flood protection provided by the WCA system for the SPF event. This model will be used to evaluate future operational changes within the WCA system, as under consideration with COP, with respect to flood protection, risk, and levee safety. The BAMM model was developed using MIKEFLOOD software, developed by Danish Hydraulic Institute (DHI). MIKEFLOOD, a dynamically linked 1-D and 2-D flood-modeling tool, combines the capabilities of the 1-D MIKE11 model and the 2-D MIKE21 model. MIKE 11 is a 1D hydrodynamic engine for rivers and open channels that has been used in flood analysis and flood alleviation design studies, real time flood and drought forecasting, and optimization of reservoir and canal gate and structure operations. MIKE 21 is a 2D hydrodynamic model used in simulation of overland flow, waves, sediment dynamics, water quality, and ecology. USACE's BAMM team is preparing a website to publish the findings of the study in fall of 2018. The link for the website will be shared with the COP PDT once the study is concluded.

5 USACE ENGINEERING SOFTWARE VALIDATION AND TECHNICAL REVIEWS

The COP PDT is responsible for producing quality work products. A Review Plan for COP has been prepared in accordance with Engineering Regulation 1165-2-209. The regulation uses a risk-informed decision process to identify appropriate reviews. District Quality Control (DQC) reviews and Agency Technical Review (ATR) will be performed on selected products. Independent External Peer Review (IEPR) and planning model reviews may be required per Engineering Circular 1105-2-412. In addition to review of the modeling tools, the modeling strategy for the project will go through a separate ATR process to familiarize the Hydrology and Hydraulics (H&H) ATR reviewer with the COP modeling tools well in advance of the final plan selection and EIS compilation.

RSM

RSM is approved for use for application in South Florida, including its sub regional applications. RSMGL, RSMBN, and NSRSM have therefore been validated through the Corps Engineering Model Certification process established under the Engineering and Construction (E&C) Science and Engineering Technology (SET) initiative, managed by the USACE Hydrology, Hydraulics, and Coastal Community of Practice (HH&C CoP). All RSM applications, except MDRSM, have been applied to CERP projects and have gone through detailed ATR reviews during the project-specific applications. Engineering software validation review and/or certification is not required for new applications of the RSM. ATR review of the application of the RSMGL and MDRSM will be conducted during the COP.

- ***MDRSM:*** COP will be the first application of the newly developed MDRSM application. Since the MDRSM model will be applied for COP and other CERP projects (C-111 Spreader Canal and CEPP Validation Reports), the USACE is coordinating an IMC technical review of the new tool following completion of the calibration and validation. The IMC technical review will ensure the MDRSM tool is commensurate with other regional hydrologic planning models used in support of the CERP program, and the results of the review may identify additional model enhancements needed prior to COP and CERP application. The staff from the USACE Jacksonville Engineering branch will work with the COP modeling team to generate and submit any necessary packages of information and facilitate working through any necessary responses as the process moves forward.

MIKE FLOOD

Already in HH&C approved software list.

6 RESOURCING

Resourcing needs will determined by the IMC.

7 SCHEDULE

The draft schedule of anticipated modeling tasks are provided in Figure 9. The key dates for the modeling activities are:

- MAR 2018: Modeling Strategy
- OCT 2017 - APR 2018: Evaluation Methodology
- APR 2018: MDRSM Model Calibration & Corps reviews
- MAY-JUN 2018: MDRSM IMC Technical Review & Vet COP Recommendations
- JUN-AUG 2018: Corps ATR Review
- MAR-APR 2018: RSMGL Base Condition
    - 2019 Existing Condition (No Action)
- MAR-AUG 2018: MDRSM Base Conditions
    - 2019 Existing Condition (No Action)
    - 1983 Base Condition – Assumptions table unchanged from 2004 CSOP PDT version

- 1994 GRR C-111 Base Condition – Assumptions table unchanged from 2004 CSOP
- APR-JUN 2018: Round 1 Alternatives (RSMGL regional modeling only)
- AUG-OCT 2018: Round 2 Alternatives (RSMGL and MDRSM models)
- NOV-DEC 2018: Round 3 Optimization of Preliminary Preferred Plan

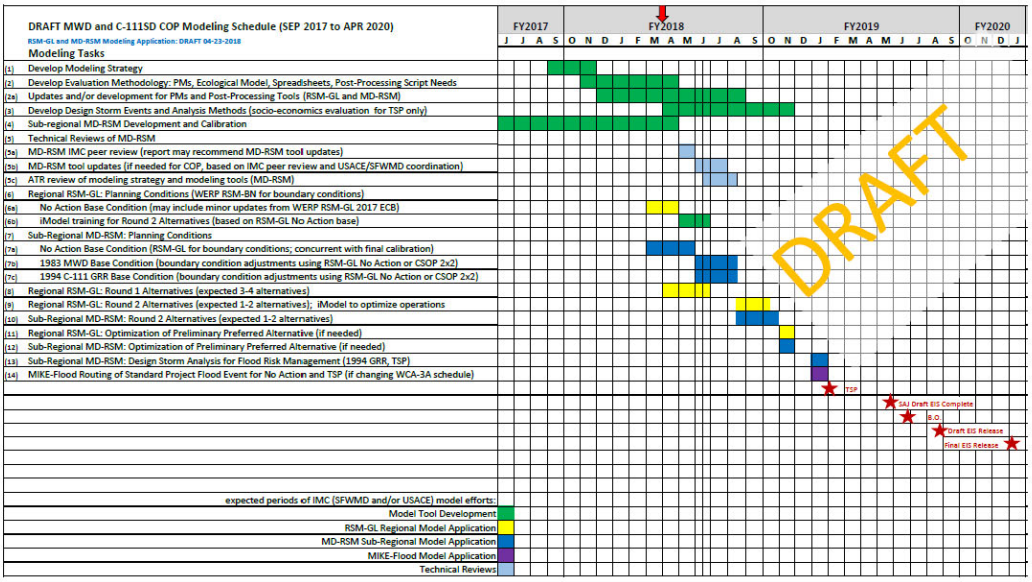

Figure 9. Draft schedule of modeling tasks

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SUPPLEMENT A:

COP GOALS, OBJECTIVES, AND CONSTRAINTS

Combined Operational Plan (COP)

Purpose:
Define water management operations for the WCA-3A and WCA-3B outlets, structures in the L-31N and C-111 basins constructed as part of the C&SF Project and the recently constructed components of the MWD and C-111 SD projects.

Documents Produced:
Water Control Plan and EIS with adaptive management appendix

Objectives:
1. Improve water deliveries (timing, location, volume) into ENP and take steps to restore natural hydrologic conditions in ENP given current C&SF infrastructure and features expected to be completed by the time of implementation, to the extent practicable by

    a. Changing schedule of water deliveries so that it fluctuates in consonance with local meteorological conditions, including providing for long term and annual variation in ecosystem conditions in the Everglades (Timing) (P.L. 101-229, Section 101b)
    b. Restoring NESRS as a functioning component of the Everglades hydrologic system (Location) (P.L. 101-229, Section 101b)
    c. Adjusting the magnitude of water discharged to ENP to minimize effects of too much or too little water (Volume) (1992 MWD GDM, Section 44)
2. Maximize progress toward restoring historic hydrologic conditions in the Taylor Slough, Rocky Glades, & eastern Panhandle of ENP.
3. Protect the intrinsic ecological values associated with WCA-3A and ENP.
4. Minimize the damaging freshwater flows to Manatee Bay/Barnes Sound through the S197 structure and increase flows through Taylor Slough and coastal creeks (1994 C-111 GRR, Section 5.2)
5. Include consideration of cultural values and tribal interests & concerns within WCA-3A and ENP.

Constraints:
1. C&SF project purposes
2. 1962 Flood Control Act (P.L. 87-874) Authorizing Project Works in South Dade County
3. 1968 Flood Control Act (P.L. 9-483) Authorizing the SDCS
4. 1989 ENP Expansion Act (Everglades National Park Protection and Expansion Act of 1989, P.L. 101-229)
5. 1992 MWD GDM (1992 General Design Memorandum): mitigation for project induced flood damages
6. 1994 C-111 GRR: flood damage reduction
7. ERTP WCA-3A Regulation Schedule (pending results of the Baseline and Modification Modeling [BAMM])
8. L-29 Canal maximum stage (8.5 ft NGVD) (2008 Tamiami Trail LRR)
9. 2008 Tamiami Trail Modifications Relocation Agreement (FDOT/USA)
10. 2000 General Re-evaluation Report for the 8.5 SMA
11. 2016 Canal 111 South Dade Final Limited Reevaluation Report
12. 2016 MWD Completion Technical Analysis

Planning Considerations:
1. Burial Resources Agreement
2. Avoid or minimize adverse effects to cultural resources. Explore opportunities to develop monitoring protocols for "at risk" cultural resources
3. Water Quality Standards (CEPP language - Section 6.3.2 Paragraphs 1-4)
4. Maintain multi-species objectives (2012 WCP) and comply with requirements of the applicable BO from USFWS to include the July 2016 ERTP BO and the CERP C-111SC Western Project
5. Consider compatibility with future restoration actions including CEPP. Reasonably connect the planning under this project authority to other near-term changes that are likely to be implemented in the system in the next few years using an Adaptive Management framework.
6. Explore opportunities for enhancing the recovery of federally and state listed species under the Endangered Species Act, the USACE's authorities for MWD and C-111 projects and operational considerations.
7. Explore opportunities to enhance flood control and mitigation.

Scope:
1. Raise the maximum operational limit in the L-29 canal up to 8.5 feet NGVD (Operational limit based on the Tamiami Trail LRR).
2. Relax the 6.8 foot NGVD constraint at G-3273 and evaluate whether the previous G-3273 constraint can be removed, or if an alternate constraint and location is warranted as a protective measure for residential areas to the east, particularly the 8.5 SMA.
3. Operate pump station S-356 to manage seepage and water stages in the L-30 and L-31N canal levels between S-335 and G-211.
4. Modify the Rainfall Plan for discharges from WCA-3A
5. Modifications to the WCA-3A Regulation Schedule below Zone A (including IOP/ERTP Column 1 and Column 2 operations) pending results of the Baseline and Modification Modeling (BAMM) Flood Routing Study of the WCAs
6. Modifications to operation of the C&SF structures for flood protection (including S-197)
7. Operation of S-328 (proposed under the SFWMD Florida Bay Initiative in 2016)
8. Ecological water deliveries to Taylor Slough (Page 5-1 of the C-111 SD GRR)
   NOTE: Regulation schedule changes for Lake Okeechobee will not be included in the COP. Regulation schedule changes for WCA-1 and WCA-2 will not be included in the COP, but changes may be included in the COP alternative modeling (e.g. sensitivity run prior to the TSP) in order to ensure sufficient flexibility is included in the COP Water Control Plan to accommodate a future WCA-1 and WCA-2A Regulation Schedule study.

Planning Conditions:
1. 1983 Base – identifies the level of flood mitigation that will be maintained in the COP process; represents the conditions in the 8.5 SMA before MWD was implemented, consistent with the requirements set forth in the 8.5 SMA 2000 GRR Record of Decision.
2. 1994 GRR C-111 Base – identifies the minimum level of flood protection that will be maintained in the COP process.
3. 2019 Existing Condition-- represents conditions assumed in place at the time of implementation of the COP Water Control Plan; this base condition will include the following: (1) MWD Increment 1.1 and 1.2 (operational changes required under the July 2016 ERTP BO and in response to new information gained during the 2016 Temporary Emergency Deviation; L-29 Canal maximum operating limit of 7.8 feet NGVD); (2) existing C&SF project infrastructure and Regulation Schedules (including 2008 Lake Okeechobee Regulation Schedule); (3) MWD Tamiami Trail Modifications 1-Mile Bridge and Raised Roadway; (4) Tamiami Trail Next Steps 2.6 Mile Western Bridge (completion scheduled for December 2018); (5) full construction of C-111 South Dade to include Contracts 8, 8A and 9; (6) 8.5 SMA project features to include C-358 and S-357N; (7) Miami-Dade Limestone Products

Association (MD-LPA) 5-mile Seepage Cutoff wall along L-31 North; and (8) current permitted operations for the SFWMD C-111 Spreader Canal project components (includes G-737 and S-199/S-200 at expanded 300 cfs each); (9) the expanded capacity at S-333 completed by SFWMD (component of the Central Everglades Planning Project); and (10) removal of portions of the old Tamiami Trail Roadway, south of WCA 3A by the ENP (component of the Central Everglades Planning Project).

Alternative Formulation and Modeling:
1. Initial array of Alternatives
2. Screening of Alternatives
3. Round 1: Modeling of selected alternatives (likely 3-4) plus 2019 Existing Condition; hydrologic modeling will only apply the regional RSM-GL.
4. Round 2: Alternative(s) developed that incorporates the best components Round 1 alternatives; hydrologic modeling will apply both the regional RSM-GL and the sub-regional MD-RSM, with potential application of the M3ENP MIKE-SHE model by ENP.
5. Round 3: Optimization of the Round 2 alternatives, if needed, to balance the ecological restoration objectives of the MWD and C-111 South Dade projects while demonstrating compliance with the COP constraints (based principally of evaluations of the Round 2 alternatives from the MD-RSM); hydrologic modeling will apply both the regional RSM-GL and the sub-regional MD-RSM, with potential application of the M3ENP MIKE-SHE model by ENP

Evaluation Methods:
1. Hydrologic Models: RSM-GL/MD-RSM, Mike-She model developed by ENP.
2. Ecological analysis using Eco Planning tools (examples include MARL Prairie Habitat Suitability, WADEM, Apple Snail, Slough PM, Soil oxidation PM, etc.)
3. 2016 ERTP BO RPA Hydrological Targets
4. Water Quality – using RSM-GL model output

Other Factors that may affect scope/schedule:
1. New information from G-3273/S-356 Field Tests (Increment 1/1.1/1.2/2)
2. Modeling support and funding (assumed through DOI MOU with SFWMD)
3. Time frame – Implement COP by 2019
4. BAMM flood routing analysis: potential new WCA 3A stage constraints
5. Flood analysis – estimate economic damages –versus– use only hydrological performance measures
6. Burial Resources Agreement and ERTP effects determination
7. Planning conditions or alternative formulation different from above
8. ESA

SUPPLEMENT B:

WESTERN EVERGLADES RESTORATION PROJECT

RSM-GL MODELING UPDATE

Summary Overview: WERP Modeling Updates and Baseline Scenarios (cont)

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- Calibration efforts were completed in late 2017 and new modeling baselines were released on January 22, 2018:
  - WECB – represents "current" conditions circa 2016
  - WFWO – represents "future" conditions including Central Everglades and other authorized projects.
- While these updates generally represent a more accurate depiction of the regional system represented by RSMGL, a number of changes can be observed and require rigorous review by project teams and users of model data.

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RSMGL Overview

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- RSMGL = Regional Simulation Model Glades-LECSA; an application of RSM to model hydrology in the remnant Everglades, Big Cypress National Preserve and most of the Lower East Coast Service Areas (LECSA)
- For WERP: RSMGL was expanded to include the Feeder Canal Basins; C-139 Annex, western Tamiami Canal and Loop Road.

WERP Project Area : ~1,204 sq. miles
RSMGL model extent : ~5,943 sq. miles

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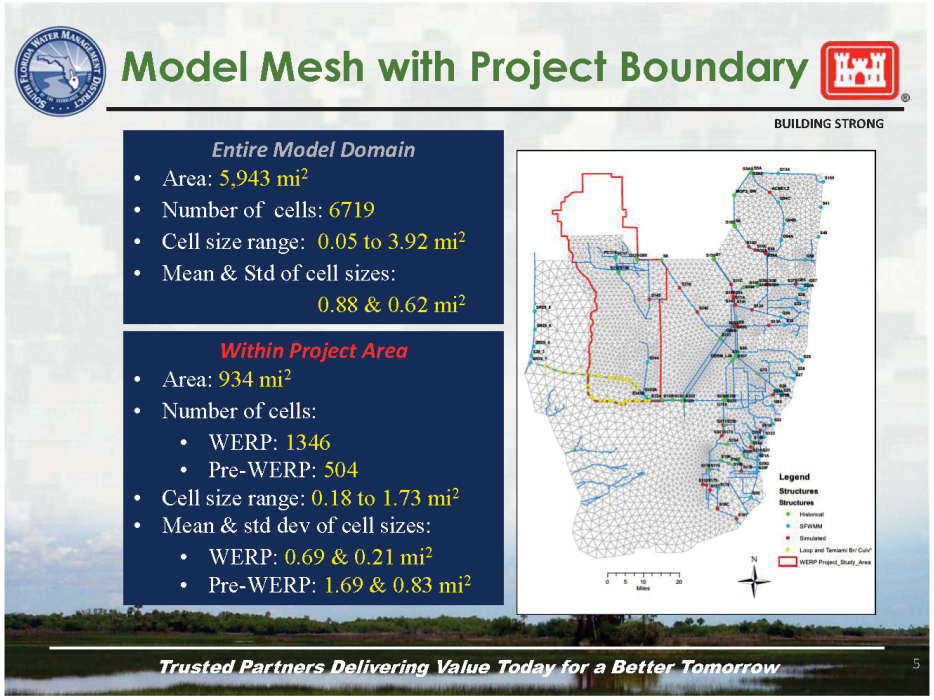
Model Mesh with Project Boundary
BUILDING STRONG
Entire Model Domain
Area: 5,943 mi²
Number of cells: 6719
Cell size range: 0.05 to 3.92 mi²
Mean & Std of cell sizes: 0.88 & 0.62 mi²
Within Project Area
Area: 934 mi²
Number of cells:
WERP: 1346
Pre-WERP: 504
Cell size range: 0.18 to 1.73 mi²
Mean & std dev of cell sizes:
WERP: 0.69 & 0.21 mi²
Pre-WERP: 1.69 & 0.83 mi²
Legend
Structures
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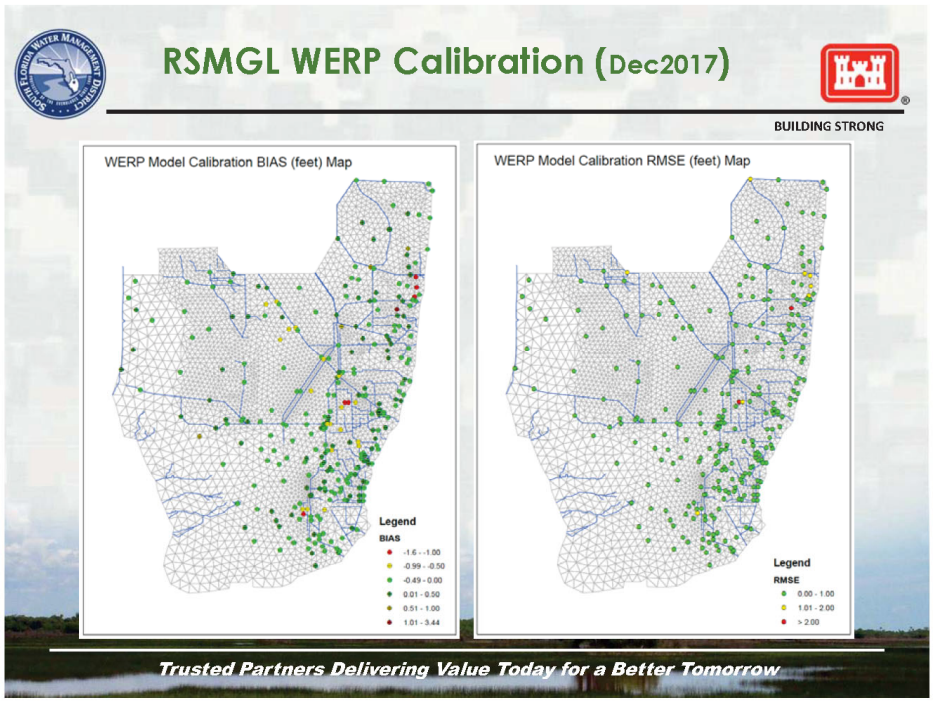
RSMGL WERP Calibration (Dec2017)
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WERP Model Calibration BIAS (feet) Map
Legend
BIAS
WERP Model Calibration RMSE (feet) Map
Legend
RMSE
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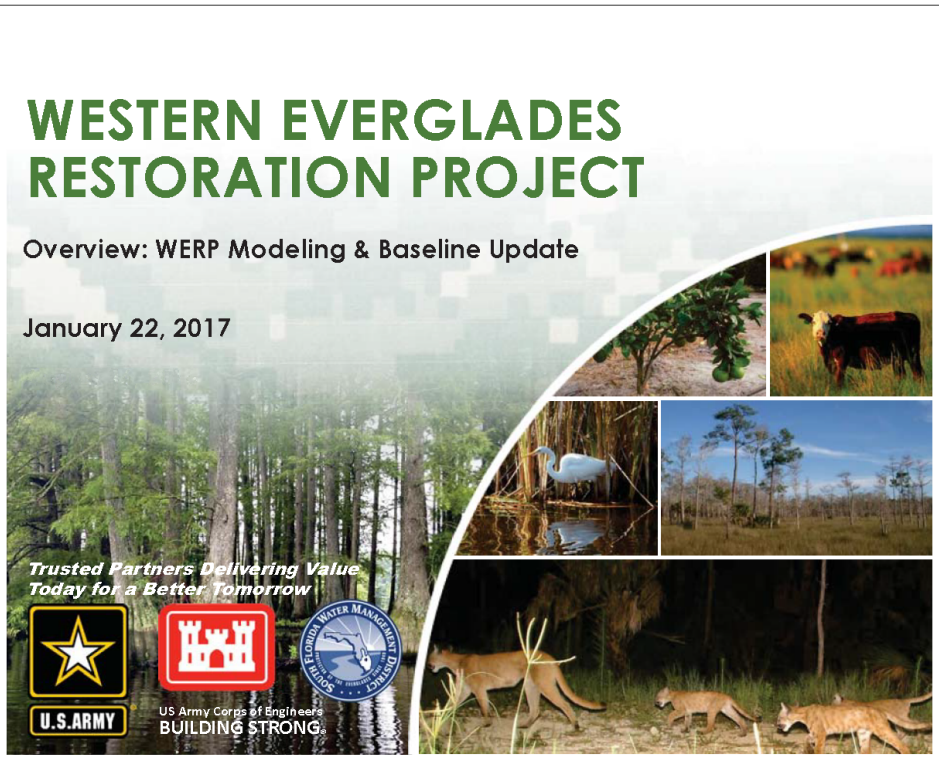
WESTERN EVERGLADES RESTORATION PROJECT
Overview: WERP Modeling & Baseline Update
January 22, 2017
Trusted Partners Delivering Value Today for a Better Tomorrow
U.S.ARMY
US Army Corps of Engineers
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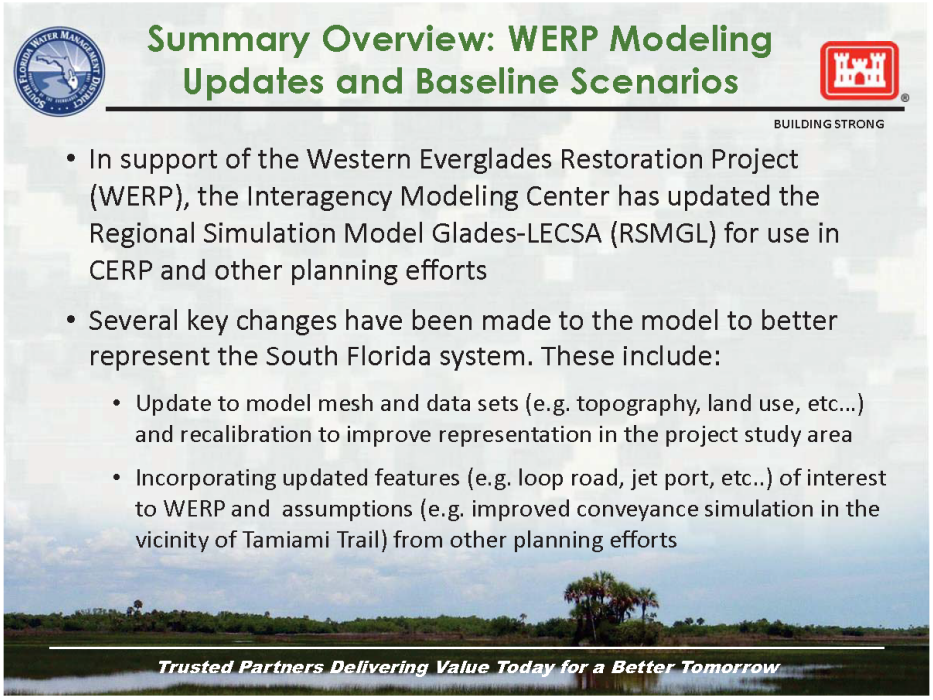
Summary Overview: WERP Modeling Updates and Baseline Scenarios
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• In support of the Western Everglades Restoration Project (WERP), the Interagency Modeling Center has updated the Regional Simulation Model Glades-LECSA (RSMGL) for use in CERP and other planning efforts
• Several key changes have been made to the model to better represent the South Florida system. These include:
• Update to model mesh and data sets (e.g. topography, land use, etc…) and recalibration to improve representation in the project study area
• Incorporating updated features (e.g. loop road, jet port, etc..) of interest to WERP and assumptions (e.g. improved conveyance simulation in the vicinity of Tamiami Trail) from other planning efforts
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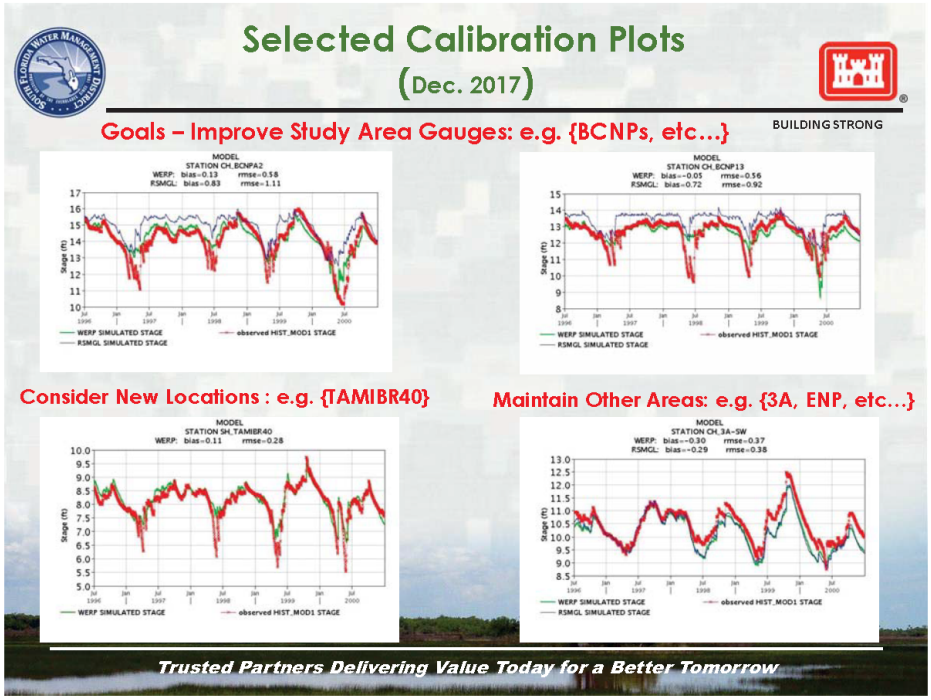
Selected Calibration Plots
(Dec. 2017)
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Goals – Improve Study Area Gauges: e.g. {BCNPs, etc…}
Consider New Locations : e.g. {TAMIBR40}
Maintain Other Areas: e.g. {3A, ENP, etc…}
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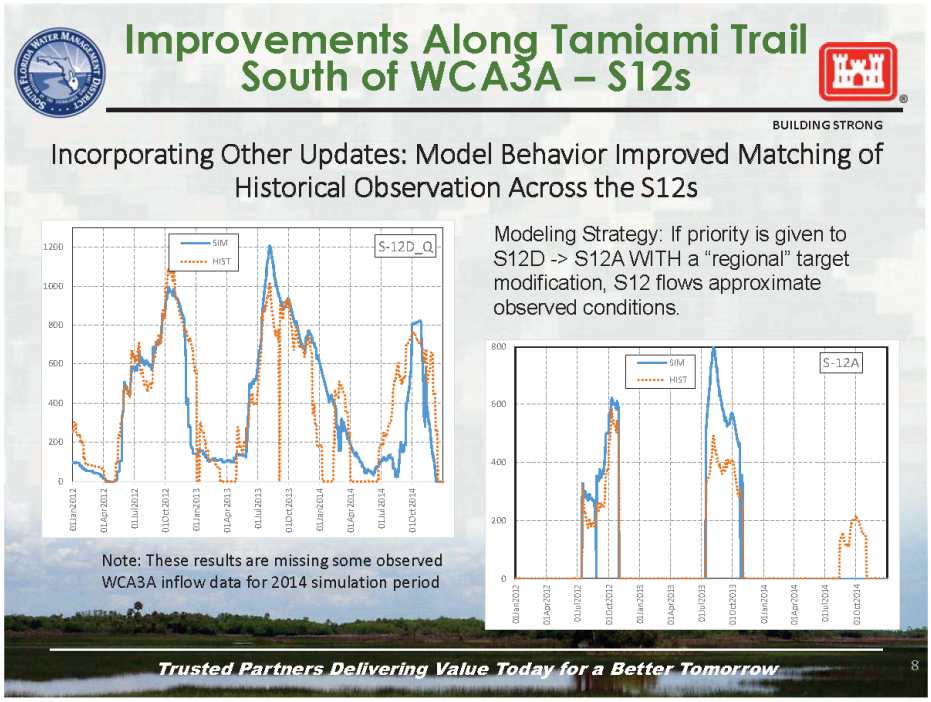
Improvements Along Tamiami Trail South of WCA3A – S12s
BUILDING STRONG
Incorporating Other Updates: Model Behavior Improved Matching of Historical Observation Across the S12s
Modeling Strategy: If priority is given to S12D -> S12A WITH a "regional" target modification, S12 flows approximate observed conditions.
Note: These results are missing some observed WCA3A inflow data for 2014 simulation period
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8

More Detail if Desired…

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- Beyond this high level overview, more detail on these outcomes (and other improvements) can be found in presentations made to the WERP PDT on June 22, 2017 and December 19, 2017.
- Model improvements efforts will also be further documented as part of the WERP modeling support (Calibration Report Addendum and IMC Model Documentation Reports)

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Baseline Comparisons

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- Calibration outcomes and localized model testing show a broad range of improvements; comparing to legacy planning efforts is a logical additional step.
- "Current" comparisons to help illustrate trends:
  - 2012EC = Central Everglades PIR current baseline with ERTP operations
  - ECB16 = ERTP operations incorporating Tamiami Trail improvements
  - WECB = ECB16 incorporating WERP model improvements
- "Future" comparisons to help illustrate trends:
  - ALT4R2 = Central Everglades PIR "with restoration" condition
  - WFWO = ALT4R2 incorporating WERP model improvements

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Example Flow Comparisons in RSMGL

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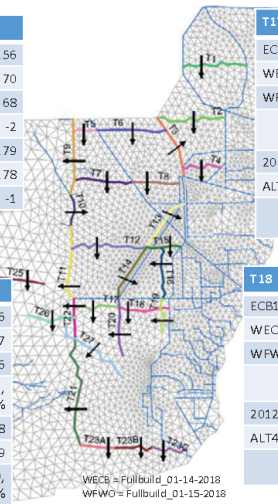
RSM Glades-LECSA - Transects



T10	Total, kaf/yr	Dry	Wet
ECB16	183	27	156
WECB	104	34	70
WFWO	103	35	68
DIFF1	-1	1	-2
2012EC	221	42	179
ALT4R2	222	44	178
DIFF2	1	2	-1

T17	Total, kaf/yr	Dry	Wet
ECB16	333	131	202
WECB	317	137	180
WFWO	257	125	132
DIFF1	-60, 81.1%	-12, 91.2%	-48, 73.3%
2012EC	394	167	227
ALT4R2	319	143	176
DIFF2	-75, 81%	-24, 85.6%	-51, 77.5%

T26	Total, kaf/yr	Dry	Wet
ECB16	275	69	206
WECB	165	48	117
WFWO	116	30	86
DIFF1	-49, 70.3%	-18, 62.5%	-31, 73.5%
2012EC	216	48	168
ALT4R2	186	37	149
DIFF2	-30, 86.1%	-11, 77.1%	-19, 88.7%

T18	Total, kaf/yr	Dry	Wet
ECB16	106	69	37
WECB	106	69	37
WFWO	698	325	373
DIFF1	592, 6.6x	256, 4.7x	336, 10.1x
2012EC	73	47	26
ALT4R2	754	341	413
DIFF2	681, 10.3x	294, 7.3x	387, 15.9x

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Example RF/ET Comparisons in RSMGL

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Comparison of Rainfall/ET Ratio (ann. avg. for 1965-2005 POR)

	Western Areas	WCA3A	ENP
ECB16	1.54	0.99	1.09
WECB	1.32	0.98	1.10
WFWO	1.32	0.98	1.09
2012EC	1.54	1.00	1.08
ALT4R2	1.54	0.99	1.07

Trends make sense, but less total water in Western Areas after recalibration

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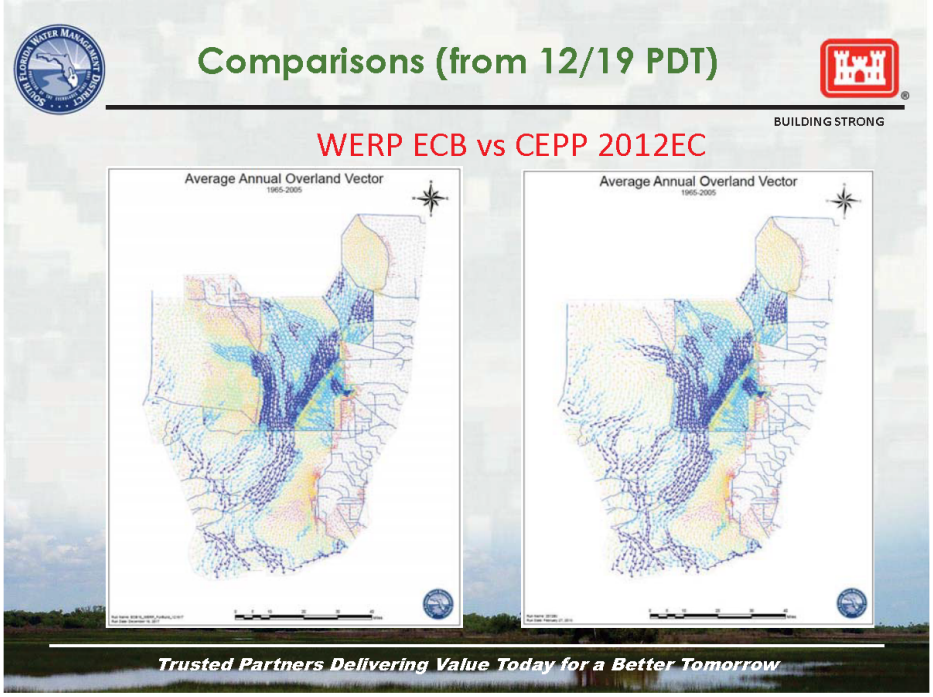
Comparisons (from 12/19 PDT)
BUILDING STRONG
WERP ECB vs CEPP 2012EC
Average Annual Overland Vector
1965-2005
Average Annual Overland Vector
1965-2005
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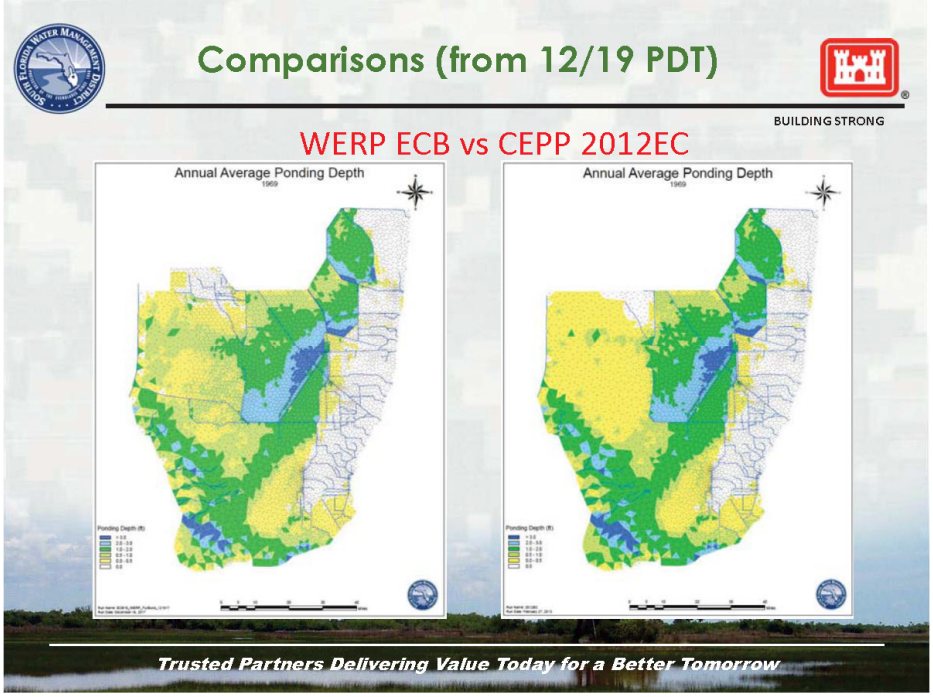
Comparisons (from 12/19 PDT)
BUILDING STRONG
WERP ECB vs CEPP 2012EC
Annual Average Ponding Depth
1969
Annual Average Ponding Depth
1969
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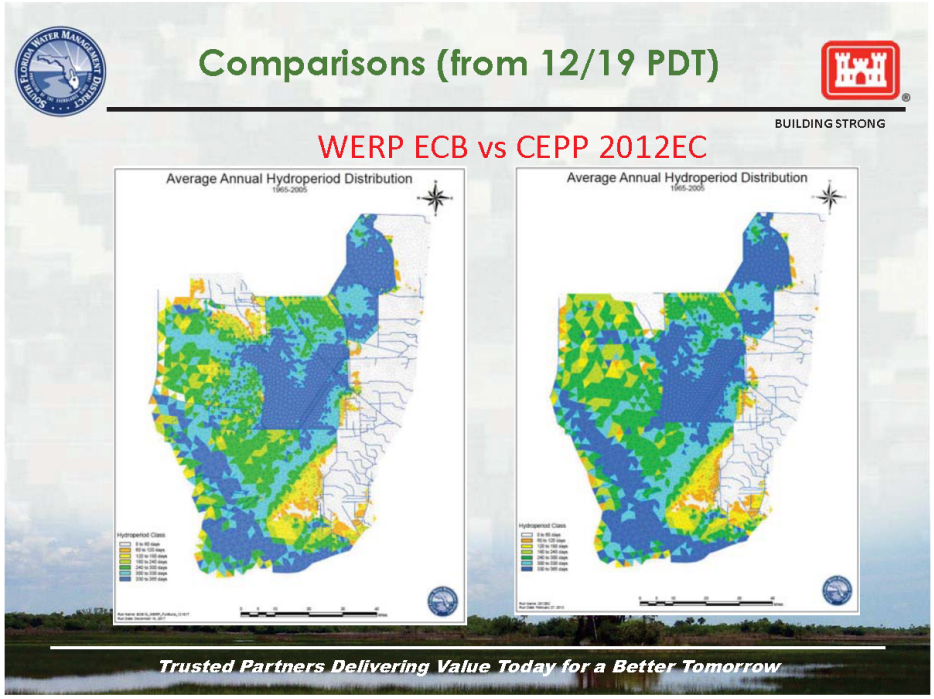
Comparisons (from 12/19 PDT)
BUILDING STRONG
WERP ECB vs CEPP 2012EC
Average Annual Hydroperiod Distribution
1965-2005
Average Annual Hydroperiod Distribution
1965-2005
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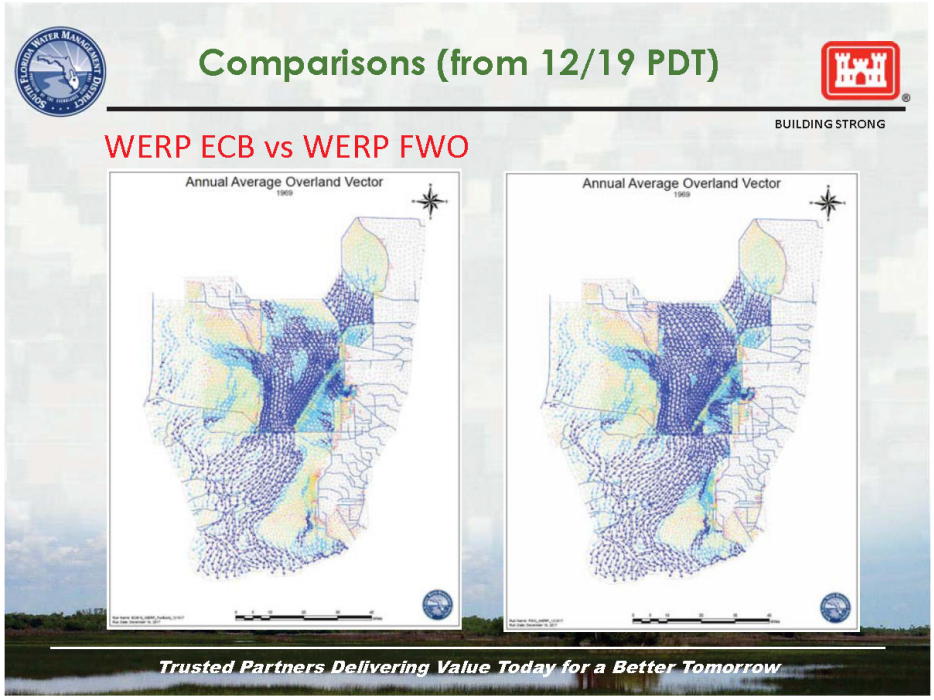
Comparisons (from 12/19 PDT)
BUILDING STRONG
WERP ECB vs WERP FWO
Annual Average Overland Vector
1969
Annual Average Overland Vector
1969
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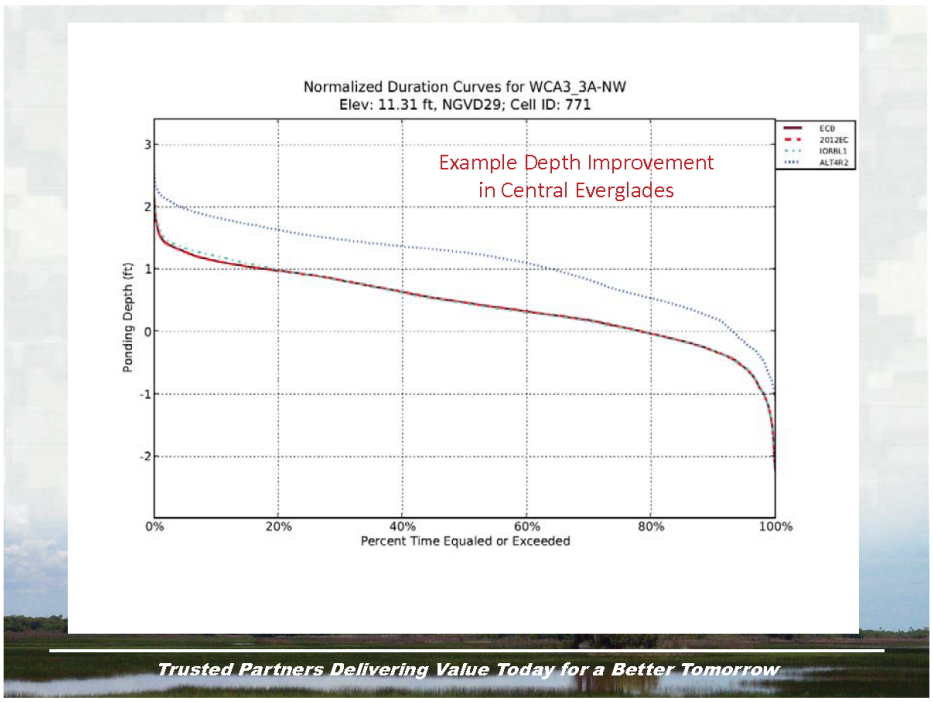
Normalized Duration Curves for WCA3_3A-NW
Elev: 11.31 ft, NGVD29; Cell ID: 771
ECB
2012EC
IORBL1
ALT4R2
Example Depth Improvement
in Central Everglades
Ponding Depth (ft)
3
2
1
0
-1
-2
0%
20%
40%
60%
80%
100%
Percent Time Equaled or Exceeded
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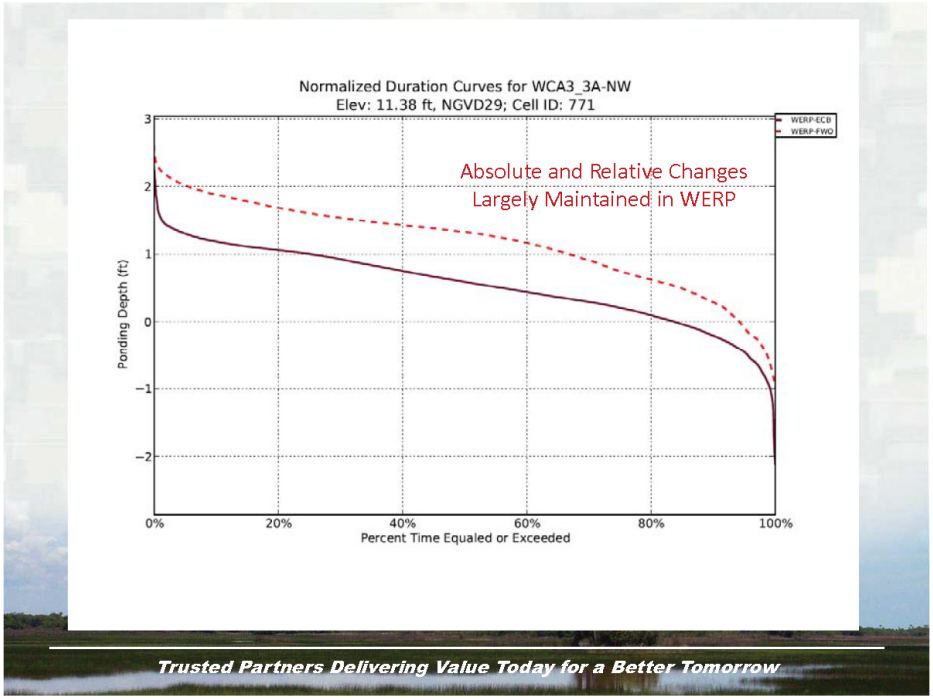
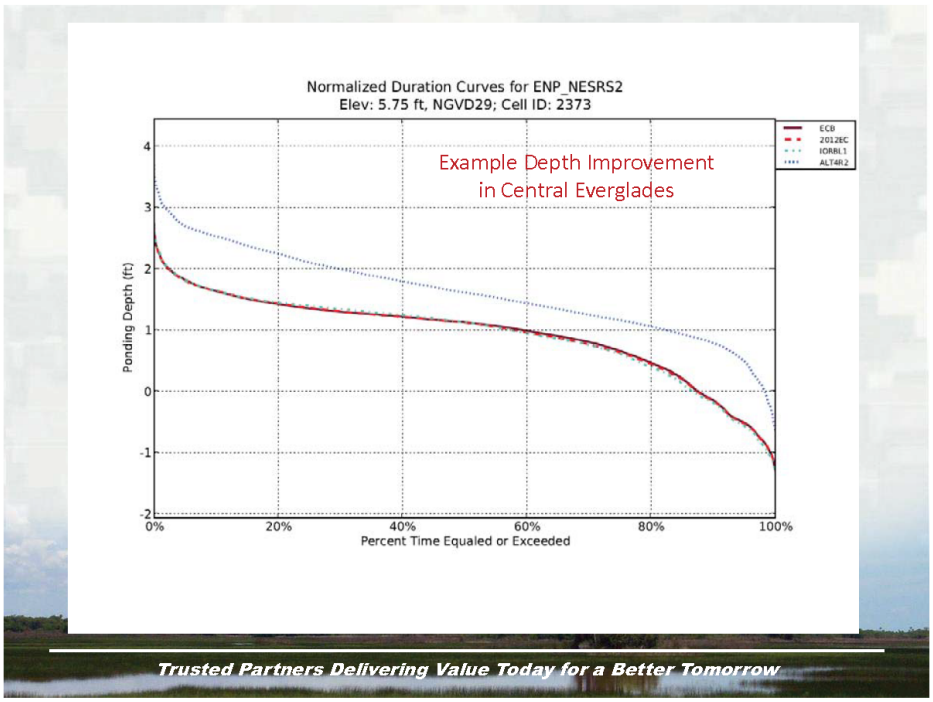

Normalized Duration Curves for WCA3_3A-NW
Elev: 11.38 ft, NGVD29; Cell ID: 771
WERP-ECB
WERP-FWO
Absolute and Relative Changes
Largely Maintained in WERP
Ponding Depth (ft)
3
2
1
0
−1
−2
0%
20%
40%
60%
80%
100%
Percent Time Equaled or Exceeded
Trusted Partners Delivering Value Today for a Better Tomorrow


Normalized Duration Curves for ENP_NESRS2
Elev: 5.75 ft, NGVD29; Cell ID: 2373
ECB
2012EC
IORBL1
ALT4R2
Example Depth Improvement
in Central Everglades
Ponding Depth (ft)
4
3
2
1
0
-1
-2
0%
20%
40%
60%
80%
100%
Percent Time Equaled or Exceeded
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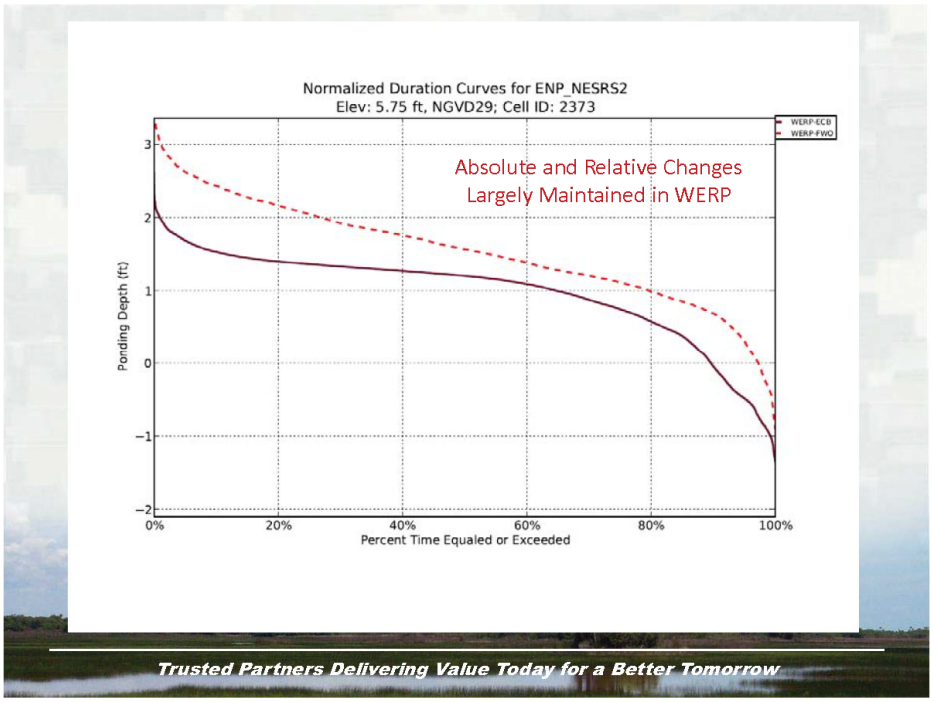
Normalized Duration Curves for ENP_NESRS2
Elev: 5.75 ft, NGVD29; Cell ID: 2373
WERP-ECB
WERP-FWO
Absolute and Relative Changes
Largely Maintained in WERP
Ponding Depth (ft)
3
2
1
0
−1
−2
0%
20%
40%
60%
80%
100%
Percent Time Equaled or Exceeded
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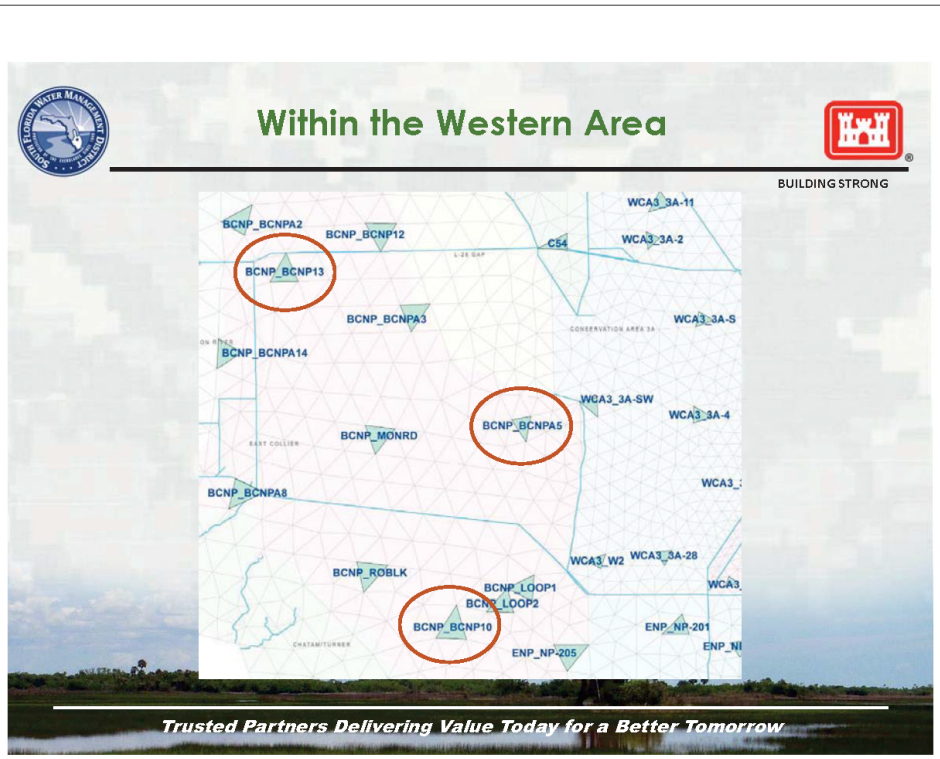
Within the Western Area
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BCNP_BCNPA2
BCNP_BCNP12
BCNP_BCNP13
BCNP_BCNPA3
BCNP_BCNPA14
BCNP_MONRD
BCNP_BCNPA5
BCNP_BCNPA8
BCNP_ROBLK
BCNP_LOOP1
BCNP_LOOP2
BCNP_BCNP10
ENP_NP-205
ENP_NP-201
C54
WCA3_3A-11
WCA3_3A-2
WCA3_3A-S
WCA3_3A-SW
WCA3_3A-4
WCA3_W2
WCA3_3A-28
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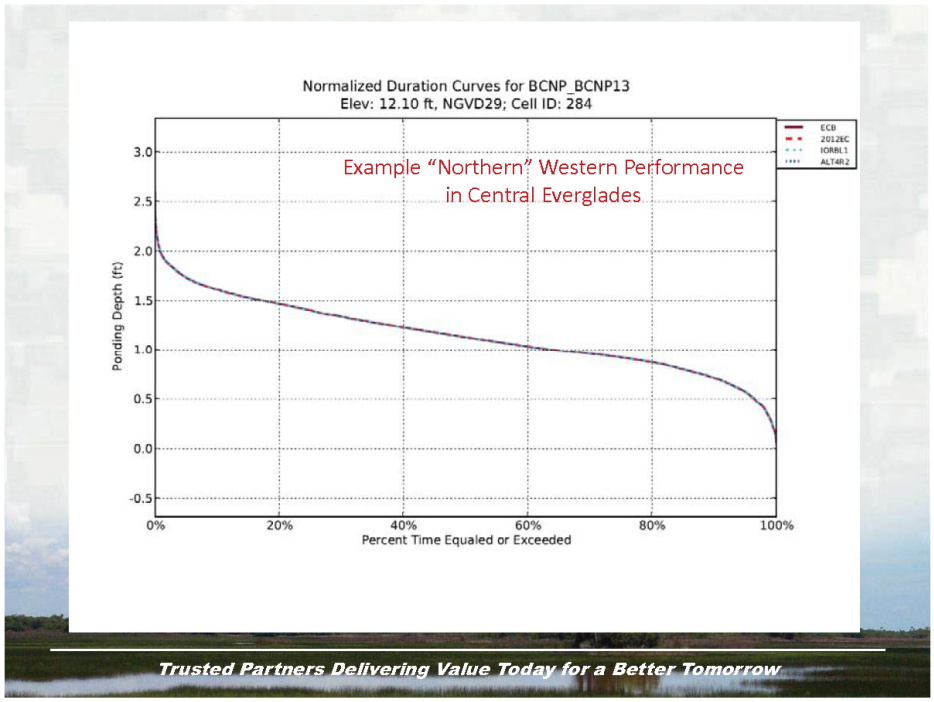
Normalized Duration Curves for BCNP_BCNP13
Elev: 12.10 ft, NGVD29; Cell ID: 284
Example "Northern" Western Performance
in Central Everglades
ECB
2012EC
IORL1
ALT4R2
Ponding Depth (ft)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0%
20%
40%
60%
80%
100%
Percent Time Equaled or Exceeded
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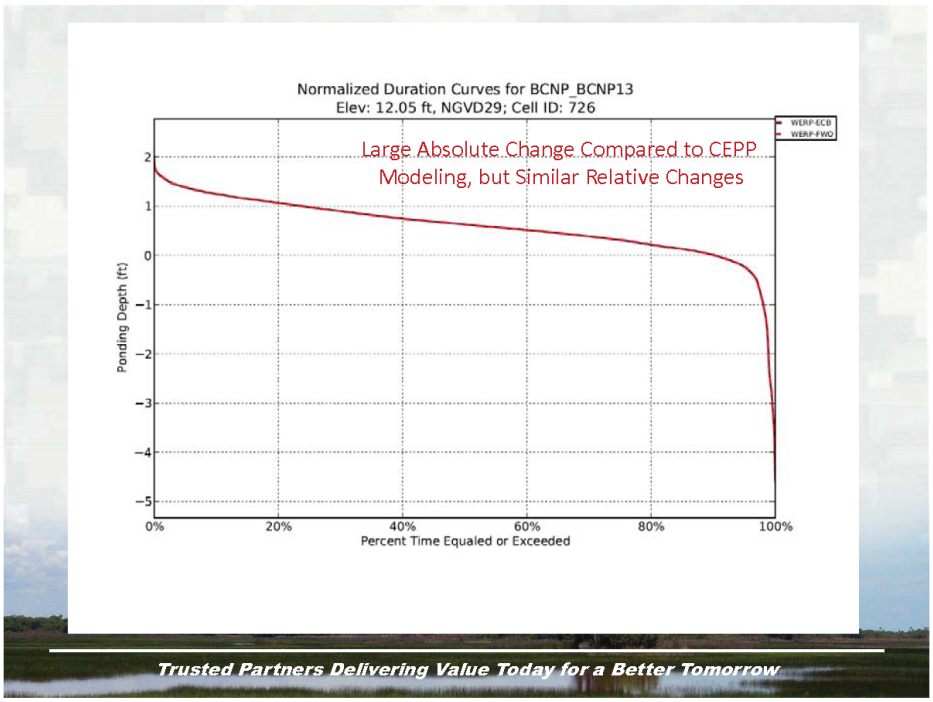
Normalized Duration Curves for BCNP_BCNP13
Elev: 12.05 ft, NGVD29; Cell ID: 726
WERP-ECB
WERP-FWO
Large Absolute Change Compared to CEPP Modeling, but Similar Relative Changes
Ponding Depth (ft)
2
1
0
−1
−2
−3
−4
−5
0%
20%
40%
60%
80%
100%
Percent Time Equaled or Exceeded
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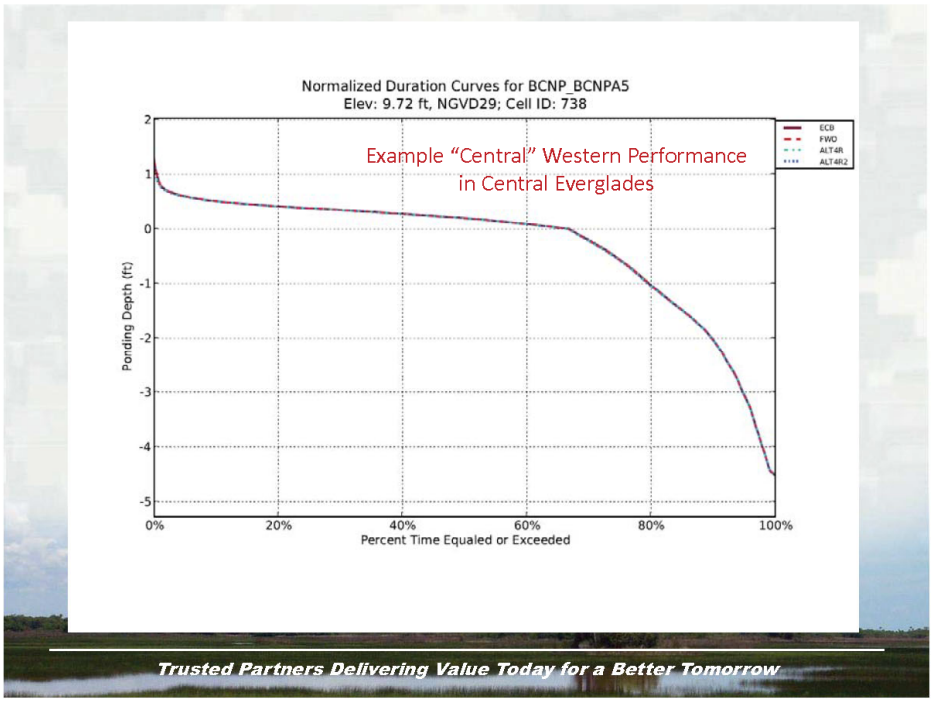
Normalized Duration Curves for BCNP_BCNPA5
Elev: 9.72 ft, NGVD29; Cell ID: 738
ECB
FWO
ALT4R
ALT4R2
Example "Central" Western Performance in Central Everglades
Ponding Depth (ft)
2
1
0
-1
-2
-3
-4
-5
0%
20%
40%
60%
80%
100%
Percent Time Equaled or Exceeded
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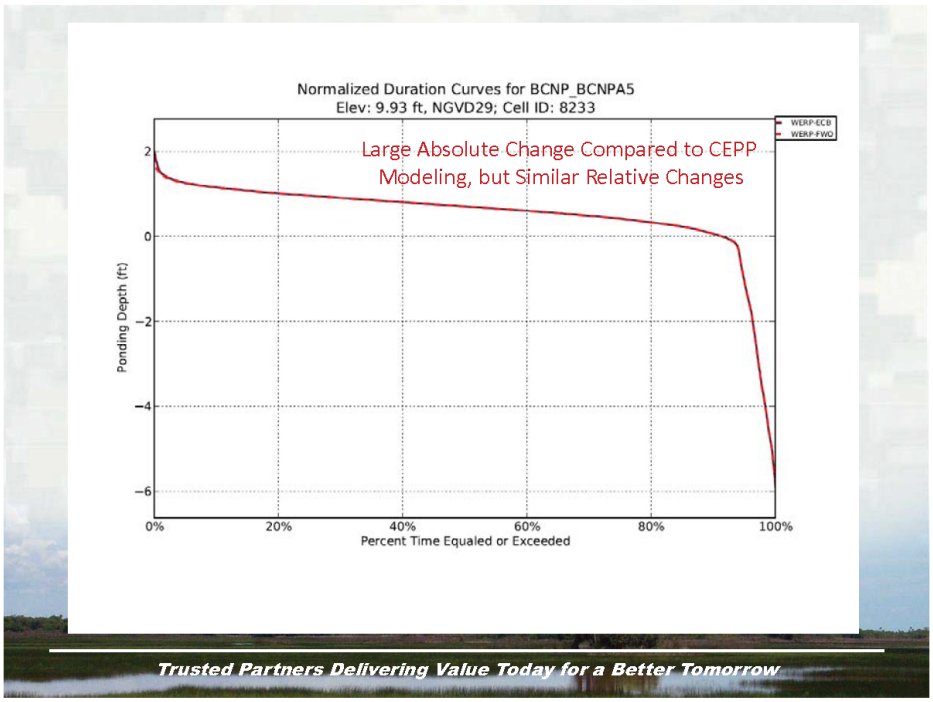
Normalized Duration Curves for BCNP_BCNPA5
Elev: 9.93 ft, NGVD29; Cell ID: 8233
WERP-ECB
WERP-FWO
Large Absolute Change Compared to CEPP Modeling, but Similar Relative Changes
Ponding Depth (ft)
2
0
−2
−4
−6
0%
20%
40%
60%
80%
100%
Percent Time Equaled or Exceeded
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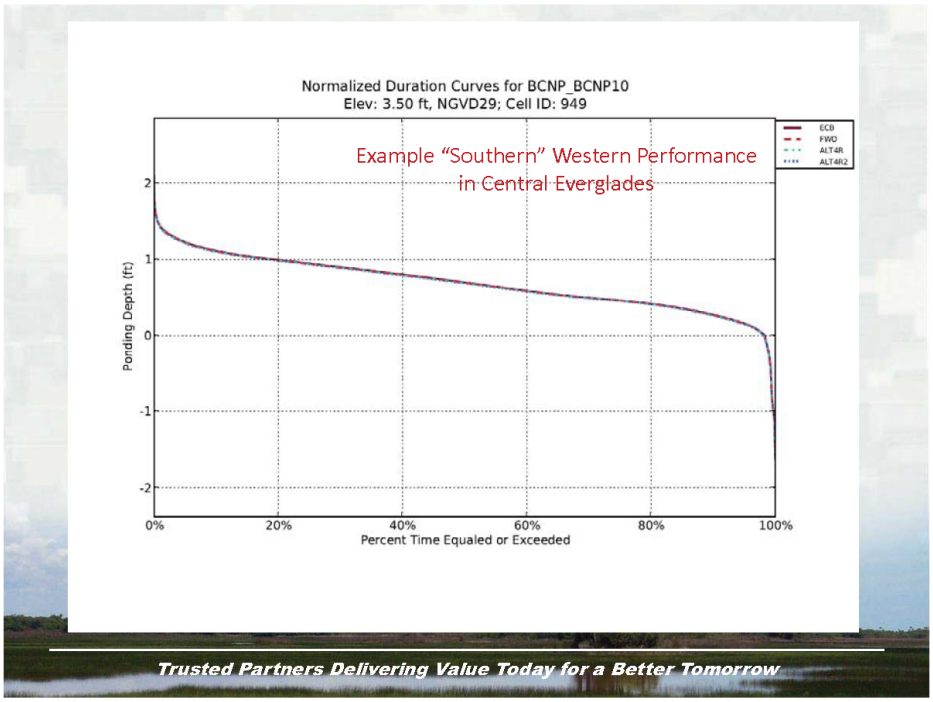
Normalized Duration Curves for BCNP_BCNP10
Elev: 3.50 ft, NGVD29; Cell ID: 949
ECB
FWO
ALT4R
ALT4R2
Example "Southern" Western Performance in Central Everglades
Ponding Depth (ft)
2
1
0
-1
-2
0%
20%
40%
60%
80%
100%
Percent Time Equaled or Exceeded
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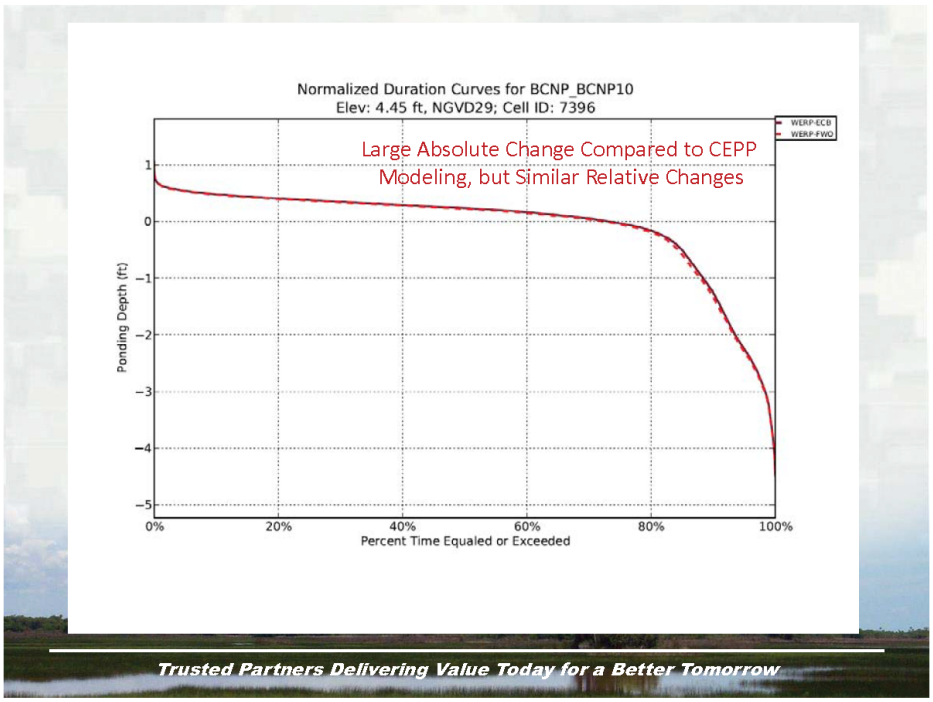
Normalized Duration Curves for BCNP_BCNP10
Elev: 4.45 ft, NGVD29; Cell ID: 7396
WERP-ECB
WERP-FWO
Large Absolute Change Compared to CEPP Modeling, but Similar Relative Changes
Ponding Depth (ft)
1
0
−1
−2
−3
−4
−5
0%
20%
40%
60%
80%
100%
Percent Time Equaled or Exceeded
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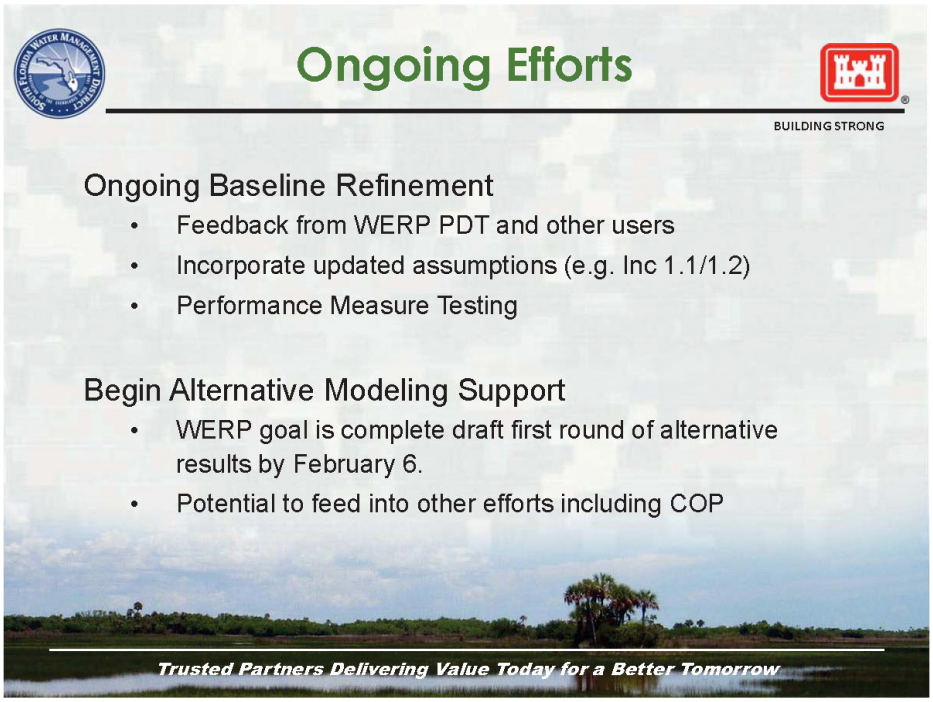
Ongoing Efforts
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Ongoing Baseline Refinement
• Feedback from WERP PDT and other users
• Incorporate updated assumptions (e.g. Inc 1.1/1.2)
• Performance Measure Testing
Begin Alternative Modeling Support
• WERP goal is complete draft first round of alternative results by February 6.
• Potential to feed into other efforts including COP
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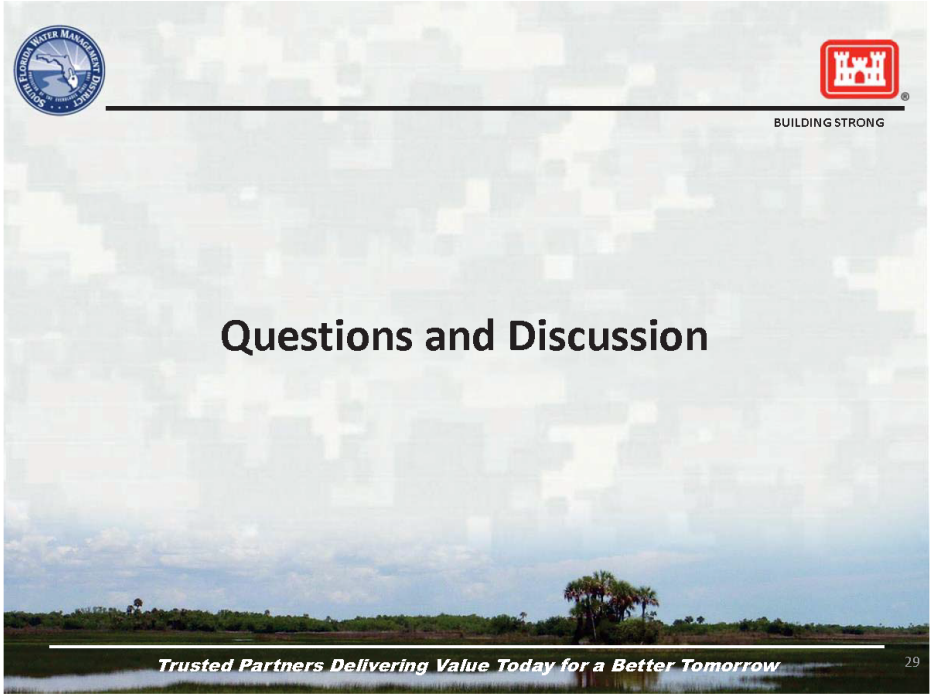
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Questions and Discussion
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