17.0 Next Steps

RECOVER has identified needs to improve performance measure development and application. Each section below gives a brief overview of identified needs and general information about how RECOVER expects to address them. Performance measure development and refinement is a dynamic process and actions identified below are first in a series of steps to continually approve upon ecological meaningfulness of performance measures.

17.1 Future Evaluation Tools

At present, evaluation components of CERP system-wide performance measures are highly dependent on hydrologic model output, primarily the South Florida Water Management Model (SFWMM). The SFWMM is a useful tool, but it needs to be supplemented by other hydrologic models. Also, we need water quality and ecological models/tools to evaluate and assess performance measures.

The South Florida Water Management District (SFWMD) is developing the Regional Simulation Model (RSM). This model is a regional hydrologic model designed to simulate coupled movement of groundwater and surface water in South Florida. Major benefits of the RSM include increased resolution of topography over that of the SFWMM, as well as a reduced and variable grid size. Also, specific components can be developed for use with the RSM and can be 'plugged' into the overall model. More information on the RSM and updates on its development can be found at the following web site: www.sfwmd.gov/site/index.php?id=342.

In an effort to identify models currently used to evaluate RECOVER performance measures, as well as unmet model needs, three classes of existing models were investigated: 1) hydrologic, hydraulic and hydrodynamic, 2) biogeochemical or water quality, and 3) ecological. Several major shortcomings were recognized: 1) RECOVER lacks easily applicable ecological models; 2) RECOVER lacks peer reviewed, regional-scale water quality models; and 3) RECOVER lacks the ability to link the three classes of models listed above. Specific recommendations can be found in the *Report on Evaluation Tools, Models, Work Plan, and Budgets* (RECOVER 2006a). This report can be found at http://www.evergladesplan.org/pm/recover/system_wide_modeling.aspx. Additionally, evaluation and assessment tool needs are identified directly on performance measure documentation sheets posted on the web at http://www.evergladesplan.org/pm/recover/eval_team_perf_measures.aspx.

Efforts are ongoing to refine and develop future tools to evaluate ecological responses to varying project alternatives. Habitat suitability indices (HSIs) and Across Trophic Level System Simulation (ATLSS) spatially-explicit species index (SESI) models have potential, but require further calibration, validation and/or peer review before application. SESI models exist for American alligator, snail kite, apple snail, wading birds, and white tailed deer. In addition to SESI models, ATLSS models include those for fish (ALFISH and ALFISHES) and sparrows, as well as high-resolution topography and hydrology models.

Similarly, water quality models are needed to simulate nitrogen and phosphorus dynamics. In the absence of applicable water quality models, regional evaluations will use water quality proxies such as duration and intensity of dry down, structural flows, and stormwater treatment area bypasses (frequency and volume). These proxies should refined in the short term to make them more quantitative until appropriate water quality models are available. Several water quality models are being developed. Hydrodynamic and water quality modeling tools specific to the Arthur R. Marshall Loxahatchee National Wildlife Refuge are being developed by the U.S. Fish and Wildlife Service (sofia.usgs.gov/lox_monitor_model/). The SFWMD, in conjunction with the US Geological Survey (USGS) and the University of Florida, is developing a water quality module for the RSM.

Long-term plans should link the three classes of models - hydrology, water quality and ecology - through a graphical user interface (GUI). A GUI will facilitate model runs and make them more robust by providing dynamic linkages, which allow feedback between the different class of models.

17.2 Sensitivity of Evaluation Tools

Current modeling tools as well as related performance measures are often not sensitive enough to evaluate system-wide effects of varying project alternatives. This is the result of low resolution of model input variables, coarse resolution of the SFWMM, and disconnects between spatio-temporal scale of the SFWMM and performance measure parameter inputs. Currently, the SFWMM is the main hydrologic model used to investigate RECOVER performance measures. Low resolution of input variables comes from both lack of accuracy of field measurements and lack of field measurements altogether throughout the system. Current measuring tools will require further refinement to increase sensitivity of input values. Due to the vast size of the South Florida landscape, it is not always feasible to take measurements across the entire system. Therefore, extrapolations are made. For example, water depth measurements at gauging stations are used to estimate water depths in other locations where gauges do not exist. Depth estimates are merely extrapolations/regressions from known depths. With increased monitoring and assessment activities and increased sensitivity of measurement tools will come the ability to reduce uncertainty associated with these extrapolations. The implementation of the *CERP Monitoring and Assessment Plan, Part 1, Monitoring and Supporting Research* (RECOVER 2004) and the final draft of the *Monitoring and Assessment Plan (MAP), Part 2 2006 Assessment Strategy for the MAP* (RECOVER 2006b), referred to as the Assessment Strategy has begun this process.

In addition to resolution of model inputs, the SFWMM is very insensitive to project alternative effects outside the model domain as well as small projects within the domain. The SFWMM was originally used to compare alternative plans during the Restudy (see Section 6.1 and Appendix D for more detailed discussion of the Restudy and Appendix D. On this broad scale, which contained all CERP projects, the SFWMM was very effective at understanding system-wide effects. When the selected plan is divided into component projects, the model is not as effective. The SFWMM is extremely coarse, based on a 2-mile by 2-mile mesh grid size. A two-mile transect in the landscape may cross several habitat types including ridge and slough, wet prairie and tree island habitats. The RSM will have increased resolution of topography and reduced grid size compared to the SFWMM. Reducing the grid size from 2 miles by 2 miles to a variable-mesh triangular matrix approximately 0.5 miles and 1.0 mile per side for urban and natural areas, respectively, will provide greater sensitivity. Greater sensitivity will potentially make current performance measures more effective at detecting differences in project alternatives.

Additionally, vertical accuracy (depth and elevation) of the SFWMM is within ± 6 inches. This resolution makes it very difficult to determine effects of project alternatives. Based on Natural System Model (NSM) topography, from Indicator Region 110 in northern WCA 2A to Indicator Region 129 in northeast Shark River Slough (Everglades National Park), the change in elevation is approximately 7 feet, or 2.1 inches per mile, across the 40-mile transect. To determine effects of individual or smaller groups of projects, increased sensitivity will be required.

Disconnect between timing and distribution of field measurements (and performance measure inputs) and optimal timing of the SFWMM can cause additional problems with sensitivity. Many field measurements, such as those taken at water management structures, are taken at scales of seconds to minutes or hours, whereas SFWMM functions more appropriately on longer time-steps. This disconnect between resolution of field measures and resolution needed for model inputs can cause problems with performance measure model coding as well interpretation of model outputs. Stronger synchronization/standardization between field measurements and model time-steps is needed to reduce uncertainty and increase sensitivity of performance measures. The Evaluation and Assessment Teams need to consult with those developing and using models to synchornize/standardize timing and scale of data being collected with those being used in models and performance measures.

17.3 Performance Measure Sensitivity, Calibration and Validation

Sensitivity analysis, calibration and validation need to be performed for each performance measure used for evaluating alternative plans. Without these technical processes, we have no objective way of determining whether or not a difference in indicator response exists between alternatives.

Performance measure sensitivity analysis is required to determine if a metric is sensitive to simulated changes in the system. While an indicator and its associated performance measure metric may be known in the real world to be linked to water management features, it is not a given that in an evaluative model, the metric will vary in any predictable way. Sensitivity analysis will give a measure of confidence that a performance measure can detect and track water management changes proposed by CERP projects. It will also discern problems and allow an estimate of whether the problem is specific to the performance measure metric, to the model used, or if the problem can actually be attributed to project design.

Each performance measure needs to be calibrated and validated. This will allow us to determine if the performance measure is accurately representing the real-world variable, will allow improvement of models, and will achieve a more accurate evaluation of actual project effects.

17.4 Less Reliance on Model-Based Targets

Currently, RECOVER relies upon regional hydrologic models to simulate alternative project plans and represent the pre-drainage Everglades. Supplemental models simulate runoff from the Caloosahatchee and St Lucie Estuaries and canal discharges.

Dependence on models, especially the NSM, to simulate the pre-drainage Everglades began early in the Restudy process. NSM describes conditions prior to human alteration. These conditions are not fully known or understood. NSM completed a picture only partially described by research. It was corroborated by historical descriptions of the ecosystem and reference conditions; however, this was a sporadic endeavor that did not result in substantial modifications. Knowing that this simulation model is limited by its assumptions, including a relatively short period of record (31-36 years), greater reliance on independently identified (empirically-based) targets is sought.

The model-independent approach has several other advantages. Such an approach can be more consistent in developing and reviewing performance measures and their targets, including scientific and statistical criteria for their acceptance. Model-independent targets could be a means to synthesize the vast amount of information on hydrologic and ecologic characteristics of the pre-drainage Everglades. In addition, independently set targets enable performance measures to be refined with new data and information without the additional step of incorporating them into a computer model. No longer would scientists need to explain performance of models, only support identified targets. Additionally, consensus on restoration targets would become the goal instead of defaulting to model-based targets.

17.5 Refinement of Evaluation-Assessment Feedback Loop

One component of the Adaptive Management Strategy (RECOVER 2006c) is the essential feedback loop from monitoring data to evaluation tools. Areas of uncertainty associated with evaluation tools and models need refinement. Ongoing monitoring and assessment activities will provide needed data at varying scales to refine current models. As sample sizes increase and a better understanding of field conditions including processes, mechanisms and rates is gained, assessment information will be fed back into evaluation models resulting in increased sensitivity and reduced uncertainty. In addition to increased sample sizes and a better understanding of ecological relationships, the ability to make measurements more precise will provide increased sensitivity. This ongoing feedback between evaluation and assessment functions will help to identify knowledge/data gaps and focus monitoring and assessment activities.

17.6 Future Performance Measures

The current set of performance measures does not include critical components of CERP restoration such as spatial extent and ecological connectivity. The final draft of the Assessment Strategy *(*RECOVER 2006b) identifies several stressors that are operative in the system for which RECOVER has not yet developed performance measures or guidance for evaluation and assessment. These include exotic species, climate change and climate variability.

Spatial Extent and Connectivity Performance Measures

An essential characteristics of the pre-drainage system was a hydrologic regime featuring dynamic storage and sheet flow. The Central and Southern Florida (C&SFs) Project has altered hydrology in the Everglades and has resulted in reduced flows, fragmented and impounded wetland areas, and reduced spatial extent. The CERP will restore a more natural hydrologic regime. Simple, model-independent performance measures that characterize ecological connectivity, landscape fragmentation, spatial extent and landscape corridors should also be adopted.

Exotic Species

Exotic plant and animal species threaten natural ecological communities within CERP boundaries. It is estimated that over 32,000 exotic species (25,000 plants and 7,000 animals) have been introduced into Florida (Stein et al. 2000). Florida has approximately 4,000 to 5,000 native species of plants and animals. The number of exotic species that have been introduced is eight times the total number of native species in the entire state. Within CERP boundaries just 6 species of invasive exotic plants have replaced approximately 1.9 million acres of habitat (Doren and Ferriter 2001). One species alone, Old World climbing fern, has spread exponentially during the last two years. Its current range covers over 125,000 acres within CERP boundaries and model results for this species estimates over 5 million acres will be covered by 2014 (Ferriter et al. 2006). Replacement of native plant and animal species by exotics can potentially cause irreversible alterations in ecological community structure and function by altering fire regime, surface water flow, salinity, water quality, primary productivity and food web structure, to name a few. Given current and potential impacts on non-indigenous organisms in South Florida, we are obliged to begin to factor these exotic species and their impacts into our planning and research. The Assessment Strategy (RECOVER 2006b) contains a more detailed discussion of this issue.

More Attribute-Based Evaluation Metrics

More metrics measures that correspond to the attributes in the conceptual ecological models published in *Wetlands* (Barnes 2005, Browder et al. 2005, Crigger et al. 2005, Davis et al. 2005a, 2005b, Duever 2005, Havens 2005, Ogden 2005, Ogden et al. 2005, Rudnick et al. 2005, Sime 2005, VanArman et al. 2005) are needed for evaluations of alternative plans. Without these, the set of performance measures may be insufficient in its ability to evaluate potential effects on important ecosystem attributes.

17.7 Implications of Climate Change and Climate Variability upon CERP

Given CERP's geographic scope and multi-decadal planning and implementation horizons, management decisions need to be consistent with and adapt to global climate change and inter-decadal climatic variability. Global changes include sea level rise, sea surface temperature change, atmospheric carbon dioxide and large-scale changes in participation patterns. Climate variability includes the Atlantic Multi-decadal Oscillation, El Nino/El Nina, Sahel drought, and tropical storm impact. These factors will have to be considered during CERP assessments, evaluations and recommended management alternatives. The Assessment Strategy (RECOVER 2006b) contains a more detailed discussion of this issue.

17.8 Consistency of Performance Measures and Interim Goals and Targets

Performance measures and interim goals and targets were developed as separate efforts. While they were based on the same underlying information, there are inconsistencies between them. These inconsistencies need to be eliminated. The *RECOVER Team's Recommendations for Interim Goals and Interim Targets for the Comprehensive Everglades Restoration Plan* (RECOVER 2005) can be found at http://www.evergladesplan.org/pm/recover/igit_subteam.aspx.

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